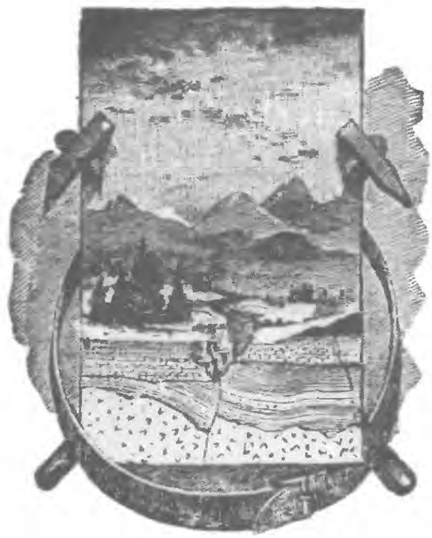
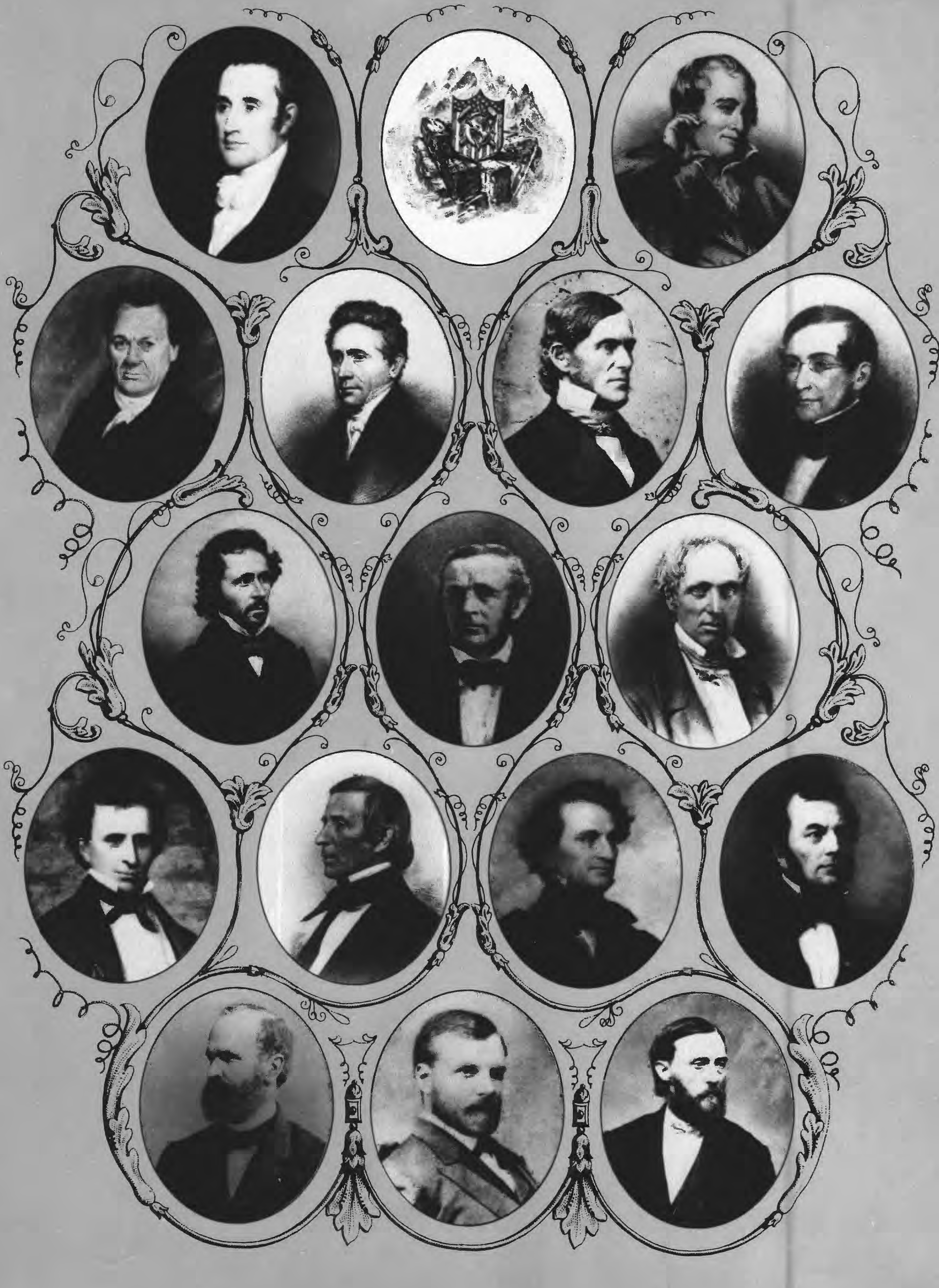
Minerals, Lands, and Geology for the Common Defence and General Welfare

Volume 1, Before 1879



UNITED STATES GEOLOGICAL SURVEY



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Page 18 of the Conference Report on HR 6471 of the 45th Congress, 3d session. When accepted by the House and Senate and approved by the President, it became the Organic Act of the United States Geological Survey. ▶

◀ See page x for identification of portraits.

Amendment numbered 90, 91, 92 & 93,

That the House recede from its disagreement to the amendments of the Senate numbered 90 - 91 - 92 - and 93,

and agree to the same with amendments, as follows:

In lieu of the entire paragraph insert the following =

For the salary of the Director of the Geological Survey, which office is hereby established, under the Interior Department, who shall be appointed by the President by and with the advice and consent of the Senate, six thousand dollars: *Provided*, That this officer shall have the direction of the Geological Survey, and the classification of the public lands and examination of the geological structure, mineral resources, and products of the national domain, and that the Director and members of the Geological Survey shall have no personal or private interests in the lands or mineral wealth of the region under survey, and shall execute no surveys or examinations for private parties or corporations; and the Geological and Geographical Survey of the Territories, and the Geographical and Geological Survey of the Rocky Mountain Region, under the Department of the Interior, and the Geographical Surveys West of the One hundredth Meridian, under the War Department, are hereby discontinued, to take effect on the thirtieth

Minerals, Lands, and Geology for the Common Defence and General Welfare, Volume 1, Before 1879

By Mary C. Rabbitt

UNITED STATES GEOLOGICAL SURVEY

A History of Public Lands, Federal Science and Mapping Policy, and Development of Mineral Resources in the United States

UNITED STATES GOVERNMENT PRINTING OFFICE: 1979

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Foreword

The U.S. Geological Survey, established by an act of Congress in 1879 to be responsible for the "classification of the public lands, and examination of the geological structure, mineral resources, and products of the national domain," is about to enter its centennial year. As an organization that has contributed to the development of the United States and an understanding of the Nation's natural resources, it is appropriate that its history be set forth for the record. For that task, we chose, not an historian but one who has been for many years a member of the Survey staff and who has a knowledge of both science and of the internal workings of the organization—Mrs. Mary C. Rabbitt.

Mrs. Rabbitt has chosen to relate the Survey's development and activities in the broader context of United States history and the role of geology and allied sciences therein. That decision rests as much on geology as on history. In 1830, Charles Lyell pointed out that "Geology is the science which investigates the successive changes that have taken place in the organic and inorganic kingdoms of nature; it enquires into the causes of these changes, and the influence which they have exerted in modifying the surface and external structure of our planet. By these researches into the state of the earth and its inhabitants at former periods, we acquire a more perfect knowledge of its *present* condition, and more comprehensive views concerning the laws *now* governing its animate and inanimate productions. When we study history, we obtain a more profound insight into human nature, by instituting a comparison between the present and former states of society." S. F. Emmons, one of the great economic geologists during the early years of the Survey, whose contribution to the development of economic geology has been likened to that of Lyell in general geology, insisted that mineral deposits could only be understood in terms of overall geologic structure.

This volume, the first of a four-volume study, is concerned with events in the United States before the establishment of the U.S. Geological Survey, during the years in which geology evolved as a science and began to influence economic development and national policy. Subsequent volumes continue the story but focus on the Survey and its role in the events and developments of later years. The method of analysis demonstrates that knowledge of the Earth and its history, processes, and resources has provided a basis for intelligent economic development; also that geologists very soon realized that uncontrolled development of the land and other natural resources could not continue, that some limitations must be made on man's use of the Earth. The Geological Survey was established when public awareness of the need for balance between development and conservation of our resources was becoming evident. That balance is even more necessary now and in the future for the "general welfare" and "common defence" of the Nation. We can be grateful for the wisdom of our Founding Fathers in providing for publicly supported studies in earth science and engineering by well-trained and motivated scientists and engineers. Such studies, undertaken objectively in the search for facts, can continue to be of great value in the formulation and execution of wise policies to protect our environment and to maintain that balance between development and conservation of the natural resources.

V. E. McKelvey

V. E. McKelvey,
Director, U.S. Geological Survey
1971–1978

Preface

Preparation of a history of an organization like the U.S. Geological Survey, whose existence has spanned so long and so exciting a period in the development of the United States, presented many problems. In 1954, for the 75th anniversary of the Survey, my husband, John C. Rabbitt, and I prepared a brief history of the Survey which was published in *Science*. It was based entirely on secondary sources, including the Survey's own bulletin 227 published in 1904, and the Institute of Government Research's monograph No. 1 of 1919. In 1947, Henry Nash Smith had published in the Mississippi Valley Historical Review a paper in which he attributed to John Wesley Powell the major influence in the establishment of the Survey. Earlier, Walter Prescott Webb and Bernard DeVoto had emphasized Powell's importance. In 1951, W. C. Darrah's biography of Powell and, in 1954, Wallace Stegner's *Beyond the Hundredth Meridian* both credited Powell with the founding of the Geological Survey. In 1957, however, Thurman Wilkins in his biography of Clarence King claimed for King the principal role in the establishment of the Survey. In 1969, when we celebrated the centennial of Powell's exploration of the Colorado River, I became acquainted with primary sources for the first time, and realized some of the difficulties in the interpretation of history.

With the centennial of the founding of the Survey only a decade away, thoughts turned to a full-scale history based on primary sources. Almost immediately there arose the problems of how to deal with the volume of material recounting the activities of the Survey during its century of existence. Most historians, I believe would have chosen to treat the material from a thematic point of view, and several possible themes were considered. The Survey could be treated as a Government agency, and its history recounted in terms of its effect on the establishment or execution of public policy. The Survey could be considered as a research institution, and its history told in terms of its contributions to science and engineering and its interaction with the professions. The Survey has played a part in the industrial development of the country, in the conservation of its natural resources, and in the preservation of its environment, but all these are only facets of one Survey.

From my own experience in the Survey's years, I know how all these phases interrelate and how often now one and now another factor, sometimes within the Survey, sometimes seemingly totally unrelated, affected the emphasis and direction of the Survey's work. What I have observed in my years on the Survey, of course, has been true throughout its history.

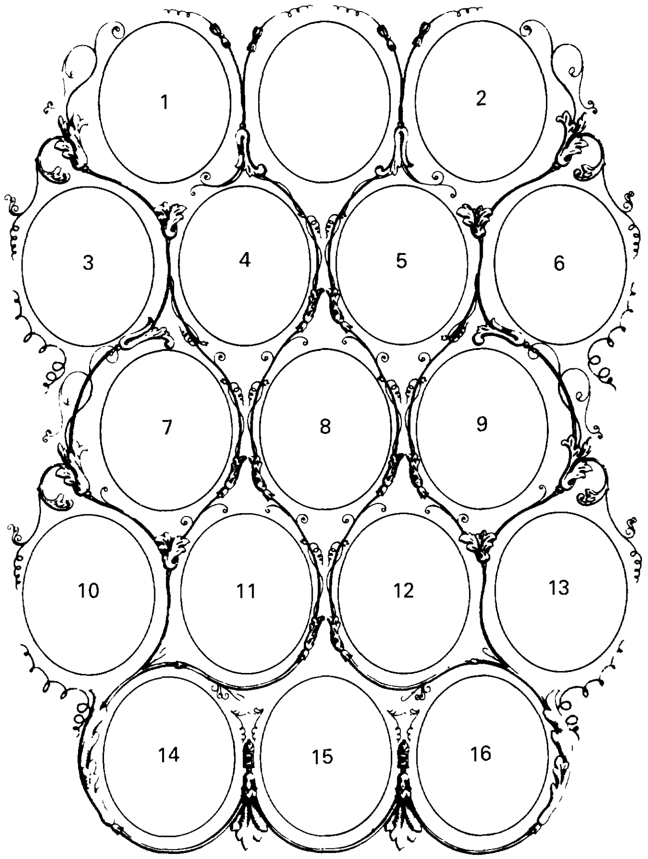
The development of Survey programs cannot be understood apart from the times of which they were part. Therefore, I have attempted to recount the history of the Survey, and particularly in this volume of the geological sciences and engineering before its establishment, in terms of public-land policy, mapping policy, science policy, and the economic development of the Nation—in the words of the Constitution, as they contributed to the common defence and general welfare of the United States. It is a history written not for historians but for the general reader to help him understand the ways of science and scientists in a Federal bureau. For that reason it follows a chronological rather than a thematic pattern and does not provide a detailed analysis of development.

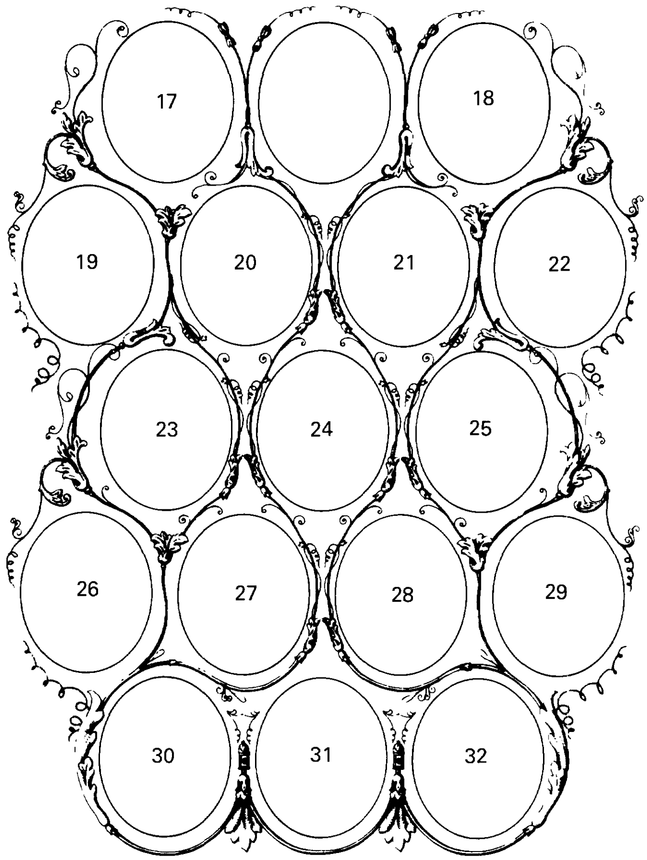
For the most part, this history is based on printed sources. Primary sources consulted include the American State Papers: Documents, Legislative and Executive, 1789–1837; the Annals of Congress, Register of Debates in Congress, Congressional Globe, Congressional Record, and the Senate and House Journals, Documents, and Reports; the reports of the State geological surveys and of the various Federal surveys; and many scientific and engineering journals. No exhaustive search of unpublished material has been made, but manuscript collections in the National Archives, the Library of Congress, the Bancroft Library of the University of California, the Huntington Library, and the University of Edinburgh have been consulted. Many secondary sources of both the 19th and 20th centuries on history, geology and related sciences, exploration and mapping, mining and mineral resources, and the administration of the public lands have also been consulted.

Illustrations have been selected with two purposes in mind: to show the changing art of scientific illustration, and to present an impression of the development of the geological sciences and mapping. Nearly all the illustrations have been published before.

I am indebted to many members of the Geological Survey for help ranging from discussion of scientific questions to recommendations on the format of publication. In particular, however, I would like to acknowledge the interest, encouragement, and advice of the seventh Director of the Survey, Thomas B. Nolan; the exceptionally thorough and detailed reviews of the manuscript for this first volume by the former Associate Director of the Survey, Arthur A. Baker, by the ninth Director of the Survey, Vincent E. McKelvey, and by Clifford Nelson, the Associate Historian; and for valuable suggestions from other reviewers of this volume, especially R. H. Lyddan, former Chief Topographic Engineer, and G. D. Robinson of the Geological Division. I am grateful to Clifford Nelson also for locating portraits in various archives and for the great interest and attention of those charged with final preparation of the manuscript for printing, especially Anne C. Sangree, Paul F. Clarke, James Caldwell, and Arthur Hiltbrand.

Keys to portraits on end papers





Inside Front Cover:

1. Benjamin Silliman.
2. William Maclure.
3. Amos Eaton.
4. Denison Olmsted.
5. Edward Hitchcock.
6. Charles T. Jackson.
7. John C. Frémont.
8. Michael Tuomey.
9. David Dale Owen.
10. Douglass Houghton.
11. Henry Darwin Rogers.
12. James Dwight Dana.
13. James Hall.
14. Josiah Dwight Whitney.
15. Clarence King.
16. Ferdinand V. Hayden.

Inside Back Cover:

17. John Wesley Powell.
18. Lt. George M. Wheeler.
19. Othniel C. Marsh.
20. James Dwight Dana.
21. William Barton Rogers.
22. John Strong Newberry.
23. William P. Trowbridge.
24. Simon Newcomb.
25. E. D. Cope.
26. John D. C. Atkins.
27. Abram S. Hewitt.
28. James A. Garfield.
29. Aaron A. Sargent.
30. Rutherford B. Hayes.
31. Carl Schurz.
32. Clarence King.

Chapter 1.
The Sum of the Past

> **Whether we consider the rocky layers enveloping the Earth, the arrangement of the forms of life that inhabit it, the variety of civilizations to which it has given birth, or the structure of languages spoken upon it, we are forced to the same conclusion: that everything is the sum of the past and that nothing is comprehensible except through its history.**
>
> **—Pierre Teilhard de Chardin**

On March 4, 1879, as the noon hour approached signifying the mandatory end of the last session of the 45th Congress, the Speaker of the House, the Honorable Samuel J. Randall of Pennsylvania, rose to his feet. He said,

> **Representatives, in a moment this Congress will expire. Its acts, whether for weal or woe, are indelibly inscribed on the pages of history. In this Hall party has been arrayed against party and interest against interest in fierce and bitter struggle; but it is due to truth to say that on every side there has been honest ambition to win popular esteem by seeking, each in his own way and according to his best judgment, the general welfare. Whether or not the desired end of the public good has been successfully attained is for time to prove.**

The Speaker of the House very likely did not have in mind H.R. 6471, an act appropriating funds for sundry civil expenses of the Government for the fiscal year ending June 30, 1880, which was among the several that the President had signed the night before. Some very controversial measures had come before that Congress, and some bills had failed when the Senate and House were unable to agree. H.R. 6471, however, included a few paragraphs establishing a new Federal bureau, the U.S. Geological Survey, to be responsible for "classification of the public lands, and examination of the geologic structure, mineral resources, and products of the national domain." In more general terms, the new agency was to have a share in the management of the public lands and to engage in both general and economic geology, pure and applied science.

For nearly 100 years, about half the life of the United States as a nation, the United States Geological Survey has continued to hold these responsibilities. The emphasis and balance of the Survey programs have changed during the years. In 1879, the Survey undertook a few investigations of the geology and mineral resources of the Western States and Territories. In 1976, the survey mission was described as "increasing the knowledge of the extent, distribution, character, and origins of the Nation's natural resources and of the geologic processes that affect the use of the land so that man may adjust his activities to the constraints imposed by the environment and so that the Earth's resources may be managed wisely" and "classifying the Federal lands and supervising mineral lease development on Federal and Indian lands." Except for the supervision of mineral-lease development, which was not envisioned in 1879, the Survey program is still encompassed by the brief words of the authorizing legislation of 1879. Time would seem to have proved that the desired end of that legislation had been successfully attained.

What were the circumstances that led to the establishment of the U.S. Geological Survey in 1879? In the ordinary course of the development of science, and of the need for increasing amounts of natural resources as the industrial era began, governments have established agencies to supply the scientific knowledge needed for resource development. The Survey of Great Britain was established in 1835, that of Canada in 1842. Many of the States in the United States set up surveys in the 1830's. The United States Survey was not established until 1879, and then it was charged with a unique combination of responsibilities—classification of the public lands as well as geologic investigations. The reasons must be sought in United States history as well as in the history of geology, and there we have a tangled web to unravel.

The public lands and geology as a separate science are about the same age as the United States. The public lands, the lands to which the Federal Government still holds title, originated in the western lands ceded to the Federal Government by the Eastern States that had claims to them in colonial charters. The public lands were enormously increased as a result of the Louisiana Purchase in 1803 and subsequent territorial acquisitions. The two problems that confronted the new Nation with regard to the public lands were how to map and how to distribute them. The mapping was entrusted to a Surveyor-General, at first an indepenfent agency, later a part of the General Land Office. The Surveyor-General was not responsible for all Federal mapping. The Survey of the Coast was established in 1807, in response to pressure from commercial interests seeking aids to navigation. The first superintendent was a geodesist, and from the beginning the Coast Survey made a highly accurate survey on a geodetic base. Ths Army Engineers were charged with mapping for various internal improvements after passage of the General Survey bill in 1824. For the defense of the frontier, the Army engineers were also concerned with mapping the West, and in 1838, a separate Corps of Topographical Engineers was established. All used different methods, and the development of Federal mapping and mapping policy is entwined in the history of all these agencies.

This disposition of the public land was an even more thorny problem and as persistent an issue in national politics as the tariff. Ths government in the beginning chose not to manage its lands as a capital asset but to dispose of them, as a source of revenue and as a means of encouraging settlement and creating a Nation of free citizens living independently on their own land. Other decisions had to be made about the mode of distribution, and pressure groups and regional interests pushed the Government in various directions. The distribution progressed with time from sale by auction to preemption and sale at a minimum price, to graduation or lowering in the established minimum prices, and finally to the donation of a homestead. At the same time, lands were granted to veterans and to the new States in the form of dowries. After the preemption law was passed, the idea of using the public land as a source of revenue was abandoned, but large grants were made to aid the construction of railroads and the establishment of colleges for the benefit of agriculture and the mechanic arts. The settler in the late 1860's had a bewildering choice of land for sale by the railroads or State agencies, or free from the Federal Government.

From the beginning, however, certain lands were withheld from sale or distribution, and the lands therefore had to be classified. The Ordinance of 1785 reserved to the government one-third part of all gold, silver, lead, and copper mines, and the land law of 1796 withheld salt springs. Classification was made the responsibility of the Surveyor. In 1807, Congress provided that the lead-bearing lands should be leased. Administration of the law was difficult, and beginning in 1829, the lead lands were gradually sold, then the copper lands. Iron lands and coal lands were ruled not mineral lands. No regulations were made about the lands bearing precious metals until 1866 when they were declared free and open to exploration and purchase.

Other classifications of public lands were set up during the course of the years as special needs arose—beginning with the setting aside of live oak and cedar lands for the use of the Navy. By 1879, eight classes of public lands were recognized—and each of them had separate regulations for disposition. However, except in a few instances, no special provision had been made for securing an accurate classification in advance of disposition, and the surveyors were still responsible. In actual practice, the deputy surveyors were unable to classify the land as well as survey it, and the classification was made by affidavits from the interested parties.

The role of science in the Federal Government also changed during the course of the first century of independence. In the beginning, the only provision for science made in the Constitution of the United States empowered Congress to promote its progress by securing to inventors the exclusive rights to their discoveries, in other words, for patents. Science and education in time became linked with the issue of internal improvements. Internal improvements were at first considered the prerogative or responsibility of the States, and an amendment to the Constitution was deemed necessary for the Federal Government to undertake their construction. The doctrine of implied powers of the Constitution was proposed early in the 1790's and affirmed by the Supreme Court in 1819 but remained controversial. By the mid-1830's, however, the attitude toward Federal science began to change as the needs of an expanding nation demanded scientific knowledge. It was not until 1862, however, that Congress, in establishing the Department of Agriculture, acknowledged that its power to lay and collect taxes to provide for the common defense and general welfare included the support of scientific research. The development of Federal science in general must be considered as part of the Survey's background.

Government use of geology began in county organizations about 1820 and somewhat later in the States. The roots of geology and its sister science, geography, go far back into ancient times, but their development was especially a phenomenon of the later 18th and early 19th centuries and must be related to other phenomena of the same era, the beginning of industrialization and the expansion of geographic frontiers. The development of these sciences also had marked national characteristics. In England, sedimentation and stratigraphy were stressed, in France, paleontology, in Germany, mineral resources. In the United States, the development of geology was to a large extent practical, linked to the improvement of agriculture or the development of mineral resources, and general geology or geologic research was a later development. Geography evolved from a descriptive to a systematic science in Europe and was imported to the United States in mid-19th century, where it became engrafted on geology.

In the 1830's, nearly all the Eastern States established State geological surveys in connection with internal improvements and the development of natural resources. None was considered a permanent organization, however, and most lasted but a few years, although their end was hastened by a depression. The first Federal geologist was employed by the Topographical Engineers in 1803 and again in 1836. The General Land Office employed a geologist in 1839 to classify some of the lead lands in the upper Mississippi Valley. A decade later, the General Land Office employed geologists to classify the copper lands in Michigan and other lead lands in the upper Mississippi Valley. Both these surveys were more extensive and intensive than those in the 1830's, but neither was permanent. Ths Corps of Topographical Engineers made several explorations of the West in the 1840's, but the officers relied on their own scientific training or reports from eastern scientists on referred collections rather than take along a geologist or naturalist.

During the 1850's, however, geologists and naturalists accompanied both the explorations for the route of a pacific railroad and other explorations in the southwest and northwest and added greatly to the knowledge of the West. At the same time, State surveys again flourished, especially in the south and Midwest, in aid of agriculture or the development of mineral resources, and some of the States began topographic mapping.

Although Americans had been considered primarily practical scientists, and theories have been developed to account for that predilection, the American had always been torn by two conflicting desires, the ideal of a peaceful life of agrarian simplicity and the yearning for creature comforts. If such comforts are to be supplied at reasonable cost, some need of organized industry is implied. The industrial era began later in the United States than in Europe, and the development of manufactures, especially those depending on mineral resources, was slow and was dependent for many years on a protective tariff. The tariff laws are thus a thread in our tangled web. In the 1830's, as the States began to make use of geology, the mineral industry also began to use science to explore for new resources and to make better use of existing resources. Both iron and coal industries made use of geologists, and the profession of consulting geologist was born. By 1855, the iron industry had grown sufficiently to organize an association to promote its interests, including that of improved technical education. The value of manufactured products exceeded the value of agricultural products in 1859, but the increasing industrialization was obscured for the next few years by the Civil War. Development after the Civil War was very rapid, and in 1871, the American Institute of Mining Engineers (AIME) was formed, as one member said, because scientific research was essential, and the day of reliance on a high tariff was gone forever. The use of geology by the mineral industry was also a factor in the decision to establish the U.S. Geological Survey.

From 1867 onward, the progress toward a single national survey is somewhat clearer. The first of the so-called Great Surveys was established in that year, under the Army Engineers but directed by a civilian, to study the geology and natural resources along the line of the Pacific railroad. Originally planned for 3 years, it was extended to 6 years of fieldwork and a total of 11 before completion of reports. A survey of the natural resources of the newly admitted State of Nebraska in 1867 under the General Land Office grew in 1870 to a Geological and Geographical Survey of the Territories under the Department of the Interior with annual appropriations and no planned end. The Geographic Surveys West of the 100th Meridian begun by the Army Engineers for military purposes were approved in 1872, with the anticipation that they would continue for at least 15 years. A fourth survey, begun as a daring exploration of the canyons of the Colorado River, eventually became the Geographical and Geological Survey of the Rocky Mountain Region. It was less permanent than the others, however, and most appropriations were made for the completion, rather than for the extension, of this survey. The conflicting military and civilian interests in mapping the West were investigated by Congress in 1874 but were not resolved.

By 1878, the surveys of the General Land Office, relentlessly imposing their rectangular grid on western deserts and mountains, were in disfavor in many quarters. Congress asked the National Academy of Sciences to consider all the surveys and recommend a plan for surveying and mapping the Territories of the United States to obtain the best results at the least cost.

One more factor must yet be considered—the development of a movement for the conservation of natural resources. The United States had been blessed with fertile land and an abundance of resources, but Americans had abused and abandoned the land. The raid on land resources reached its height sometime in the early 1860's; then, as settlers moved onto the treeless prairies, where rainfall was sometimes scanty, the realization came that the lands were not inexhaustible. In 1864, George Perkins Marsh, often considered the fountainhead of the conservation movement, pointed out that man was fast making the Earth uninhabitable by wanton destruction, waste, and neglect; he expressed the hope that geologic, hydrographic, and topographic surveys would supply the facts from which the interaction between man and nature might profitably be determined. In that same year, the Federal Government granted to the State of California the Yosemite Valley and the Mariposa Grove of Big Trees for public use, the first attempt to preserve a scenic area for the pleasure of the people. The movement for conservation of the renewable resources and for preservation of natural wonders gathered strength in the 1870's. A congressional commission investigated the possibilities of irrigation. The Department of the Interior under Carl Schurz made determined steps to preserve the forests. And in 1872, Congress established the first national park in the Yellowstone Valley.

The conservation of the nonrenewable mineral resources is a separate problem from that of renewable resources, although wise use is the common necessity. In the conservation of nonrenewable resources, however, waste is particularly to be deplored. European nations had long since recognized the special problem and had established elaborate mining codes and administrative bureaus to enforce them. European mining engineers were trained to extract the maximum amount of ore. In the 1840's, Michael Tuomey, State Geologist of South Carolina and later of Alabama, pleaded for better technical education and decried the waste prevalent in mining. One of the objectives of the American Iron Association formed in 1855 was the encouragement of the formation of schools of mining. The first school of mines in the United States (Columbia College, New York City) was established in 1864, and technical education in mining and metallurgy improved steadily thereafter. By the late 1870's, however, even those who hoped that knowledge and corporate responsibility would accomplish the conservation of mineral resources were beginning to think of Government action. Knowledge of the precious metals was especially important because of monetary crises. For several years a Commissioner of Mining Statistics under the Treasury Department regularly investigated and reported on the status of mining in the Western States and Territories, although he called his figures estimates rather than statistics. However, these reports had been discontinued about the time many nations adopted the gold standard, and the currency issue began to assume serious proportions in the United States.

Historians of the past often debated whether men make things happen or are molded by inexorable forces, and, depending on the examples chosen, a case can be made for either side. Today, history is said to consider man and his environment, the effects of man on his environment and of the environment on man, but that is begging the question. To write history in those terms means not only knowing the environment of the past but understanding the perspective of men of that past on their environment, a perspective which would seem to be very different from ours. However, more than 2,000 years ago, a wise man, foretelling in one sense Lyell's thesis that geological processes of the past were the same as those now in operation, said:

> **Generations come and generations go, while the earth endures forever. The sun rises and the sun goes down; back it returns to its place and rises there again. The wind blows south, the wind blows north, round and round it goes and returns full circle. All streams run into the sea, yet the sea never overflows; back to the place from which the streams ran they return to run again.***What has happened will happen again, and what has been done will be done again, and there is nothing new under the sun.**

It has been said many times that history repeats itself. It only seems to repeat because there is a kind of uniformitarianism in human nature. Today we know more than the men of old, and we have new problems and new ways of solving problems, but human reactions to problems have not changed. It is only, as Qoheleth said, "The more a man knows, the more he has to suffer."

With that as a theme, let us in the following chapters examine the history of the United States and the development of the interaction between scientists, engineers, and statesmen and the environment, which produced public-land policy, Federal science and mapping policies, and which supported the economic development of the United States and increased public awareness of the importance of wise use of our natural resources.

Chapter 2.
Western Pilgrims

Americans are the western pilgrims, who are carrying along with them that great mass of arts, sciences, vigour, and industry, which began long since in the east; they will finish the great circle.
—Michel-Guillaume-Jean de Crèvecoeur

Of the two basic industries of man, agriculture is certainly the older, but mining, more especially of the metals, has played a fundamental role in the development of civilization and frequently a critical role in history. Agriculture was the means of sustaining life. Metals made life richer or easier. They captured the imagination, inspired acquisitiveness, even the pursuit of knowledge to make their acquisition easier. Of all metals, gold and silver, the precious metals, were most desired. The heavenly city in the *Book of Revelations* is said to be of pure gold, clear as crystal.

Metals were used first for ornamental purposes, gold perhaps as early as 10,000 B.C., silver somewhat later. Copper was the first metal used for practical purposes, for tools along about 4000 B.C. and then combined with tin to make bronze. Phoenician and Greek traders made long voyages in search of tin, which was scarce in the Near East; tin mining in Spain, and the Bronze Age, began about 2500 B.C. Iron may have been used for tools as early as 2500 B.C. but its use became widespread, and the Iron Age began, about the 14th century B.C. Lead was used for ornamental purposes about 5000 B.C., and for practical purposes somewhat later, but it never attained the importance of copper, tin, and iron in prehistoric time. Silver was the first metal used for money, at least as early as 2000 B.C. in Babylon. The only other metal known to antiquity was mercury, used in religious ceremonies and for medicinal and cosmetic purposes, and also for the recovery of gold and silver. Production at Almaden, Spain, began about 400 B.C. These seven metals, the so-called biblical seven, were the only metals in common use until well along into the 19th century.

Coal, which with iron was the foundation of the industrial age, was referred to in the writings of Aristotle and Theophrastes in the 4th century B.C. and was used by the Romans in Britain before 400 A.D. It was first used for commercial purposes in China in the 13th century, but the great increase in its use began much later, and for centuries mining was almost entirely restricted to metals.

Under the Roman Empire, the precious metals, gold and silver, took on new importance. The only known mineral resources in the territory of the early Roman community were nonmetallic, primarily construction materials. As Roman dominion was extended and neighboring peoples were conquered, their territory usually became public land, to be leased to citizens of Rome. The mines, however, were considered prizes of war. Some yielding the base metals might remain in private hands for a price, but gold and silver mines became state property.

After the collapse of the Roman Empire, Western Europe became economically dependent on Eastern Europe and the Middle and Far East which were more advanced. The precious metals were gradually drained from Europe to the East to pay for eastern goods. When the Renaissance began in Europe, the demand for oriental goods increased, and the Italian port cities, midway between Asia Minor and Western Europe became the chief beneficiaries. The rising nation states to the west soon realized the disadvantage to them of the Italian monopoly and began to seek a more favorable basis of trade. Most of their effort went into a search for a direct route to the East in order to avoid the middlemen. The Portuguese began their work of discovery shortly after 1400 and eventually reached the Orient by going around the coast of Africa. As a result, virtually a new monopoly in Eastern goods was established at Lisbon, and Europe's economic center of gravity began to shift from the Mediterranean to the Atlantic.

Spanish explorers who also sought a route to the East instead discovered a New World. Portugal remained in undisputed possession of the trade with the Orient, but Spain's disappointment was assuaged when the New World was found to contain vast treasures of silver and gold. The Spanish crown fostered the mining of these metals in the New World, and the centuries-old trend was reversed. Bullion began to flow into rather than out of Europe.

The transfer of wealth from the New World to Europe led to the development of the mercantilist philosophy—that the wealth and power of a nation depended on its stock of precious metals—and all enterprises were designed to enhance this wealth and power. Each nation therefore endeavored to create a self-sufficient economy, and in this endeavor, colonies became important. The colonies were presumed to exist for the benefit of the mother country, to produce the raw materials that the mother country would otherwise have to buy, and to buy manufactured goods from the mother country.

By the end of the 16th century, Spain had placed its mark on America from Cape Horn to the Rio Grande, the foundations had been laid for most of the present Latin American nations, and Spanish conquistadors had explored the whole southern section of the United States from South Carolina to California in search of treasure or the strait that would be the passage to India. In 1598, Spain took formal possession of the province of New Mexico, and in 1609, the Spanish governor founded the city of Santa Fe. Spanish power then, however, was already past its zenith.

The Dutch, French, and English were at first content to prey on the Spanish treasure ships; then they attempted to gain footholds in the Caribbean and South American areas from which the wealth was coming. As the Spanish power began to decline, the English established colonies in North America—in Virginia in 1607 and in Massachusetts in 1620. The French made their first settlement even farther north, at Quebec in 1608, and began to move from there into the interior of the continent. The Dutch made their first settlement in New Amsterdam in 1624. In none of these areas were precious metals found, but there were other sources of wealth to be exploited. The French and the Dutch became interested in fur. The English began to reap the fruits of empire in more prosaic fashion, from the land, the forests, and the sea.

Only the English colonies made any real effort to exploit other mineral resources, and it was the English colonies that eventually placed a permanent mark on most of North America. Shortly after the arrival of colonists in Virginia, a feverish hunt was made for gold. Captain John Smith described it as "no talke, no hope, nor worke, but dig gold, wash gold, refine gold, load gold," but the shipload of glittering dust sent to London proved to be not gold at all, but mostly mica. However, in the following year, 35 tons of iron ore were shipped to England and yielded 17 tons of iron "as good as any in Europe." When the reorganized London Company in 1619 tried to set up an economic development program for the colony, they sent skilled workmen to aid the colonists, among them several ironmakers. Ironworks were set up at Falling Creek, a tributary of the James River about 66 miles above Jamestown. The Indian massacre of 1622, however, ended that venture before it was fairly started. Tobacco was in great demand in England, tobacco growing was suited to the land and available labor, and so tobacco became the principal source of revenue, and Virginia was committed to an agricultural economy.

Puritans of the Massachusetts Bay colony were the first to undertake successful mining ventures. The Pilgrims, who preceded them by several years, arrived in winter, and their first problem was survival. In time, the Pilgrims turned to the sea, and fish became their principal staple for trade, though they also engaged in agriculture, stock raising, and, to a degree, trading with the Indians for furs. The beginning of the Massachusetts Bay colony coincided with a period of political and religious upheaval in England, and, as a result, migration to that colony was much greater than to Virginia or Plymouth, as many as 20,000 arriving in the first 10 years. Many of the Massachusetts Bay colonists were from well-to-do families, paying their own way or pooling their resources within a church congregation. Many were well educated, or skilled in various trades; they had more capital and more business experience than did the Pilgrims. The New England soil was not conducive to great agricultural enterprises, so economic activity was soon diverted into other channels, to fishing, lumbering, and shipbuilding.

The manufacture of iron in England had made great progress during the 15th and 16th centuries. As early as 1483, the importation of manufactured articles of iron or steel that would compete with domestic production was forbidden, and a century later the English had become so skilled in iron manufacture that they were exporting iron goods, even, it is said, cannon for the Spanish navy. Though by 1630, a growing scarcity of timber to make charcoal had forced many furnaces and forges to shut down, iron goods were still second only to textiles in England's export trade.

By mercantilist theory, the colonists should not have engaged in iron making in competition with the mother country. Practice, however, did not always conform to theory. Iron ore was discovered near Lynn, Massachusetts, shortly after the settlement of the colony. Specimens of the Lynn ore were taken to England and "The Company of Undertakers for the Iron Works" was organized and advanced £1,000 to establish an ironworks. One of the members of the company was John Winthrop, Jr., son of the governor of the colony, and a member of the Royal Society. The first ironworks were set up on the banks of the Saugus in 1643; later, other ironworks were set up at Braintree, Taunton, Concord, Rowley, Canton, and several other towns. Bog and pond ores were used, and timber was abundant for charcoal and waterpower. The dies for the pinetree shillings were made at one of the forges of the Lynn works in 1652, and Boston's first fire engine was also produced there; most of the iron, however, went into iron pots, nails, and farm tools. Colonists moving outward from the Massachusetts Bay area settled in Connecticut, where they set up ironworks at New Haven in 1658, and in Rhode Island, where ironworks were established at least by 1675 in Pawtucket, and possibly much earlier. Small lead mines were also opened up in Massachusetts and Connecticut to obtain lead for ammunition.

There was no mining elsewhere until New Amsterdam became an English colony. The Puritans assumed control of the English Parliament in 1648 and immediately made efforts to regain the English monopoly of the colonial trade that had been taken over by the Dutch during the years of the Cromwellian rebellion. During the Anglo-Dutch conflict thus precipitated, the British captured New Amsterdam and it became an English colony. New

Englanders promptly moved southward and settled in New Jersey. The first ironworks were set up in Monmouth County in 1674.

William Penn had had experience with the iron furnaces in Sussex, the center of the English industry, and hoped to encourage mining in his "Holy Experiment" in Pennsylvania. In 1683, he reported the existence of iron in various places in his colony; in 1685, he included iron and "perhaps" copper among the "things that we have in prospect for staples of trade." A prospectus for future colonists, written in 1698 by Gabriel Thomas, stated that iron ore "which far exceeds that in England, being richer and less drossy" had been found and also coal, but it was well into the 18th century before any ironworks were set up or any coal mining begun.

The Anglo-Dutch rivalry for American empire came to an end in 1689, when William of Orange succeeded James II as King of England. Economic interests in England then moved to check the growing strength of France, and French-English rivalry for empire became an important factor in colonial development for the next several decades.

There were several friction points between the two powers in the New World. The English settlements stretched along the Atlantic seaboard from Maine to Carolina and had a population of about 200,000. The economy in the southern colonies was almost wholly based on agriculture, but in New England and New York, a more diversified economy had developed, including lumbering, shipbuilding, and the production of naval stores as well as agriculture and stock raising. The northern and middle colonies had also established a network of triangular trade relations in order to obtain money to pay for English manufactured goods. Lumber, livestock, provisions, and other goods were sent to intermediate ports and exchanged for coin, bills of exchange, or goods that were in demand in England. The most important of these was the trade with the Caribbean area.

Although the French had made their first settlement in Canada in 1608, shortly after the English arrived in Jamestown, and had moved outward over the interior of the continent as far west as the Rocky Mountains and south to the Gulf of Mexico, there were only about 12,000 people in all that vast area. The French were primarily interested in the fur trade, but the English were beginning to challenge them in the Hudson Bay region. The French had established themselves first in the Newfoundland fishing grounds, but there too, rivalry had developed. They had hoped that Canada would be able to supply the French West Indies with provisions and raw materials, but Canada had proved a disappointment on that score, and so they looked with covetous eyes at New England and New York.

The French had done very little to develop any mineral resources. They had noted the lead ore in the Mississippi Valley and had made some crude attempts to extract lead for ammunition. For a brief time toward the end of the 17th century, Nicholas Perrot operated some lead mines in the Upper Mississippi Valley. Coal had been observed along the Illinois River and had been recorded on Louis Joliet's map of 1673 and Marquette's map of 1681. The French knew of the masses of native copper in the Lake Superior region and even dutifully shipped home specimens along with glowing descriptions of mountains of gold and silver.

The rivalry between English and French for control of the continent erupted periodically into border wars. King William's War, the first phase of the struggle, came to an inconclusive end in 1697. At the end of Queen Anne's War, in 1714, the French lost Newfoundland, Nova Scotia, and the Hudson Bay area to the English.

The French then planned to exploit the resources of the Mississippi Valley in the hope of establishing settlements that would keep the English blocked off east of the mountains and confine the Spanish to the southwest. The privilege of working mines and engaging in commerce in the Territory of Louisiana was granted to La Compagnie de la Louisiane ou d'Occident, more commonly known as the Company of the West. Philippe Renault, son of a French ironmaker, was sent out in 1719, accompanied by miners and mineralogists, to search for precious metals and to begin mining operations. The hoped-for gold and silver were not found, but in 1720, parties sent into the Ozark hills of Missouri discovered lead ore which Renault worked profitably for several years. The hostility of the Indians and the end of the wild speculation in which the Company of the West was involved brought the enterprise to an end, however, and in 1742, Renault returned to France. The mines were abandoned, ending the first period of lead mining in Missouri.

In the English colonies the iron industry expanded greatly during the early 1700's. A steady growth in manufacturing enterprises had taken place in the northern and middle colonies as more and more settlers arrived and labor shortages were overcome, and both woolen goods and iron products, on which England's colonial export trade depended, were being manufactured. When the woolen industry in England declined in 1699, the condition was attributed to the increase of the colonial manufacturers; Parliament passed the Woolens Act prohibiting the export of wool or woolen cloth from any colony. The intent was to permit household manufactures but to make commercial production impossible. The development of iron manufacturing, however, was allowed to continue unhindered.

About 1710, New Jersey ironmakers began to exploit the magnetic ores, and in 1716, the first successful ironworks was set up in Pennsylvania, on Manatawny Creek, near Pottstown in Berks County. Shortly afterward, another iron enterprise was set up on French Creek in Chester County, and a third furnace was erected 8 miles north of Pottstown in 1720. Ironworks were also set up in Virginia and in Maryland, and a few years later, in North Carolina. In 1740, the manufacture of iron was begun in New York, though the ore was brought from Connecticut, but a decade later, magnetite ore was discovered in New York. In 1750, Massachusetts began to develop the brown hematite ores in the western part of the State.

At mid-century, iron was being made in all the colonies except Georgia, and from pots and pans, tools and handmade nails, the ironmakers had gone on to manufacture muskets and cannon and to set up slitting mills for the manufacture of nail rods. Blister steel was being made in Connecticut and Pennsylvania. Bar iron had been exported regularly to England since 1717, and about 3,000 tons of bar and pig iron were being exported each year.

The iron industry was the only one that competed in any way with that of the mother country. Coal had been discovered in Virginia in 1701 by a group of French Huguenots to whom the colonial government had allotted a tract of land along the James River; it was used locally. A mining company had been chartered for the production of copper at Simsbury, Connecticut, in 1709, but the mines were soon abandoned and the openings used as a prison. Copper had been discovered in New Jersey in 1719, and small quantities were shipped to England. Small lead mines were also worked in New England.

The American iron industry had reached the stage of development that forced the British to take action. The American manufacture of iron had been questioned for many years, but no action had been taken because of conflicting interests in England. Although some wanted the entire industry suppressed, others, interested in a supply of cheap pig iron, wanted the colonial metal to be imported free of duty and all fabrication in the colonies suppressed. By 1750, England was unable to supply its own requirements for iron because of the scarcity of wood to make the charcoal used in smelting and refining. The annual production, which had been nearly 180,000 tons in 1615, had dwindled in 1740 to only 17,000 tons. To maintain the colonial supply of bar and pig iron for the English iron and steel industry, the Iron Act of 1750 was passed, permitting importation of American pig and bar iron duty-free but forbidding the erection or continued use of slitting or rolling mills, forges, or furnaces in the colonies. The law was strictly enforced, and thenceforth American iron manufacture was restricted to production of pig and bar iron and castings from blast furnaces.

During this half century, the population of the English colonies had continued to grow. New settlers came not only from England, but also from Germany, France, Scotland, Ireland, and Switzerland. Philadelphia was the point of entrance for the majority, and Philadelphia became as important as Boston and New York. People began moving westward from the narrow coastal zone, into the valleys behind the Appalachian front, southwestward into the Virginia Piedmont, through the Shenandoah Valley, and on into the western Carolinas.

New mineral resources were discovered during the westward movement. Benjamin Winslow in his survey of the upper Potomac River in 1736 observed "cole mines" along the Savage River in western Maryland—the first report of coal in the Appalachian region. Coal was found in the southern part of West Virginia in 1742, in Kentucky in 1750, and in western Pennsylvania and Ohio in 1753. Lead was also discovered in southwestern Virginia in 1750, and the lead mines were worked by a Colonel Chiswell until shortly after the beginning of the American Revolution.

During the 1740's, speculators began to exploit the area beyond the Appalachians, and several land companies were formed. The Ohio Company was granted 200,000 acres by the Privy Council in 1749, and Virginia also made claim to the western country. Even more alarming to the French in the Ohio Valley were the traders who were moving freely into the area, and they decided to erect a series of forts, thus instigating the last of the French and Indian Wars. By the Peace of Paris, which was signed in 1763, France ceded to Great Britain all of French Canada, except two small islands in the St. Lawrence, and all French territory east of the Mississippi, except New Orleans. Spain, which had entered the war against the British, ceded Florida to Great Britain. By a secret treaty, Spain acquired from France all French territory west of the Mississippi as well as the port of New Orleans.

Relations between the American colonies and Great Britain then took on a new aspect. With the French and Spanish menace removed, American dependence on England was lessened, and England no longer felt the need to act cautiously in order not to antagonize colonial allies. At the same time, England found itself faced with a large national debt, heavy taxes at home, and the problem of administering a greatly enlarged empire. The war had revealed the insecurity of the western frontier against Indian raids; also, westward expansion was no longer needed as a defense measure. By a Royal Proclamation in 1763, a rigid geographic limit was set to western settlement. The crest of the Alleghenies was to be the dividing line between the colonies and Indian territory. Indian territory west of the line was placed under the control of the military commander-in-chief, and the Crown assumed the sole right to dispose of the western lands. New regulations, aimed at raising revenue and reasserting administrative control of the colonies were issued.

In the wake of a normal postwar decline in business, the British program seemed to the colonists calculated to ruin the colonial economy. The westward movement, despite the Royal Proclamation, continued. Protest against the economic regulations began in Massachusetts but soon spread to the other colonies. At first there was sporadic rioting. Then economic boycotts were imposed against taxed goods. (The young gentlemen at Yale College have been credited with starting this movement by unanimously agreeing not to make use of any foreign spirituous liquors.) After Bostonians threw the British tea in the harbor (in Charleston, they simply locked it up), Parliament closed the port of Boston and radically altered the Massachusetts charter. Virginia called for a continental congress. Before the Congress met, Parliament passed the Quebec Act, which placed the southern boundary of that province at the Ohio River, thus depriving four colonies, which claimed land west of the Allegheny crest, of their territory and adding to colonial grievances.

The first Continental Congress met in Philadelphia on September 5, 1774, formed an association that agreed to stop all imports of English goods within 3 months and all exports to British ports within a year, and adopted a resolution approving the opposition of Massachusetts to Britain's colonial administration. The war then became inevitable, and it began on April 19, 1775.

The Second Continental Congress met in Philadelphia on May 10, 1775, resolved to put the colonies in a state of defense and asked the people of Canada to join the resistance. More than a year later, on June 7, 1776, Richard Henry Lee of Virginia offered the resolution that the United Colonies "are, and of right ought to be, free and independent states." Although it was decided to postpone a decision on the resolution until July 1, a committee was appointed to prepare a Declaration of Independence. On July 1, Congress, sitting as a committee, debated the Lee resolution, and the motion to adopt was carried. On the following day, Congress in formal session took the final vote, which was unanimous. A committee was then appointed to prepare a plan of confederation.

The lands west of the Allegheny Mountains claimed by some of the colonies became a source of contention in preparing the plan of confederation. Under the Royal Proclamation of 1763, those lands had reverted to the crown, and under the Quebec Act of 1774, those northwest of the Ohio River had been given to the Province of Quebec. The committee considered limiting the western boundaries of the States but abandoned that idea. Then in August 1777, during the debate over acceptance of the Articles of Confederation, Pennsylvania, New Jersey, Delaware, Maryland, New Hampshire, and Rhode Island, whose charters gave them no western lands, proposed that Congress be empowered to limit the western boundaries of the States. The motion failed, and over the protests of these States a clause was added to the Articles providing that no State be deprived of western lands for the benefit of the United States. The Articles were adopted on November 15, 1777, and sent to each State for ratification. Maryland, on December 15, 1778, announced her refusal to ratify until the western lands were ceded to Congress. Maryland remained adamant, and not until Virginia yielded and ceded her lands on January 2, 1781, did Maryland agree to sign. March 1, 1781, was the formal date of final ratification, and on the following day Congress assumed the title "The United States in Congress Assembled."

The public domain became a reality in 1783. The Revolution effectively ended with the British surrender at Yorktown on October 18, 1781, but the peace treaty was not signed until September 3, 1783. One of the problems faced by the American and British commissioners during the long negotiations was the almost total lack of accurate maps of North America upon which to determine the boundaries of the United States. John Mitchell's map on a scale of 1:2 million, published in 1755, was used. The boundaries between the United States and British America were finally set as the St. Croix River, the St. Lawrence-Atlantic watershed divide, the 45th parallel, a line through the Great Lakes and their connecting waterways, and a line from Lake Superior to the Mississippi River. Because of some inadequacies in the Mitchell map, disputes later developed over parts of this boundary. A line through the middle of the Mississippi River south to the 31st parallel, the 31st parallel, the Apalachicola River, and the St. Mary's River divided the United States from Spanish territory.

To deal with the problem of disposing of the public land, the Congress appointed a committee with Thomas Jefferson as chairman. On May 7, 1784, the committee reported "an ordinance for ascertaining the mode of locating and disposing of lands in the western territory," entirely in Jefferson's handwriting, which was modified only slightly before being adopted on May 20, 1785. The Ordinance of 1785 provided that these lands be surveyed on a rectangular system, divided into townships 6 miles square, each township being divided into 36 sections. Land was to be sold at public auction when surveyed, and the title cleared in minimum lots of one section at a minimum price of $1 an acre. Three commissioners were to conduct the public sale; an independent officer, the Geographer, was to direct surveys.

The Ordinance of 1785 embodied three new principles that formed a basis for public-land policy: survey before settlement; a mathematically designed cadastral survey; and a standard land unit. Classification of the public lands into various categories was implicitly, if not explicitly, a part of the Ordinance also. The Ordinance of 1785 reserved "one third part of all gold, silver, lead, and copper mines to be sold or otherwise disposed of, as Congress shall hereafter direct," thus requiring classification of the lands into mineral and nonmineral. The clause was presumably a revenue measure, although, as no such mineral deposits were known in the area in question, it may simply have been carried over from the crown charters for the colonies.

The first Geographer of the United States was Thomas Hutchins, who had been geographer-surveyor for the Southern Army. When the war began, the American army had little in the way of maps, but the British had a wealth of material that could be distributed to their forces in the field. American mapmakers had relied on the English to engrave and print their maps, and no adequate facilities existed in the colonies for these services. After repeated requests from General Washington, who fully appreciated the usefulness of maps, the Continental Congress on July 25, 1777, authorized him to appoint a geographer and surveyor. Robert Erskine, who was appointed to the position 2 days later, created a corps of surveyors and assistants which became, in effect, the first central mapping agency. After Erskine's death in 1780, Simeon DeWitt became the geographer, and in 1781, Hutchins was appointed. DeWitt became Surveyor-General of New York in 1784.

The public lands delayed adoption of the Articles of Confederation; the mineral industry helped hasten their end. When the Declaration of Independence was proclaimed, the American iron industry was the only mineral industry of any consequence, and it, despite the restrictions of the Iron Act, was greater than that of England. The iron industry prospered during the Revolution, as British goods could not be obtained. Virginia coal was not sufficient to meet all colonial demands when coal supplies from England were cut off at the beginning of hostilities, and some effort was made to develop other deposits, but with little success. An attempt was even made to use Pennsylvania anthracite in the arsenal at Carlisle, Pennsylvania, despite the known difficulties in its use. Copper was not in demand. Lead was in such short supply that lead for bullets was obtained at times by melting down statues, including, or perhaps even especially, those of George III.

The end of the war was followed by an economic depression that was made more acute by the fact that England began to treat the United States as a foreign nation. England was already on the threshold of a technological development that would soon lead her to a commanding position in manufacturing, and English goods were cheaper than those available elsewhere. During the war, for example, English ironmakers had begun to use bituminous coal, instead of charcoal, and the steam engine in the blowing of blast furnaces. These improvements so increased and cheapened British iron products that after the war British iron manufactures were able to compete successfully with the American product despite the cost of transportation.

Many people soon realized that the United States had to develop her own manufactures and become less dependent on foreign sources if she were not to remain a raw-material-producing nation with the attendant disadvantages. To protect infant industries, import duties were needed. Under the Articles of Confederation, only the States could impose duties. Ironmakers were among those who wanted protection, but ironmakers in Pennsylvania and New Jersey petitioned their legislatures in vain to impose duties on iron. A tariff, though for revenue rather than protection, however, was one of the principal reasons for the abandonment of the Articles of Confederation for a new instrument of government.

One of the greatest problems under the Articles of Confederation was taxation. Congress could requisition funds from the State governments but could not tax the people directly, and when the States did not honor Congressional requisitions, funds were insufficient to pay the expenses of the government, including payment of the public debt and maintenance of the army and navy. A movement to strengthen the central government gained force, based in large part on a proposal to give Congress the power to impose tariffs in order to raise funds. Finally, Virginia called a convention in September 1786 to which five States sent delegates. That convention adopted a report drafted by Alexander Hamilton and called for another convention to be held in Philadelphia in May 1787 "to devise such further provisions as shall appear to them necessary to render the constitution of the Federal Government adequate to the exigencies of the Union." That convention took unto itself the task of preparing an entirely new instrument of government, which it adopted on September 17 and referred to the Congress then meeting in New York. On September 28, Congress referred it to the States for action, and by June 21, 1788, nine States, sufficient to establish it as the instrument of government, had ratified the Constitution. On July 2, 1788, the Congress of the Confederation accepted the new constitution, and in September arranged for conduct of government under the new order to begin on March 4, 1789.

The Constitution of the United States contains no specific reference to the public lands or the development of mineral resources, and the only direct reference to science is in Article 1, Section 8, which says that Congress can, among other things, "promote the progress of science and the useful arts, by securing for limited times to authors and inventors, the exclusive right to their respective writings and discoveries." From the beginning, therefore, the government of the United States displayed a preference for practical science.

Colonial science was largely natural history. Only a few practiced the discipline of theoretical or pure science, then known as natural philosophy. Colonial scientists had early become a part of the international natural history circle which had members in England, France, Holland, Sweden, Germany, and Italy who corresponded regularly, visited each other, and exchanged specimens. The New World was a subject of intense interest, and most of the information about it was channeled to others through England. By the same token, European developments were readily transmitted to the

New World. Although colonial interests broadened during the 18th century, colonial scientists remained colonial, that is, their activities were geared toward contributing to the scientific community of western Europe rather than toward developing an American community. Early efforts to establish local scientific societies were at best only partly successful. The colonial scientist preferred to be a member of a European society. The American Philosophical Society was formed in 1743 but failed after what seemed a brilliant beginning. The first permanent society, a renewed American Philosophical Society, was formed in 1767, less than a decade before the Declaration of Independence. The second was the American Academy of Arts and Sciences, established in 1780. American scientists were interested in minerals, volcanoes, and earthquakes as natural phenomena.

Whether the Federal or the State Governments or any one else should support geologic investigations was not a question at the time, for geology, as a science distinct from natural history or mineralogy, could be said to have been born while the American Revolution was in progress and to have reached only the age of argument when the Constitution was adopted. In 1775, Abraham Gottlob Werner became Inspector and Teacher of Mining and Metallurgy at the mining academy which had been established at Freiberg in Saxony in 1767. Werner, who was primarily a mineralogist, taught that all rocks, with the exception of the products of modern volcanoes, had been deposited from water, for the most part from the sea, and believed in a universal, or near universal, succession of formations controlled by successive changes in the composition and extent of the ocean. Great numbers of students flocked to his classes from every civilized country, but not all agreed with his ideas. An opposing school developed at the University of Edinburgh. In 1788, James Hutton's theory of the Earth, in which the Earth was regarded as a machine actuated by deep-seated heat and safeguarded by volcanoes, was published. Hutton's presentation raised a storm of discussion, and as George Washington was being inaugurated as the first President of the United States, the geological world was beginning to divide into Neptunists and Plutonists.

The Constitutional provision was more clearly intended for the benefit of the practical scientists or mathematical practitioners, who were the most numerous. These were the surveyors and navigators, the makers of maps and charts, those who produced the tools for carrying on various enterprises. Congress soon found itself with more petitions to test new inventions than it could handle, and in 1790, a patent board, the Secretaries of State and War and the Attorney General, was set up to consider them.

The first U.S. Congress passed the first tariff law on July 4, 1789, and then began the organization of the executive departments of the Federal Government: the Department of Foreign Affairs on July 27 (renamed the State Department on September 15), the War Department on August 7, the Treasury Department on September 2, and the Office of Postmaster General on September 22, the court system and the Office of Attorney General were set up on September 26. President Washington chose as his first Secretary of State, Thomas Jefferson, then serving as minister to France, and as first Secretary of the Treasury, Alexander Hamilton, who had been his aide-de-camp and personal secretary and who had played an active role in the preparation and ratification of the Constitution.

Hamilton and Jefferson represented opposite viewpoints on the future course of the United States and their views generally reflected or formed the basis for the two national parties that formed during the early period of the Republic, Hamilton's views, those of the Federalists and Jefferson's, those of the Anti-Federalists or Republicans. Hamilton believed in a diversified economic system with active encouragement of finance, industry, and commerce by the government, whereas Jefferson envisioned the United States as a great agricultural nation, composed of innumerable individual freeholders and broadly diffused wealth, a nation free of industrialism, urbanism, and organized finance.

Hamilton had the initial advantage because of his position as Secretary of the Treasury; Jefferson, moreover, remained in his post as minister to France until March 1790. At the request of Congress, Hamilton in 1790 and 1791 prepared three reports: on public credit, a plan for disposing of the public lands, and on manufactures. The *Report on the Publick Credit* stated that the United States must have credit for government, industrial development, and commercial activity, and that future credit would depend on how existing obligations were met; it proposed ways and means of funding the public debt, including the State debts. Despite some opposition, Hamilton's proposals were accepted by Congress, and, stimulated by these fiscal policies, a period of prosperity supplanted the postwar depression.

The *Report on Manufactures* proposed a system of tariffs to protect industry, bounties for agriculture, and a network of internal improvements under federal sponsorship. Iron and coal were among the industries to be encouraged. Hamilton said "a copious supply" of coal "would be of great consequence to the iron branch," predicted that the use of coal for household fuel would increase "in proportion to the decrease of wood, by the progress of settlement and cultivation," and thought it would be worthwhile to consider a bounty for production, or premiums for opening new mines. At the time, ironmaking was in a depressed state and had been since the end of the Revolution. Wood was still the principal fuel for all purposes, although Virginia coal was used locally, some was shipped to Atlantic ports, and settlers west of the Allegheny crest had begun to use coal for domestic purposes.

The proposals in the *Report on Manufactures* met with a notable lack of enthusiasm, and none were adopted at the time. They were never completely discarded, however, and were periodically revived; eventually some were passed. Hamilton was simply ahead of his time. It was not until the 1840's that American iron manufacturers began to make extensive use of coal. The equally far-sighted Assistant Secretary of the Treasury, Tench Coxe, it might be noted, purchased extensive tracts of coal land in Pennsylvania that were developed more than 75 years later by his great grandson, Eckley B. Coxe, one of the founders of the American Institute of Mining Engineers.

The *Report on a Plan for Disposing of the Public Lands* provided for purchase of lands in both large and small units, the former for revenue, the latter to accommodate the inhabitants of or emigrants to the western country. Hamilton proposed that a General Land Office be established at the seat of government to handle large purchases and that offices in the Northwestern and Southwestern territories be established for small purchases. He recommended that land be sold at 30 cents an acre, that no credit be allowed for sales of less than a township 10 miles square or for longer than 2 years, that at least one-fourth of the price be paid at the time of sale, and that security be provided for the remainder. The Southwestern territory to which Hamilton referred comprised the lands that had been North Carolina's. North Carolina had ratified the Constitution in November 1789, when the Bill of Rights became a certainty, and Congress had accepted the cession of its western lands on April 2, 1790.

Problems very soon began to arise with both the surveying and sale of the public lands. The Ordinance of 1785 required that before the lands in the public domain could be sold, they were to be surveyed in accordance with a system of lines oriented to the true meridian. One of the great problems in surveying with the instruments then available was this determination of the true meridian. The surveying proceeded slowly, and settlement did not await the completion of the survey. Many areas became populated before the Federal surveys were completed, and the land already settled frequently did not conform to the legal system.

In 1796, after a lengthy debate on land policy, Congress passed a new land act. It established the Office of Surveyor-General, and instructed the Surveyor General to engage a sufficient number of skillful surveyors as his deputies to survey and mark the land without delay. The lands were to be divided into townships 6 miles square, half of which, taken alternately, were to be further divided into 36 sections of 640 acres each. The deputy surveyors were to note in their fieldbooks all mines, salt licks and springs, mill seats, watercourses, and the quality of the lands so the Surveyor-General could have prepared a description of the lands for the officers supervising the sale—in effect, the lands were to be classified before sale. All salt springs, together with sections 1 mile square that included the springs, and four sections in the center of each township were reserved to the United States. Single sections were to be sold at land offices which were established at Cincinnati and Pittsburgh. The undivided townships were to be offered for sale at the seat of government in quarter-township units, excluding the four at the center. The minimum price was raised to $2 an acre, with one-twentieth at the time of sale, a moiety within 30 days, and the balance within a year. The 1796 Land Act thus included some of the principles, but not the details, of the Hamilton plan.

The Land Act was further revised in 1800. Except for a minor recession from 1796 to 1798, the time was one of substantial prosperity, and the population steadily increased. New immigrants continued to arrive from Europe, perhaps as many as 50,000 in the first decade. In 1798, the Mississippi Territory was organized, covering the region between Georgia's western border and the Mississippi River, but there was little movement into the area because of the hostility of the Indians and the Spanish control of West Florida. The Northwest Territory, however, continued to grow, and in 1799, Congress advanced it to the second stage of territorial government in accordance with the provisions of the Ordinance of 1787. William Henry Harrison was elected territorial delegate and promptly began a campaign to liberalize the land system. In May 1800, Congress reduced the minimum unit of sale to 320 acres, extended the time for payment to 4 years, and established more local land offices to provide easier access by settlers. The new land law was an immediate success as far as disposal of the land was concerned. In the first 18 months under the new law, 400,000 acres were sold in comparison with less than 50,000 under the 1796 act. Most of the land, however, was purchased by speculators rather than settlers.

At the same time, however, Congress took steps to manage some of the natural resources of the public domain. John Adams' administration was troubled by the possibility of war with France, and the Department of the Navy was established to help "provide for the common defence." Live oak and red cedar were then the most suitable woods for naval vessels, so Congress in 1799 set aside for the use of the Navy the live oak and red cedar lands. The Navy needed "very liberal use of copper" and copper at that time cost "not less than half a dollar a pound" so Congress in the spring of 1800 authorized the President to employ an agent to collect information on the Lake Superior copper mines and to ascertain whether the Indian title had been extinguished to such lands as might be required if it were deemed expedient for the United States to work such mines. In the Land Act of May 1800, the Surveyor General was also given authority to lease the reserved saline lands.

Chapter 3.
Cherished for its Own Sake, 1801–1829

> **While Science will be cherished *for its own sake*, and with a due respect for its own *inherent* dignity; it will also be employed as the handmaid to the Arts. Its numerous applications to AGRICULTURE, the earliest and most important of them; to our MANUFACTURES both mechanical and chemical; and, to our DOMESTIC ECONOMY, will be carefully sought ought, and faithfully made.**
>
> **—Benjamin Silliman**

The election of 1800 was seemingly a peaceful revolution and a triumph of the democratic system. During the Federalist era, Americans had been divided on foreign policy, on an industrial versus an agrarian economy, and on centralized versus decentralized government. The election of Thomas Jefferson as President and resounding victories by Republican congressional candidates indicated that the electorate had chosen the way of simplicity and isolation. Time proved otherwise.

Jefferson wanted to encourage western migration and keep the United States an agrarian nation. Both Jefferson and his Secretary of the Treasury, Albert Gallatin, wanted to liquidate the public debt as soon as possible. These two factors largely controlled public land policy. In 1802, when the admission of Ohio as the first State from the Northwest Territory was being considered, Secretary Gallatin proposed that the Federal Government retain control over the public lands within the borders of the new State, that tracts of public land sold thereafter be exempt from all taxes for a period of time, that section 16 in each township be granted to the State for support of schools, and that the State be granted the salt springs and the use of a percentage of the net proceeds of the sale of public lands for the construction of roads leading to and through the State. When Ohio was admitted, most of these provisions were included, although in less liberal form than Gallatin had proposed. The salt springs and adjacent land totaling 28,320 acres were granted to the State, but Congress decreed that the springs were to be leased, not sold, and for not longer than 10 years at a time.

The purchase of Louisiana in 1803 doubled the area of the United States. Louisiana, comprising all the territory between the Mississippi and the Rockies, had been in Spanish possession since 1769, but less than 1 percent of it had been settled. France acquired the province by a secret treaty on October 1, 1800, as the French tried to replace the loss of Canada by a profitable base in North America. Late in 1801, Bonaparte sent an expeditionary force to Hispaniola with orders to suppress the Negro republic there and then to take possession of New Orleans and Louisiana. Though Jefferson was pro-French, the prospect of a French army in Louisiana was not a pleasant one. When the Spanish governor of Louisiana withdrew the right of transit at New Orleans from American traders, the West rose in wrath. Jefferson then commissioned James Monroe as envoy extraordinary to France with instructions to attempt to purchase New Orleans and the Floridas. Bonaparte, about to renew war with England, and unable to make headway in the Hispaniola campaign, decided to sell all of Louisiana, and on April 30, 1803, the treaty of cession was signed. On November 30, Louisiana was formally handed over by the Spanish governor to a French prefect who, in turn, transferred it to the United States 3 weeks later.

The Louisiana Purchase involved the Federal Government in mineral-land problems, for lead was already being mined in Missouri under Spanish and French grants, but by the Ordinance of 1785, one-third part of all lead mines was reserved to the United States. Moses Austin, who prepared a report on the Missouri lead mines in 1804, estimated that 530,000 pounds of lead, worth $36,500, had been produced in the preceding 3 years and predicted that the time was not far off when the district would furnish lead sufficient not only for the United States but all Europe "if moderate encouragement is given by the government, and protection against the Osage Indians, who yearly plunder the inhabitants." However, no immediate action was taken beyond providing for determination and confirmation of the Spanish and French land grants and extending the U.S. land surveys over the new territory. In December 1806, John Grant, a member of the Kentucky legislature, forced the issue by requesting permission to work a lead mine that he had discovered in Indiana Territory. The land offices had little information on the mines, so to prevent their sale at the same price as nonmineral lands, the Secretary of the Treasury, Albert Gallatin, suggested to the Chairman of the House Committee on Public Lands that the Government withhold all mineral lands from public or private sale. On March 3, 1807, by act of Congress, all lead mines in Indiana Territory were reserved from sale, and the President was authorized to lease lead mines for a period of not more than 3 years. The first leases called for a royalty of 10 percent of the processed lead. Attempts to put the leasing provisions into effect in Missouri as well ran into difficulties because of the existence side by side of land with previous title and public land.

By Republican principles, such matters as education, science, and internal improvements were State responsibilities, and the Federal Government could not support them without an amendment to the Constitution. However, in 1802, the Corps of Engineers was established as a military academy at West Point, and West Point, a Federal institution, became the first engineering school in the Nation.

In 1803, Captains Meriwether Lewis and William Clark were sent on an exploring mission to the source of the Missouri River, ostensibly to make trade agreements with the Indians and find a water route to the Pacific for commerce. They were also prepared, however, to collect information on the whole range of natural history and to fix geographic positions by astronomical observations so that a map of the region could be made. Jefferson himself was enough of a scientist to provide detailed instructions for the expedition, but he also arranged to have Captain Lewis instructed in some of the finer points by some of his scientist friends in Philadelphia.

The first scientific agency in the Federal Government was established in 1807. Again the stated motive was practical—commercial interests had been demanding better charts of coastal waters and navigational aids—but it was a proposition of the American Philosophical Society that led to the establishment of the Survey of the Coast. F. R. Hassler, a trained and experienced geodesist, had migrated to the United States as part of a land-speculating colony that collapsed. The Philosophical Society suggested to the President that Hassler be put to work on a general geodetic survey of the coast, and Congress was induced to appropriate $50,000 for the survey because of its commercial and military importance. The organization of the work was entrusted to the Secretary of the Treasury but was postponed because of the urgency of other affairs.

By 1807, a growing tension in international affairs diverted public attention from domestic problems. Great Britain and France were at war, and the United States was feeling the effect because of the interference with its commerce and the impressment of American seamen. In December 1807, President Jefferson recommended an embargo, which Congress speedily approved. The embargo prohibited the departure of any U.S. ship for a foreign port and required those in the coastwise trade to post a bond double the value of the craft and cargo as a guarantee that the goods would be relanded at a U.S. port. American industry was stimulated, but commerce suffered as both exports and imports declined.

Both iron and coal industries benefitted by the embargo. The iron industry began to expand but even with the stimulation provided by the embargo, there were only 153 blast furnaces in all the United States in 1810, and only about 54,000 gross tons of cast iron were produced. Great Britain in 1806, the nearest year for which statistics are available, produced more than a quarter of a million tons of iron. When the shipment of coal from the Virginia mines fell off as the result of the embargo, the anthracite producers in eastern Pennsylvania were able to establish a foothold in the coal market, but wood remained the principal fuel.

Opposition to the embargo, strongest in the mercantile areas of New England and New York, brought the Federalists back into power in State governments, and in Congress, a coalition of Federalists and the Republican faction led by John Randolph of Virginia passed the Non-Intercourse Act, repealing the embargo and reopening trade with all nations except France and Great Britain. The act also authorized the President to proclaim resumption of trade with France or Great Britain if or when either one repealed its decrees that were injuring American commerce. Jefferson signed the measure on March 1, 1809, as one of his last official acts.

The Land Act of 1800 had encouraged sales of public land, and settlement of the Old Northwest had proceeded rapidly during Jefferson's administration. The Northwest Territory had been divided in 1800, the western part becoming Indiana Territory. By 1809, the Indians had ceded some 48 million acres by treaties, and Indiana Territory was divided, its westernmost part being organized as Illinois Territory. Then Tecumseh and his brother, sons of a Shawnee chief, began to organize an Indian confederacy to stop alienation of their lands and resist the westward sweep of white settlers.

Although the embargo had been repealed, the commercial warfare continued. President Madison, who succeeded Jefferson on March 4, 1809, issued a proclamation in April legalizing trade with Great Britain, having been assured by the British Minister to the United States that orders in council would be repealed. The Non-Intercourse Act was revived in August when the British Foreign Secretary disavowed the Minister's action. In May 1810, Congress reversed that action and reopened trade with both France and Great Britain, promising that if either removed its restrictions before March 3, 1811, the Non-Intercourse Act would be revived against the other. In the brief interlude in the commercial warfare, the Coast Survey project which had been in abeyance since 1807 was again taken up, and Hassler was despatched to England to obtain instruments.

In the elections of 1810, nearly half the House failed to be reelected. Many young Republicans from agrarian areas in the South and West, whose people were not affected by the maritime issues, were elected because of their nationalist and expansionist sentiments. Those from the West wanted to destroy the frontier Indian menace, which they attributed to British intrigue and incitement, and incidentally to annex Canada. Those from the South, where there was trouble with the Creek Indians, wanted to wrest Florida from Spain, Britain's ally. Among those elected in 1810 were Henry Clay of Kentucky and John C. Calhoun of South Carolina.

When the 12th Congress assembled in November 1811, the war hawks assumed positions of leadership. Seniority was tossed to the wind as Henry Clay was elected Speaker and John C. Calhoun became floor leader and then head of the Foreign Relations Committee. Madison's message to Congress was both anti-British and anti-French and called for preparations for national defense. As Congress convened, an Indian battle on the northwestern frontier further inflamed anti-British sentiment. In the summer of 1811, Tecumseh had gone south to enlist the Creek Indians in his league, and General William Henry Harrison, governor of Indiana Territory, was persuaded to move against the Indians in his absence. On November 7, the Indians attacked the American force while it was in camp but were beaten back after a day-long battle. Three weeks later, the Foreign Relations Committee called for 50,000 volunteers, arming of all merchant ships, and the outfitting of warships. To all intents and purposes, this was an unofficial declaration of war.

Another expansionist, Senator Thomas Worthington, who had gone to Northwest Territory as a surveyor but stayed to become a member of the territorial legislature, advocate of Ohio statehood, and one of Ohio's first Senators, started the move to improve the disposal of public lands. On November 13, 1811, he submitted a motion that a committee be appointed to consider the matter with leave to report by bill or otherwise. A bill to establish a General Land Office as a bureau of the Department of the Treasury was eventually reported out and passed by the Senate on February 27, by the House in April, and approved by the President on April 25. The General Land Office was to be headed by a Commissioner whose duties were "to superintend, execute, and perform all such acts and things touching or respecting the public lands of the United States and other lands patented or granted by the United States, as have heretofore been directed by law to be done or performed in the office of the Secretary of State, of the Secretary and Register of the Treasury, and of the Secretary of War." The Commissioner was authorized to employ a sufficient number of clerks to carry on the work, provided that their total annual compensation did not exceed $7,000. The Office of the Surveyor-General was not included and was continued as a separate agency.

War was officially declared in June 1812. It was far from a popular one. New England was especially opposed and threatened to secede. In the elections in November 1812, Madison carried the South and West and was reelected, but DeWitt Clinton, the anti-war candidate, carried all the Northeastern and Middle Atlantic States except Vermont and Pennsylvania. Peace negotiations began almost as soon as the war did, but time was lost over an attempt at mediation by the Russian Emperor. By the time direct negotiations began, Britain was in no hurry for peace. Napoleon abdicated in April 1814, releasing British troops for service in America. The Treaty of Ghent signed on Christmas Eve 1814 said nothing about neutral rights and the impressment of seamen, over which the conflict had officially begun. When the negotiations began, the British demanded establishment of a neutral Indian buffer state in the Northwest, and territorial concessions along the line from Maine to west of Lake Superior, but in the end, the prewar territorial status was restored, and a boundary commission was proposed to settle the boundary between Canada and the United States.

The war had a substantial and, for the most part, adverse effect on the American economy. The method of war financing was inflationary, and the general price level substantially increased, but the price of goods ordinarily purchased abroad or transported by water increased over and above the general level while the price of goods customarily exported fell. The Southern

States, where the economy depended on exporting tobacco, rice, and cotton, were especially hard hit. In Virginia, where the soil was already beginning to show the effects of long-continued use, conditions were more serious than in the rest of the area. Textile and iron manufacturing enterprises in the Northeastern and Middle Atlantic States, however, were aided by the exclusion of imports.

The end of the war brought a renewed demand in America for European goods and in Europe for such American exports as wheat, flour, tobacco, rice, and cotton. The production and export of agricultural products soon restored prosperity to the agricultural segment. The industrial segment did not prosper correspondingly. The Hamiltonian idea of protection of infant manufactures through imposition of a tariff was revived and was regarded with more interest than when it was first proposed. The problem was complicated by the fact that the customs revenue was the primary source of the Government's income. A tariff that would exclude foreign goods and protect American manufactures would not produce revenue. A tariff act was enacted in 1816, but it was a compromise. Protection was extended to iron manufactures and textiles. The tariff did not solve the problem of foreign competition for iron manufacturers, however, and American production of pig iron was essentially stationary from 1810 to 1820. Lead mining, on the other hand, attained considerable importance in Missouri during the second decade of the 19th century. Henry Schoolcraft visited the area in 1818 and reported that 27 mines were in operation and 1,130 men were employed.

Once the war was over, the Coast Survey was finally able to get underway, but soon ran into difficulties. Hassler had been marooned in England during the war but returned to the United States in 1815. President Madison allowed him a salary of $3,000 and $2,000 for expenses, and measurement of a base line began in 1816. In 1817, critics began to question the slowness of the operation, and in 1818, the survey was transferred to the Navy.

Management of natural resources on the public domain was advanced to a second stage in 1816 when the Secretary of the Navy was instructed to explore the live oak and red cedar forests acquired with the purchase of Louisiana and to select tracts to satisfy the requirements of the Navy. Agents were appointed both to select the desired tracts and to protect them from trespass.

Westward migration resumed after the war and increased to enormous proportions. Settlers moved into the Lake Plains and also the Mississippi Valley, the Gulf Plains, and the Southwest. Indiana was admitted as a State in 1816. A series of treaties with the Indians encouraged settlement in middle Georgia, western Alabama, and Tennessee. In 1817, Mississippi was admitted as a State, and the Territory of Alabama was created.

As the frontier moved westward, there was a growing need for adequate transportation facilities to link the outlying, predominantly agricultural regions with eastern markets. Practical necessity suggested the need for change in Federal policy on internal improvements. In December 1816, in his last message to Congress, President Madison recommended construction of a network of roads and canals to be subsidized by the Federal Government, but said that a constitutional amendment would be necessary first. John C. Calhoun of South Carolina introduced the measure in the House to create a permanent fund for internal improvements but did not prepare any amendment. Although the Constitution did not specifically authorize internal improvements, he said, sanction could be drawn from the "general welfare" clause and from the power to establish post roads. The bill was passed, such opposition as there was being based on sectional rather than on constitutional grounds. Madison, on his last day in office, vetoed the bill on constitutional grounds. The failure of the Calhoun bill did not alter the need for internal improvements but made it incumbent upon the States to establish their own programs. New York was first—the State legislature in 1817 authorized construction of a canal from Albany to Buffalo, to link the Hudson River with Lake Erie; others followed with somewhat less ambitious projects.

By 1817, when James Monroe became the fifth President of the United States, several Jeffersonian concepts of democracy had taken on a strong Hamiltonian tinge. In his inaugural address, Monroe spoke in general terms of the need to encourage industry, trade, and commerce and to foster manufacturing in order to free the Nation from dependence on foreign imports and provide a market for American raw materials. He held to the need of a constitutional sanction, however, for construction of a system of roads and canals. In his first message to Congress in December 1817, he made specific recommendations about a protective tariff and proposed that an amendment to the Constitution to authorize federally sponsored internal improvements be submitted to the States. He also invited Congress to consider anew the method of disposal of the public lands. The public lands had increased in value, and he believed that they should be disposed of to the best advantage of the Nation rather than permit capitalists who could buy up large blocks of land to amass the profits.

There was no problem about the tariff. The bill was passed in April 1818. The iron industry received increased protection, and the duties on textiles, which had been scheduled to decrease, were extended to 1826.

The Senate and the House differed over the need for an amendment to the Constitution on internal improvements. A bill to amend the Constitution was introduced in the Senate, but the House Committee on Internal Improvements presented a report stating that Congress had the power to construct roads and canals and accusing the President of invading the privileges of the legislature. Speaker Henry Clay called the President to task for his "irregular and unconstitutional" behavior in expressing an opinion before any specific legislation was adopted. The House then adopted a resolution requesting the Secretaries of War and Treasury to prepare a report on a general plan of internal improvements and requested the Secretary of War further to advise Congress as to the extent of its authority. The Senate then dropped the proposed amendment.

As the Secretary of War was the same John C. Calhoun who had sponsored the bill on internal improvements that Madison had vetoed on his last day in office, the House evidently expected a restatement of his position that Congress had the necessary authority. However, Calhoun drew up the requested general plan but acceded to President Monroe's request that all passages intimating that Congress had the power to construct internal improvements be omitted. Monroe himself prepared a long essay on his interpretation of the Constitution in which he made a fine distinction between Congressional power to appropriate money for and its power to authorize construction of internal improvements. He was persuaded not to send it to Congress, and the question of internal improvements was temporarily put aside because of other problems.

The boundaries between British and American territory were peacefully negotiated in 1818 by Secretary of State John Quincy Adams. The two countries agreed that the northwest boundary between the United States and British territory in North America would be the 49th parallel from the Lake of the Woods, in present-day Minnesota, to the crest of the Rocky Mountains. This line established the northern boundary of the Louisiana Purchase which had not been defined in 1803. West of the Rocky Mountains, no boundary was established, but the two powers agreed that the Oregon country would be open to both American and British citizens for 10 years and that the joint occupation would not be considered prejudicial to the territorial claims of either. Adams also negotiated a treaty with the Spanish government in 1819 by which the western limits of the Louisiana Purchase were defined as extending from the mouth of the Sabine River on the Gulf of Mexico in a general northwesterly direction along the Sabine, Red, and Arkansas Rivers to the 42d parallel and thence due west to the Pacific Ocean. In the same treaty Spain also renounced all claims to West Florida and ceded East Florida to the United States, and the United States in turn renounced all its claim to Texas.

A nationwide controversy on States' rights was touched off in the spring of 1819 by the Supreme Court's landmark decision in the case of M'Culloch versus Maryland. The case involved an act of the legislature of the State of Maryland taxing a branch of the Bank of the United States which the Court unanimously declared unconstitutional and void. In his opinion, Chief Justice Marshall gave a detailed exposition of the Constitution and its "loose" construction. "Let the end be legitimate, let it be within the scope of the Constitution, and all means which are appropriate, which are plainly adapted to that end, which are not prohibited,*** are constitutional." The opinion supported the nationalist position and so had implications far beyond the matter of State taxation of a Federal bank.

A major economic crisis began to develop in the spring of 1819, the result of overexpansion of credit during the postwar years and the collapse of the export market. The effect was immediate and drastic in the South, which was primarily agricultural, but every segment of the economy was involved by the end of the year. Widespread speculation in land, stimulated by the liberal credit provisions in the Land Act of 1800, had marked the postwar boom. In the fall of 1819, Secretary of the Treasury William Crawford reported that the Government had disposed of $44 million worth of land since 1789 but had been paid only half that amount up to September 30, 1819. Changes in the disposal of public land were obviously necessary, and in April 1820, Congress passed a new land act, reducing the minimum price to $1.25 an acre and the minimum purchase to 80 acres but requiring full payment in cash on the day of purchase. In theory, this was to benefit the individual settler and discourage the speculator. Because of the depression and almost universal indebtedness, however, it resulted in an almost complete cessation of land sales.

Another major crisis developed in the spring of 1819 over slavery, brought to the fore by Missouri's petition for statehood. When the enabling legislation came before Congress in February 1819, amendments were introduced to prohibit the further introduction of slaves and to provide for the eventual freeing of the children of slaves already in Missouri. The amendments were passed by the House but defeated in the Senate, and there was no compromise. The organization of Arkansas Territory came before Congress at the same time, but the proposal to forbid further slavery there was defeated, and the Territory was organized on March 2, 1819, with its northern boundary at 36°30′ and no restriction on slavery.

In the spring of 1820, a compromise enabled Missouri to be admitted as a State. When the 16th Congress convened in December 1819, Maine, which had been a district of Massachusetts, petitioned for statehood. By admitting Maine as a free State and Missouri as a slave State, the number of slave and free States remained equal. The Missouri Compromise also provided that slavery would be prohibited in the Louisiana Purchase north of 36°30′. Maine was admitted as a State on March 15, 1820, but Missouri not until August 10, 1821, the delay resulting from problems in obtaining approval of the Missouri State Constitution.

The Census of 1820 showed that the United States was still an agrarian nation but that the urban population (those living in communities of 2,500 or more) was increasing. New England was the most urbanized section, and there manufacturing, especially of textiles, had begun to expand. The Middle Atlantic States were partly urbanized, partly agricultural. The largest cities in the country were New York, with 124,000 inhabitants, and Philadelphia, with 113,000, but the States of New York and Pennsylvania were at the same time the leading wheat-producing States. Pennsylvania was also the leading mining State in the Nation. Mining, however, was of only slight importance in the United States as a whole. Despite the protection afforded by the tariffs of 1816 and 1818, the value of American pig iron had not increased between 1810 and 1820. The coal product had increased, but even by the most optimistic estimates was only 330,000 tons, about two-thirds of which was mined in Pennsylvania. In the South, agriculture was supreme. The invention of the cotton gin had encouraged a tremendous expansion in cotton growing, tobacco production had stabilized, and production of sugarcane in Louisiana was beginning to increase. However, much farmland was being abandoned in Eastern and Southeastern States, and a westward shift of agriculture was underway.

If agriculture was to remain the basic pursuit in the American way of life in those eastern areas. some means must be found of restoring prosperity. Edmund Ruffin of Virginia was one of the pioneers in the use of the scientific method. Ruffin had assumed charge of a farm in Prince George County after the death of his father in 1813. Much of the farmland had then been abandoned, and he set out, with little practical or theoretical knowledge, to find why the land had lost its fertility. His first experiments were failures. Then he observed that sorrel and pine grew on poor lands and that calcareous earths were absent. He adopted a suggestion from Sir Humphrey Davy's *Elements of Agricultural Chemistry*, began experimenting with marl, and obtained favorable results. From these experiments, he concluded that soils, once fertile, had been reduced by harmful cultivation, had become "acid" and had thereby lost their power to retain manures. The condition could be corrected by application of calcareous earths, and fertility equal to or greater than the original could then be acquired by use of fertilizers, crop rotation, drainage, and good plowing. His theories were presented to the Prince George Agricultural Society in 1818 and were published 3 years later.

By 1819, geology had made great progress as a science in the various centers in New England, New York, and Philadelphia. In 1802, Yale had established a department of science, the first in the country, by dividing the chair of mathematics and natural philosophy and appointing Benjamin Silliman professor of chemistry, mineralogy, and natural history. Silliman, then about 22, had recently been admitted to the bar and was serving as a tutor in law and had not even the most rudimentary knowledge of science. He therefore went to Philadelphia where he spent 5 months attending the lectures on chemistry at the Medical School of Philadelphia. He later spent 2 years studying at the University of Edinburgh. Silliman gave his first lecture at Yale on April 4, 1804, and in 1806 prepared his first geologic report, a sketch of the mineralogy of New Haven. In 1810, he proposed to the Connecticut Academy of Sciences that a geological survey of the State be made. The Academy approved the idea but had no funds, so the project did not get underway. In 1812, Professor Silliman began teaching a separate course in geology at Yale.

Harvard established a Massachusetts Professor of Natural History in 1805, but the incumbent of the position stressed botany. A Harvard graduate, Parker Cleaveland, was appointed professor of mathematics, natural

Benjamin Silliman

Silliman had a great influence on the development of science in the United States in the first half of the 19th century. He was a gifted teacher and, as professor of chemistry and natural history at Yale College from 1802 to 1853, did much to establish the study of science on an equal footing with the traditional curriculum. As founder and first editor of the *American Journal of Science,* and as a public lecturer, he made the country conscious of the value of science. (Photograph of oil portrait by John Trumbull courtesy of the National Portrait Gallery, Smithsonian Institution.)

philosophy, chemistry, and mineralogy at Bowdoin College in Maine in 1805. Like Silliman, Cleaveland had no previous training in science and, until he became interested in mineralogy, was undecided between a career in the church or the law. In 1816, Professor Cleaveland published the first American attempt at a systematic treatise on mineralogy. The full title was *Treatise on Mineralogy and Geology,* but the geology occupied only 50 of the 668 pages.

In New York, the most influential scientist was Dr. S. L. Mitchill, who received an M.D. from Edinburgh in 1786. In 1792, Dr. Mitchill became professor of natural history, chemistry, and agriculture at Columbia College, a position he resigned in 1801 to enter the U.S. Congress. In 1797, he established the first strictly scientific journal in the United States, the *Medical Repository*. He also helped found the Society for the Promotion of Agriculture, Arts and Manufactures, under whose auspices he made a mineralogical investigation of the banks of the Hudson River. Dr. Mitchill was also the first president of the American Mineralogical Society, founded in 1799 for "the investigation of the mineral and fossil bodies which compose the fabric of the globe; and more especially for the natural and chemical history of the minerals and fossils of the United States."

One of Dr. Mitchill's students at Columbia, Dr. Archibald Bruce, who had obtained an M.D. from Edinburgh, in 1800, and spent 2 years on the continent of Europe studying and collecting minerals, began publication of the *American Mineralogical Journal* in 1810. This was the first American publication designed primarily for geologists and mineralogists, but its life was short.

Philadelphia science centered around the American Philosophical Society and the University of Pennsylvania. There William Maclure, who moved to the United States in 1796 after making his fortune in merchandising, became a patron of science and an active scientist. In 1809, the American Philosophical Society published his memoir on his observations on the geology of the United States, which included a colored geologic map of the region east of the Mississippi River. The classification of formations adopted by Maclure was largely Wernerian; he recognized four classes of rocks: Primitive, Transition, Secondary, and Alluvial. A revised edition was published in 1817.

In England, William Smith, a civil engineer, had discovered that each sedimentary rock had its own distinguishing assemblage of fossils and that he could recognize a specific unit even when the characteristic rock type was different. His first geologic map, of an area around the city of Bath, was published in 1799. In 1815, he produced the first geologic map of England and Wales. Georges Cuvier, professor of natural history at the College de France, using Smith's methods, worked out the detailed stratigraphic sequence of vertebrates and marine invertebrates in the Tertiary rocks of the Paris Basin and in 1812 showed conclusively that many fossil invertebrates

William Maclure

Maclure was born in Scotland and first visited the United States in 1782 at the age of 19. After acquiring a fortune in a mercantile business, he retired to devote his life to science and philanthropy. He settled in the United States, became an American citizen, and began an ambitious work of a geological survey of the country. His geological map, published in 1809, was the first of such scope in the history of geology. (Courtesy of the Library of Congress.)

had no known living counterparts. A translation of Cuvier's essay was published in the United States in 1818 along with S. L. Mitchill's *Observations on the Geology of North America*.

It was Yale's Professor Benjamin Silliman who provided the stimulus for many developments in geology thereafter. In 1818, he began publication of the *American Journal of Science and the Arts*, which ever since has been a principal publishing medium for geological papers. The first issue of the *Journal* included a report by Edward Hitchcock, who had studied under Silliman, on the geology and mineralogy of a section of Massachusetts; the report contained a geological map, colored by hand. In 1818, Amos Eaton, who had also been a student of Silliman's, published his *Index to the Geology of the Northern States* as a text for classes in geology at Williams College and also, on the invitation of Governor DeWitt Clinton, delivered a course of lectures on the subject to the New York State Legislature. In 1819, the American Geological Society was organized. Although Maclure was elected president and Silliman only the second vice president, Silliman presided at the first meeting, which was held at Yale College.

Professor Silliman's influence may have extended beyond academic circles. The Secretary of War, John C. Calhoun, had been one of Silliman's first students at Yale and had remained his good friend. Calhoun, being of an expansionist frame of mind, was promoting expeditions to the West. Under his orders, two expeditions were organized in 1819: that of Major Stephen H. Long to the Rocky Mountains and that of General Lewis Cass along the south shore of Lake Superior to the sources of the Mississippi River. Calhoun encouraged the acquisition of scientific information as well as infor-

Amos Eaton

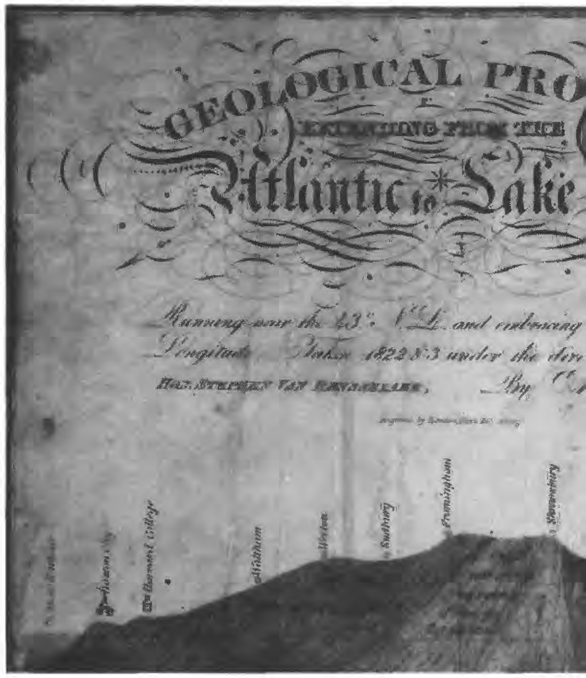
Born in the year of American Independence, Eaton graduated from Williams College in 1799 and entered the legal profession. He became interested in natural science, particularly botany, and in 1815 adopted science as his profession and entered Yale to study under Silliman. He was influential in the establishment of the Rensselaer Polytechnic Institute, and as a member of its faculty taught many who became leading geologists. (Photograph of portrait courtesy of the Rensselaer Polytechnic Institute.)

mation on the geography of the regions. Dr. Edwin James, a pupil of Amos Eaton's, was attached to the Long expedition as botanist and geologist. Henry Schoolcraft's book on the lead mines of Missouri had brought Schoolcraft to the attention of the Secretary, and he was attached to General Cass's expedition, which was to investigate the deposits of copper, lead, and gypsum supposed to exist in the Northwest. In the reorganization of the War Department under Calhoun, a centralized topographical unit had been added, and a course in military and topographical engineering was begun at West Point.

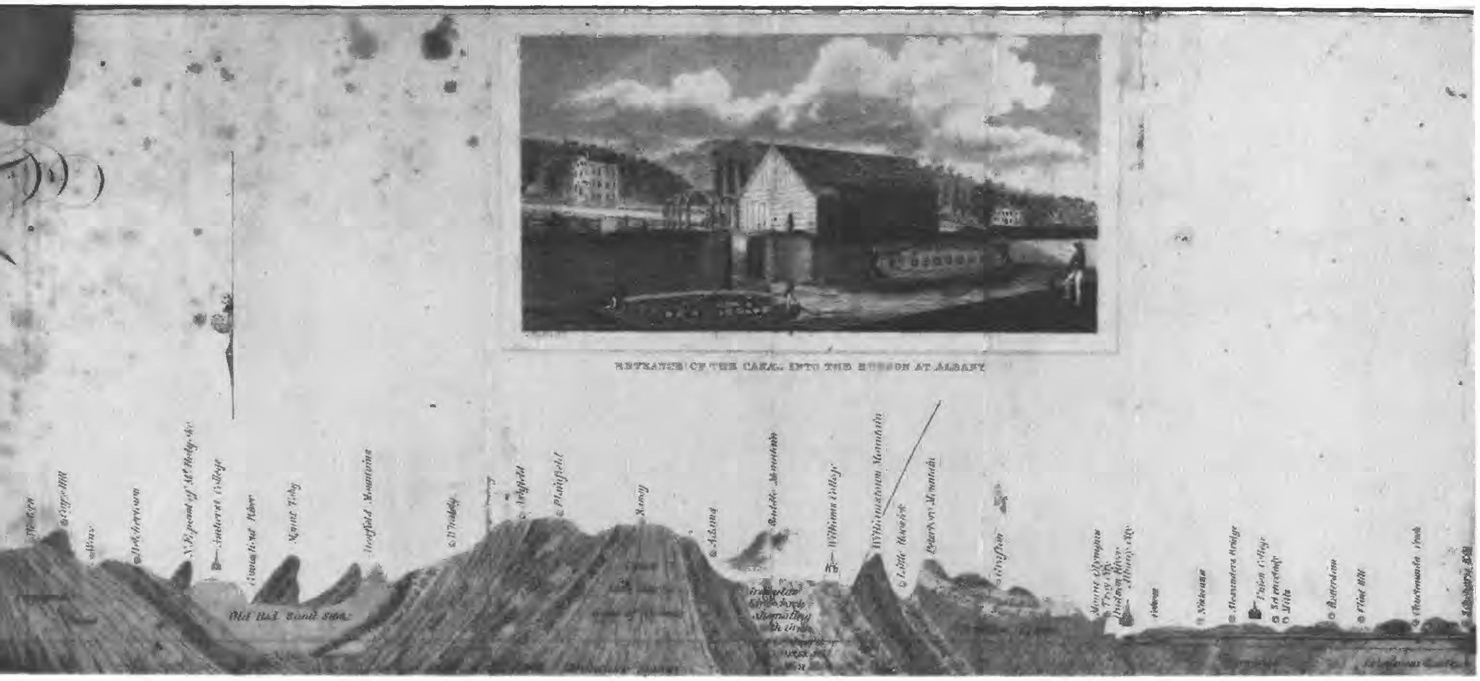
The States took responsibility for aid to agriculture as they had for internal improvements. In New York, the State legislature in 1819 provided \$10,000 in State funds to aid county agricultural societies, which would have as one of their purposes the general promotion of science, with the proviso that an agricultural society be formed in each county. In the summer of 1820, Stephen Van Rensselaer, president of the Agricultural Society of New York employed Amos Eaton to make a geological survey of Albany County, which was described as the "first attempt yet made in this country, to collect and arrange geological facts, with a direct view to the improvement of agriculture." In the following year, Eaton made a geological and agricultural survey of the adjoining Rensselaer County, and, having completed these two surveys, he proposed a geological survey of the district adjoining the Erie Canal with the idea of expanding the survey eventually to cover the entire State. Van Rensselaer agreed but suggested that Eaton "have the sanction of a scientific geologist and one known to the public." Silliman's aid was solicited and given; he agreed to publish reports of the survey in the *American Journal of Science*. During the Erie Canal survey, Eaton conceived the idea of a school wherein the students would learn by doing. He proposed it to Van Rensselaer, who again agreed, and the Rensselaer School, later the Rensselaer Polytechnic Institute, was established in November 1824 "for the purpose of instructing persons, who may choose to apply themselves, in the application of science to the common purposes of life."

In 1821, another student of Professor Silliman's, Denison Olmsted, professor of chemistry, mineralogy, and geology at the University of North Carolina, approached the North Carolina Board on internal improvements with the idea that he spend his vacations making a geological and mineralogical survey of that State. He asked only \$100 to defray his expenses, but the Board referred his request to the General Assembly and the General Assembly did not act on it. In 1823, however, the North Carolina General Assembly authorized the Board of Agriculture to employ "some person of competent skill and science to make a geological and mineralogical survey," and Denison Olmsted began work. His first report, which was published in 1824, included several pages on the gold mines of North Carolina. In the early 1800's, gold in sufficient quantity to create some excitement had been found in Cabarrus County, North Carolina, and soon afterwards in adjacent Montgomery County. Washings were carried on in the small stream's for several years thereafter, and when Olmsted made his survey, they were still being carried on in three areas. Olmsted's report was thus the first report on geology of the precious metals in the United States.

The gold was of sufficient interest to Olmsted that he prepared a separate paper, "accompanied by some Geological speculations not consistent with the nature" of a report to the Board of Agriculture; this paper was published in the *American Journal of Science* in 1825. The gold, he reported, was found in an area of about 1,000 square miles in the southern part of the State in "a thin stratum of gravel enclosed in a dense mud, usually of a pale blue colour, but sometimes yellow" which might be at the surface or as much as 8 feet below the surface in the bottoms where the alluvium had accumulated.



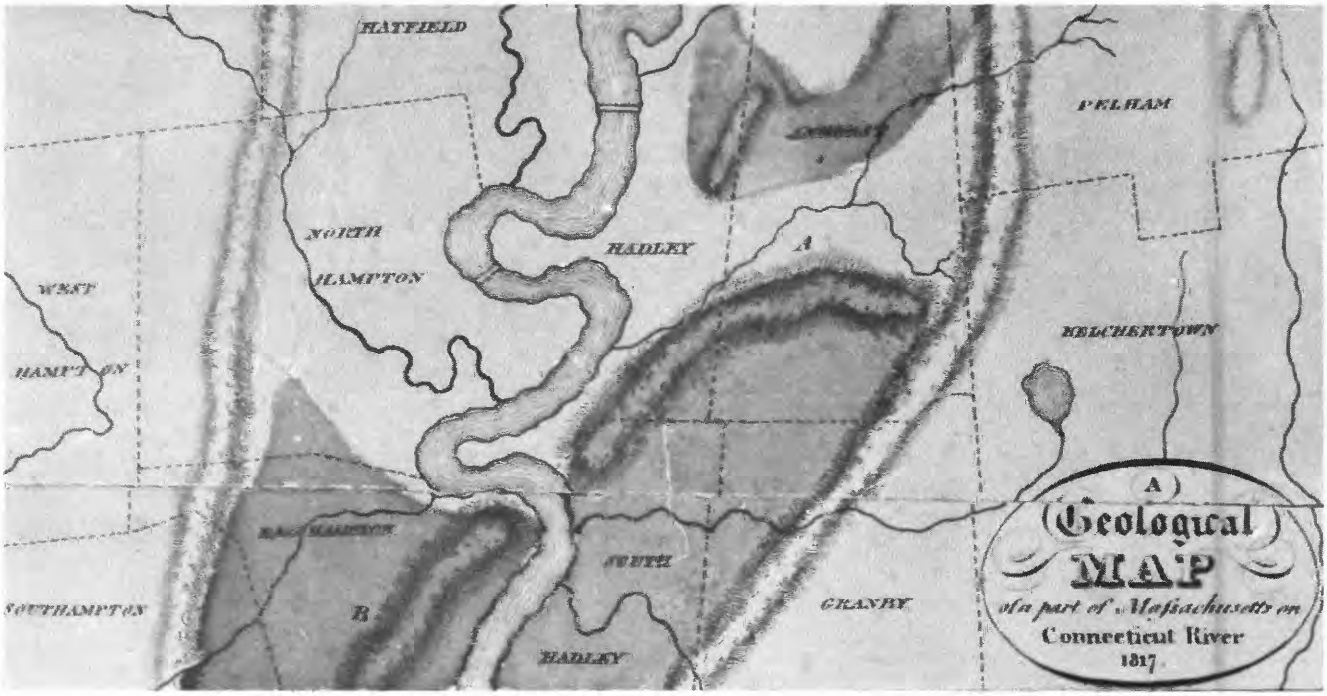
Amos Eaton said in 1822 that unfortunately for geology, A. G. Werner, the father of the science, had never published an elementary system, and knowledge of his views depended largely on the notes of his students. Werner had recognized only four classes of rocks: Primitive, Transition, Secondary, and Superincumbent, and Eaton deplored the recent custom among geologists of cutting up and subdividing which was on the point of ruining the simplicity of the Wernerian arrangement, as the same custom among botanists had already nearly ruined the Linnean system of vegetables. In his geological profile from the Atlantic to Lake Erie, a portion of which is shown here, Eaton adhered to the Wernerian classification. (From Amos Eaton, 1824.)

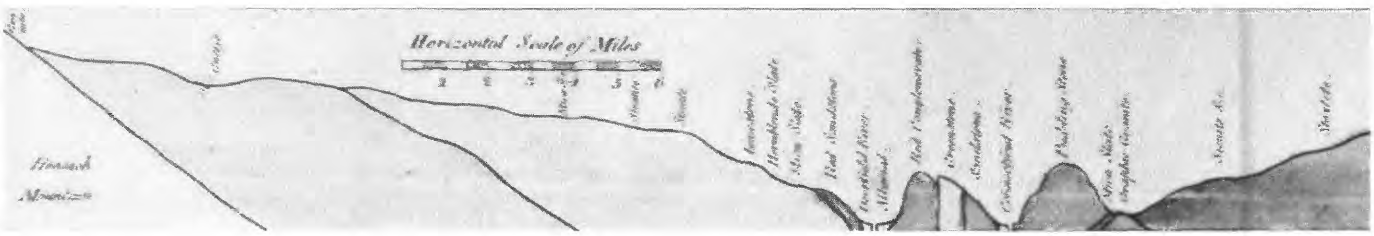


"This auriferous stratum, and similar strata which exist in various parts of the world," Olmsted remarked, "are believed by Geologists to have been a deposit from water after having been broken up and agitated by strong currents; in short, to be standing monuments of the Deluge." It was therefore unlikely, he thought, that the present streams had brought down the gold or that the gold would be found below the mud and gravel layer. Nor did the facts warrant any expectation of a great gold mine in the vicinity from which the lumps and grains had been derived. Olmsted recognized that the gravel in the auriferous layer was probably derived from the great Slate Formation, but he thought it improbable that veins of gold would be found in the slate.

The admission of Missouri revived the problems with mineral lands because lead mining was of considerable importance in the State. The United States had retained title to the lead lands in Illinois when it was admitted as a State in 1818, but leasing there was simpler because there were no previous titles to the land except the Indian claims, and most of the miners came after the reform in the land laws that required cash on the day of purchase. The Missouri General Assembly petitioned Congress to grant the lead mines to the State shortly after Missouri was admitted. Congress, however, transferred management of the lead lands from the Treasury Department to the War Department, and Colonel George Bomford, head of the Ordnance Bureau, recommended that the post of commissioner or superintendent of the lead lands be established because of the difficulties involved in administering them. Neither Missouri's petition nor the Colonel's recommendation was approved.

In his annual message to Congress in December 1822, President Monroe said that because of the importance of the lead to the public defence, the lead mines should be managed "with peculiar care" and suggested that an agent skilled in mineralogy be appointed to superintend them. The presidential recommendation notwithstanding, in January 1823, Senator Thomas Hart Benton introduced a bill to authorize sale of the mineral lands, but it was tabled. In December 1823, his colleague, Senator David Barton, introduced a bill to authorize sale of the lead mines and salines. That also failed.





Hitchcock also followed the Wernerian system in his map which covers the area from a few miles south of Northhampton, Massachusetts, to the northern boundary of Brattleboro, Vermont, and Chesterfield, New Hampshire. The Primitive, Transition, and Secondary rocks are described in more detail in his section, from which, Amos Eaton said, one could learn much more than from his map. (From Edward Hitchcock, 1818.)

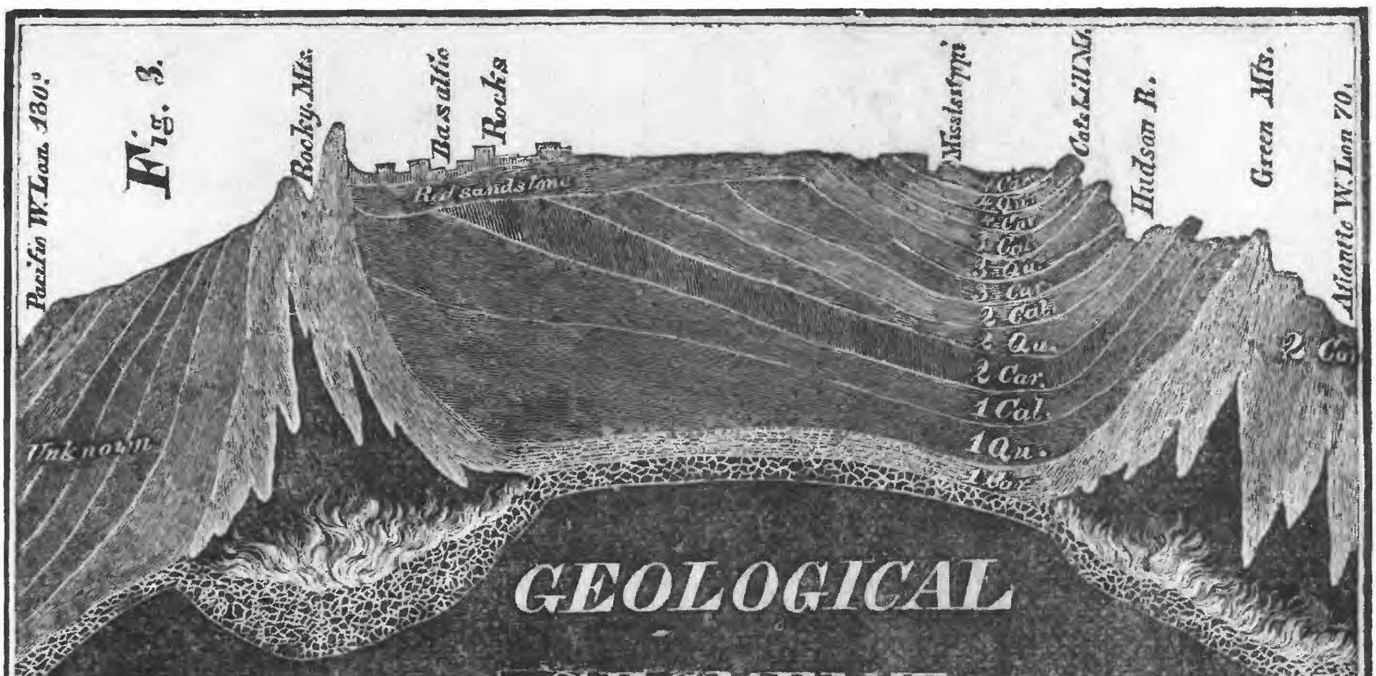
In 1824, the Commissioner of the General Land Office, George Graham, recommended that the mineral lands be sold, giving two reasons: (1) as a source of revenue, lands containing iron ore or agricultural lands of the best quality were also valuable, and there was no reason to discriminate against lead lands; (2) as a source of national wealth, lands managed by private enterprise would be more productive than those managed by government. In 1824, however, Lieutenant Martin Thomas was appointed first Superintendent of Lead Mines for Missouri and the West. The Lieutenant entered upon his assignment with enthusiasm. In Missouri, all earlier leases had expired, but several new ones were arranged. Inspection of the area then convinced him that a great deal of mineral land had not been reserved, and he thereupon withdrew several tens of thousands of acres more. Temporarily forestalled, Senator Benton turned his attention to a second desire of the West, cheap land, and introduced a bill for graduating the price of public lands.

In his 1822 annual message, Monroe rather cautiously recommended an increase in tariff rates to encourage manufactures. In the best of worlds, this would not be necessary, but in the event of war or even commercial rivalries, it was desirable to be strong at home. The question of internal improvements was still unresolved. In 1822, Congress had passed a bill for repair of the National Turnpike, construction of which had been halted by the panic of 1819, and for the collection of tolls. Monroe had vetoed the bill, holding that Congress did not have the right of jurisdiction and construction, and again recommended a national system of internal improvements be sanctioned by an appropriate amendment to the Constitution.

In his 1823 message, Monroe more strongly recommended a review of the tariff for the purpose of providing increased protection to encourage manufactures. He also suggested that Congress might consider if it might be advisable to authorize the employment of engineer officers to examine the ground for a Cumberland-Ohio canal then being discussed and report thereon, and Congress might also consider the advisability of having them extend their examination to routes through which the Ohio might be connected with Lake Erie. Congress this time needed no special urging. A new tariff bill increased protection for iron and textiles and added lead to the list of protected industries. The House of Representatives established a select committee to deal with the question of roads and canals under the chairmanship of Joseph Hemphill of Pennsylvania. The Committee prepared a bill authorizing estimates of roads and canals required for national military, commercial, or postal purposes, and authorized funds for engineering surveys to make the estimates. The General Survey bill was passed promptly by Congress, and as it avoided the constitutional question of construction, it was approved by President Monroe on April 30, 1824. Henry Clay, in defending the protective features of the tariff, had called the combination of the protective tariff and a national system of internal improvements an "American system." It had a very Hamiltonian cast.

The inauguration on March 4, 1825, of John Quincy Adams brought to the Presidency a man as dedicated to science as Thomas Jefferson. Unlike Jefferson, however, and Madison and Monroe after him, Adams did not regard a constitutional amendment as necessary for the Federal Government to support internal improvements, education, or science. In his first annual message to Congress in December 1825, he took a broad national view of constitutional powers and made many recommendations: construction of

In this "geological segment" published in 1830, Eaton showed his concept of the structure of the Earth beneath the North American continent, including the internal nucleus, the remaining areas of combustible matter giving rise to mountains, and the crust. Although he had earlier deplored the custom of subdividing the Wernerian classification of rocks, he divided the crustal rocks into four series, each of which he further divided, in ascending order, into carboniferous, quartzose, and calcareous rocks. (From Amos Eaton, 1830.)



Denison Olmsted

As State Geologist and Mineralogist of North Carolina from 1823 to 1825, Olmsted was mainly concerned with mineral resources and their utilization. In 1825 he became professor of mathematics and natural philosophy at Yale, and his scientific work thereafter was in physics and astronomy. (Courtesy of the Library of Congress.)

roads and canals at Federal expense, a national university, an astronomical observatory, standardization of weights and measures, the exploration of the interior of the United States and the Pacific Northwest coast, a naval academy corresponding to West Point to produce scientific and accomplished officers for the Navy, a Department of the Interior to relieve other departments of the multiplying burdens of home affairs, and a new executive department to supervise internal improvements and science. Many of these recommendations were adopted in later years but none in his term of office.

The manner in which Adams had been elected was one reason that it was difficult for him to achieve his objectives. The electoral vote in 1824 had not been decisive. Andrew Jackson had actually received the greatest number of electoral votes, with Adams second, but there were four candidates and none received a majority. The election was therefore submitted to the House of Representatives. Henry Clay, who had received the smallest number of electoral votes and who was therefore eliminated from the contest in the House, advised his friends to vote for Adams, and Adams was elected. Jackson's followers regarded the election as stolen and made immediate plans for the next election. In Congress, the Jacksonians opposed almost any Adams proposal, "partly from principle and partly from perversity."

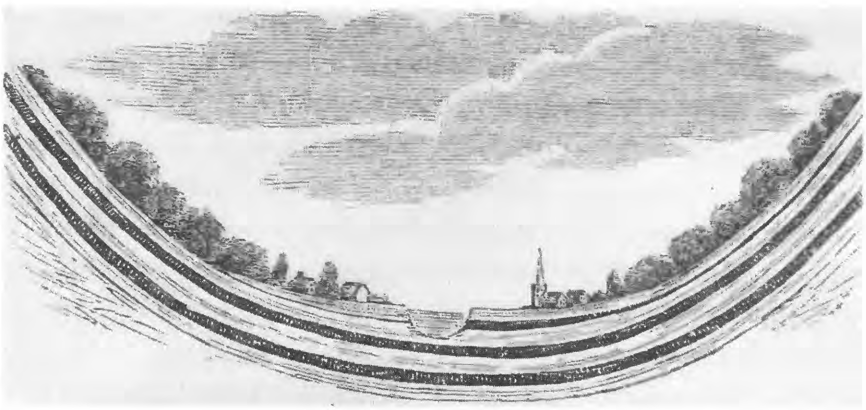
Adams was believed to hold the conventional Northeast ideas on the tariff and the public lands, and this too made it difficult for him to get his way.

But for this, he might safely have presented the scientific and educational parts of the program to Congress and the people. The West, of course, wanted cheap land and the right of preemption. The Northeast opposed cheap land, for if revenue from land sales increased, there was less justification for the tariff. Senator Benton also charged that eastern "capitalists" wanted to keep their workers in eastern factories rather than moving westward to become independent farmers. Adams never suggested an increase in the price of public land and never opposed laws that would bring about lower prices, but the impression prevailed that he had committed himself to high prices for public lands as a source of revenue to pay for a Federal system of internal improvements and a high tariff to protect manufacturers rather than a tariff for revenue that could be used for internal improvements.

The lead lands continued to be an issue during the Adams administration. A few months after his appointment as Superintendent of Lead Mines for Missouri and the West, Lieutenant Thomas obtained approval for a change in the leasing program. Each miner had been required to pay the Government in pure lead 10 percent of all the metal obtained from his ore, and this was difficult unless the miner had his own smelting facilities. Thomas arranged to license smelters from which the Government would then collect its rent lead. Smelters were required to post a $10,000 bond. Leases which allowed a lessee to smelt his own ore required a $5,000 bond and the employment of 20 people. Diggers' permits allowed the holders to exploit specified parts of the government land but required them to sell all minerals to the licensed smelters. The diggers' permits became far more common than leases. The mining methods were primitive. Most of the miners removed only the ore that was easily accessible from the surface, and the average miner probably made less than a dollar a day. But under Lieutenant Thomas, the mines experienced a phenomenal growth.

Senator Benton continued to fight for sale of the mineral lands, and Lieutenant Thomas became his favorite whipping boy. By 1827, even Lieutenant Thomas was convinced that the Missouri lead lands should be offered for sale. His reason, however, was the need to concentrate attention on the more lucrative and less troublesome lead lands of the Upper Mississippi Valley.

Miners began to arrive in great numbers in the Illinois lead lands about 1825, and by June 1827 there were 2,384 digging permits in force and 8 smelters. Between April 1825 and the end of October 1826, the Government received 140,553 pounds of pure lead from the smelters as rent. By 1827, the lead production of the Upper Mississippi region exceeded that of Missouri, even though the Indians resisted the movement of whites into the area and hindered the mining as much as possible. In 1827, Illinois petitioned for cession of the mineral lands within its borders, but the petition was denied.



Silliman, who became interested in the growing coal industry of Pennsylvania, provided this ideal section of the geologic structure at Wilkesbarre. It was, he said, "without any pretension to accuracy in the proportions or number of strata." Only a generation later, J. Peter Lesley, State Geologist of Pennsylvania in 1875, who was noted for a somewhat barbed wit, remarked that the simplicity of Silliman's section affected "the weary eyes of the coal geologist today like a moonlit street after a hot and noisy 'Saturday evening.' " Another ideal section at Wilkesbarre, published in 1866, is shown on page 156. (From Benjamin Silliman, 1830.)

The tariff also became a divisive issue. The woollen interests of the Northeastern States were dissatisfied with the Tariff of 1824 because it failed to eliminate British competition, and they sought higher duties. A bill that would have made importation of woollen articles virtually prohibitive was passed by the House in 1827 but was defeated in the Senate. The rejection of the bill touched off a movement for higher duties in general. The domestic iron industry was meeting strong competition from English pig and rolled iron, which was being produced at steadily decreasing cost because of the use of coke, and from Swedish and Russian hammered bar iron, which was produced more cheaply than the domestic product because of cheaper labor costs and the availability of great forests from which to produce charcoal. The Harrisburg convention in the midsummer of 1827 proposed establishment of a minimum-valuation principle on textiles and additional duties on other goods, including hammered bar iron and steel.

After the elections of 1826, the Jacksonians, or Democratic Republicans as they were then called, took control of the Congress. The Harrisburg proposal was rejected, but the Jacksonians decided that the tariff issue could be used to discredit Adams in the 1828 election. The House Committee on Manufactures framed a bill imposing very high duties on raw materials, on which New England wanted duties to be low, and eliminating some of the protective features pertaining to woollen goods. The South was opposed to any form of protective tariff, and it was anticipated that New England would also vote against the bill, that no tariff bill would therefore be passed, and that the Adams men, rather than the South, would be blamed for the failure. However, in the final vote, New England representatives voted for the bill despite its deficiencies, and the bill passed both houses. Even as ardent a Jacksonian as Senator Benton also voted for the tariff because it included a duty on lead which would aid the Missouri lead mines.

The Tariff of 1828, or the Tariff of Abominations as it was later called, was the high point of the protective movement. Increases were made in the specific duties on all kinds of iron, and iron production improved to 165,000 tons in 1830, although it continued to lag far behind that of Great Britain.

In the short session of Congress that began in December 1828, the Jacksonians succeeded in bringing about a change in the status of the Missouri lead lands. In January 1829, Senator Barton once more presented a memorial from the Missouri General Assembly requesting sale of the reserved lead lands, and on March 3, 1829, Congress conferred authority on the President "to expose to sale" as other public lands, the reserved lead mines and contiguous lands in the State of Missouri, with the proviso that at least 6 months public notice be given together "with a brief description of the mineral region in Missouri and the lands to be offered for sale, showing the number and localities of the different mines then known, the probability of discovering others, the quality of the ore, the facilities for working it, the further facilities, if any, for manufacture of shot, sheet lead, and paints, and the means and expense of transporting the whole to the principal markets of the United States." The Missouri lead lands were offered for sale in October 1830 and passed from control of the United States.

Chapter 4. Accession to Resources and Knowledge, 1829–1841

What an accession would be made to our resources, and to a knowledge of our country, were a thorough examination to be instituted into our mineralogical, geological, and even botanical riches! How worthy the genius of our government to have an accurate geological map, with an accompanying report, accessible to all citizens!

—Edward Hitchcock

In the presidential election in 1828, Andrew Jackson was triumphantly elected President, and John C. Calhoun was reelected Vice President. The change in leadership was as profound as the change in 1800. During the intervening years, Congress had gradually asserted its leadership over the executive, especially after the election of Henry Clay as Speaker. Monroe had been able to maintain executive leadership in foreign policy but not in domestic affairs, and John Quincy Adams, although thoroughly committed to the principle of executive leadership, was unable to persuade Congress to enact his program. The election of Jackson brought a return of strong presidential leadership. The National Republicans, or the Whigs as they became known, then reversed their position and supported a strong Congress rather than a strong executive.

The change also marked a return to Jeffersonian simplicity and democracy. In his inaugural address, Jackson pledged himself to a proper regard for States' rights and a revamping of the Federal civil service. He made no clear statement of policy on the tariff or the public lands, but internal improvements and the diffusion of knowledge he said were of high importance "so far as they can be promoted by constitutional acts of the Federal government." In his first message to Congress, he also questioned the constitutionality of the First Bank of the United States and said that it had failed to establish a sound and uniform currency.

The tariff of 1828 had posed a critical issue. Although the South in general opposed the protective tariff, it was the South Carolina legislature that adopted a set of resolutions in December 1828 that termed the tariff unconstitutional, and it was the Vice President of the United States, John C. Calhoun, who had written the accompanying document which claimed that a single State could nullify an act of Congress until three-quarters of the States had justified the law through an amendment. Calhoun foresaw the development of a permanent division between the North, already becoming industrialized, and the South, remaining agricultural. South Carolina thereafter assumed a more radical position on the question of States' rights.

The public lands in turn provided the forum for discussion of the nullification issue in Congress. When the new Congress convened in December 1829, a proposal by Senator Foot of Connecticut that Congress look into the possibility of slowing down the sale of public lands touched off a spectacular debate. It began on the public lands, then veered to the nature of the Constitution. Senator Robert Hayne of South Carolina presented the case for nullification. It ended late in January with Senator Daniel Webster's reply to Hayne, which once every school child had to memorize, and its stirring conclusion "Liberty and Union, now and forever, one and inseparable."

President Jackson soon made his position clear; he stood with Webster, not Calhoun. Congress passed a measure permitting preemption on the public lands for 1 year. The tariff was unchanged.

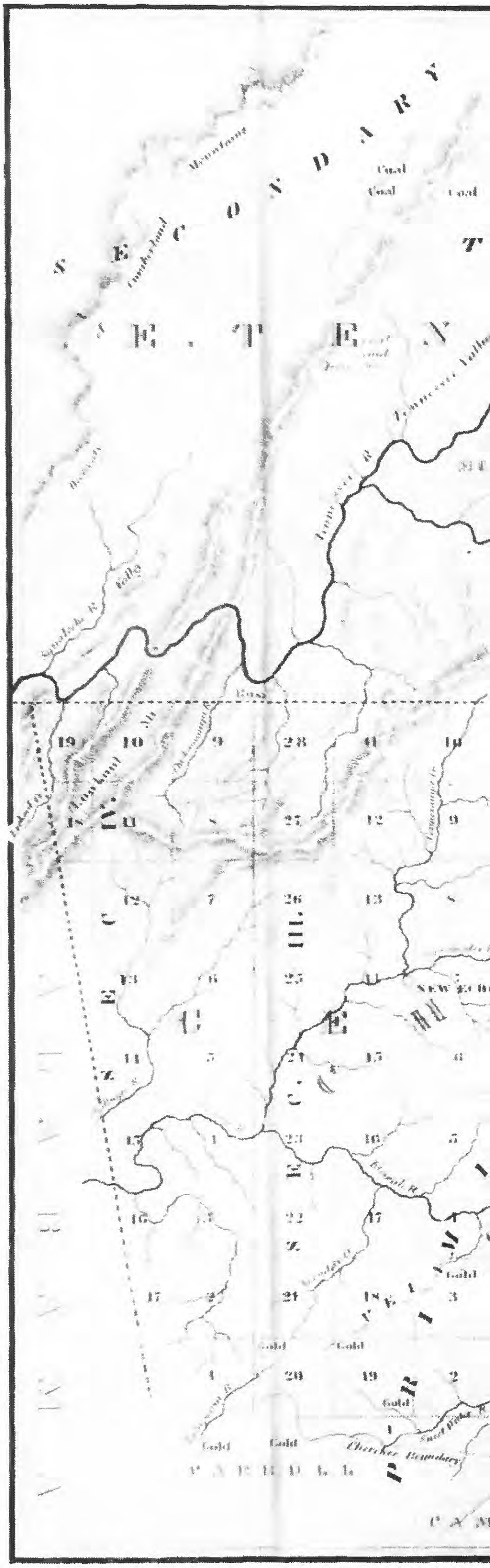
The discovery of gold-bearing rock in place in North Carolina in 1825 also had an effect on many policies of the Jackson administration. The first discovery in Montgomery County was followed shortly afterwards by a similar discovery in Mecklenberg County. General interest was excited, and the surrounding area was then thoroughly explored, and the search extended to other States. Gold was discovered in Virginia and South Carolina, and then, in the summer of 1829, in Habersham County, Georgia. The Georgia discovery may be one of the first based on geologic reasoning. Judge Jacob Peck said that a "gentleman of the name of Wilhero made researches by comparing the face of the country and appearance of the branches and streams with the gold section in North Carolina, and found deposits of gold through Habersham and Hall counties, and then discovery followed discovery." The Georgia deposits were richer than any previously found. Between 1804 and 1827, North Carolina had deposited a total of $100,000 in gold at the Mint; Georgia's first deposit in 1830 was $212,000.

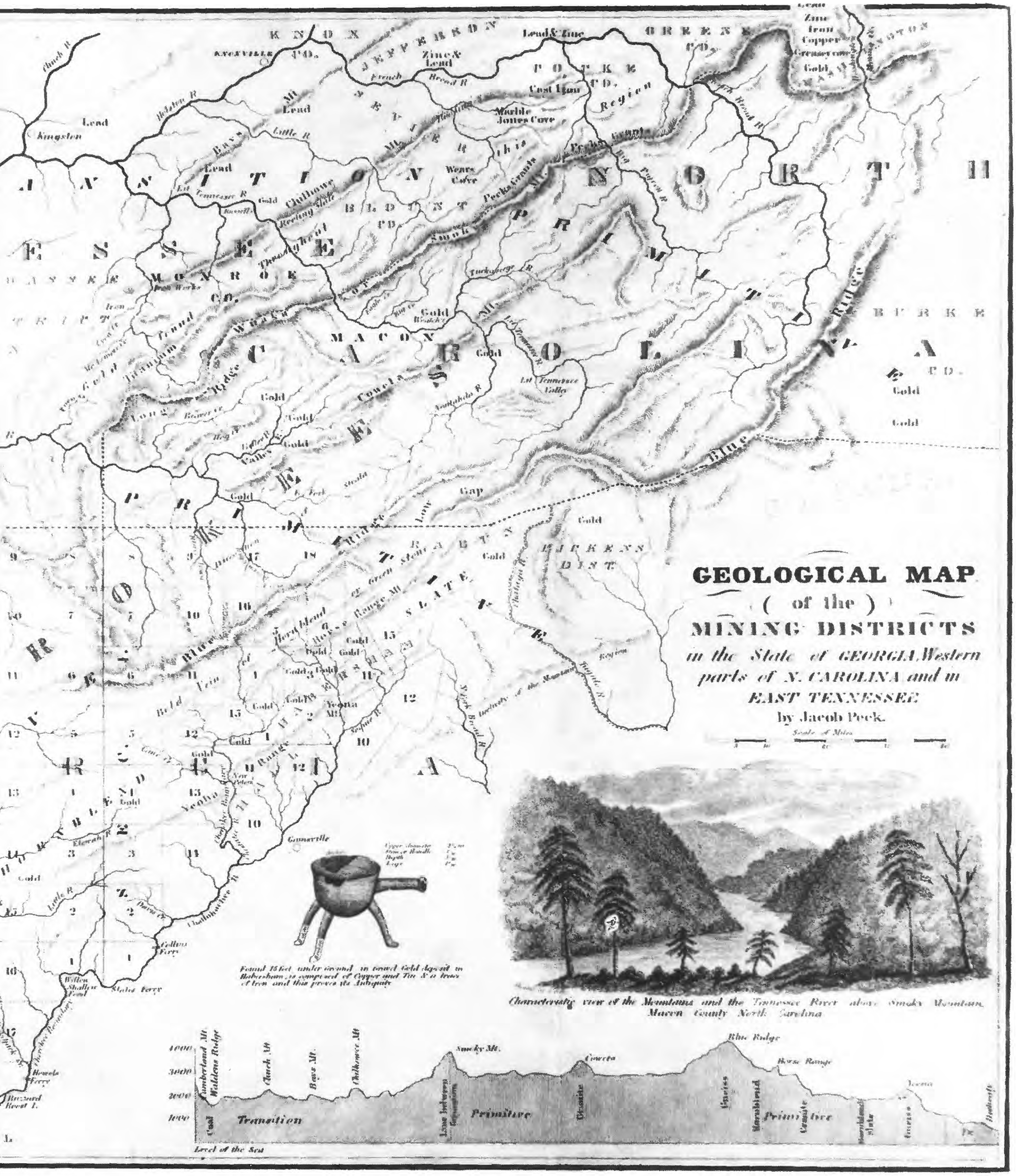
After the initial discovery in Georgia, the exploration for gold moved into the northwestern part of the State to which the Cherokee and Creek Indians still held title. Judge Peck said that "the indications of gold were not strong, but research caused it to be proclaimed richer than any part of the region hitherto explored." The problem of the southern Indians was thereby brought to a head.

Several years before, as the Eastern States became more crowded, plans had been made to move the remaining Indians. In 1825, President Monroe made it an official government policy, recommending to Congress that provision be made to transfer them to the plains beyond the Mississippi, which were thought to be uninhabitable by white men. The northern Indians, being few, were moved without too much trouble, but the southern tribes resisted. The Cherokee had been recognized since 1791 by a series of treaties as a nation with its own customs and laws, and during the Adams administration, their treaty rights were protected, though settlers encroached on their lands. In December 1828, Georgia declared the laws of the Cherokee nation null and void. The Cherokee sought relief in the Supreme Court after gold was discovered on their lands, but an injunction against the State was denied. In another case, a year later, however, the Chief Justice held that the National Government had exclusive jurisdiction in the Territory of the Cherokee Nation, but Georgia defied the Court, and President Jackson, who was pursuing a vigorous policy of removing the Indians, upheld the State. In 1835, the Cherokee finally capitulated and agreed to move to Indian territory.

Almost no gold coins had been minted in the United States until this time, but the gold fever became so intense that there was agitation to establish a mint in the gold region itself; each State where gold had been found claimed that a mint was necessary for the development of its gold resources. Senator Benton, who was the administration's chief spokesman in the Senate, fought for the mints against strong opposition, as the constitutional right of the States, and eventually three were built: one at Charlotte, North Carolina; one at Dahlonega, Georgia; and a third at New Orleans, Louisiana.

The mints were part of the hard-money policy of the administration. Jackson disliked banks and held the Jeffersonian idea that specie was the only





Jacob Peck's map of the mining districts in Georgia, western North Carolina and eastern Tennessee, part of which is shown here, is one of the earliest mineral-resource maps. (From Jacob Peck, 1833.)

sound form of money. An application for recharter of the Bank of the United States, which had come to be accepted by many Jeffersonians, was passed by Congress in 1832 but was vetoed by the President. The Bank became the principal issue in the campaign of 1832, and when Jackson was overwhelmingly reelected, he took it as a mandate to proceed. He proposed to remove Government deposits from the Bank of the United States and place them instead in selected State or local banks but had some difficulty in getting a Secretary of the Treasury to take the required action. Two Secretaries were removed from the position before Attorney General Roger B. Taney was appointed and issued the order at the end of September 1833. Ironically, the Senate later refused to confirm Taney's appointment as Secretary of the Treasury.

After this, the administration began to pursue a hard-money policy vigorously, with Senator Benton, known as Old Bullion because of his adamant views, again the administration's chief spokesman in the Senate. Taney and Benton between them worked out a twofold program to increase the metallic basis of the currency: a revaluation of gold, which would restore it to circulation, and the suppression of small paper money. The Second Coinage Act of June 28, 1834, decreased the amount of gold in the American dollar, established the ratio of 16 to 1 between gold and silver, and, in effect, overvalued gold at the American mint. The new coins, which were issued in August 1834, were derisively known as Benton's mint drops or Jackson yellow boys, but there was nonetheless an almost immediate increase in the amount of specie, both the total available and the amount in circulation. Silver coins, however, were undervalued and were driven out of circulation. As the silver coins were for small amounts, a problem was thereby created for business.

The gold discoveries, coming at a time when so many States were organizing internal development programs, provided the more practical-minded geologists with a better means of promoting the establishment of geological surveys than had the needs of agriculture or even the internal improvements. During the 1830's, 16 State surveys were organized, and a Federal survey of sorts was authorized, nearly all of them for the investigation of natural, chiefly mineral, resources. Benjamin Silliman and Amos Eaton were both more than 50 by this time and did not become personally involved in any of the surveys, but some of their students were conspicuously part of the effort.

Massachusetts established a State Board of Internal Improvements in 1828, whereupon, Professor Edward Hitchcock, who had attended Professor Silliman's lectures and served informally as his assistant while pursuing theological studies at Yale, began a campaign to interest the State in a geological survey, part of which was a lengthy review of Olmsted's report on the North Carolina survey which Professor Silliman had published in his *American Journal of Science* in 1827. Glossing over the fact that Olmsted had not discovered the gold in North Carolina, Hitchcock concluded the review by asking "the intelligent*** whether such a development of internal resources as this Report exhibits, does not amply remunerate the state of North Carolina for the comparatively trifling expense of this survey; and whether so great success, attending the efforts of an individual, who was obliged at the same time to execute the duties of arduous professorship, does not strongly recommend that this example be followed by the other states of the Union?"

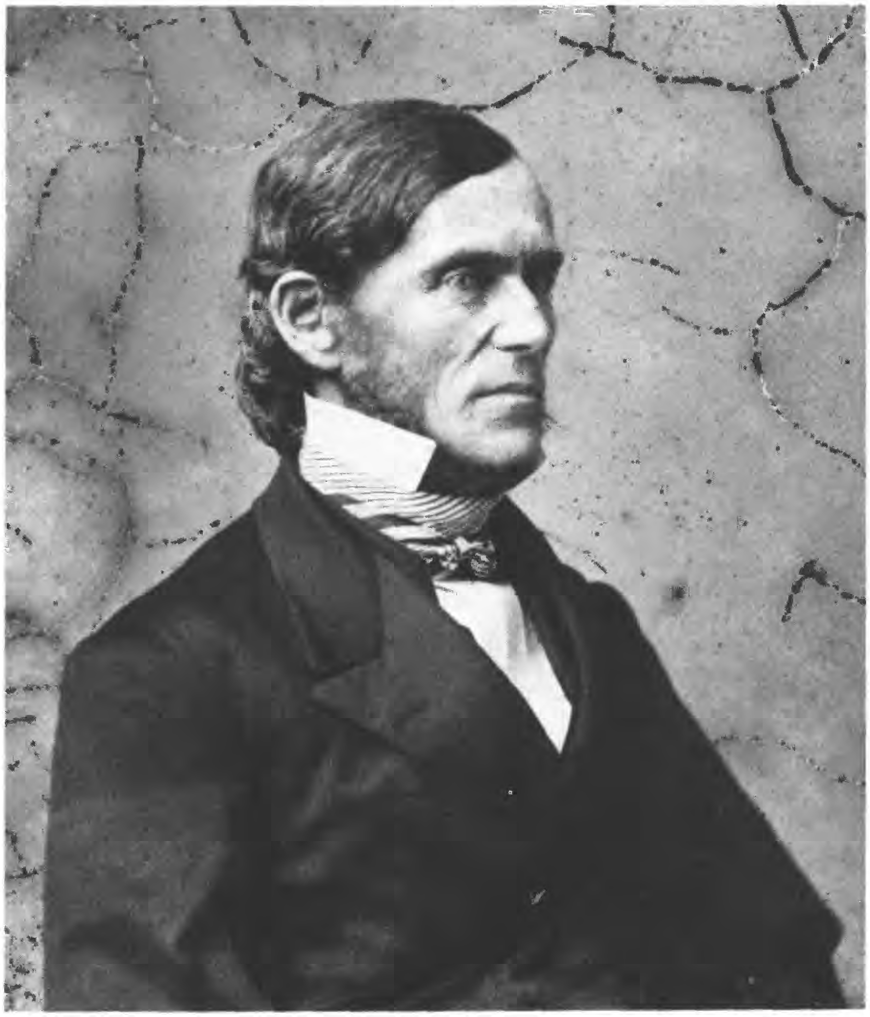
In March 1830, the Massachusetts legislature appropriated money for preparation of a map of the Commonwealth. Governor Levi Lincoln, Jr., who had organized the State's Board of Internal Improvements, asked that the appropriation be increased so that the geology might also be shown and the "presence of valuable ores, with the localities and extent of quarries, and

Edward Hitchcock

Hitchcock, professor of chemistry and natural history at Amherst College, was head of the geological survey of Massachusetts from 1830 to 1833, the first State survey to be carried to completion. His first report, published in the *American Journal of Science* in June 1832, included a map of the mineral resources of the State which predates Jacob Peck's map by a few months. (Courtesy of the Library of Congress.)

Charles T. Jackson

Jackson gave up the practice of medicine for chemistry and mineralogy in 1836. In that year he became head of the geological survey of Maine, in 1837 of Rhode Island, and in 1839 of New Hampshire. In 1847, he was appointed U.S. Geologist to survey the mineral lands in the Lake Superior District of Michigan. His interests were not confined to geology, and in 1846 he and W. T. G. Morton received a patent for the use of "letheon," or ether. (Courtesy of the Smithsonian Archives, Record Unit 7177, George P. Merrill Collection, circa 1800-1930.)



of coal and lime formations, objects of enquiry so essential to internal improvements, and the advancement of domestic prosperity would be discovered, and the possession and advantage of them given to the public." The legislature passed the requested appropriation a week later, the first State geological survey came into being, and Professor Hitchcock was, naturally, placed in charge.

His first report, on the "economical geology" was submitted in January 1832 and reprinted in full in the July issue of the *American Journal of Science*. Professor Hitchcock reported that the State was exceptionally well endowed with building stone; its coal and lignite would be more valuable in the future when other sources were less readily available; iron was so abundant that the demand for centuries to come would not exhaust it. Lead, copper, zinc, manganese, tin, and silver were also present, though only in small quantities. Gold, the Professor had not found, but he was able to announce the existence of a deposit in southern Vermont and to suggest where it might be sought in Massachusetts. However, as the Governor had expressed some doubt that gold was an unmixed blessing, he added prudently that it might be "doubtful whether the discovery of gold would be a public benefit, since, as your Excellency has well observed, it might lead to the greedy pursuit of this uncertain gain, and to the sure sacrifice of habits of industry and economy, and virtuous self-denial, which the ordinary pursuits and requirements of business induce."

The second State survey was established in Tennessee in December 1831. In October, Dr. Gerard Troost, professor of chemistry, mineralogy, and geology at the University of Nashville, addressed the State legislature on the mineral resources of the State so that the members might become acquainted with what was known and take steps to promote future development. Troost had been born in Holland in 1776 and educated there and in France and Germany. He had come to the United States in 1810 enroute to Java on a scientific expedition, but had remained and become a citizen, purportedly because of the abdication of his patron, Louis Napoleon, as King of Holland and the surrender of Java to the English, but partly, no doubt, owing to the charms of Miss Margaret Tage of Philadelphia whom he married in January 1811. With Maclure, Thomas Say, Charles Lesueur, and others, he had joined Robert Owen's utopian society at New Harmony in 1825 but, disillusioned, had left there in 1827 for Nashville. On his own he had made several exploratory trips in various parts of Tennessee.

In his address, Professor Troost emphasized the varied mineral wealth of the State, telling the legislators that he looked forward to the time "when our Cumberland mountains, rich in excellent iron ore and coal, will become the Birmingham of the West," and that he had found "an excellent quality of that zinc ore of which in Europe the best brass is manufactured," as well as lead, "marble of as many varieties, and equal if not superior to the finest Italian," manganese, and magnetic iron ore; he found it polite to refer casually to "the gold found in several of the counties of our eastern extremity." Knowledge of geology was important not only to the miner, he said,

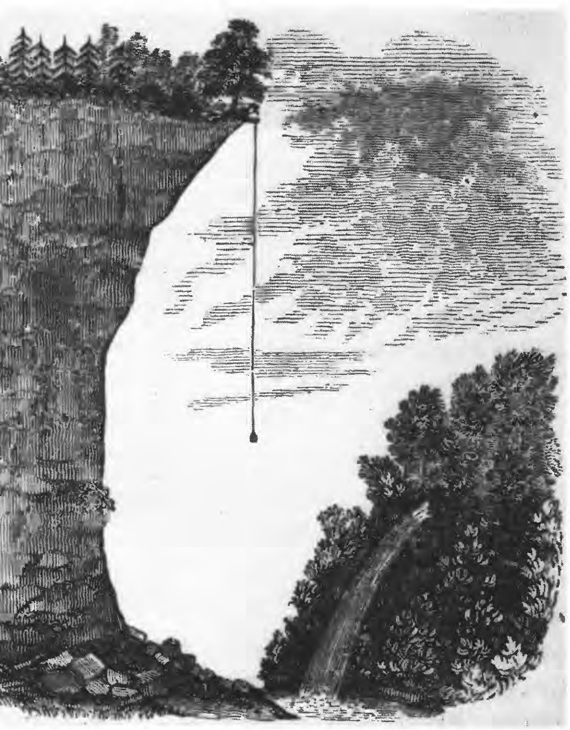
This illustration of gentlemen engaged in geological pursuits, on October 8, 1836, is taken from an atlas of plates accompanying the first report of the Maine survey. It was drawn by Jackson and hand-colored, and the gentleman in the center, shown examining a rock, could well be Jackson. Jackson titled the plate "View of Mount Ktaadn from Butterfield's Ranch." (From C. T. Jackson, 1837.)

but was necessary for the civil engineer in surveying routes for canals, railroads, and turnpikes, and of great advantage to the geographer in making his maps. Two months later he was rewarded with the appointment as "Geologist, Mineralogist, and Assayer for the State," a position he continued to hold by biennial reappointment until 1849.

Troost's reports dealt with a variety of subjects: coal, iron, marl, soils, timber, and waterpower, the suitability of the region for grass and stock and for the cultivation of cabbage and potatoes. He insisted that iron would become one of the principal sources of wealth in Tennessee, proposed that "nowhere could a foundry for a national arsenal be more judiciously situated," and promoted the development of the zinc ores. Sent by legislative order to make a survey of the Ocoee district where gold had been found, he reported "my opinion is that gold is not so abundant . . . as is generally supposed" and then with gentle humor derided the efforts of those who would find gold by wondrous signs or the divining rod.

Efforts were made in 1832 to establish State surveys in Pennsylvania, New Jersey, and Ohio, but none was successful. The Geological Society of Pennsylvania was organized in the early spring with the avowed purpose of using its influence to bring about a geological survey of the State. The president was John B. Gibson, the distinguished Chief Justice of Pennsylvania, and the two vice-presidents were Nicholas Biddle, President of the Bank of the United States, and Colonel Stephen H. Long of the Army Engineers, leader of the 1819 exploration of the Rocky Mountains. A committee of three was appointed to memorialize the legislature, but nothing came of it. The Governor of New Jersey in his annual message to the legislature proposed establishment of a geological survey on the ground that it would result in valuable discoveries in the way of mineral wealth, but the legislature did not heed the plea. In Ohio, Judge Benjamin Tappan, in an address to the Historical and Philosophical Society, set the wheels in motion by suggesting that the society begin the work of a survey in Ohio in the expectation that the State would complete it.

Hitchcock's effort to measure the height of a cliff was depicted by Mrs. Hitchcock. Hitchcock said, "On letting down a stone from this spot with string attached, I found it required a length of 194 feet before the water was reached. I have scarcely ever felt such a creeping and shrinking of the nerves and such a disposition to draw back as here. Even though I took hold of bushes with both hands, I could not comfortably keep my eye turned long into the frightful and yawing gulf; for it seemed as if it needed only a stamp of the foot, or perchance only my weight, to cause the rock on which I stood to follow the example of multitudes of the same kind that were strewed at its base. Still I suppose the actual danger to be quite small." (From Edward Hitchcock, 1841.)



Congress had revived the act of 1807 establishing the Coast Survey in 1832. Commercial interests needed charts of the coast more urgently than ever, and the Navy had done very little on the problem since it had taken over the function in 1818. The act of 1832 authorized the employment of anyone considered desirable, without so stating the reinstatement of Hassler as Superintendent. The act also stated that "nothing in this act, or the act hereby revived, shall be construed to authorize the construction or maintenance of a permanent astronomical observatory." A. H. Dupree suggests that what Congress feared was not scientific activity as such or even the appropriation of money to accomplish a particular end, but the creation of a permanent scientific bureau with a long-term commitment of funds. The survey of the coast was a specific task which could be completed; an astronomical observatory was something else again.

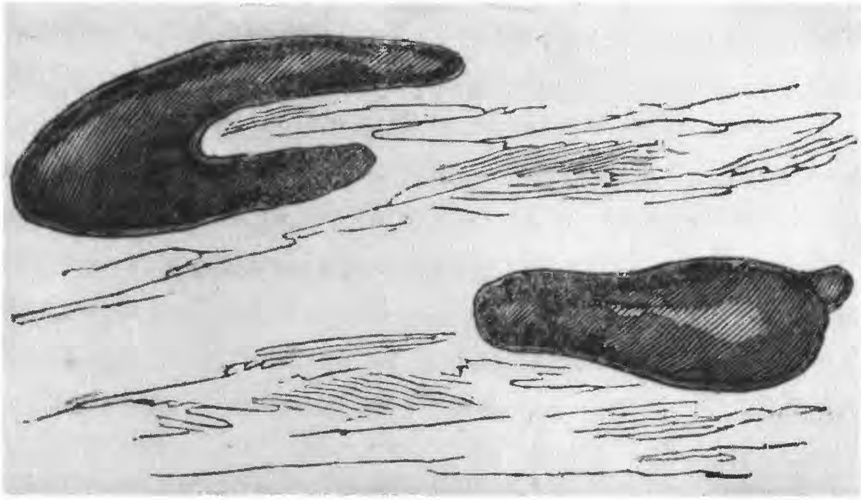
The first move toward establishment of a Federal geological survey was made in July 1832, when Senator William Marcy of New York presented a memorial to the Senate on behalf of G. W. Featherstonhaugh. Sometime in 1828, Featherstonhaugh, born in England but a resident of New York State for many years, returned from a trip to Europe where he had renewed acquaintance with English geologists and had been elected a Fellow of the Geological Society of London. Featherstonhaugh proposed that the office of State Geologist of New York be established, but Amos Eaton, who had not completed the reports on the Erie Canal survey, immediately protested that this would take credit from his efforts and proposed instead that he prepare a geological map of New York and adjoining parts of neighboring States.

Some geological methods, however, have not changed in more than a century. (From C. T. Jackson, 1837.)

Van Rensselaer agreed to finance the work, and Eaton lost no time in sending a note to Silliman's journal for publication. Featherstonhaugh soon thereafter moved to Philadelphia where he began publication of the *American Journal of Geology* as a rival to Silliman's *American Journal of Science*. He soon ran into financial problems and turned to Senator Marcy for assistance. The memorial "praying for the patronage of Congress, in aid of this journal and also in investigating the geology, mineralogy, and natural history of the United States" was the result.

Senator Marcy was a powerful sponsor, a member of the Albany Regency headed by Martin Van Buren who had just been nominated as Vice President, and the memorial was referred to Secretary of War Lewis Cass who was reputed to find it difficult to say no. Six months later, after some nudging by Congress, Secretary Cass did endorse the proposed investigation but said that the Military Academy was equipped to carry it out. He also, however, forwarded a letter from Featherstonhaugh, which stated that his plan could be effected without incurring great expense because it would only be necessary to add "one suitable person" to the already existing topographical service. The Committee on Ways and Means was then instructed to enquire into the expediency of authorizing the employment of the suitable person to aid the Topographical Bureau in "ascertaining the geology and mineralogy of each of the several States of the Union, with a view to construction of a mineralogical and geological map of the whole territory of the United States." After due deliberation, the Committee concluded that all this

Both Hitchcock and Jackson took care to provide the general public with the real explanation of certain features of popular interest. *Lusus naturae* were pseudofossils, rocks weathered to resemble forms such as the boot. The devil's footmarks, near Wickford, Rhode Island, were also peculiar erosional forms. The local explanation was that the devil had tarried with a wayward squaw, and this was the point from which they took off for the nether regions, his footmark, the cloven hoof, to the left of hers, with the big toe pointing forward. (From Edward Hitchcock, 1841; C. T. Jackson, 1840.)

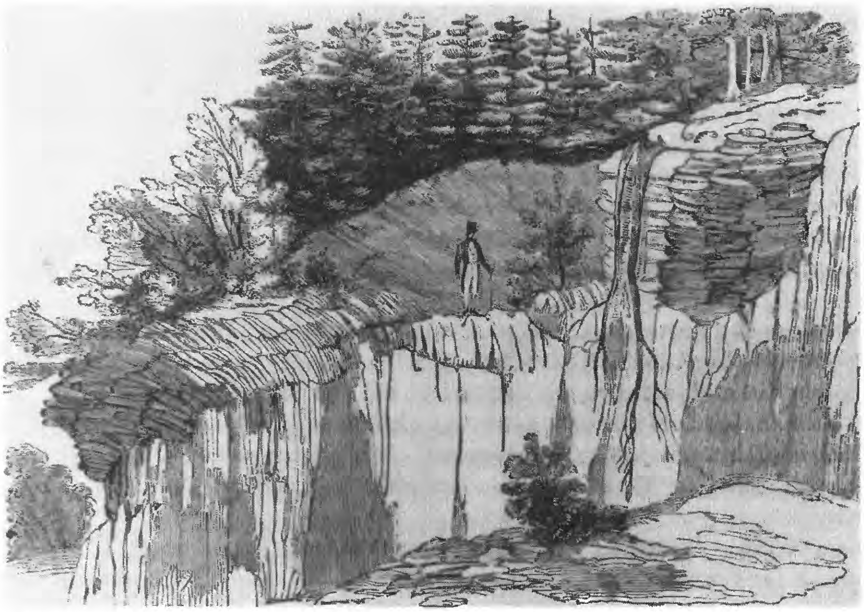


could be done without any increase in the annual appropriation under the provision of the General Survey Act of April 30, 1824, simply adding it to the duties of the Topographical Bureau.

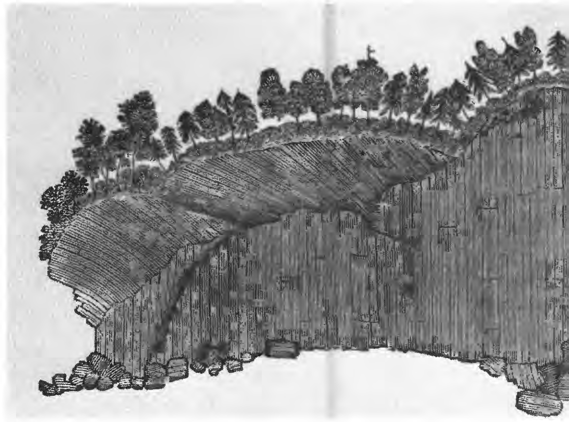
Lieutenant Colonel J. J. Abert, head of the Topographical Bureau, was reluctant to use funds for geologic investigations without specific authorization. However, during the summer of 1833, he assisted Joseph N. Nicollet in his plan to map the upper Mississippi region by loaning him instruments and giving him "letters of protection and hospitality" addressed to commanding officers and Indian agents in the area. Nicollet, an astronomer and a member of the French Academy, had come to the United States in 1832 after disastrous financial reverses in Paris. He had landed at New Orleans and made his way up the Mississippi to St. Louis where he came under the patronage of Pierre Chouteau of the American Fur Company. His mapping plans are said to have been made known to the War Department by Chouteau and a Major Taliaferro of Fort Snelling, but the fact that he also visited F. R. Hassler, head of the newly revived Coast Survey, who became very fond of him, was not a hindrance. Colonel Abert had known Hassler since West Point days, had been his principal assistant on the first Coast Survey when it finally got under way in 1816, and was one of his staunchest supporters.

In 1833, the governors of Virginia and Missouri had also both urged upon their legislatures consideration of a State geological survey. Governor Lilburn W. Boggs of Missouri thought of the survey as part of a general system of internal improvements, as one might expect from a frontier area, but gold had been found in Virginia, and Governor John Floyd was more interested in the "great wealth which lies buried in the earth," needing only "the examination of men of science to bring before the country and make known its value and usefulness to capitalists, who would be induced to engage in fitting it for commerce thereby creating new sources of wealth." Neither legislature responded to the gubernatorial proposals that year, although in Missouri, surveys of several rivers were started, and a geological examination of the Osage River valley was made under the direction of Dr. Henry King, president of the Western Academy of Natural Sciences, at St. Louis.

In March 1833, the Maryland legislature authorized the appointment of a competent engineer to prepare a plan for the complete map of the State and an assistant to the engineer to make the necessary geological researches and report on the expediency and probable cost of a geological survey of the State. Among those who had been urging the State map upon the legislature was 20-year-old John Henry Alexander, a graduate of St. John's College in



Both Edward Hitchcock and C. T. Jackson visited a slate quarry in Guildford, Vermont. Hitchcock confessed himself at a loss to imagine what caused the disturbance in the slate (top). "Among the endless variety of geological hypotheses that have been proposed, I could not call one to mind, which would apply at all to this phenomenon, unless it be the supposition formerly advanced, that the last deluge might have been produced by the impinging of a comet against the earth! I confess I could not but inquire whether this might not have been the point of contact." Jackson's sketch (bottom) was made by the Reverend Mr. Cranch. Jackson was more concerned about the problems of the slate industry caused by the declining prices. (From Edward Hitchcock, 1833; C. T. Jackson, 1844.)



Annapolis at 14, who had taken up the study of law and then, anticipating the importance of railroads and the development of coal and iron on the future of the nation, had given up the law to devote himself to applied science. On May 25, 1833, Alexander was appointed the engineer, and Julius T. Ducatel, professor of chemistry and geology at the University of Maryland, as the assistant. Ducatel, then 37, had been educated at St. Mary's College in Baltimore and in Paris and had been teaching for several years. His major interests had been in pharmacology and toxicology.

Ducatel and Alexander took a broader view of their assignment than had Hitchcock or even Troost. They concluded that the geological investigation meant "not only an inquiry into the mineral constitution of the different sections of the state, but a development of all its resources, in so far as these are dependent upon the occurrence within its territory of such substances belonging to the soil, as have already been, or are capable of being applied to useful purposes, in agriculture, manufactures, and the arts; the collection likewise of facts relative to its hydrology, by which they understand, besides an inquiry into the nature of the mineral waters that occur within its limits, an examination of the peculiar circumstances under which the natural flow of streams is determined, with a view, principally, to establish the amount of its water power, and, in a word, every point of information usually embraced under the head of the physical geography of a country." Together they made a reconnaissance of the State between May 25 and September 6, 1833, and on December 27 presented a preliminary report and recommendations to the Governor, which was reprinted in full in the January 1834 issue of the *American Journal of Science*.

On February 25, 1834, the act to "provide for making a new and complete map and a geological survey" was passed, and the offices of Topographical Engineer and Geologist for the State of Maryland were established. Alexander and Ducatel were appointed to these posts.

Ducatel began his investigations on the Eastern Shore and in southern Maryland, paying special attention to the deposits of marl. Knowledge of the agricultural uses of marl was then being widely spread through the efforts of Edmund Ruffin of Virginia whose first paper, *An Essay on Calcareous Manures*, published in 1821, had already been expanded to book length. Eventually, Ducatel visited almost the entire State and made special studies of the coal and iron deposits of the Frostburg basin.

Alexander's work was hampered by the requirement that he make surveys for internal improvements, as directed by the legislature, though he did prepare several county maps, special maps for Ducatel's reports, and a map of the State at a scale of 1:200,000. Ducatel introduced Alexander to F. R. Hassler, the head of the Coast Survey, so the young man could get advice on instruments, and between the two there sprang up a lasting friendship. Hassler was a firm advocate of Federal and State cooperation in conducting surveys, and Alexander and he worked out such a plan for Maryland. Alexander then recommended to the Governor that the State postpone further work on the State map until such time as it could take advantage of the Coast Survey's more refined mapping. Eventually, a form of Federal-State cooperation was worked out, although not for several years. Meanwhile, Alexander had time to devote to iron and coal enterprises in the western part of the State.

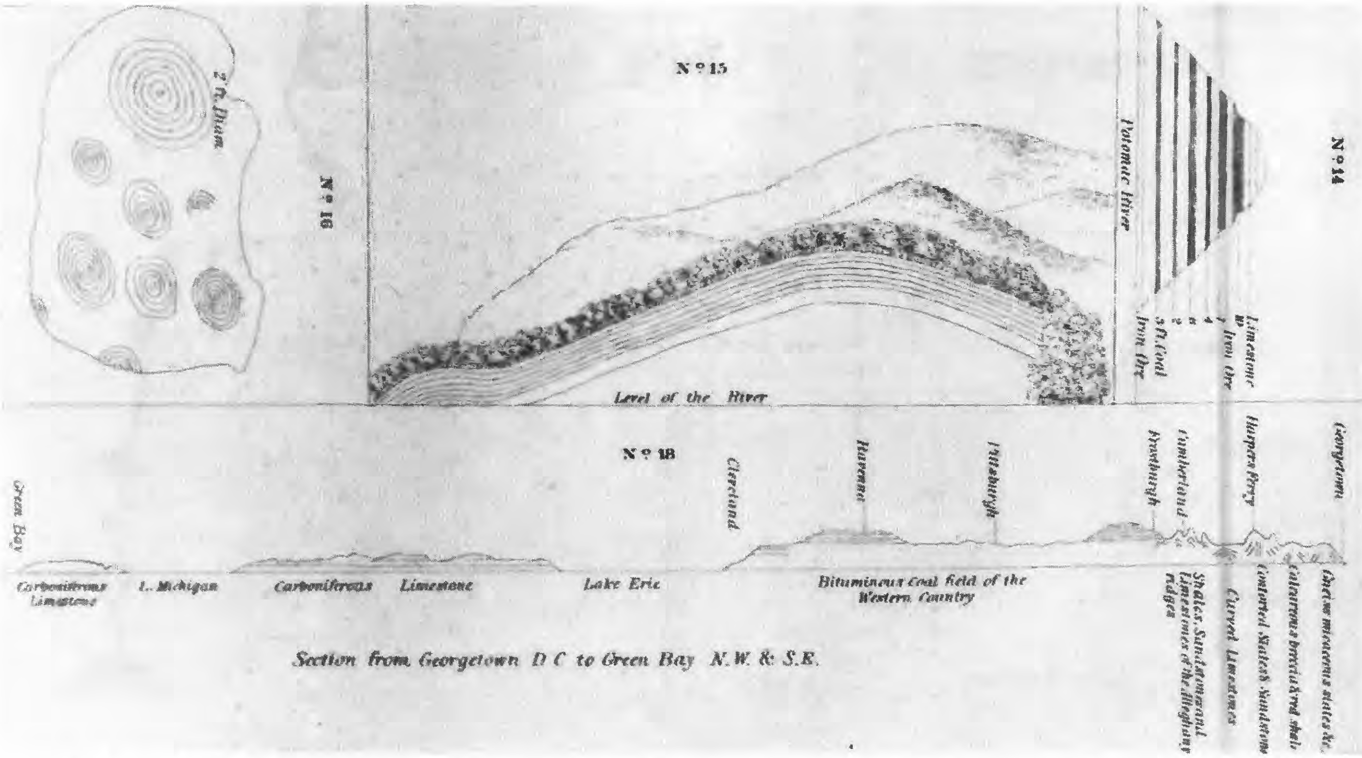
In his annual report to the Secretary of War in October 1833, Colonel Abert asked that specific authorization be obtained from Congress, by joint resolution or otherwise, for diverting $5,000 a year of the appropriation for surveys to "geological investigations, and to the construction of a geological map of the United States." Evidently he had reconciled in his own mind the relevance of geological investigations to internal improvements, for he wrote that "few subjects connected with the duties of this bureau open so many and so important national advantages, or are adapted to redound more to internal commercial prosperity and to national scientific fame" as the "development of these great resources of wealth and commercial intercourse, which now lie inert and buried in the bowels of the earth." In fact, he said, "the propriety of articial roads and canals may in many cases be considered as entirely dependent upon them or as the mere machinery by which they are brought into being and activity." He further stated that efforts to date had been partial and limited by the means of individuals, and that "such extensive resources as we are represented to possess *** can be correctly developed only by national encouragement of a regular system of scientific investigation pursued with steadiness and intelligence, and its results fairly exposed to the efforts of our enterprising countrymen."

Authorization was given in the supplementary appropriations bill of June 28, 1834, and in July, Featherstonhaugh was sent to make a geological and mineralogical survey of the Ozark Mountains. Colonel Abert patiently explained in his annual report:

> **It is not merely those questions of abstract science which are involved in his observations; it is not merely the additional light which will be thrown by his researches upon various subjects which now agitate and occupy the learned of the world, which are to give interest to this duty, and will place its patrons in the attitude of the enlightened and liberal friends of scientific truths, but it is the development of immense and hitherto unknown sources of wealth and active inland trade, the exposing of various deposits of coal, iron, lead, and the precious metals, and the encouragement these will furnish to industry and the profitable employment of capital.**

In February 1835, he presented his report, the first 42 of its 97 pages being devoted to a discussion of general principles. In 1835, Featherstonhaugh, again under instructions from Abert, made a geological reconnaissance "from the seat of government by the way of Green Bay and the Wisconsin Territory to the Coteau de Prairie, an elevated ridge dividing the Missouri from the St. Peter's River." His second report again contained a great amount of preliminary matter but also a discussion of the geologic structure and stratigraphy. Thereafter, the first Federal geological survey was discontinued.

Geology had by then undergone a revolution. When Featherstonhaugh was in England, Cuvier's idea that the disappearance of characteristic faunas had been caused by sudden and widespread catastrophes was accepted by



The illustrations in the reports of G. W. Featherstonhaugh, the first U.S. Geologist, were simple and economically prepared. Counterclockwise from the top right, this one shows a section in western Maryland containing six workable veins of coal and two bands of iron ore; Dan's Mountain, near Frostburg, Maryland; cherty limestone on the banks of the Mississippi where Featherstonhaugh observed beds were occasionally made up of concentric circles; and the section from Georgetown, D.C., to Green Bay, Wisconsin. (From G. W. Featherstonhaugh, 1836.)

most of those who no longer believed in deposition from the universal ocean. The idea of a geologic time scale, however, was still primitive. The Rev. W. D. Conybeare and William Phillips had used the term "Carboniferous" to describe a system of coal-bearing rocks in central Britain, and Jean J. D'Omalius d'Halloy had applied the term "Cretaceous" to the chalk beds of the Paris Basin, both in 1822, but the terms were descriptive only. In that year, Charles Lyell, a 27-year-old Oxford graduate and amateur geologist, became a barrister in London. In 1823, Lyell was elected one of the two secretaries of the Geological Society of London and went to Paris, then the scientific capital of the world, to learn French. Among the scientists he met was Louis Constant Prevost, who proposed that an intermixture of freshwater and marine shells that he had discovered should be explained on the basis of a comparison with modern conditions rather than by appealing to unknown causes on a catastrophic scale. Prevost paid a return visit to England in 1824, where the friendship developed. In early 1825, Lyell met Roderick Murchison, a former Army officer, recently a country gentleman, who was attending lectures in science at his wife's behest. They too became friends. The mixture was ready to inaugurate a new era in geology. In 1825, however, young Lyell's father insisted that he devote his attention to the law, and the revolution was postponed for a few years.

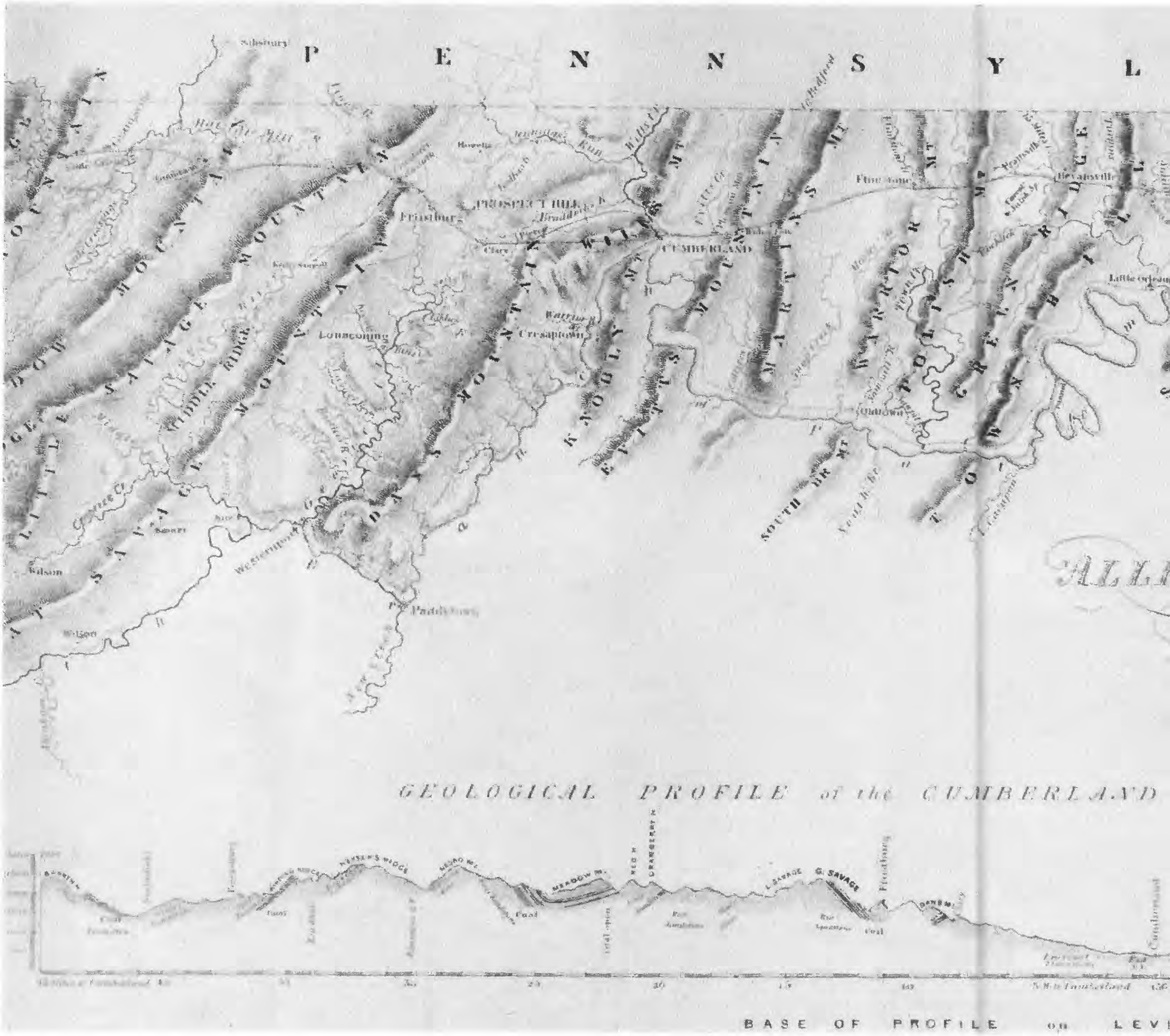
In 1827, Charles Lyell decided to write a book on geology, as there was a dearth of books in English on recent developments. Scrope's book on the volcanoes of central France raised new questions in his mind, and in March 1828, he and Roderick Murchison decided to go to the Auvergne and see the volcanic country for themselves. When he left England, Lyell was mentally prepared to look for the explanations of geologic phenomena in terms of processes going on in modern time. From his experience on the continent, he concluded not only that analogies might be drawn between present and past conditions but that present conditions on the Earth's surface could only be understood in terms of historical development. He returned to London in February 1829 and began work in earnest on his manuscript; he completed the *Principles of Geology* in June 1830. Its full title was *Principles of Geology. Being an Enquiry How Far the Former Changes of the Earth's Surface are Referable to Causes Now in Operation*. In it, he defined geology as "the science which investigates the former changes that have taken place in the organic, as well as in the inorganic kingdoms of nature" and divided the agents of change into aqueous, which were "incessantly labouring to reduce the inequalities of the earth's surface to a level" and igneous, which were "equally active in restoring the uneveness of the external crust." "Our estimate," he said, "of the value of all geological evidence, and the interest derived from the investigation of the earth's history, must depend entirely on the degree of confidence which we feel in regard to the permanency of the laws of nature."

The second volume of the *Principles,* dealing with the organic world, was published in early January 1831. The third and last volume was published in April 1833. In the last, Lyell surveyed the whole sequence of geological formations, beginning with the most recent and proceeding to the successively older units. He proposed the names Pliocene, Miocene, and Eocene for the Tertiary formations and discussed secondary formations and the principles to be used in correlating them. An unnamed reviewer, presumably Silliman, said in the *American Journal of Science* that Lyell

> has done much to recall geologists from extravagant speculations, and to allure them back to a course of strict induction; thus placing geology, side by side, with the other sciences of observation. If he has repressed the excursions of our imaginations into unknown scenes in unknown ages, he has exalted our conception of the number and magnitude of great geological events which have happened within the historical era. ***While, therefore, he does not permit us to imagine that great catastrophes were, in a sense, peculiar to the earliest periods, he proves that catastrophes and great movements have been common in all ages, and there is an incessant onward march in physical operations.

When the third volume of Lyell's *Principles* was published, two young Americans, Henry Darwin Rogers and David Dale Owen, were in London for advanced study and thus had firsthand exposure to the new ideas. Rogers was the son of Dr. Patrick K. Rogers, late professor of natural philosophy and chemistry at William and Mary College, and brother of Professor William B. Rogers, who then held that position. He had been elected to the chair of Chemistry and Natural Philosophy in Dickinson College, Carlisle, Pennsylvania, in January 1830 but had remained there only a little more than a year. In the winter of 1831–32 he had been in New York where he spent much time with Robert Dale Owen, son of the founder of the New Harmony colony, and had met David Dale Owen, Robert's younger brother, who had come to the United States in 1828. Rogers left for London in May 1832, and David Dale Owen followed a few months later. When they returned to the United States in 1833, Rogers began lecturing on geology at the Franklin Institute in Philadelphia, and Owen entered the Ohio Medical College in Cincinnati.

There was a favorable upturn in the national economy in 1834. Money was again being invested in land, mining, and manufacturing, and the overvaluation of gold in the Second Currency Act began to attract capital from abroad. Most of the States were burdening themselves with debt to pay for internal improvements, and many of them were willing to undertake geological surveys in the hope of improving their position. In New Jersey, the legislature provided for a geological and mineralogical survey of that State on February 26, 1835, and Professor H. D. Rogers was appointed to conduct it. In Virginia, Professor William B. Rogers, whose interest in geology had been awakened after his brother's return from England, testified before



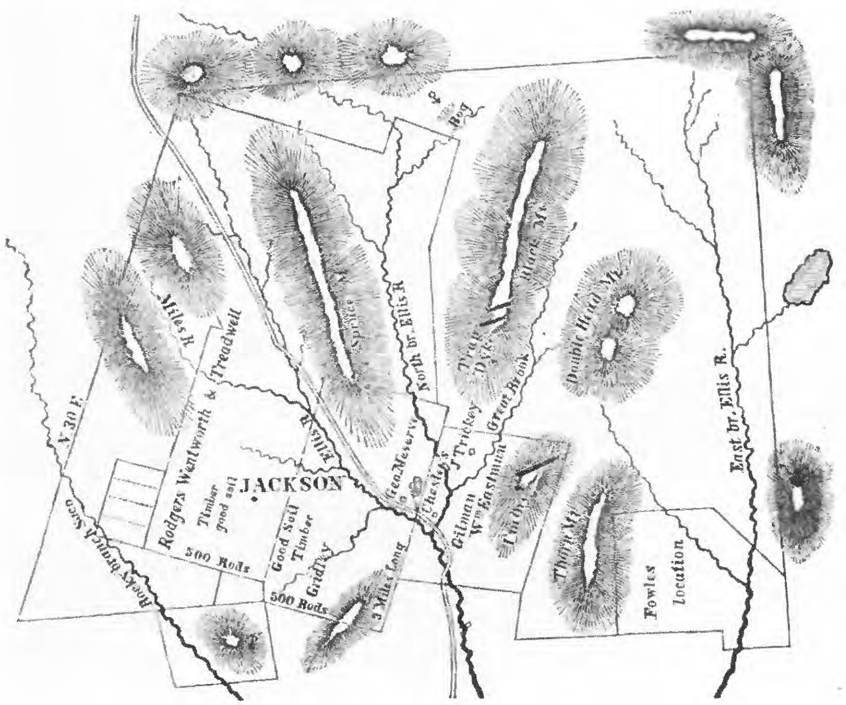
the select committee of the Assembly considering memorials from Morgan, Frederick, and Shenandoah Counties asking for a survey, and the committee found his remarks so engrossing that he was asked to address the entire legislature in a public session. On March 6, 1835, the Virginia Assembly authorized a geologic reconnaissance of the State in preparation for a more thorough survey.

In Connecticut, the legislature authorized the governor in the spring of 1835 to appoint a committee of suitable persons to make a geological survey of the State. Governor Henry W. Edwards, graduate of Yale, great-grandson of a founder of Yale, and recent recipient of an LL.D. degree from his alma mater, had recommended the survey after consultation with Professor Silliman. In his message to the legislature, he noted, in thrifty New England fashion, that a systematic examination might lead to important mineralogi-

The map and geological profile prepared by the Maryland survey covers in much greater detail some of the territory illustrated by G. W. Featherstonhaugh. (From J. T. Ducatel, 1840.)

cal discoveries, but even if it did not, the examination would aid individuals in future research, prevent waste of time and money in searching for minerals in places where they were unlikely to occur, and serve as a guide in selecting routes for railroads, canals, and internal improvements of all kinds.

Professor Silliman was asked to take charge of the survey but declined. Instead the work was divided between Charles Upham Shepard, who undertook the economic and mineralogical part, and James Gates Percival, who took responsibility for the general geology. Shepard had graduated from Amherst in 1824, where the only lectures he remembered were those by Professor Eaton, and had served as Silliman's assistant from 1827 to 1831 before becoming lecturer on natural history at Yale and professor of chemistry at South Carolina Medical College. Percival was a graduate of Yale in 1815 and had a degree in medicine.



Jackson's map of the town of Jackson, New Hampshire (a small town near Pinkham Notch in the eastern part of the State, now a summer and ski resort), is typical of the period. Note especially, however, the attempt to classify the land—as good soil, timber, or bog. (From C. T. Jackson, 1844.)

Professor William Rogers' report of his preliminary reconnaissance was submitted to the Virginia legislature in January 1836, and on February 29, a systematic geological survey of the State was authorized. The Virginia law was more detailed and specific than those that had preceded it, presumably because of Professor Rogers' influence, and it included pure as well as practical science. Whereas Professor Hitchcock had been appointed "to make a geological examination of the Commonwealth *** in order that the same may be inserted on the map," Professor Troost was charged with making a geological survey of the State of Tennessee "with a view, as far as practicable, to develop the mineralogical resources thereof," and Professor Ducatel, with making "a complete and minute geological survey" of the State of Maryland "with as much expedition and despatch as may be consistent with minuteness and accuracy," Virginia wanted a "complete and detailed geographical survey" and a "careful and accurate examination and analysis of the various soils . . . as also of the principal ores, marls, saline and mineral waters." When the work was completed, the geologist in charge was to make a final report, giving "in detail, the result of all surveys, examinations, and discoveries which shall have been made, geological, chemical, and topographical, and all other matters connected therewith, which may be considered by him as likely to be in any manner useful to the public or interesting to science." He was also to "construct and prepare for engraving a complete geological map of the State, showing not only the general geological structure thereof, but plainly and accurately delineating the stratification of its principal rocks, and the position and boundary of all the mineral deposits which may now be known or be ascertained by the investigations which shall have been made, accompanying said map with such a series of sections or profiles as may be necessary to a proper exhibition of the geology of the region to which they may relate."

On March 29, 1836, the Pennsylvania legislature authorized the First Geological Survey of Pennsylvania. The Pennsylvania survey was organized on a larger scale than any of its predecessors, with an appropriation of $6,400 a year for 5 years to pay the salaries of a geologist, two assistant geologists (one of whom was to be "a scientific and practical mineralogist,") and "a competent, practical analytical chemist." Professor Henry D. Rogers, State Geologist of New Jersey, was appointed the geologist, James C. Booth and John F. Frazer, the assistant geologists, and Dr. Robert E. Rogers, youngest of the four Rogers brothers, the chemist.

The Pennsylvania law was more specific though no more comprehensive in the beginning than the Virginia law. The geologist and his assistants were "to commence and to carry on with as much expedition and dispatch as may be consistent with minuteness and accuracy, and in accordance with a plan previously submitted to the Secretary of the Commonwealth, a geological and mineralogical survey of the State, with a view to determine the order, succession, arrangement, relative position, and the dip or inclination, and also the comparative magnitude of the several strata or geological formations within the State." They were also "to discover and examine all beds and deposits of ores, coals, clays, marls, and such other mineral substances as may be deemed useful or valuable." The State Geologist was further required "to cause to be represented on the map of this Commonwealth, by colors and other approriate means, the various areas occupied by the different geological formations in the State, and to mark thereon the localities of the respective beds or deposits of the various mineral substances discovered, and on the completion of the survey to compile a memoir of the geology and mineralogy of the State, comprising a complete account of the leading subjects and discoveries which have been embraced in the survey." In 1838, as the iron and coal industries were reaching new stages of technological development, the following obligation was added to the State geologist's duties: "to make such inquiries and examinations into the present methods of mining coal and manufacturing iron as the governor shall deem expedient and proper to increase the products of the mineral resources of the State."

The survey of Maine authorized in the spring of 1836 brought another scientist with European training to the fore. The Maine survey was twofold. On March 21, the Massachusetts legislature authorized the governor to employ some suitable person or persons to make a geological survey of the public lands in the State of Maine held jointly by Maine and Massachusetts. The Maine legislature followed a week later with a resolution asking the Maine Board of Internal Improvements to provide for a survey of the entire State. Dr. Charles T. Jackson of Boston was appointed to both positions.

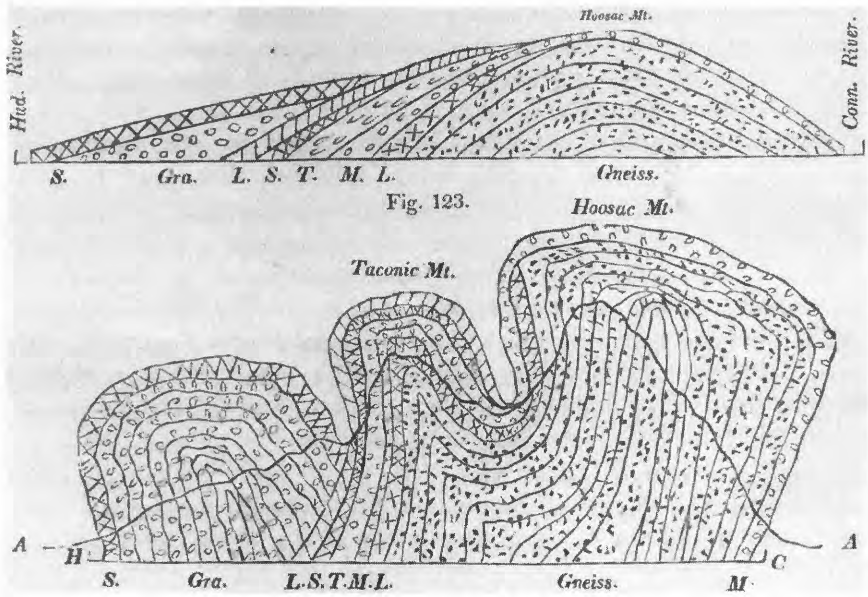
Jackson had received a medical degree from Harvard in 1829, but even as a medical student he had been interested in geology. With Francis Alger, he had made a geological investigation of Nova Scotia, and he had become acquainted with Troost, Maclure, Say, and Lesueur during geological excursions in New Jersey and New York. After graduating from Harvard, Jackson had gone to France for further study and, while there, combined medical subjects at the University of Paris with Elie de Beaumont's lectures on geology at the Ecole des Mines and lectures on science at the Sorbonne. On his return to the United States in 1832, he abandoned the practice of medicine and devoted his not inconsiderable energy and talents to scientific research. He opened a chemical laboratory for the instruction of students in mineral analysis; among his students were several who later became leading chemists. Jackson was particularly concerned with economic matters but found no mineral deposits of value, investigated reported coal beds but discounted them, found no marl to aid the rocky-soiled farms, but suggested other forms of fertilizer that might be used.

Ohio took a concrete step toward formation of a State survey with the appointment on March 14, 1836, of a committee to report to the next session of the legislature on the best method and the cost of a complete geological survey of the State. The members of the committee were Samuel P. Hildreth of Marietta, John Locke and John Riddell of Cincinnati, and Increase Lapham of Columbus. Hildreth was one of the pioneers in science west of the Allegheny Mountains. A long-time contributor to Silliman's *American Journal of Science*, he had, at Professor Silliman's suggestion, just made an extensive study of the bituminous coals of Ohio that had been published in January 1836. Locke was a graduate of Yale, to which he had been attracted by reading Silliman's account of his travels in Europe, and was then a professor at the Medical College of Cincinnati. Riddell had been graduated from Rensselaer and had gone on to the Medical College at Cincinnati where he had just received his degree. Lapham was the youngest of the four—only 24—but he had been corresponding with Silliman on geological matters since he was 16.

On April 15, 1836, the New York Assembly authorized an even more elaborate survey of that State. Amos Eaton was evidently a prime mover in the affair, although he himself did not participate in the survey, being fully occupied in teaching. In 1835, the Albany Institute, of which Stephen Van Rensselaer, Eaton's patron, was president, presented a memorial to the legislature which then asked the Secretary of State to report at the next session the most expedient method and the cost of a survey. The Secretary proposed that for the survey the State be divided into four districts and that two geologists and a draftsman be assigned to each district. The division is said to have been suggested by Professor Edward Hitchcock of Amherst, who had made the survey of Massachusetts and who was appointed geologist of the first district with C. B. Adams as his assistant. Eaton recommended Ebenezer Emmons and James Hall, who were given responsibility for the second district. Timothy Conrad was placed in charge of the third district, and Lardner Vanuxem, of the fourth. Professor L. C. Beck of Rutgers College was appointed mineralogist of the survey. Hitchcock resigned shortly to work for the reactivation of the Massachusetts survey, and on the recommendation of Eaton, W. W. Mather was then given charge of the first district.

Most of the members of the survey were professionally trained in some form of geology. Mather was a graduate of West Point and had taught geology there for several years. Emmons, who had been closely associated with Eaton for several years, was a graduate of Williams College, had also studied at Rensselaer, and held professorships at both institutions. James Hall had been one of Eaton's students at Rensselaer. Vanuxem had studied at the School of Mines in Paris and had several years' experience in geologic work in South Carolina, where he had been a professor at Columbia, and in Mexico. Only Conrad had had no formal technical training, although he was very skilled in drawing. At the end of the first season, the work was reorganized. Conrad was appointed paleontologist to the entire survey; Vanuxem moved to the third district, the central counties which included the salt springs; and James Hall took over the fourth, the counties in which the continuation of the coal formations of Pennsylvania was to be expected.

During Jackson's second administration, speculation in public lands created a surplus in the Federal Treasury. The national debt was paid off by January 1835, and in the following year, Treasury receipts from the sale of the public lands exceeded the revenue from customs. In his annual message to Congress in December 1835, the President asked for a reorganization of the General Land Office because of its greatly expanded work, and by the Act of July 4, 1836, the Office was enlarged and placed directly under the President. The Commissioner of the General Land Office was made the supervisor of the Surveyor-General. Congress, obviously concerned about a growing bureaucracy, however, specified the staff of the General Land Office



Observations of the inversion of strata, with younger rocks appearing to be under older rocks, as, for example, between the Connecticut and Hudson Rivers, puzzled geologists. Hitchcock said that the Professors Rogers of the Universities of Pennsylvania and Virginia had undoubtedly collected more facts on the subject than any of the other geologists in the United States but they had published little. To explain his observations, he suggested that perhaps that strata had been deposited as in the upper figure, and then, while they were still in a plastic state, lateral pressure had been exerted near the Hudson and Connecticut Rivers at the same time as upward pressure from gaseous or melted matter below. These forces conspired to fold the strata as in the lower figure, and the present surface, line *AA*. came about through erosion. (From Edward Hitchcock, 1841.)

in great detail. Senator Benton again brought up his scheme of graduating the price of the public lands, which he said would reduce the revenue. Senator Clay instead proposed that the surplus be distributed to the States. Congress came up with a law to "deposit" the surplus with the States as a "loan" to enable them to complete their internal development programs, and the law was signed by President Jackson on June 23, 1836; the distribution was to begin January 1, 1837.

During the last year of the Jackson administration, there was also a marked change of attitude toward science and mapping by the Federal Government. A permanent Patent Office was established, and the United States Exploring Expedition to the Pacific was authorized, both in 1836. The first Commissioner of Patents, Henry L. Ellsworth, Yale 1810, saw in the patent law the possibilities of a great scientific bureau. He believed that the scientific activities of the Government should serve the great economic interests of the country and tried to make the Patent Office a depository not only of models of patents but of specimens of manufactures and collections of minerals as well. In his view more had been done to aid commerce and manufactures than agriculture, so he attempted to make the Patent Office serve principally the agricultural interests; by making his office a clearinghouse for seeds and plants, he started an agricultural service that is accounted the ancestor of the Department of Agriculture. The United States Exploring Expedition was authorized as an aid to commerce but had the backing of some of the country's most influential scientists, including Professor Benjamin Silliman. The work of the expedition was to include not only charting of islands and hydrographic studies but also magnetism, meteorology, and natural history. Several able young scientists were rounded up for the expedition, including 23-year-old James Dwight Dana, a former student of Professor Silliman's, who had spent some time instructing midshipmen in mathematics during a cruise to the Mediterranean and was then back at Yale working out a new system of crystallography and mineralogy. Unfortunately, the expedition ran into administrative problems and did not get underway until 1838.

The States maintained their interest in geological surveys. The Georgia survey, authorized in November 1836, employed another New Englander, educated at Harvard and Dartmouth. Dr. John Cotting was an older man, ordained a Congregationalist minister in 1810, who had later taken up chemistry. Much of his professional life had been spent in western Massachusetts, teaching at the Berkshire Medical Institute, the high schools, and at Amherst College. He had recently completed a geological and agricultural examination of Burke and Richmond Counties, made at the expense of public-spirited citizens of the counties. Georgia at the time, like other Southern States, was concerned with means of transportation, and the Governor in recommending the survey to the legislature said that a proper knowledge of the geological structure of the State and its mineral resources was "necessary to a prudent and profitable location of canals and railroads and should have its influence in directing their course." The Governor also remarked that the State, especially the part within the Cherokee circuit, was "believed to abound in mines of gold, marble, iron, limestone, salt, and other valuable minerals" and a scientific examination of "these concealed treasures" should no longer be delayed. The legislature authorized the survey and provided a generous $10,000 to carry it out.

Four State surveys were organized in the spring of 1837. The Indiana survey was first, authorized on February 6, and it provided an opportunity for David Dale Owen, who had graduated from Ohio Medical College in 1836. Governor Noah Noble, who had urged the legislature to authorize a survey in 1835, was a strong proponent of internal improvements, and the Indiana law specified that the survey begin in areas near contemplated public works. Owen was obviously expecting the appointment and may have had a hand in the legislation because he knew the Governor and his brother, Robert Dale Owen, was then a member of the State legislature. He had spent several months with Gerard Troost in Tennessee in the fall of 1836, observing his methods and preparing for his new work.

Owen considered it his "duty while surveying a country so new as ours, to remember, that a State just settling, is like a young man starting in life, whom it behooves to secure to himself a competency, before he indulges in unproductive fancies." He therefore concerned himself strictly with economic geology, locating workable seams of coal, salt springs, clay and shale suitable for brickmaking, and iron. He was particularly impressed with the possibility of the manufacture of iron in the central western part of the State.

The Delaware survey was organized a week after the Indiana survey, influenced in no small measure by the Pennsylvania survey. The Delaware law was almost identical with that of Pennsylvania, except that no provision was made for assistants, and the State Geologist himself had to be "the scientific and practical mineralogist." James C. Booth, who had been an assistant on the Pennsylvania survey, was named State Geologist. The Delaware law had one unusual requirement: of the $3,000 appropriated, not more than $1,000 could be spent in any one of the three counties. Booth, who was primarily a chemist, gave the major share of his attention to the greensand and marl and reported that he devoted himself to traversing the lower counties "with a view to imparting such knowledge relative to agriculture as lay within my imagination."

On February 23, 1837, less than a month after it became a State, Michigan authorized a geological survey, and Douglass Houghton was named State Geologist. Houghton was then a young man of 28. He had studied under Eaton at the Rensselaer Scientific School, had graduated at 19, and had been given an appointment as assistant professor of chemistry and natural history. In 1830, when a group of Michigan citizens was looking for someone to deliver a course of lectures on chemistry, botany, and geology, Eaton recommended Houghton. Houghton studied medicine on the side, and in 1831 was admitted to practice and set up his office in Detroit. He also served as surgeon and botanist with Henry Schoolcraft on his 1831 expedition to discover the sources of the Mississippi. In the years between 1831 and 1837, Houghton made many friends in the area and became a close friend of Stevens T. Mason, Michigan's first governor. The Michigan law was similar to the New York law, and Houghton planned four departments: geology and mineralogy, zoology, botany, and topography, though owing to financial difficulties, all but the geology had to be abandoned.

Finally, on March 27, 1838, the Geological Survey of Ohio was authorized. The Ohio law was basically similar to the Virginia law, rather than to the New York law, except for the number of people to be employed and the date of reporting to the legislature, but the Governor appointed W. W. Mather of the New York Survey as the principal geologist. S. P. Hildreth was first assistant and paleontologist; J. P. Kirtland, second assistant in charge of botany and zoology; John Locke, third assistant; and C. Briggs, Jr., fourth assistant. Colonel Charles Whittlesey was appointed as topographic engineer. The primary object of the survey was the development of Ohio's natural resources, but in his first report, Mather made a strong plea for preparation of an accurate topographic map on which "the localities of all minerals, ores, rocks, &c. can be indicated in their proper position and relations to each other." An accurate map would require triangulation similar to that of the Coast Survey, and Mather realized that the time and expense might be greater than the legislature would deem appropriate. However, it would never have to be redone.

Before any of these surveys were fairly underway, there was a new financial crisis. On July 11, 1836, eighteen days after signing the Distribution Bill, and after Congress had adjourned, Jackson issued an Executive Order requiring that as of August 15, payment for public lands be made in specie, in essence the resolution introduced by Senator Benton in April and defeated by the Senate. Both the Specie Circular, as the executive order became known, and the plan for distribution of the surplus tightened the money market by increasing the demand for specie. Crop failures in 1835, a decline in agricultural exports, an unfavorable balance of trade, and the failure of British firms that had invested in American securities, all of which led to demand for specie, aggravated the financial difficulties. In May 1837, 2 months after Martin Van Buren became President as Jackson's chosen successor, New York banks suspended specie payments, and within 10 days, banks throughout the country followed suit. The breakdown in the monetary system was followed by a general paralysis in business and widespread unemployment.

Business remained stagnant well into 1838 and then began to rally. The Specie Circular was repealed in May, and internal improvement ventures again went forward, but recovery was temporary. Commodity prices declined again, there was another flurry of bank failures, and toward the end of the year, banks again suspended specie payments. The depression settled in to stay until business was again stimulated by the Mexican War.

The depression had a disastrous effect on State geological surveys. Between 1830 and 1837, fourteen surveys had been established in as many States, but in the seven lean years that followed, all except the Tennessee survey were discontinued or suspended for lack of appropriations. Two were established in 1839 but were of short duration, and in 1842, geology, with only a few exceptions, was again largely the province of professors.

The two surveys established in 1839 were both in New England, and both were directed by Dr. Charles T. Jackson. On December 26, 1838, the Rhode Island Society for the Encouragement of Domestic Industry resolved to memorialize the legislature regarding a geological and agricultural survey of the State and appropriated $500 for it, subject to the State's making an additional appropriation. The State appropriated $2,000 in January 1839 and in April, contracted with Dr. Jackson for the work.

The New Hampshire legislature was more prodigal. On June 24, 1839, it authorized a mineralogical and geological survey of the State and appropriated $2,000 a year for 3 years to carry it out. Dr. Jackson was appointed State Geologist of New Hampshire, even though he would be unable to begin work until the following year.

Disposal of the public lands, including the mineral lands, remained a live issue during the depression, although overshadowed to a degree by monetary reform. The general preemption measure of 1830 had been for 1 year only, but it had been followed by similar measures in 1832 and 1834, and in June 1838, another preemption law extended the privilege for 2 years. A bill for permanent prospective preemption was introduced in 1839 but was sidetracked because of the greater interest in the currency issue, and in 1840, the Preemption Act of 1838 was extended for another 2 years. Senator Benton continued to argue for graduation of the price of the public lands, now on the grounds that more people would take advantage of reduced prices because of the depression, so the government's revenue would be increased. Senator Clay again brought forth the idea of distribution of the proceeds of public land sales to the States and found that many of the Western States and some of the Southern States, which needed funds to complete internal improvement projects, were more receptive to the idea.

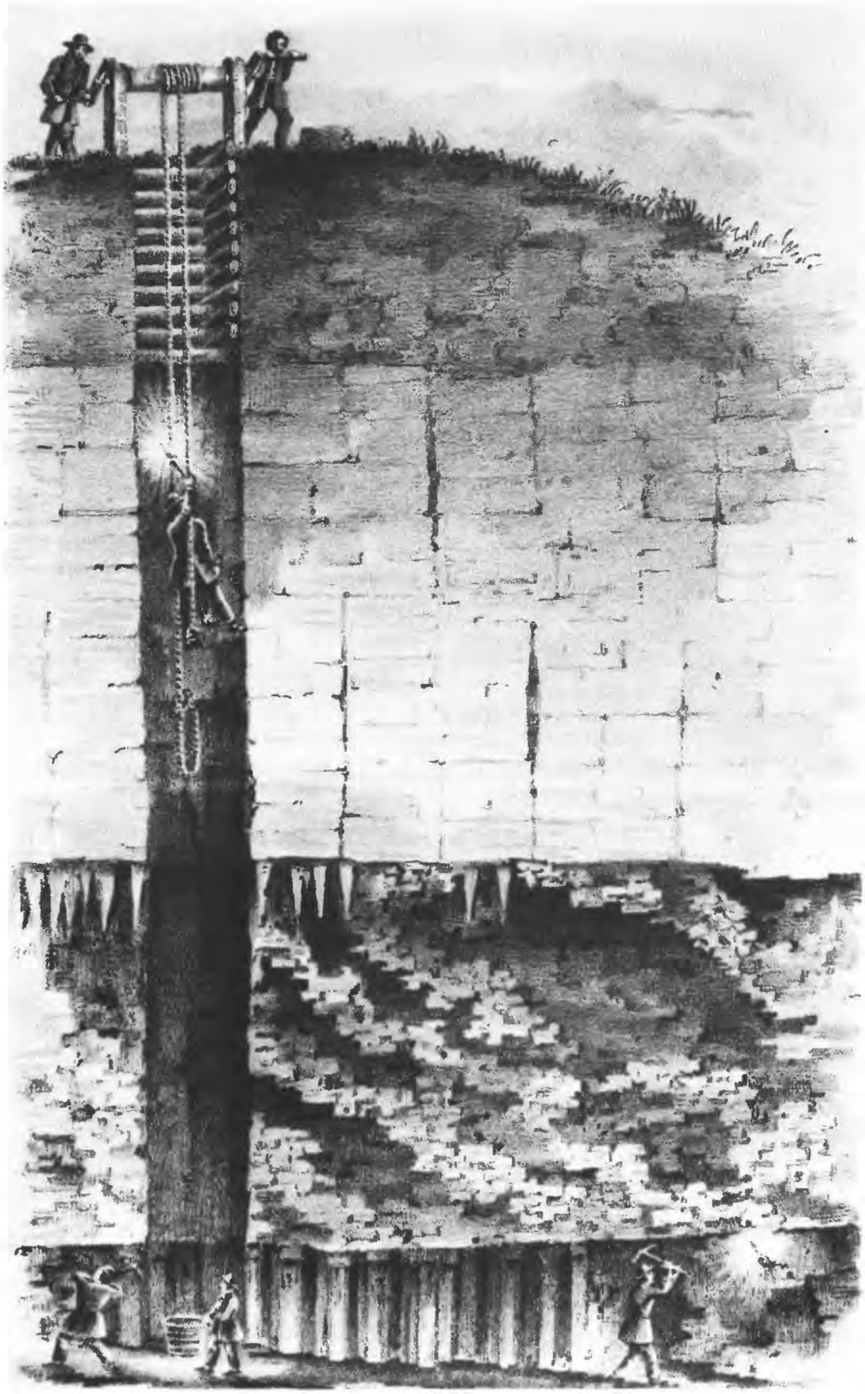
Lead mining in the Upper Mississippi Valley was now thoroughly entangled in the public land question. Lead prices dropped in 1829, and in the wake of the price drop, problems began in the leasing program. There had been some trouble earlier when the miners were required to sell only to licensed smelters, because the requirement, in effect, created a buyer's market, but the problem was resolved when the Superintendent issued an order that the smelters must pay 350 pounds of lead or a monetary equivalent for each 1,000 pounds of ore. At the time that the price of lead dropped, the cost of living was beginning to rise. Pressure began for sale of the nonmineral land for agricultural purposes. Then came pleas for rent reduction, the smelters began to renege on their tax payments, and the miners began to balk at taking out permits.

Very little mining had taken place on the western side of the Mississippi River until after the Indians were defeated in the Black Hawk War of 1832, but settlement and mining development were rapid thereafter. In June 1834, Congress established a land district in the western half of Wisconsin Territory, including the lead region, "any law of Congress heretofore existing to the contrary notwithstanding." When President Jackson opened the Mineral Point land district, however, he specifically excluded the lead lands from sale. The House of Representatives that year passed a bill authorizing the sale of all mineral reserves, but it died in Senate Committee.

Both miners and farmers wanted the land, and one could not always tell where the lead lay under the rich soil. Neither the Superintendent nor the Register of the Land Office was in full sympathy with leasing policy, so intentionally or unintentionally, much mineral land was sold for agricultural land, and much of the Wisconsin lead land passed into private ownership. The Government could not collect lead rent from private owners, and by 1836, Federal regulations were generally being ignored.

Efforts were being made during all this time to obtain authorization for sale of the mineral lands. In December 1838, the Senate approved a bill permitting sale, but the House did not act on it. Instead, in February 1839, the House asked the President to prepare and present to the next Congress a plan for the disposal of the public mineral lands, "having reference as well to the amount of revenue to be derived from them, and their value as public property, as to the equitable claims of individuals upon them" and to provide as well information on the location, value, productiveness, and occupancy of the public lands. A survey was authorized to collect such information as might be needed.

The Commissioner of the General Land Office, to whom the resolution was referred, found no satisfactory information in his files other than that in the report sent to the House on March 28, 1824. David Dale Owen was therefore appointed Government Geologist in August and commissioned to make a survey of an area of about 11,000 square miles in Wisconsin, Iowa, and Illinois before winter set in. By engaging 139 subagents and assistants,



In his first survey of the mineral lands, Owen reported that the lead in the Upper Mississippi Valley was almost exclusively confined to the lower parts of the Cliff limestone formation. The ore was usually found in detached masses, although with a certain degree of regularity, in the fissure. The deposits often occurred in regularly descending steps, as represented in this sketch, drawn by Owen himself, in which the gangue is dark and the lead ore somewhat lighter. The sketch also shows the mode of drifting and of ascending and descending in the shaft. (From D. D. Owen, 1844.)

whom he instructed in the elementary principles of geology, Owen was able to complete the assignment in a little more than 2 months and present a report to Congress in the following April. Owen's immediate conclusion was that "the district surveyed is one of the richest mineral regions, compared to extent, yet known in the world." The lead region had produced an estimated 30 million pounds of lead in 1839 and could produce 150 million pounds annually and furnish employment to 10,000 miners. In addition, copper, iron, and zinc ores were present. On the basis of Owen's work, Commissioner James Whitcomb of the General Land Office proposed that "an officer skilled in the sciences of geology and mineralogy" be appointed as an agent of the Land Office to explore all the public lands and thus enable the Commissioner to discriminate between agricultural and mineral lands before putting them on the market. Without such an exploration as he had conducted, Owen said, "no one would have ventured to state, or would have been believed if he had stated, results showing that these lands possess a value not heretofore attributed to them even by the most sanguine." The survey, he felt, was not only of interest to science but of extreme importance "in a pecuniary point of view" to a Government owning hundreds of millions of acres of public lands doubtless containing mineral resources.

The Senate authorized the sale of the mineral lands in April 1840 and the House in July, but no further action was taken after the Supreme Court in 1840 rendered its decision in a suit initiated to test the legality of leasing. The case involved the Gratiot brothers, who had refused to pay the Government its rent for the lead taken from the public domain. Senator Thomas Hart Benton, lawyer for the defendants, based his defense on a strict construction of the Constitution. There was no authority in the Constitution for the reservation, management, and leasing of the public lands by the Federal Government. The Court, however, unanimously upheld the constitutionality of the 1807 law, stating that "It has been the policy of the government, at all times, in disposing of the public lands, to reserve the mines for the use of the United States."

A special session of the 27th Congress, which convened on May 31, 1841, with the Whigs firmly in control of both houses, authorized permanent prospective preemption. Senator Henry Clay, who presented the Whig program, called for changes in banking laws, higher tariffs, and distribution among the States from the proceeds of the sale of public lands. To make the last palatable, he combined preemption and distribution in one bill, and the act was approved on September 4, 1841. It provided that an individual could stake a claim, to the exclusion of all others, on the public unsurveyed lands and purchase a maximum of 160 acres at the Government's minimum price, but excluded from entry all "lands on which are situated any known salines or mines." A geologist would not be needed to discriminate lands on which there were known mines, so the second Federal geological survey came to an end.

Chapter 5.
Man's True Interests, 1841–1849

> **Mind, no longer tasked in devising means to accomplish or resist schemes of ambition, usurpation, or conquest, is devoting itself to man's true interests, in developing his faculties and powers, and the capacity of nature to minister to his enjoyments.**
>
> **—James K. Polk**

The hard times that hit the Mississippi Valley in the wake of the panic of 1837 spurred a movement of small planters and farmers across the formal boundaries of the United States into foreign or disputed territory, one across the Sabine into the Republic of Texas and the other moving northwest along the Oregon Trail toward the Pacific. The solution of the problems caused thereby dominated the mid-1840's.

Texas already had a large American population. Moses Austin, of lead-mining fame, had run into difficulties with his lead and other business ventures in Missouri after the War of 1812, and in 1820, he secured a Spanish grant and permission to settle 300 families in the province of Texas. He died shortly thereafter, and his son, Stephen F. Austin, led the actual colonization in 1823. By that time, Mexico had gained its independence from Spain, and Texas was a Mexican province. The Texan economy was agricultural, cotton was the principal crop, and Texas depended heavily on slave labor. Mexico abolished slavery in 1831, but Mexico governed the provinces loosely, so Texas ignored the prohibition. In 1835, President Santa Anna of Mexico proclaimed a new unified constitution which abolished States' rights, and Texas rebelled, declared its independence, and sought annexation by the United States or recognition as an independent republic. The South favored annexation, but Northern antislavery sentiment made that impossible, and on Jackson's last day in office, March 3, 1837, the Republic of Texas was recognized. There the matter might have rested had not the movement of Americans into the area, coupled with British interest in Texas, kept the issue alive.

American interest in the Northwest had been spurred by the expedition of Lewis and Clark and by the fur traders who followed soon after them. The fur traders and trappers were followed by missionaries, and the missionaries by settlers, beginning in the 1830s. The pioneers passed over the treeless prairies, which were an unfamiliar environment and which had been labelled as the Great American Desert. Moreover, Congress in 1825 had established the area as a Permanent Indian Frontier to which the tribes from the East were transplanted and to which immigration was barred.

American opinion in the 1840's was shaped by three factors: this persistent advance of the frontier westward, distrust of England and France, and the belief that the democratic institutions of the United States must spread beyond its boundaries, eventually to the whole world. The mandate was described in the *New York Morning News* of December 27, 1845, as "our manifest destiny to overspread and to possess the whole of the continent which Providence has given us for the development of the great experiment of liberty and federated self-government entrusted to us." Manifest destiny became the catchword of the day.

It was also the destiny of the United States to become a great industrial nation but that was not so manifest in 1840, when the population of the United States was 17 million, and 89 percent of that population lived in rural areas. In the eastern part of the country, however, science was aiding in new ways the development of natural resources, and scientists were finding new freedom to engage in pure research.

Great changes in the development of mineral resources and in mineral technology were taking place, especially in the two basic industries, iron and coal. American ironmaking had lagged behind that of England. During the latter part of the 18th century, English ironmakers had made notable advances in the manufacturing process. Coke was used instead of charcoal in the blast furnace, and the development of cast-iron bellows and improvements in the steam engine increased the blast and therefore the production of pig iron. The pig iron was then converted into wrought iron by puddling rather than hammering. In the puddling process, the iron is placed in a reverberatory furnace and stirred, without being removed from the heat, through ports in the furnace wall. Although the process was wasteful—only about half the iron was recovered—the amount of iron that could be produced was so greatly increased that England immediately became the leading ironmaking nation. American ironmakers continued to cling to the traditional technology, although experiments, largely unsuccessful, were made in the use of anthracite in blast furnaces.

The first major change in American practice was the use of the hot blast in the smelting process, for which James Neilson of Scotland obtained a patent in 1828. The hot blast afforded a saving in fuel costs and an increased production of iron in a given time, but its effect was greatest when used with mineral fuels rather than charcoal. The hot blast, in fact, made the use of anthracite practicable. The Reverend Dr. Frederick W. Geissenhainer, a Lutheran clergyman of New York City, succeeded in making iron with anthracite and a strong blast of heated air and obtained a patent for the process in 1833. Three years later, George Crane of south Wales, obtained a British patent for the use of hot blast with anthracite to smelt iron ore and successfully used the process at his furnaces. Dr. Geissenhainer died before he could test the commercial feasibility of his method, and his executors sold the patent in 1838 to Mr. Crane.

In 1839, David Thomas, who had been associated with Crane in his experiments in Wales, came to the United States and built a furnace for the Lehigh Crane Iron Company at Catasauqua on the Lehigh in Pennsylvania. It was put into operation on July 4, 1840, and continued in use until 1879, the first of the early anthracite furnaces that was completely successful from both the engineering and commercial standpoints. David Thomas became known as the father of the American anthracite industry.

The discovery that anthracite coal could be successfully used in the manufacture of pig iron gave a fresh impetus to the iron industry east of the Allegheny Mountains, especially in Pennsylvania and the parts of New York and New Jersey reached by canal. Among the pioneer users were Nicholas Biddle and Peter Cooper, and in 1845, Peter Cooper's son Edward and Abram S. Hewitt set up an iron mill at Trenton on the Delaware, which was an almost immediate success because of its capacity to produce superior iron rails for the railroads.

In the same year that the Catasauqua furnace began operations, John Henry Alexander, who still retained the title of Topographic Engineer of Maryland although he drew no salary, submitted a report to the Governor of the State in the hope of encouraging facilities for the cheap manufacture of iron with mineral coal in the western part of Maryland. The George's Creek

Company, whose founder and president was Alexander, had built the Lonaconing furnace in the Frostburg coal basin of western Maryland in 1837 specifically to use coke, and in June 1839, this furnace was reported to be making about 70 tons a week of good foundry ore. In 1840, the Mount Savage Company built two furnaces near Cumberland, also to use coke. These three furnaces were the earliest to be successfully operated over a period of years using coke.

Alexander's report was written after he had made a careful examination of several establishments in Great Britain and extensive inquiries at home; it attained some fame as the first comprehensive treatise on the metallurgy of iron in the United States. Alexander covered not only the history of iron manufacture, materials and methods used in manufacturing, and the chemistry of the furnace, but also provided considerable information on the ores of iron, of which he recognized eight varieties: native and meteoric iron, magnetic and specular ore, fibrous brown hematite, carbonate of iron, silicated iron ore (which he said was "not worked in America nor in England where there is even a prejudice against it"), and titaniated iron ore.

The new techniques in ironmaking and advances in manufacturing utilizing steam engines increased the demand for coal. The improvement of navigation along streams and the construction of canals to tidewater, as well as the construction of railroads, had already given a boost to the industry, as coal, because of its bulk, was restricted to local use where cheap transportation was not available. By the 1840's, also, coal began to replace wood as fuel on the river boats.

Between 1820 and 1850, there was a phenomenal growth in the coal industry in the world, more spectacular in the United States, in the Pennsylvania anthracite region, in particular, than elsewhere. Production figures for these early years are scattered and incomplete. However, in 1906, the U.S. Geological Survey reported a total production of 3,450 short tons in 1820 and 7,018,181 tons in 1850. Howard Eavenson, basing his estimate on a summation of State records, concluded that the total production in 1820 was at least 333,765 tons and in 1850, 8,355,739 tons. For anthracite alone, for the 2 years, the Survey gives figures of 450 tons and 4,138,164 tons, and Eavenson gives 4,065 and 4,326,969 tons. Richard C. Taylor (*Statistics of Coal*, 1848) said that 365 tons of anthracite were mined in 1820 and nearly 3 million, in 1847. The total production in 1847, he estimated as about 5 million tons.

The other mineral industries at this time were not important. Gold mining in the Southeastern States had declined to a few small operations. Lead production was great enough to supply domestic needs and to provide a surplus for export, but it totaled only a few tens of thousands of tons, mostly from the Upper Mississippi Valley. The demand for copper was small, although the United States was unable to supply its own needs and imported about 3,300 tons of raw copper and copper and brass manufactures each year.

Much scientific work on mineral resources, especially coal, was done under private auspices. Walter R. Johnson, professor of mechanics and natural philosophy in the Franklin Institute, was employed for geologic investigations by some of the Pennsylvania coal companies, as were Professor Silliman and Richard C. Taylor. H. D. Rogers did some fundamental work on the origin of coal. Professor Johnson also made a series of experiments that culminated in a classification of coals according to their heating powers. J. Peter Lesley later pinpointed the beginning of Johnson's work as the beginning of the new era.

Formation of a national scientific organization had been discussed by several of the leading geologists, but caution had prevailed. As the various State surveys were drawing to a close, several of the State geologists felt a desire to compare notes. The New York survey issued an invitation for a meeting in 1840, which proved to be so useful that the organization continued, and the Association of American Geologists came into being.

The second annual meeting was held in Philadelphia in April 1841; Professor Silliman was chairman, and a committee of Messrs. W. R. Johnson, Vanuxem, H. D. Rogers, Mather, and Locke prepared the plan of meeting. There were few formal papers but a great deal of informal discussion, and much of the discussion was on practical matters. A discussion of mineral manures led to the formation of a committee to prepare a detailed report on soils and mineral manures "embodying as well the fruits of their own investigations as the results arrived at by others" for presentation at the next meeting. R. C. Taylor exhibited and described in some detail a model of the western part of the southern coal field of Pennsylvania, and H. D. Rogers discussed the Pennsylvania coal formations. Dr. Jackson gave his views on the construction of geologic maps, suggesting that uniformity in scale, coloring, and symbols among the various States was important. Others agreed, and a committee of Messrs. Jackson, Locke, and Mather was appointed to report at the next meeting. Professor Hitchcock thought a geologic map of the entire country could be completed in a few years.

Although so much of the discussion was practical, Professor Hitchcock in the anniversary address made it clear that practical geology was not the sole interest of American geologists. "The annual reports [of the State surveys] have been confined chiefly to economical geology," he said, "but it was understood from the commencement, that careful attention should be given to the scientific geology of the regions examined, and that the details should be given in the final reports." Hitchcock thought geology in the United States was 20 years ahead of what it would have been without Government support.

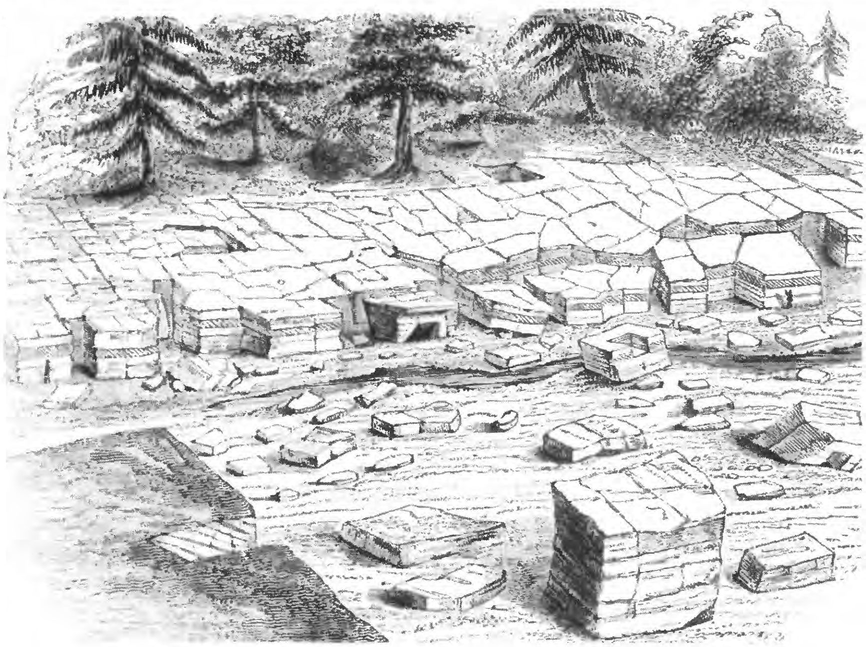
Many reasons have been adduced for American preoccupation with practical science. Alexis de Tocqueville concluded that Americans had not contributed much to basic science because of the political system in America. "Permanent inequality of conditions leads men to confine themselves to the arrogant and sterile researches of abstract truths, whilst the social condition and institutions of democracy prepare them to seek the immediate and useful practical results of the sciences." Hitchcock's assessment suggests a slight variation. In a democracy, practical ends justify the expenditure of money, and practical results justify the pursuit of pure science. David Dale Owen had drawn essentially the same conclusion when he said that it behooves a young man to secure a competency before he indulges in unproductive fancies.

At the 1842 meeting of the Association of American Geologists, paleontology and stratigraphy were the principal topics for discussion. By this time, Sedgwick and Murchison had defined the Cambrian and Silurian (and had had a falling out over the boundary), the Devonian, and the Permian; the Triassic and Jurassic had been defined on the continent. Lyell had visited the United States and had been received cordially by American geologists. David Dale Owen gave a paper on the geology of the Western States for which he had prepared two 18-feet-long sections, one from the Unaka Mountains of Tennessee to the mouth of the Wisconsin and the other from Chickasaw Bluff on the Mississippi to Pittsburgh. Owen tried to correlate the American rocks with those of Europe on the basis of paleontological evidence. James Hall, who followed him with a paper on the geographical distribution of fossils in the older rocks of the United States, exhibited a section from eastern New York to the Mississippi and declared "that the

The New York survey pioneered in understanding of American stratigraphy. Emmons proposed the term "New York System" as the equivalent of Werner's Transition System, at the base of which was the Potsdam sandstone. The illustration is of the Ausable Chasm, in northeastern New York, a tourist attraction even then. At Birmingham a flight of stairs had been constructed so visitors, like the elegantly dressed gentleman shown for scale, could descend to the bottom of the gorge to inspect the towering walls and the turbulent river. (From Ebenezer Emmons, 1842.)

The Trenton limestone lies above the Potsdam sandstone, separated from it by the Calciferous sandrock. It was named for the falls on West Canada Creek, pictured above, and the falls for the town of Trenton in Oneida County. It is well characterized by fossils, several of which are peculiar to it. This woodcut, based on a drawing by R. C. Taylor from which Mrs. James Hall made the woodblock, shows the character of the Trenton limestone, both its horizontal layers as they appear transverse to the stream, and vertical joints. (From Lardner Vanuxem, 1842.)▶

The Conglomerate, the representative of the Carboniferous System, is the equivalent of the Millstone grit of England, where it was considered the base of the Secondary System. It is of little importance in New York except as showing the remains of an important formation which once extended widely over the southern tier of counties. The drawing by E. N. Horsford, is a rather surrealistic view. (From James Hall, 1843.)▶



rocks which in England are called Silurian, and which in this state we have termed the New York system, are known to be of great extent in this country."

When the final reports of the New York survey were published in 1843, Hall wrote:

> **Nowhere is there known to exist so complete a series of the older fossiliferous rocks as those embraced within the limits of the State, and for the reason that in New York, where the means of investigation are best afforded and where the whole series is undisturbed, there is manifested the most complete and continuous succession, showing but one geological era for the deposition of the whole. In that era the earth first witnessed the dawn of animal life and ages of its greatest fecundity in marine organisms and the approach of the period when it became fitted to support a vegetation so luxuriant and universal, of which no modern era has afforded a parallel.**

The New York system actually comprehended the Cambrian, Silurian, and Devonian systems of the English geologists, and was the equivalent of the Transition system of Werner. In fact, Ebenezer Emmons had proposed the name "New York Transition System," but Hall had dropped the "Transition." Emmons also proposed the term "Taconic System" for a series of

1.

Primary rocks, below the New York System, were also observed. This woodcut of the primary rocks in a cut along the side of the Utica railroad near Herkimer, New York, shows the joints or fractures usually found in these ancient rocks. (From Lardner Vanuxem, 1842.)

rocks in a belt some 15 miles wide near the Massachusetts border, which he said were distinct from the Primary rocks but below the New York system.

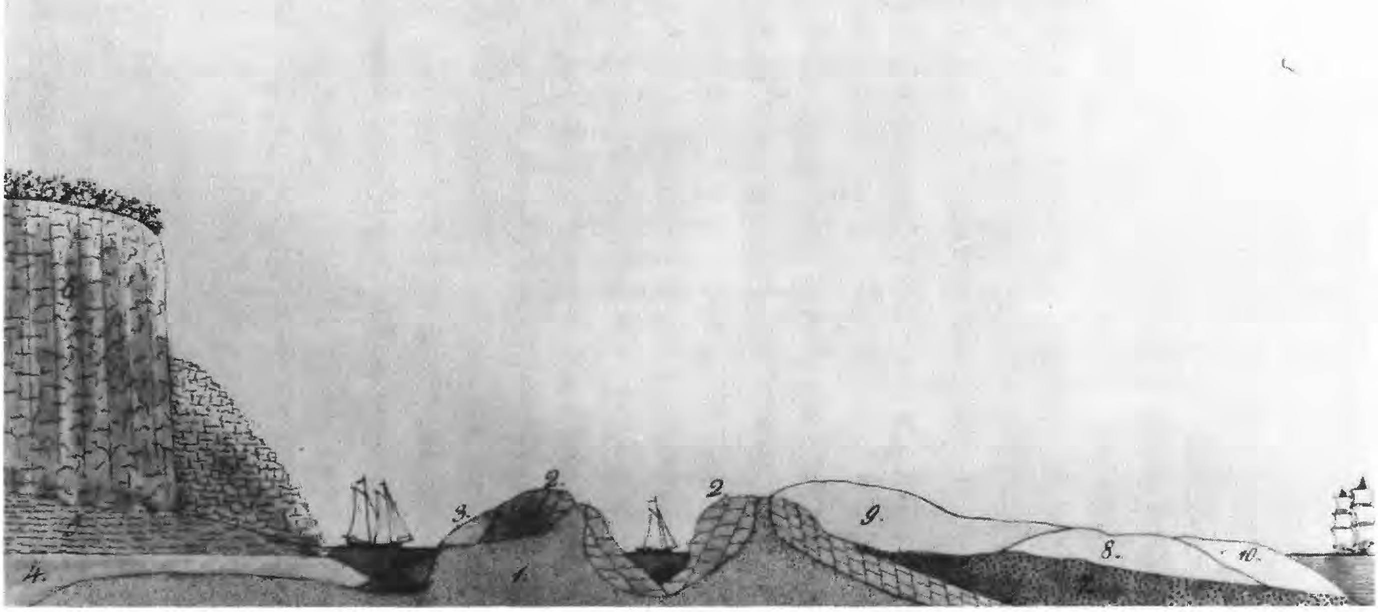
When the Association of American Geologists met in 1844, H. D. and W. B. Rogers proposed a system of classification and nomenclature of the Palaeozoic rocks of the United States. Their use of the term "Palaeozoic," proposed by Adam Sedgwick in 1838, immediately signalled a disagreement with Hall, and they pointed out at the beginning that their work was based on rocks in the Appalachian system, which were more than 30,000 feet thick in comparison with the 6,000 feet in the New York System. The Rogers brothers proposed to deduce from the study of the organic remains and mineral characteristics in different parts of the Appalachian system, a classification "in harmony with the natural relationships of the different members throughout the region which they occupy as to *time* and *circumstances of origin*—which in other words, shall express the various epochs and changes in their true relative importance." The primary idea, they said, would be that of order in time, but the language should be of such "pliancy as to admit of expressing by some simple adjunct all the modifications of type exhibited by particular divisions of the system in different or distant regions." Hall congratulated them on being able to do so much with fossils, but the brothers claimed he had misunderstood. They had based their classification on structural evidence first and had found that the paleontological evidence was in accord. The Rogerses objected strongly to any nomenclature based on an examination of local districts and thought sufficient data were at hand for a general classification. Hall and others, however, advocated a more cautious method and the adoption of a provisional nomenclature based mainly on that of Europe.

Federal scientific endeavors were for the most part keyed to exploration and mapping, and Joel R. Poinsett of South Carolina, who became Secretary of War in the Van Buren cabinet in March 1837, was responsible for much of what was done. Poinsett, himself a naturalist in the European tradition and a very able man, proceeded to revitalize his department, which was responsible for supervision of internal improvements and administration of the mineral lands as well as protection of the frontier. When the Secretary of the Navy became ill, Poinsett was also given responsibility for management of the United States Exploring Expedition. Poinsett chose Lieutenant Charles Wilkes as commander, issued a general order that the objects of the expedition were scientific and useful, not military, and in August 1838, 27 months after it was authorized, the expedition sailed from Norfolk, Virginia, around the world. Some of the scientists who had been recruited in 1836 had become discouraged, but James Dwight Dana was one who retained interest, and he sailed with the expedition.

In the Army Reorganization Act of 1838, provision was made for expanding the Topographical Bureau, and its status was raised to that of an independent corps, equal in rank to the Corps of Engineers, whose duties were to explore and develop the continent. Colonel Abert and Secretary Poinsett immediately made arrangements to secure Joseph Nicollet's services. Nicollet made two expeditions in 1838 and 1839, assisted by Lieutenant John C. Frémont of the Topographical Engineers, a young protege of Poinsett's, and then settled down to prepare a map of and report on the hydrographic basin of the Upper Mississippi River.

The needs of the Wilkes Expedition led to the establishment of other institutions in the Federal Government. When Wilkes was about to sail, the Navy Department requested Lieutenant James H. Gilliss of the Depot of Charts and Instruments and William Cranch Bond of Massachusetts to make astronomical and magnetic observations at home for comparison with those made on the expedition. The Depot of Charts and Instruments was ostensibly a storehouse, established in 1830 to take care of all nautical instruments, books, and charts when they were not in actual use. The first officer in

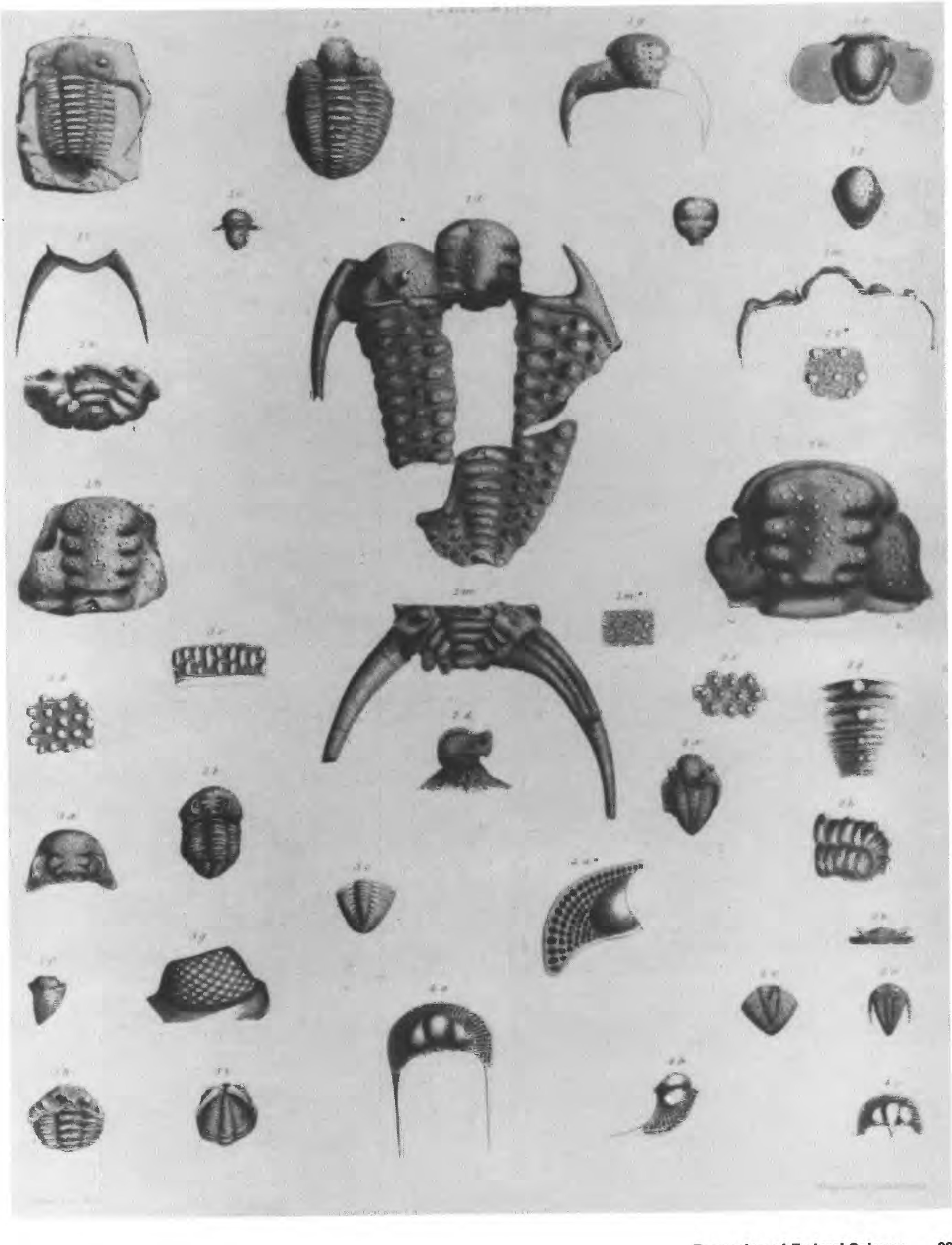
At about the same time that geologists of the New York survey were proposing the New York System, Issachar Cozzens, the librarian of the New York Lyceum, began to make geological sections and maps of his own because he found most of the elementary works on geology were "mere collections of hard names and foreign references." He hoped by adding historical facts, anecdotes, and reminiscences to induce people to read and become interested in "the greatest of all sciences." The original of this delightful section, which "has nine, and probably ten, distinct rocks or formations, in a stretch of 20 miles" is hand-colored in rich greens and strong reds. (From Issachar Cozzens, 1843.)

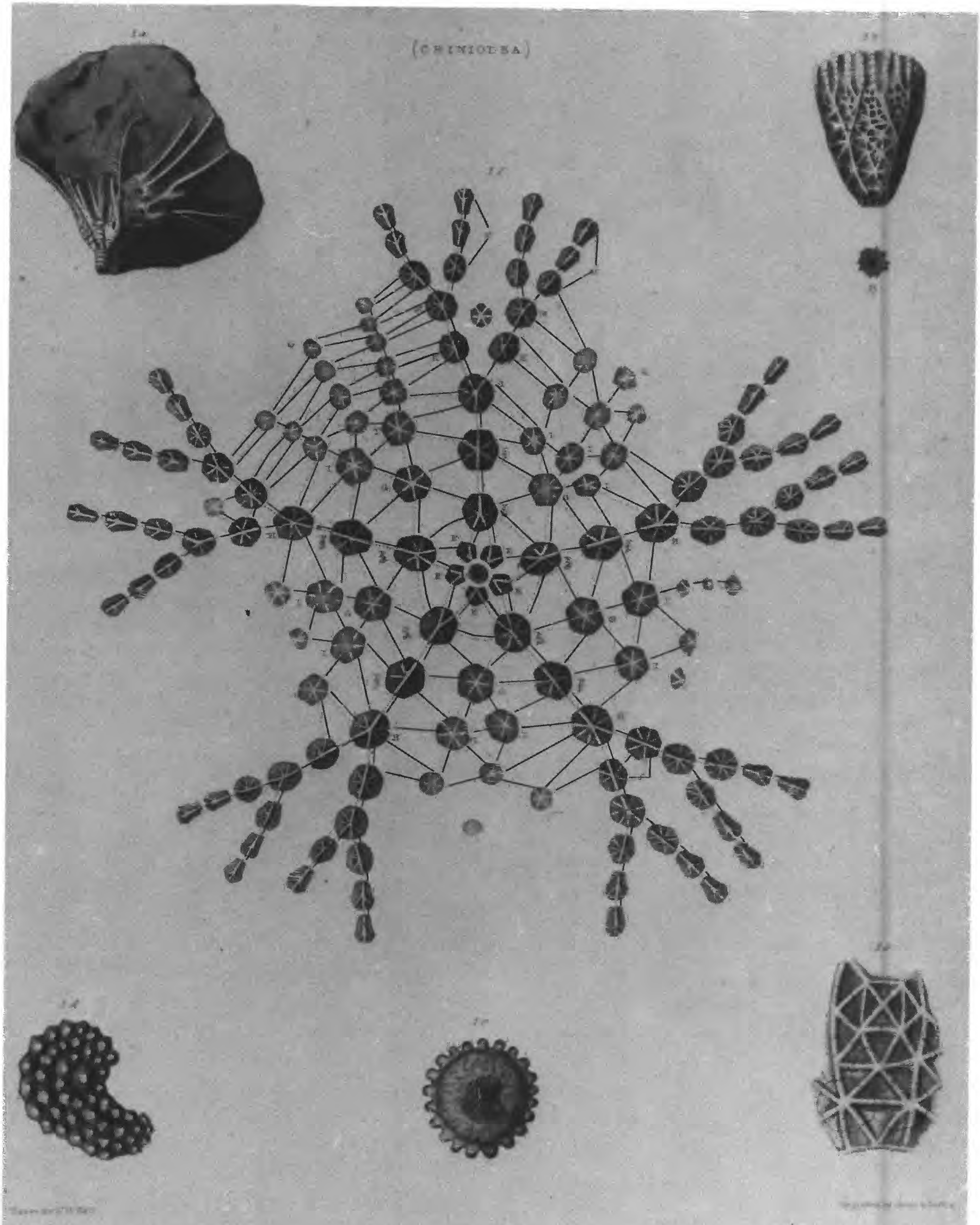


◀The New York survey did not make any extensive studies of mineral resources. The Rossie lead mine in St. Lawrence County was discovered in 1836, and for the next few years there was great excitement and speculation—an endemic mania, according to Ebenezer Emmons. The mine, which attained a certain celebrity among mineralogists for its crystals of galena and calciferous spar, was worked for only a few years because, according to J. D. Whitney, for lack of geologic knowledge it had been opened up the wrong way. (From Ebenezer Emmons, 1842.)

When James Hall came to describe the fossils of the▶ New York system, he followed the order of succession of the various strata that had been determined by Lardner Vanuxem, Ebenezer Emmons, and W. W. Mather, deeming the geologic succession of more importance than a zoological classification. Only in this way, he said, could their true value for geologic research be determined and their relative chronological importance be assigned. Mrs. Hall drew many of his fossil plates, including those of the trilobites shown here and the crinoids on the next page. (From James Hall, 1847.)

charge had mounted a transit instrument for determination of accurate time in order to rate the chronometers. The second built a small observatory for the transit. Gilliss, who was the third, converted his storehouse into the Naval Observatory. He made so many and so varied observations to aid the Exploring Expedition that in 1841, when he asked for an adequate building, he was able to convince the House Committee that hydrographic, astronomic, magnetic, and meteorologic observations were needed for the practical business of the Navy, and Congress authorized the building and funds to construct it. (Bond, incidentally, went on to become Director of the Harvard Observatory in 1839). In 1840, Secretary Poinsett organized the National Institution for the Promotion of Science, in part to handle the collections of the Wilkes expedition. In 1841, Congress appropriated $5,000 for the care of the collections, a curator was appointed, and space was obtained in the New Patent Office building. When General Harrison became President in 1841, however, Secretary Poinsett retired to South Carolina, and during the next 4 years there were four Secretaries of War, none of whom seemed interested in science. In 1842, Congress appropriated $20,000 for the care and preservation of specimens that came to the National Institute but required that they be under the care of a person appointed by the Joint Committee on the Library, and in 1843 Congress took over full charge of the Wilkes expedition's collections and publications.





The appropriations for charting the coast were steadily increased. The principle of civilian control seemed firmly established when the Coast Survey was transferred to the Treasury Department in 1836, but Hassler had a problem in getting and training scientific personnel and had to draw most of his assistants from the officer corps of the Army and Navy. He supplied books and instructed them in the use of instruments and in the application of physics and mathematics to surveying problems, and when he succeeded in keeping officers assigned to the Coast Survey long enough, they became highly competent. The charting of the coast, however, did not proceed rapidly enough to satisfy the critics. In 1841 the House of Representatives undertook a full-scale investigation, and a serious effort was made to cut the appropriation, now grown to $100,000. The select committee, however, had difficulty in judging the quality of the work, and in the end recommended only that the Survey be reorganized. Congress adopted a plan that allowed the Survey to keep its appropriation and remain under civilian control, but it set up a board, consisting of the Superintendent, his two principal assistants, two naval officers, and four topographic engineers, to pass on plans.

John C. Frémont became the most famous of all the Topographical Engineers. In 1842, Lt. Frémont, who had by then married Senator Benton's daughter, was given command of an expedition to the Rocky Mountains. The Wilkes Expedition had spent some time exploring the coast of the Pacific Northwest after its return from the Central Pacific in April 1841. In 1843, Lt. Frémont was ordered to connect his reconnaissance of 1842 with the surveys of Commander Wilkes on the Pacific Coast and to return by the Oregon Trail. The expedition had a political as well as a scientific motivation: it would point up the importance of the Oregon country. After completing his official objective, Frémont did not return as directed but turned south and explored southern California and the Southwest, which were then Mexican territory. The expedition eventually returned to St. Louis in August 1844.

◀Crinoids of the New York System, drawn by Mrs. Hall. (From James Hall, 1847.)

Nothing was known of the geology of the West until The United States Exploring Expedition (the Wilkes expedition) returned in April 1841 and explored the Pacific Northwest coast and the Columbia River. Several overland expeditions were sent out, and James Dwight Dana, who accompanied one of these expeditions south to California, recognized in Shasty Peak a dormant or extinct volcano, noted its two summits, and surmised that each had been a place of ejection. The smaller, he said, appeared as if it might bear the same relation to the larger as Vesuvius to Somma. (From J. D. Dana, 1849.) ▼

John C. Frémont

John C. Frémont of the Topographical Engineers made several exploratory trips to the West beginning in 1841. His reports aroused great interest in that almost unknown part of the continent, and his maps were used as guides by those migrating to the West. (Courtesy of the Library of Congress.)

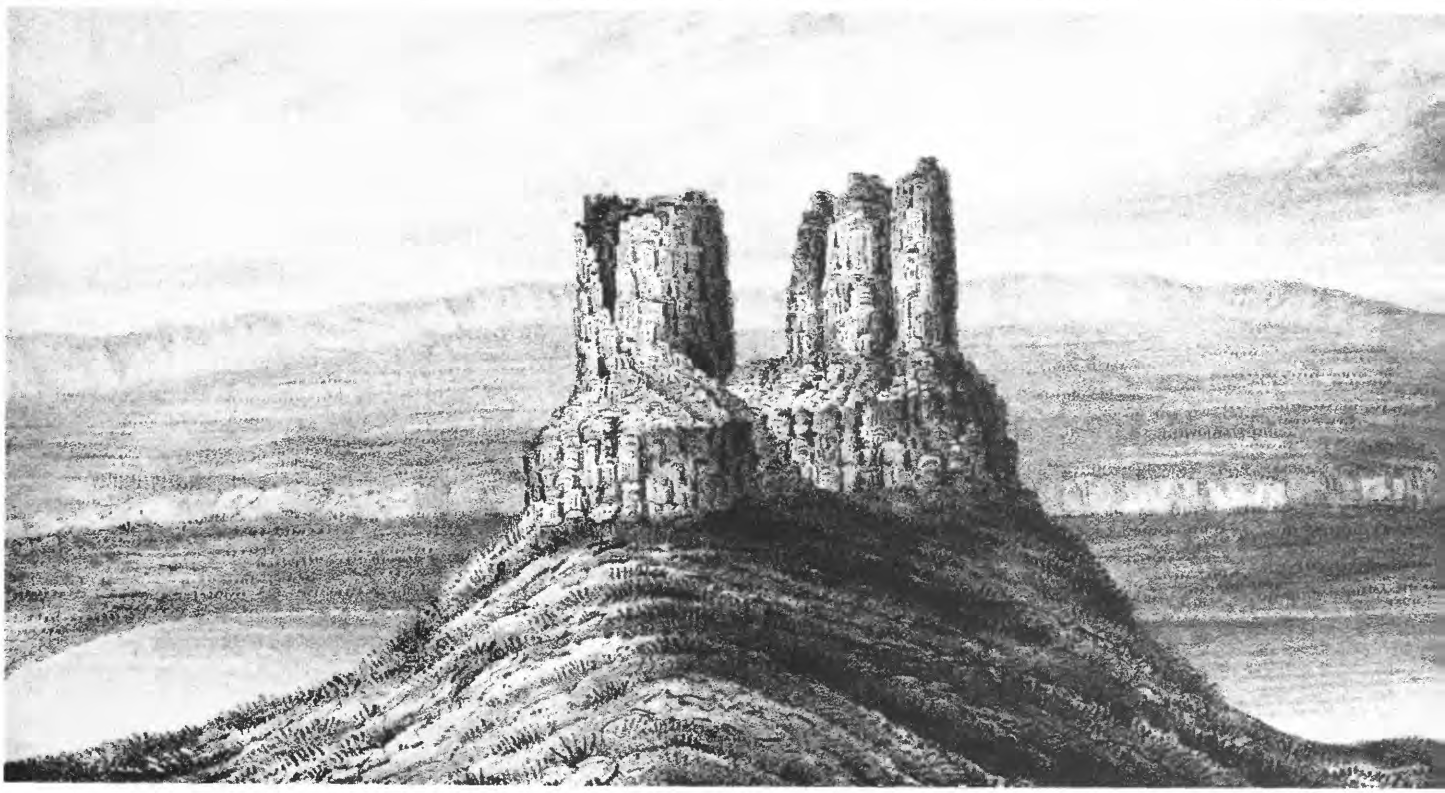
Frémont prepared two reports on his expeditions which are noted for their comprehensiveness. Frémont was not only geographer and topographer but scientist as well, trained by Nicollet. He collected botanical specimens, minerals, fossils, and made geological observations. His map of the region traversed contained errors, but it was the most important of the decade and remained significant until the Civil War. James Hall said that his collection of geological materials presented "sufficient materials to form some probable conclusions regarding the whole region from this side of the Rocky Mountains, westward to the mouth of the Columbia River."

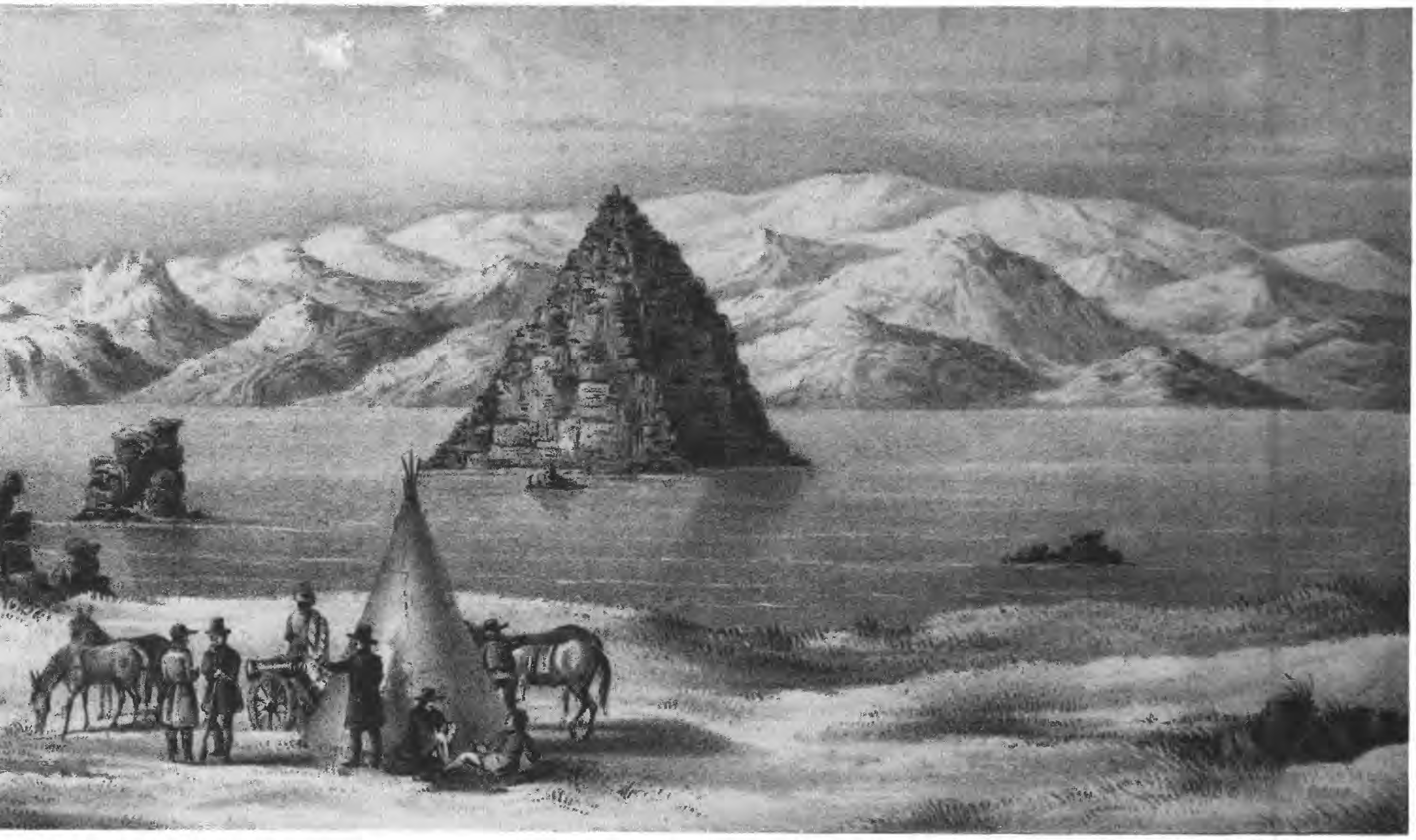
Alexander Dallas Bache, who became Superintendent of the Coast Survey after the death of Hassler in 1843, was largely responsible for expanding the concept of federal science. Bache was a man of high scientific attainments, as was Hassler, but Bache was also a man of great executive ability, and he possessed the personal characteristics needed for successful administration of a government organization. Bache was the great-grandson of Benjamin Franklin and the grandson of Alexander J. Dallas, Secretary of the Treasury when the Coast Survey began its work. He graduated from West Point in 1825, at the head of his class although he was only 19, but after a brief career in the army he had been elected professor of natural philosophy and chemistry at the University of Pennsylvania. Bache began with the practical: he divided the coastline into sections, in each of which a base line was measured and triangulation extended. This method of operation not only accelerated the work, it also avoided sectional jealousies and made it a matter of sectional pride to have the survey extended in each area so Congress then more readily saw the need for appropriations. In his second year as Superintendent, new instruments were perfected and new methods introduced, and exploration of the Gulf Stream began. Later, Bache was able to begin observations on tides, on the magnetism of the earth, and on gravity, and the Coast Survey under his direction became a broadly based scientific organization.

The debates in Congress on the disposition of the Smithson bequest reflected the changing views of science in the Federal Establishment. James Smithson, a British chemist, had died in 1829, leaving, in the event of the death of his heir, all his property to the United States "to found at Washington, under the name of the Smithsonian Institution, an Establishment for the increase and diffusion of knowledge among men." In 1836, after word was received that the last heir had died, Congress voted to accept the bequest but did not decide how to use it. The early debates assumed that the Smithsonian Institution would be a national university, which had long been a thorny issue, but others proposed an agricultural experiment station, an institution for experiments in physical sciences, or a system for collecting meteorological observations. John Quincy Adams wanted the income used for an astronomical observatory, and Secretary of War Poinsett thought of a great museum. In 1844, when Congress again took up the question, other elements were introduced, a public library, cheap popular publications, or a normal school for the graduate instruction of teachers. Eventually a bill was passed in 1846 that included explicitly or implicitly a library, a museum, an art gallery, research, and education, with authority vested in a board of regents and administrative supervision in a Secretary.

Alexander Dallas Bache was a member of the first Board of Regents, along with his uncle, Vice-President George M. Dallas, and his brother-in-law, Secretary of the Treasury Robert J. Walker. The first Board of Regents passed a resolution that the Secretary be a man possessing eminent scientific acquirements, capable of advancing science and promoting letters by original

This hill on the Columbia River, near the mouth of the "Walahwalah" River, was observed by Frémont in October 1843 and sketched to show the columnar structure of the basalt of the Columbia valley. (From J. C. Frémont, 1845.)





researches and effort, and Joseph Henry, who had recommended Bache for the position of Superintendent of the Coast Survey, was elected as the first Secretary. Henry, then approaching 50, had been professor of natural philosophy at Princeton since 1832. He was an experimental physicist, one of the few at the time anywhere and perhaps the only one in the United States. He had discovered the law of electromagnetic induction and had realized the oscillatory nature of electric currents; his investigations of electricity and magnetism had anticipated many more modern developments.

Pyramid Lake was so named by Frémont, whose attention was attracted by the "very remarkable rock in the lake" which "presented a pretty exact outline of the great pyramid of Cheops." The lake, in the southern part of Washoe County, Nevada, is almost completely encircled by high rugged mountains and is the most picturesque sheet of water in the Nevada valleys. (From J. C. Frémont, 1845.)

To Henry, science was only pure science. He took out no patents on his inventions or discoveries, believing that it was the duty of the scientist to show what was possible and to leave to the inventor the application of the discovery to practical uses. Henry chose to interpret the Smithsonian's mission as a directive to support original research and the publication of its results, and during his long tenure of office he succeeded in making the Smithsonian the symbol of science in America.

Only two State surveys were formally established. In December 1842, the South Carolina legislature resolved that the interests and pursuits of that State were essentially agricultural and that a survey "for the examination of our soil discovery and application of marl lime, and developing all other resources and facilities of improvement" would prove "among the most efficient means of giving value to her soil, increasing her products, multiplying her population, and diffusing national and individual prosperity." Edmund Ruffin of Virginia was appointed as agricultural surveyor and concentrated for the following year on soil improvement and the use of marl.

Ruffin was succeeded after that one year by Michael Tuomey, Irish-born but educated at Rensselaer, and a man with ideas of his own. After graduation from Rensselaer, he had gone south where he served as an engineer on a railway in North Carolina and then as a teacher in Virginia; in the latter post, he had come in contact with several well-known geologists. Tuomey set out to educate South Carolinians on the advantages of diversification. He pointed out that there were two forms of geology, which had a definite mutual relationship. The first, which he called "descriptive geology," was concerned with study of the crust of the Earth, the materials of which it is formed and the manner in which they are arranged, the organic remains enclosed therein, the forces presently in operation and those in the past that had produced the present form and appearance of the crust. The other, or "practical geology," was the application of the knowledge thus acquired to the ordinary affairs of life; it enabled the miner to discover substances useful in the arts such as minerals and ores; it enabled the engineer to determine the character of the country where his operations might be carried on and to anticipate the difficulties that might be encountered; it aided both engineer and architect in the selection of proper materials for construction; and it

Frémont's first view of "the waters of the Inland Sea, stretching in still and solitary grandeur far beyond the limit of our vision" was one of the "great points" of his exploration. "As we looked eagerly over the lake in the first emotions of excited pleasure," he said, "I am doubtful if the followers of Balboa felt more enthusiasm when, from the height of the Andes, they saw for the first time the great western ocean." Frémont later explored the lake in a small india-rubber boat shaped somewhat like a bark canoe. (From J. C. Frémont, 1845.)

formed the basis for agricultural science by pointing out the origin and character of soils.

Tuomey set out first to make a general geologic reconnaissance of the State and then to undertake certain practical geologic studies. Both his first report in November 1844 and the complete report that followed in 1847 dealt largely with these practical matters, and though the legislature proclaimed agriculture as South Carolina's first concern, Tuomey gave as much or more attention to iron ores and iron manufacturing and gold mining and the extraction of gold from its ore as to soils, lime, and manures. He recognized three kinds of iron ore in South Carolina, of which brown hematite was the most common; he called attention to the development of the hot blast and the use of mineral fuel elsewhere, but at the same time he pointed out that although there was no possibility of finding coal in the State, charcoal iron was premium grade and there was no reason for lack of success in South Carolina. The chief value of the gold mines, he said, lay in the great thickness of the beds and veins and not in their peculiar richness. No one should engage in the business with the hope of becoming suddenly rich, but a fair remuneration could be obtained by working with industry, perseverance, and skill.

Tuomey was even a precursor of the conservationists; in his report urging strongly the preservation of the forests in the mining districts of the State, and condemning waste, he wrote:

> **The Geologist who would close a report on the minerals and mines of the State, without adverting to the frightful disregard of the future everywhere evident, would discharge his duty but indifferently. If an individual opens a limestone quarry, he supplies himself from the surface of the bed, throws back the refuse and superincumbent earth, to be removed by some one else, or perhaps by himself. A gold mine is destroyed that a rich vein may be followed which offers immediate profit, and the surface of the beds of iron ore is skimmed over to the destruction of the underlying beds, because a few tons can be obtained at a cheaper rate. Such a course as this needs no argument to point out its ruinous consequences.**

Tuomey did not change the course of the State, which was already wedded to agriculture, and when he was called to be professor of geology at the University of Alabama, the South Carolina Survey was suspended.

Tuomey pursued much the same course later in Alabama. He was appointed State Geologist in January 1848, but given no funds. In his first report to the legislature in 1849, he outlined methods of improving iron manufacture, warned against mining with regard for present cheapness and disregard for the future, but also provided considerable information on coal, which he had gathered by extensive travel and study. Coal had been known and used in Alabama for some time, and a scientific note on it had been published in 1834 in the *American Journal of Science.* In 1849, about 200 persons were engaged in the coal trade in Alabama, but only three beds were worked underground and the rest was taken from river or streambeds during low-water stages. Tuomey reported that chemical analyses indicated that Alabama coal was suitable for production of gas as well as for fuel, and that if the heating power was related to the amount of carbon, as Walter Johnson had inferred from his experiments on coal, Alabama coal would do well, although, said Tuomey, there were discrepancies in the data that made any comparison somewhat less than ideal.

The only other State survey established in this decade accomplished little. Professor Charles B. Adams, professor of chemistry and natural history at Middlebury College, was appointed State Geologist of Vermont in 1844. Several collections of rocks and minerals were made, but no provision was made for a report, and in 1847, when appropriations ceased, Professor Adams accepted a professorship at Amherst College and moved to Massachusetts.

Michael Tuomey

Tuomey, State Geologist of South Carolina and later of Alabama, tried to interest the South in economic diversification. He was also one of the first to speak out for conservation of mineral resources. (Courtesy of the Smithsonian Archives, Merrill Collection.)

Another Federal geological survey was also authorized. Douglass Houghton, State Geologist of Michigan, had explored the Upper Peninsula in the summer of 1840, and in February 1841, he reported to the State legislature the presence of resources of copper in commercial quantities. The existence of copper in the Lake Superior region had long been known, although no mining had been done. Houghton, moreover, pointed out that "the true resources have as yet been but little examined or developed, and even under the most favorable circumstances we cannot expect to see this done but by the most judicious and economical expenditure of capital at those points where the prospects of success are the most favorable." It seemed unlikely that anyone would get rich mining copper in northern Michigan, or even be interested. The Michigan legislature was not sufficiently impressed with the possibility to appropriate funds for continuation of the Michigan Geological Survey. However, prospectors did begin to move toward the area from the Upper Mississippi Valley lead lands.

Douglass Houghton

State Geologist of Michigan 1837-1841, professor of geology and mineralogy at the University of Michigan 1838-1845, mayor of Detroit 1842-1843, and U.S. Geologist 1844-1845. (Courtesy of the Library of Congress.)

The Michigan copper lands were unsurveyed public lands, and before anything could be done about mining, a settlement had to be made with the Chippewa Indians who lived in the area, and the land had to be surveyed. Congress appropriated the funds for purchase of the land, a treaty was negotiated by which the Chippewa ceded 25,000 square miles to the Federal Government, and the cession was ratified on March 12, 1843. The linear surveys were begun immediately and progressed rapidly enough for the first mining permits to be issued in 1844.

The Upper Peninsula also contained rich iron deposits. Houghton had known of them but had not mentioned iron in his 1841 report because he did not think that the iron was of sufficient economic value; in that he was right—at that time. There was wood in abundance to make charcoal, but iron technology was already turning to coal, which was not locally available. Even if it had been, transportation was an almost insurmountable problem. In September 1844, while the linear surveying party was near the eastern end of Teal Lake, not far from Negaunee, W. A. Burt, the deputy surveyor, noticed that his compass needle was behaving erratically and giving readings 87° from normal. Ascribing the effect to the nearness of iron, he and his associates searched for outcrops, found several, and, satisfied that they had found the source of the difficulty, continued their work. Burt had invented the solar compass several years before for use under just such conditions. Houghton, however, was able to use the iron deposits to promote Federal support for his geologic work. At the meeting of the Association of American Geologists, he had read a paper on the importance and practicability of combining the linear and geologic surveys that so impressed the Association that it resolved to memorialize the Government on the subject. Houghton and Burt presented a plan to the Commissioner of the General Land Office, the Commissioner recommended the plan to Congress, funds were appropriated, and Houghton was appointed to direct the work. The work began in the summer of 1845, but unfortunately Houghton was drowned during an early snowstorm in October, and the project was then abandoned.

Leasing of the mineral lands was still controlled by the War Department and in Michigan, the permit holder, once he had made a location, had to apply to Washington for a lease, accompanying his application with a surety bond for $20,000. The maximum leasing period was 10 years. The leasing requirements favored business interests over individuals, but the restriction of the maximum leasing period meant that large capital investments would not be warranted, so speculators were favored most of all.

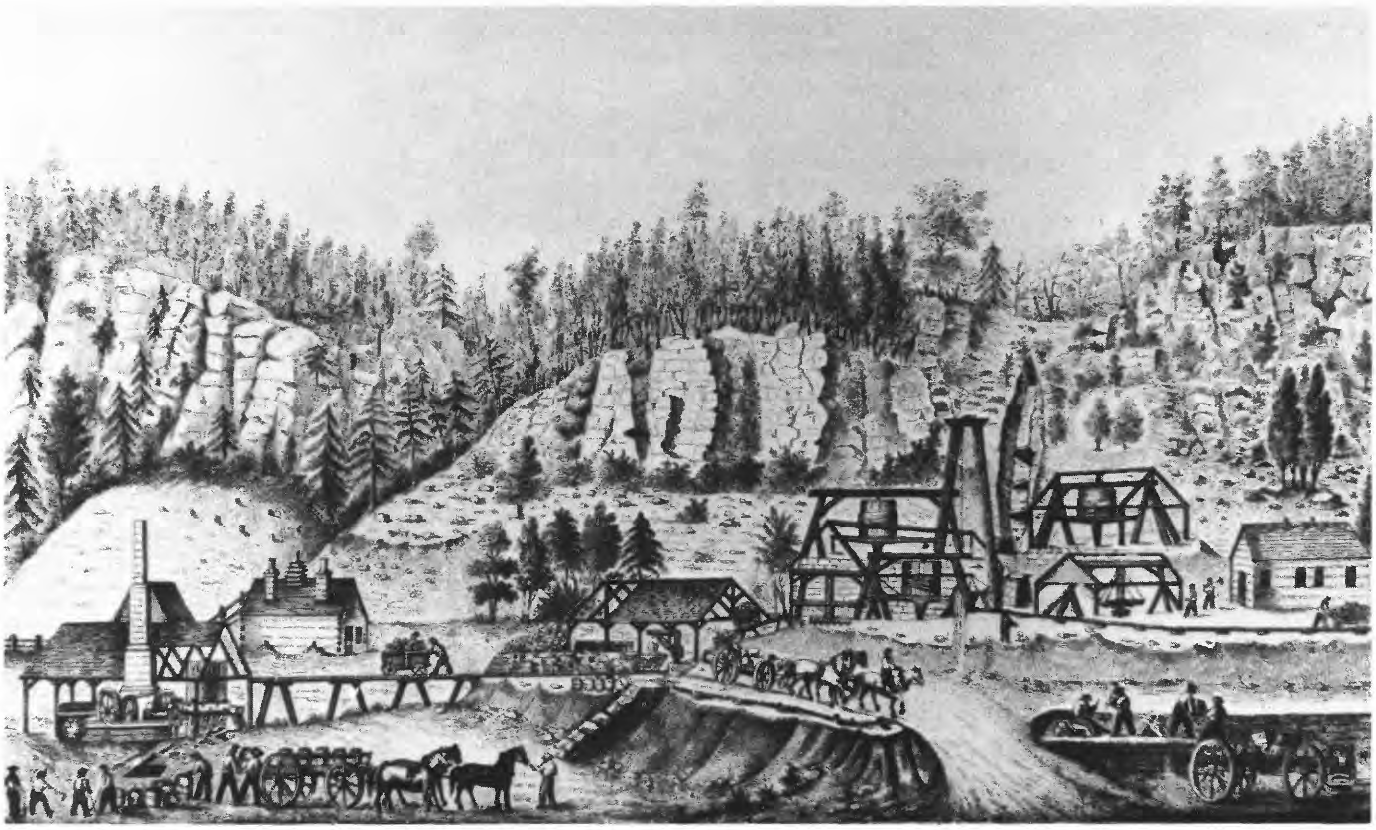
In the summer of 1844, David Henshaw of Massachusetts, who had been Tyler's Secretary of the Navy for a brief period, employed Dr. Charles T. Jackson to examine the area. Keeweenaw Point was then an almost unbroken wilderness. The Government's mineral agency office had been set up at Copper Harbor, and Charles Gratiot of St. Louis had a crew of explorers on hand, but nothing of significance had been discovered. Jackson found that "native copper and native silver existed there in regular veins, which could be advantageously wrought by mining operations," and the Pittsburg & Boston Company was formed to mine for copper and silver on Keeweenaw Point.

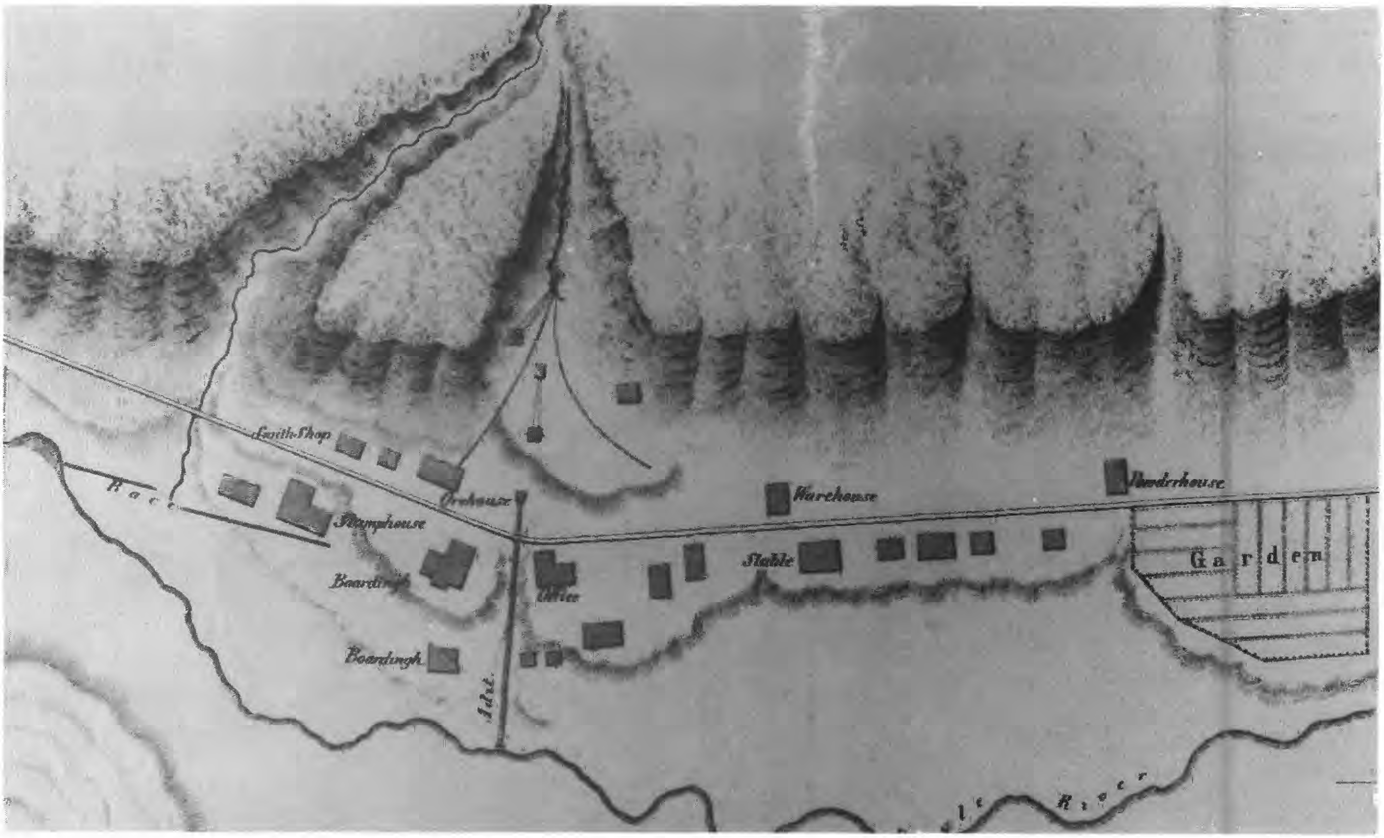
Dr. Jackson visited northern Michigan again in the summer of 1845, this time accompanied by Josiah Dwight Whitney, who had been his assistant on the New Hampshire survey. Whitney was a graduate of Yale in 1839, where he had come under the influence of Professor Silliman and discovered an interest in natural science. He was thus a few years younger than James Dwight Dana and Benjamin Silliman, Jr. Whitney had spent the winter of 1839 studying chemistry with Dr. Robert Hare of the University of Pennsylvania and then under Jackson. When the New Hampshire survey ended, Whitney having determined on a career in geology, went to Europe for advanced study at Paris and Berlin. Michigan was more crowded in 1845 than it had been in the previous summer. Whitney said: "the shores of Keeneenaw Point were whitened with the tents of speculators and so-called geologists." No copper had been mined as yet, the miners and prospectors having contented themselves with searching for and picking up loose masses of copper on the surface. After examining evidence of a copper deposit in a cliff on the southwestern branch of the Eagle River, Jackson and Whitney recommended that exploration begin through the foot of the cliff. The Pittsburg & Boston's first mine had been a failure, but an adit at the recommended site struck a mass of metallic copper at 70 feet, the first found by underground mining in the Lake Superior region. In the next 8 years, the Cliff mine produced more than $1.3 million worth of copper.

A second "discovery" was also made in the iron district in 1845. The Jackson Mining Company had been organized in June 1845 to explore the mineral districts on the southern shore of Lake Superior. P. M. Everett, the president, wanted to locate a copper mine, but members of the exploration party were guided instead to an "iron mountain" near the site of Burt's discovery by an old Indian chief. The iron was rather easily mined—the operation was more like quarrying than mining as the ore was found in knobs and ridges above the general level of the land—but was still not economically practicable.

In 1845, American attention was focussed more on Texas than Michigan. In April 1844, President Tyler had negotiated a treaty of annexation, only to have it rejected by the Senate 2 months later. The Texas question had then become a prime issue in the presidential election campaign of 1844, and James K. Polk, who strongly favored the annexation, was elected. After

The Cliff mine on Keeweenaw Point was the first of the great copper mines of northern Michigan. This illustration is partly plan, partly landscape. The cliff in the background is crystalline greenstone. The vein traverses it in a nearly perpendicular direction. The mining ground is below the cliff in a belt of amygdaloidal trap. Poppet-heads and whims for raising the ore and water are at the entrance to the shaft. Near the center is the building used for preparing the rock and ore. The building at the extreme right contains the stamps and washing apparatus. (From J. W. Foster and J. D. Whitney, 1850.)





the election, President Tyler recommended to the lame duck Congress that Texas be admitted as a State by joint resolution, which did not require a two-thirds vote as did a treaty. The joint resolution was enacted on February 28, 1845, and on his last day in office, President Tyler sent word to Texas President Sam Houston that the consent of the Lone Star Republic was all that was necessary to make Texas the 28th State.

The Democratic platform had also called for occupation of Oregon. A division of the Oregon territory had been discussed in 1842 during negotiations preceding the Webster-Ashburton Treaty, which settled the disputed boundary between Maine and New Brunswick and adjusted the boundary between the United States and Canada from Vermont and New York westward to the Lake of the Woods, but no conclusion had been reached. In 1843, the Western States began agitating for annexation of the whole Oregon country up to the border of Russian Alaska. President Tyler opened negotiations in 1844, offering to divide the territory along latitude 49° N. but the British insisted on the Columbia River as the dividing line, and the matter was dropped. Mr. Polk had other objectives in mind, including legalization of the sale of mineral lands, a revision of the tariff, and acquisition of California. Mexico had shown some inclination to dispose of the province, and Polk wanted to acquire it lest England or France get it first. The Texas question, however, was the most pressing.

At the end of March 1845, Mexico broke off diplomatic relations with the United States. After a special session of the Texas Congress voted for annexation on June 23, Mexico increased its armed forces to resist the annexation, and General Zachary Taylor and his Army of Observation were ordered to move into Texas and establish a base on the south bank of the Nueces River. American knowledge of southwestern geography was then singularly deficient, and before any campaign against Mexico could start, it was nec-

This topographical plan of the Cliff mine was made from a survey in November 1847 by S. W. Hill for Jackson. It shows several features of interest as well as the topography. Note the two boardinghouses close to the adit and an extensive garden beyond the stables. (From C. T. Jackson, 1849.)

essary to acquire some accurate idea of the country in which operations would have to be conducted. Thus, three trans-Mississippi expeditions were launched in the spring of 1845. Colonel Stephen W. Kearney led a dragoon reconnaissance along the Oregon Trail to South Pass, then southward along the mountain front to Bent's Fort, to gather information on the Plains country, keep open the emigrant trail to Oregon, and impress the Indians with American military power. Lt. W. B. Franklin of the Topographical Engineers was the expedition's topographer and mapmaker. Captain Frémont was ordered to explore the Arkansas-Red River country to locate supply routes, but that expedition became a march from Bent's Fort through the Rocky Mountains and across the Great Basin to California. Lt. James W. Abert, originally assigned to the Frémont expedition, explored the Comanche country along the Canadian River and completed Frémont's original mission. Frémont, for his part, found that the desert country of the Great Basin was not as formidable as supposed and indicated a probable new route for overland communication.

In October 1845, the people of Texas ratified the legislature's action in accepting annexation, and Texas became a State on December 29. While most eyes were on Texas, President Polk was also making moves toward the acquisition of California. In October, the American consul at Monterey re-

David Dale Owen

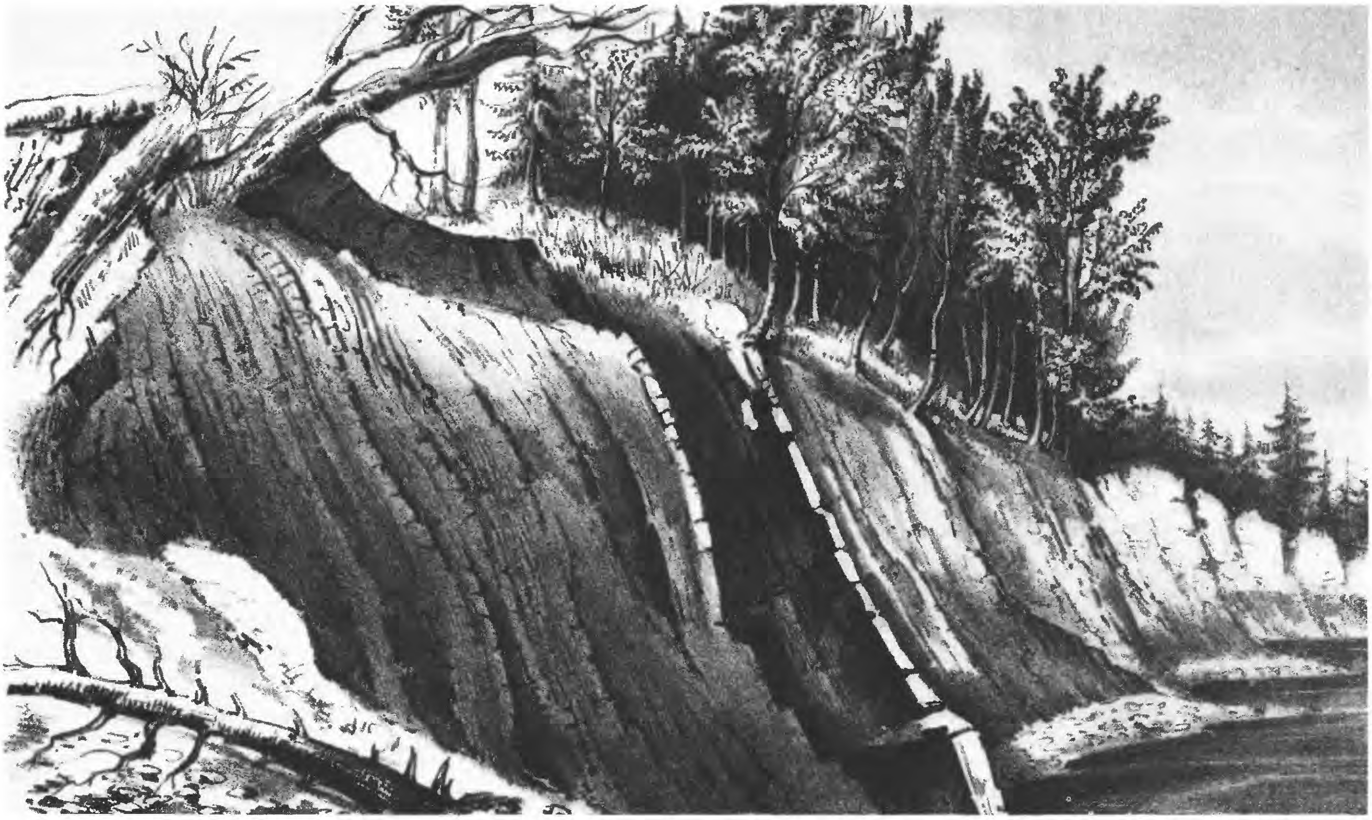
Owen was a master of geological reconnaissance and also an artist of uncommon skill. Twice he was appointed U.S. Geologist to make surveys of mineral lands in the Upper Mississippi Valley, once in 1839 and again in 1847. He also served as State Geologist of Indiana, Kentucky, and Arkansas. (Courtesy of the Smithsonian Archives, Merrill Collection.)

ceived a message from the Secretary of State that "Whilst the President will make no effort and use no influence to induce California to become one of the free and independent States of the Union, yet if the people should desire to unite their destiny with ours, they would be received as brethren, whenever this can be done without affording Mexico just cause for complaint." Then in November, President Polk sent a special mission to Mexico in an attempt to negotiate recognition of the Rio Grande as the southern boundary of the United States and to purchase New Mexico and California.

Secretary of the Treasury Robert Walker outlined a tariff program to Congress in December 1845 that called for variation of the tariff in accordance with the demand for imported goods. The highest duties would be imposed on goods for which the demand was most inelastic, whereas goods for which the demand was most elastic would be placed on the free list. The theory was that people will buy some goods regardless of the cost, and that these goods should bear the highest duties and provide revenue. The Act of July 30, 1846, returned to the principle of ad valorem rather than specific duties and established several schedules in which the various articles were classed. Those with which the protective controversy had been most concerned, including iron and other metals and metal manufactures, were placed in Schedule C which levied a duty of 30 percent.

The tariff led to an amicable settlement of the Oregon question. The British at this juncture were willing to make concessions in Oregon in exchange for a lower American tariff, and the United States was willing to negotiate to obtain a relaxation of British import restrictions and to keep Britain out of the Mexican situation. The treaty ratified by the Senate on June 15, 1846, extended the existing British-American boundary along the 49th parallel west to the Pacific but left Vancouver Island as British territory.

The second Owen survey in the Upper Mississippi Valley area was not so hurried and not confined to practical geology. Owen found the structure of these granitic rocks on the Chippewa River, in places subcolumnar like basalt and in others, schistose, of special interest because of its similarity to the granitic rocks of central France. The outcrop was also of scenic interest; Owen noted that the water "foams around piles of rock, that obstruct its passage, as it winds its way through the dark pine forest, and lends some variety and interest to the scenery of this part of the Chippewa, which is, for the most part, too same and flat to be otherwise than monotonous and tame." (From D. D. Owen, 1848.)



D. D. Owen made a careful distinction between natural sections, such as those in cliffs and bluffs, and those which were drawn to show inferred relations of the rocks. In this natural section, just above the point where the 4th principal meridian strikes the southern shore of Lake Superior, superficial deposits rest unconformably on tilted strata of red sandstone. Geologists of experience, Owen said, differed widely as to the period to which these sandstones should be assigned because the most diligent search had not brought to light any fossils except a few impressions of fossil seaweeds. Douglass Houghton had believed them to be the equivalent of the New Red sandstone (Triassic) as had Owen at first. In his 1852 report, however, Owen concluded they were below the Paleozoic base, or Azoic. (From D. D. Owen, 1848.)

In 1845, the Supreme Court issued a second opinion on the leasing of mineral lands. The second case involved H. H. Gear who had occupied Federal land in 1827 and mined it without obtaining a digging permit. Congressman John Hardin, counsel for Gear, argued that the 1807 law had reserved the mineral land from sale for future disposal by, but not for use of, the Government, and that the law had been repealed by implication by several public-land acts, in particular the act of June 1834 establishing the Mineral Point land district. The Court found in favor of the Government, but the vote was divided 4 to 3, and two of the justices, in a minority opinion, argued that the 1834 law had in fact repealed the 1807 reservation.

In his first annual message to Congress in December 1845, President Polk asked for changes in the mineral land laws. The system of managing the mineral lands he characterized as "radically defective." In the preceding 4 years, a total of $6,354.74 had been received in rent of the lead lands, and the expenses of administering the lands had been $26,111.11. He recommended that the mineral lands be placed under the superintendence and management of the General Land Office, as were other public lands, that they be brought into market and sold "reserving to the Government an equitable percentage of the gross amount of the mineral product," and that the preemption principle be extended to resident miners and settlers at a minimum price to be established by Congress. Mr. Hoge of Illinois promptly submitted a bill authorizing the sale of lands in Illinois, Wisconsin, and Iowa "supposed to contain lead ore."

Sale of the reserved mineral lands in the States of Illinois and Arkansas and the Territories of Wisconsin and Iowa was authorized on July 11, 1846. Leaseholders were permitted to buy their holdings at $2.50 an acre if they took the whole tract covered by their permits. Others could buy as much as they wished, but not less than 40 acres, at a minimum of $5.00 an acre. Preemption was permitted after the auction at double the minimum.

The leasing of the copper lands in Michigan had been even less successful than leasing in the lead regions, and as a result of the wild speculation there, the issuance of permits had been suspended in May 1846. In his message to Congress in December 1846, President Polk asked for authorization to sell the public lands containing copper and other ores as well. Before adjourning in March, Congress by Acts of March 1 and March 3, 1847, transferred the custody of the mineral lands from the War Department to the Treasury Department (which again included the General Land Office), established the Lake Superior Land District in Michigan and the Chippewa Land District in the Territory of Wisconsin, and authorized sale of the mineral lands in these districts on the same terms as had been set in the legislation of the previous summer for the lead lands.

Before the lands in the Lake Superior and Chippewa districts could be sold, however, Congress decreed that geological examinations be made to determine which lands should be classed as mineral and which as agricultural. The General Land Office employed Dr. Charles T. Jackson, who had examined the area for private interests in 1844 and 1845, to make the survey of the Lake Superior district, and Dr. David Dale Owen, who had made the 1839 survey of the lead region, to make the survey of the Chippewa district. Jackson took as his assistants John Wells Foster, who had been a member of the Ohio Survey, and Josiah Dwight Whitney. Owen's assistant was Dr. Joseph Norwood, a member of the medical faculty at St. Louis University.

The Jackson survey was beset by more than the usual number of difficulties. Michigan was a State, and its representatives in Congress, imbued with State pride, felt that no outsider could do justice to the work. They therefore proposed, unsuccessfully, that the head of the survey be required to reside in the State, that all the chemical work be done in Michigan, and that only citizens of Michigan be employed as assistants. Jackson himself was opposed to reservation of mineral lands, and in his report in 1849, he said:

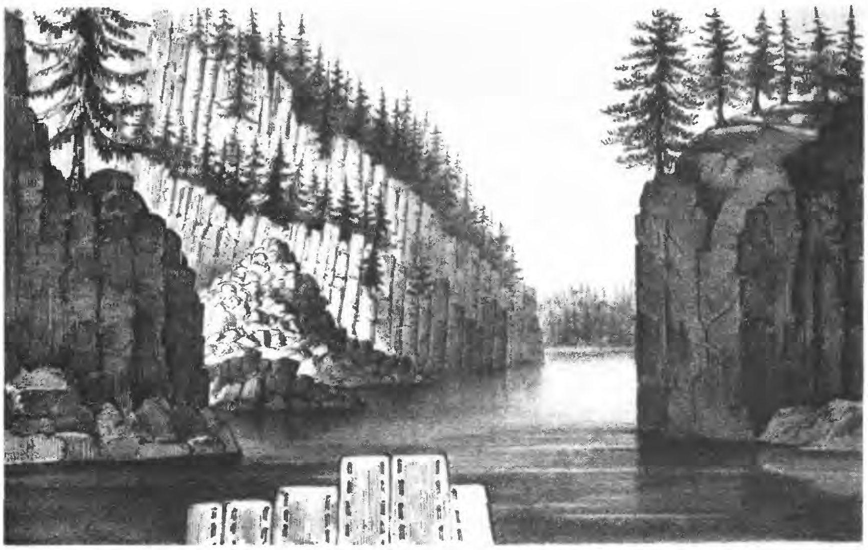
> **It may be useful to the public to cause geological and mineralogical surveys to be made for their information, but I am satisfied that the reservation of mineral lands is a great evil to the country, and that the Government never can derive revenue from such sources, while the restriction most seriously embarrasses the settlement of newly acquired territory. The above remarks are applicable to the whole copper region, and I would not advise the reservation of any part of it as mineral land.**

Opposition to the survey led to Jackson's resignation in 1849 and the appointment of Foster and Whitney to complete the work.

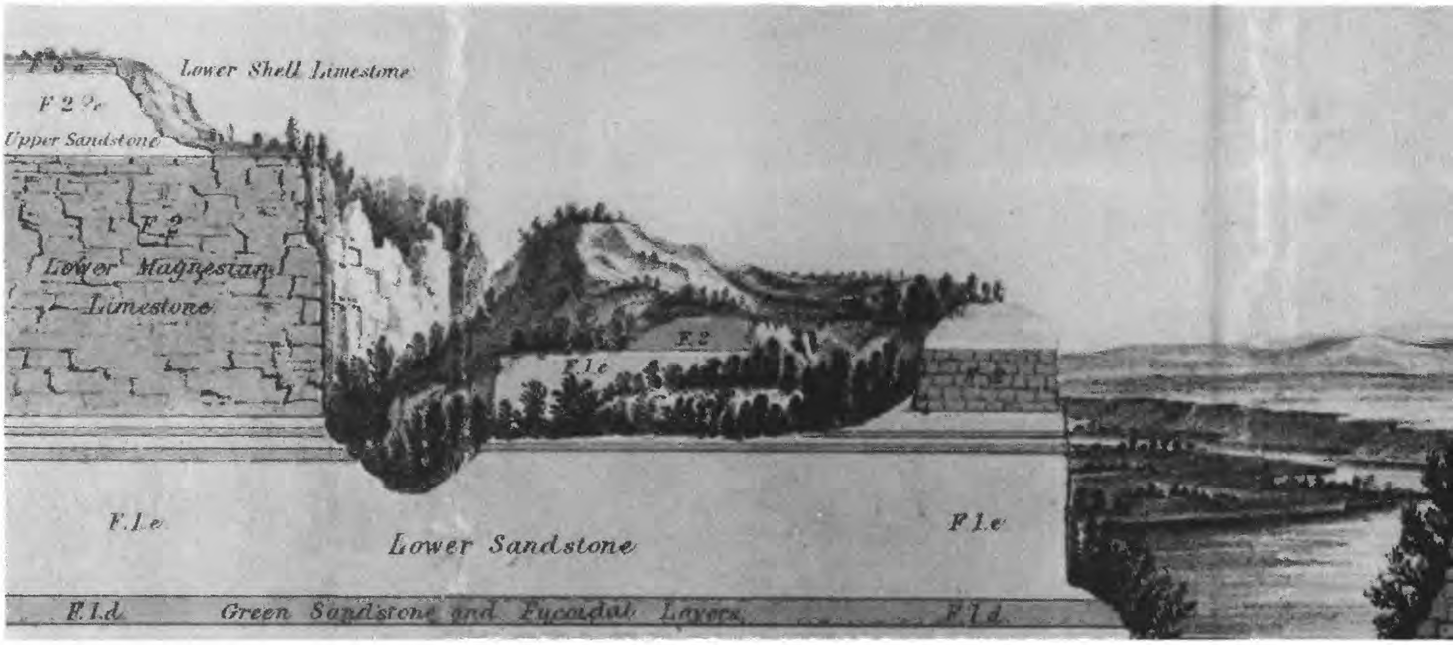
Owen, with characteristic energy, surveyed about 46,000 square miles in the Chippewa district of Wisconsin and northern Iowa, and in April 1848, he submitted a report of 134 pages and maps to Congress which, he said, clearly indicated "what regions are most likely to yield ores and where it would be a loss to search for them." He was then instructed to make a survey of a more extensive region in Iowa, Wisconsin, and Minnesota Territory and was engaged in this work until 1851, with the assistance of J. G. Norwood as Assistant Geologist, and Drs. John Evans and B. F. Shumard, B. C. Macy, C. Whittlesey, A. Litton, and Richard Owen as heads of subcorps. In his final report in 1852, Owen said that over the entire region, it would be wholly unnecessary to make further examinations with regard to reservation of lands. "Coal and iron, in abundance, and also other valuable minerals have, indeed, been found, and their localities carefully determined, but it has not been customary to make mineral reservations, on behalf of the United States, except of tracts promising profitable veins of lead, of copper, or of one of the precious metals."

Owen undertook scientific research as well, but in his final report he found it necessary to say that it had been his aim to make the strictly practical and business part of the survey the chief end and that "scientific researches, which to some men seem purely speculative and curious, are essential as preliminaries to these practical results." Among the achievements of the survey was a geologic map, the most extensive yet made by an American geologist, of an area extending from 38°–49° N. and 89°30′–96°30′ W., the establishment of the Palaeozoic base in the Mississippi Valley, and the discovery of fossil remains in rocks that had hitherto been regarded as destitute of organic remains.

J. W. Foster and J. D. Whitney completed the Lake Superior survey after Jackson's resignation and were able to include general geology in their work. They furnished the Commissioner of the General Land Office with four maps on which sections and quarter sections supposed to contain valuable copper and iron deposits were indicated. They then prepared elaborate reports on the copper and iron regions in which they discussed not only the physical geography, climate, geology, mining, metallurgy, and statistical information, but also the drift, attempted to link the New York section with the western section, and introduced the term "Azoic" for rocks in which they found no fossils and which everywhere underlaid the rocks containing the lowest forms of animal life.



In the Dalles of the St. Croix, about 30 miles from its confluence with the Mississippi, intrusive rock forms the perpendicular walls on both sides of the river, rising to heights of 100 to 170 feet. The illustration from the 1848 report (top), drawn by Owen, emphasizes the nature of the columnar masses. The illustration from the 1852 report (bottom), an engraving by E. P. Vollum cut on wood by C. E. Dopler, is clearly based on his field sketch, but it is a more artistic rendering of the scene. The St. Croix River here has been designated as a national scenic waterway. (From D. D. Owen, 1848 and 1852.)



In the geologic sections made in the Upper Mississippi Valley area by the Owen survey, each formation is designated by a number, beginning the lowest, F. 1., and subdivisions are indicated by letters, as F.1.a., F.1.b., and so on. The Lower Magnesian limestone is F.2. Owen's survey provided the first data on the beds below the white sandstone at the top of F.1. and the first fossils in the rocks below the grey and blue fossiliferous beds. (From D. D. Owen, 1848.)

The trend toward pure science was perhaps reinforced by the arrival of European scientists as residents rather than visitors. Louis Agassiz was one of the first to arrive. Abbott Lawrence gave Harvard University $50,000 to set up the Lawrence Scientific School, and Louis Agassiz became its professor of natural history in 1848. Agassiz, born in Switzerland, had moved to Paris, then the center of zoological research, in 1832. Through the influence of Baron Alexander von Humboldt, he was given a professorship at Neuchatel, where he continued his researches in zoology and paleontology and began a series of pioneer studies on glaciation. In 1848, Arnold Guyot, another Swiss scientist, arrived and also took up residence in the Boston area. Guyot was primarily a geographer and held a doctorate from Berlin. Geography in Europe had by this time been almost transformed from a descriptive and encyclopedic form to a quantitative and systematic science, largely through the work of Humboldt and Karl Ritter, both of whom stressed the interdependence of all phenomena on the Earth's surface and looked for general laws underlying the diversity of nature. Guyot introduced some of their ideas to the United States in his Lowell Institute lectures in 1852 and in his book *The Earth and Man*.

Professor Benjamin Peirce, Perkins Professor of Astronomy and Mathematics at Harvard, was then serving as consultant to the Coast Survey in its work on longitude at Harvard Observatory. Then, in 1849, the Nautical Almanac was also set up in Cambridge; Lieutenant Charles Henry Davis, who had spent several years with the Coast Survey, was its first head. Davis had become a close friend of Superintendent Bache and was related by marriage to Peirce. Peirce became adviser to the new work as well. As A. H. Dupree points out,

> **This arrangement, besides interlocking the Nautical Almanac closely with the Coast Survey, emphasized the role of Harvard as a center of government scientific work and the position of Peirce as scientific adviser.**

At Yale, both pure and applied science were encouraged. Benjamin Silliman, Jr., who had graduated from Yale in 1835, had become his father's teaching assistant, then associate editor of the *American Journal of Science*. In 1845–1846, he had delivered what is believed to be the first course in agricultural chemistry in a series of lectures in New Orleans; in 1846, he published a textbook, *First Principles of Chemistry*, and in 1847, he had helped establish a school of applied chemistry at Yale. The brother-in-law of Benjamin Silliman, Jr., James Dwight Dana, who had left Yale before graduation, had been a member of the Wilkes Expedition, had become an editor of the *American Journal of Science*, and had published on mineralogy and crystallography, on the distribution and composition of corals, and on the origin of continents and volcanoes of the moon, was appointed professor of natural history at Yale in 1849.

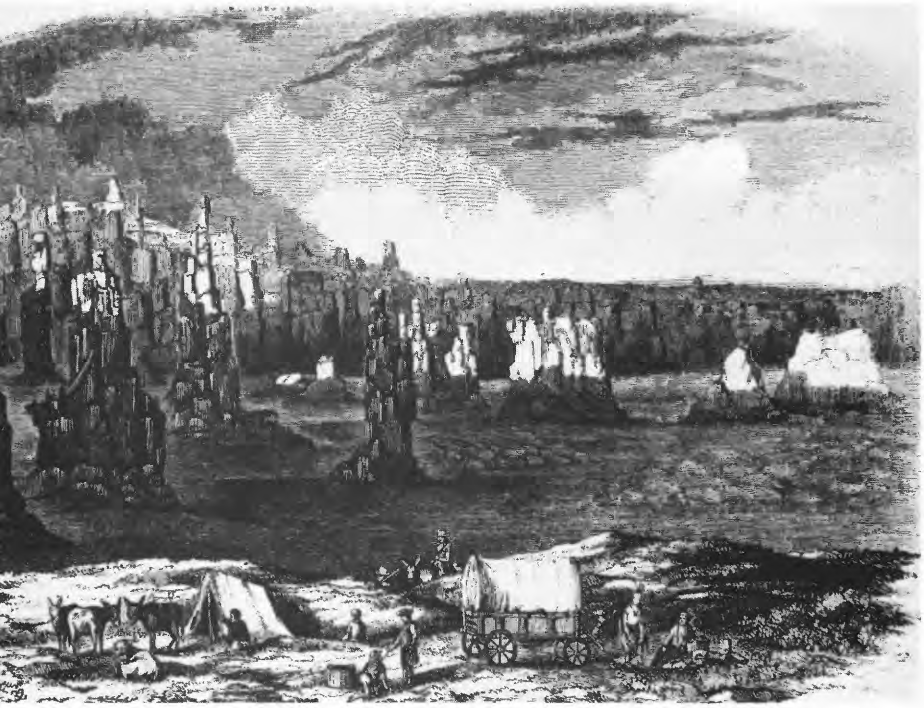
The transformation of the Association of American Geologists and Naturalists into the American Association for the Advancement of Science (AAAS) accompanied this broadening concept of science. Although several members, notably Henry D. Rogers, foresaw the possibility, even urged it, it was at the Boston meeting in 1847 that a resolution was adopted to increase the scope of the organization and to become the American Association for the Advancement of Science. Rogers, Professor Benjamin Peirce of Harvard, and Louis Agassiz, who had then just arrived in the United States for his Lowell Institute lectures, were chosen to revise the constitution and rules. The new constitution, adopted at the Philadelphia meeting in 1848, opened the membership to members of scientific societies; to collegiate professors of natural history, physics, chemistry, mathematics, and political economy, and of the theoretical and applied sciences generally; and to civil engineers and architects. The goals of the organization were to "promote intercourse between those who are cultivating science in different parts of the country" and "to give a stronger and more general impulse, and a more systematic direction to scientific research in our country."

Toward the end of the decade, as scientists began to engage in pure research, the mineral industry, except for coal, began to experience some difficulties. Iron production reached a peak of about three-quarters million tons in 1847 but then declined for a short time. The decline was attributed by some ironmasters to the Walker Tariff which did not protect the native product against British iron on which the price had been lowered as the result of commercial disasters and the famine of 1848. Efforts to obtain an increase in the tariff led A. S. Hewitt, Trenton's 27-year-old ironmaster, into politics. In 1849, he helped arrange two State conventions, and at the New Jersey convention, he was made chairman of the committee on petitions and correspondence and drafted a memorial to Congress.

Lead production was declining. The southeastern Missouri mines had reached a peak in 1845; a year or so later, mining in the Upper Mississippi Valley became more difficult and expensive as the surface ores were depleted, and a steady decline set in. Lead mining began on a small scale in southwestern Missouri in 1848 and increased steadily, but production was not great enough to offset the decline elsewhere, and in 1849, the United States again became a lead-importing nation.

A native zinc industry was established in 1848, when the New Jersey Zinc Company was organized. Zinc was the last of the seven common metals to come into world use, and no commercial production of the metal took place anywhere much before the 19th century. The Government arsenal at Washington made a set of standard weights and measures of zinc in 1838, but the New Jersey Zinc Company's was the first attempt at commercial production. The first attempts to manufacture the metal were unsatisfactory because of the amount of iron and manganese in the ore.

Richard C. Taylor compiled, over a period of several years, a comprehensive collection of scientific and practical information on coal, the first of its kind, which was published in 1848. Taylor, considered by his contemporaries an outstanding economic geologist and mining engineer, was English



John Evans visited the Mauvaises Terres or Bad Lands of Nebraska under Owen's sponsorship and called them "one of the most extraordinary and picturesque sights that can be found in the whole Missouri country." They appeared, he said, to have been formed, partly by an extensive vertical fault, partly by the long-continued influence of the scooping action of denudation. A midsummer visit was especially difficult because the rays of the sun were reflected back from the walls, "unmitigated by a breath of air, or the shelter of a solitary shrub." However, he added, the "drooping spirits of the scorched geologist" did not flag, for the fossil treasures were ample reward. (From D. D. Owen, 1852.)

born and educated. He had been associated in business with William Smith, the father of English stratigraphy, and had been instructed by him in mining and geology; he had also been a member of the British Ordnance Survey and had been among the pioneers in geologic mapmaking. In 1830, he had come to the United States and thereafter engaged in the exploration and development of mining properties, first in Pennsylvania and then in other parts of the United States, Cuba, Panama, and New Brunswick.

Taylor called his book *Statistics of Coal. The Geographical and Geological Distribution of Mineral Combustibles or Fossil Fuel, including, also, Notices and Localities of the Various Mineral Bituminous Substances, Employed in Arts and Manufactures, Illustrated by Maps and Diagrams; Embracing, from Official Reports of the Great Coal-Producing Countries, the Respective Amounts of Their Production, Consumption and Commercial Distribution, in All Parts of the World; Together with Their Prices, Tariffs, Duties, and International Regulations. Accompanied by nearly Four Hundred Statistical Tables, and Eleven Hundred Analyses of Mineral Combustibles, with Incidental Statements of the Statistics of Iron Manufactures, Derived from Authentic Authorities*. The *London, Edinburgh and Dublin Philosophical Magazine and Journal of Science* said that "comprehensive as the title of this work appears, it does not yet convey a just idea of its scope, or the extent of the subject matter. Did its title stand, 'Coal the civilizer; its natural history, productions and application,' it would perhaps convey to the casual reader a more just idea of the object and contents of the work."

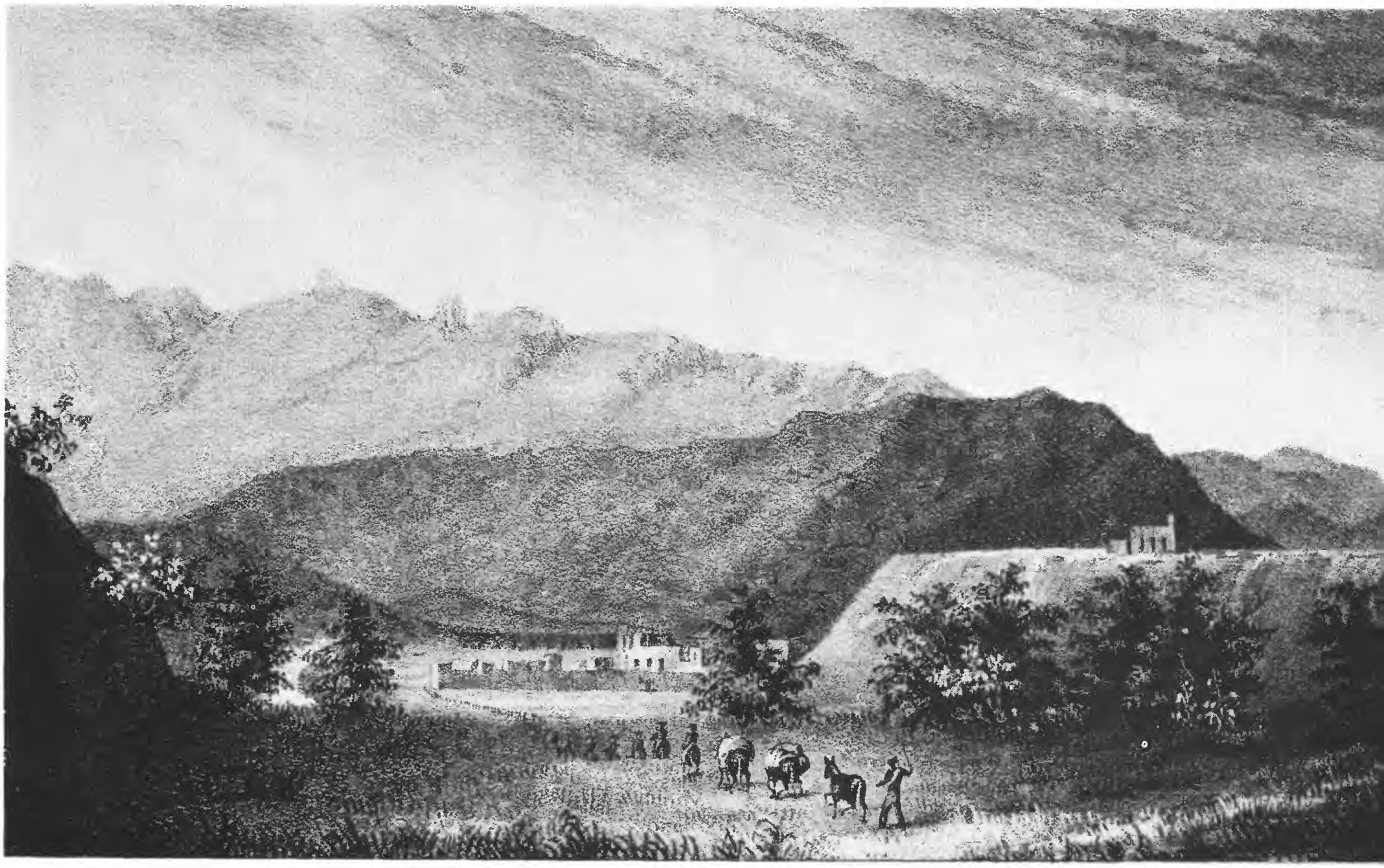
Coal throughout the world, according to Taylor, was found in four positions in the geological column: in the upper part of the transition series; in the coal formation, properly speaking; in the "marnes irisées"; and in the Lias formation. Above the last, the vegetal debris was found most generally as lignite, although under exceptional conditions, the lignite of the Cretaceous and Tertiary formations had in some places been transformed to coal.

The coal he classified into fat bituminous, blazing, or coking; dry; very dry, semibituminous, or steam coals; and anthracite. He noted, however, that Professor Johnston had stated at the 19th annual meeting of the British Association for the Advancement of Science that the true basis of classification must depend on the chemical composition. The dry coal and anthracite appeared in general to be older than the fat or flaming coals, although anthracite might very often be the result of metamorphism. In general, however, he said that the more gas that a combustible contained, and the higher the amount of oxygen and hydrogen, the more modern it was.

In the United States the principal coal fields were the Allegheny, which was also known as the Appalachian or Endless Mountain Coal-field, and the Central Coal-field, usually known as the Illinois Coal-field. The Allegheny Coal-field, which extended through eight States including Ohio, covered an area of 65,300 square miles. The Central Coal-field, which included parts of Kentucky, Indiana, and Iowa as well as Illinois, covered an area of 56,200 square miles. Outliers of these fields were found in the Richmond basin of eastern Virginia and the anthracite regions of Rhode Island and Massachusetts. Coal was newly discovered in Michigan and was known to exist in Missouri, Texas, and scattered places along the Pacific Coast. A deposit of brown coal stretched along the entire eastern front of the Rocky Mountains.

Taylor did not foresee a very large market on the eastern seaboard for bituminous coal from the Allegheny field as long as anthracite was available, but he thought that there would be an extensive demand for Pennsylvania, Ohio, and perhaps Michigan coal in the Great Lakes area. Much coal would undoubtedly be needed to smelt the Lake copper ores. The Ohio coal field had tremendous reserves, and Ohio coal made excellent coke. The Maryland coal he thought was the best in the Nation. It was intermediate between the fat bituminous coals of the Pittsburgh area and the nonbituminous varieties of the anthracite area and had a deservedly high reputation as a generator of steam.

The Michigan mines were the principal source of copper in the United States. During the war with Mexico, William H. Emory of the Army Topographical Engineers, who made a reconnaissance from Santa Fe to the junction of the Gila and Colorado Rivers, visited the Santa Rita del Cobre copper mine in southwestern New Mexico. It was deserted at the time although the Indians, the Spaniards, and the Mexicans had all worked the native copper there at various times. (From W. H. Emory, 1848.)



Taylor, it must be noted, said that the problem of collecting mining statistics in the United States was more difficult than in other parts of the world. "The wide distribution of property in America is unfavorable to the collection of such statistics. The process must, at all times, be unpopular, and the results extremely uncertain. This species of investigation savours too much of scrutiny into the private concerns of men, and is unsuited to the spirit of republican institutions." He pointed out, however, that the production of coal in Pennsylvania alone gave employment to more workmen and more capital than all other mining in the Union combined, with the exception of the iron industry. The importance of coal to the future of Pennsylvania, he said, "in connection with the corresponding advance of her manufacturing industry, surpasses the power of computation."

The Mexican War came to an end in 1847. Mexico City was captured by U.S. troops in September, and in November, a new Mexican president authorized peace negotiations. By the terms of the Treaty of Guadalupe Hidalgo, Mexico relinquished all claims to Texas above the Rio Grande and ceded New Mexico and California to the United States. The treaty was signed on February 2, 1848, ratified by the United States Senate on March 10 and by the Mexican Congress on May 25, and proclaimed by President Polk on July 4, 1848.

On January 24, 1848, nine days before the Treaty of Guadalupe Hidalgo was signed, James W. Marshall discovered gold in the tailrace of a sawmill he was building at Coloma, on the South Fork of the American River, in California. By the time the treaty was proclaimed, San Francisco was all but deserted, and all California seemed on the move toward the gold fields. Colonel R. B. Mason, commanding the Tenth Military Department and Military Governor of California, made a tour of the northern part of California during the summer of 1848 and reported that "upwards of 4,000 men" were working in the gold district and that "from $30,000 to $50,000 worth of gold, if not more, was daily obtained."

Colonel Mason also reported that

> **The entire gold district, with very few exceptions of grants made some years ago by the American authorities, is on land belonging to the United States. It was a matter of serious reflection with me how I could secure to the Government certain rents or fees for the privilege of procuring this gold; but, upon considering the large extent of country, the character of the people engaged, and the small scattered force at my command, I resolved not to interfere, but to permit all to work freely, unless broils and crimes should call for interference.**

The discovery of gold in California altered the course of United States history. The mineral-land problems to which the Colonel alluded were not resolved for many years. The gold had an immediate effect on the economy and on the trend toward industrialization. Other problems resulting from the discovery held center stage for the next few years.

Chapter 6.
Gold is the Touchstone, 1849–1855

> **Gold is the touchstone whereby to trie men.**
>
> **—Thomas Fuller**

Slavery, not gold, was the basic issue in the organization of the territory newly acquired from Mexico. In July 1848, when President Polk sent a special message to Congress on the subject, Congress was then struggling to establish a Territorial government for Oregon, which had been acquired in 1846. The provisional laws of Oregon excluded slavery, and there were those who questioned whether Congress had the power, under the Constitution, to prohibit slavery in the territories. Finally, in July 1848, the Senate validated the provisional laws of Oregon insofar as they were compatible with the Constitution but forbade the Territorial legislatures of New Mexico and California to pass laws on slavery. Oregon was clearly north of 36°30′, but California was split by that line and New Mexico was below it. The House tabled the Senate bill and passed its own bill for organizing Oregon Territory with restrictions on slavery. The Senate adopted the House bill, and the President signed it on August 14. California and New Mexico remained unorganized.

Slavery thus became an issue in the 1848 presidential election campaign. Polk had pledged himself to a single term, and the Democrats nominated General Lewis Cass, who had indicated approval of local determination of the status of slavery. The Democratic platform denied that Congress had power to interfere with slavery in the States. The Whigs nominated General Zachary Taylor but took no stand on the slavery issue beyond rejecting a proposed resolution affirming the power of Congress to control slavery in the territories. A Free Soil party was formed in opposition to slavery and nominated Martin Van Buren. Taylor was elected, partly because of the splitting of the Democratic vote between Cass and Van Buren, but 13 Free-Soilers were elected to the House, and they would hold the balance of power between the 112 Democrats and 109 Whigs.

Rumors of the gold strike began to reach the East in late summer and were confirmed by President Polk in his December 1848 message to Congress. He repeated his recommendation regarding organization of the new territory and, in addition, asked that provision be made for a geological and mineralogical examination of the region and that measures be adopted

> **to preserve the mineral lands, especially such as contain the precious metals, for the use of the United States; or, if brought into market, to separate them from the farming lands and dispose of them in such manner as to secure a large return of money to the treasury, and at the same time lead to the development of their wealth by individual proprietors and purchasers.**

The lameduck Congress took no action on any of these recommendations, but in the closing days of the session it did establish a new executive department, to which it transferred the General Land Office. Secretary of the Treasury Robert Walker drafted the legislation to separate certain functions from the Treasury Department to a new Home Department. It was introduced on

February 12, 1849, was passed quickly by both houses, and signed into law on March 3, 1849. In the course of the debate, the name of the new department was changed to the Department of the Interior. In addition to the General Land Office, the Pension Office, the Patent Office, and the Office of Indian Affairs were transferred to the new department, and supervision of the upcoming 1850 census was also lodged in the new department.

On March 4, 1849, General Zachary Taylor became President, and a Whig administration took over. Legend has it that on Inauguration Day, General Taylor told the retiring President that California and Oregon were too far away ever to become States. However, even as he made the observation, the long trek to California was beginning. Those who traveled by sea arrived in July and August; those who went overland were a little later. There had been about 14,000 people other than Indians in California in the summer of 1848. By the end of that year, there were about 20,000, and by the end of 1849, the population was approaching 100,000. The State Department sent a Mr. T. B. King to examine and report on the population, production, and resources of California. He made a rapid tour of the gold region in the summer of 1849 and estimated that about $40 million worth of gold had been extracted from the washings in 1848 and 1849 and that the probable yield for 1850 would be $50 million. Even Josiah Dwight Whitney, hard at work on the Lake Superior copper surveys, felt the lure of California and wrote to his brother in December 1848 that "we are already planning to secure the geological survey of that interesting land." In 1849, however, he was called on instead to succeed Jackson as co-director with Foster of the Michigan surveys.

California did not wait for Congress to set up a territorial organization. In October 1849, a convention at Monterey adopted a constitution which specifically prohibited slavery. In November, the people ratified it, and when President Taylor's first annual message to Congress was read on December 24, a State government was already in operation. In his message, he recommended favorable consideration should the people of California apply for admission as a State, at the same time urging Congress to "abstain from the introduction of those exciting topics of sectional character which have hitherto produced painful apprehensions in the public mind."

Taylor also urged the establishment of a branch mint in California that would "afford important facilities to those engaged in mining as well as to the government in the disposition of the mineral lands," commissions to examine and decide the validity of the land titles, establishment of the offices of Surveyor-General in New Mexico, California, and Oregon, and a geological and mineralogical examination in connection with the linear surveys. Thomas Ewing, the first Secretary of the Interior, also stressed the need for some action on the public lands, pointing out that "the deposits of gold, wherever found in the Territory, are the property of the United States," but there was no way to protect or dispose of them until Congress acted.

Ewing added:

> **It is due to the nation at large that this rich deposit of mineral wealth should be made productive, so as to meet, in process of time, the heavy expense incurred in its acquisition. It is also due to those who become the lessees or purchasers of the mines that they should be furnished by the government with such scientific aid and directions as may enable them to conduct their operations not only to the advantage of the treasury, but also with convenience and profit to themselves.**

On January 29, 1850, Senator Henry Clay introduced a series of resolutions in an effort to remove the slavery issue from contention. The resolutions called for admission of California as a free State, recognition of the right of the territorial governments in the rest of the Mexican cession to permit or prohibit slavery as they chose, and relinquishment of Texan claims to parts of Mexico in return for U.S. assumption of the pre-annexation debt of the Republic of Texas. These resolutions were balanced by others guaranteeing the Federal Government's noninterference with slavery in the District of Columbia but abolition of the slave trade in the District, a stricter fugitive slave law, and a declaration that Congress had no right to interfere with slave trading among the slave States. The ensuing debate was one of the bitterest and most extended in congressional history. President Taylor opposed the Clay resolutions and was determined to have California admitted without trading anything for it, but Taylor died suddenly on July 9 and Millard Fillmore became President. Senator Clay was forced to retire because of age and infirmity, and Senator Stephen A. Douglas of Illinois took over leadership. Fillmore's more conciliatory attitude toward compromise, and Douglas' efforts, resulted in the passage of five separate acts in September 1850 that became known as the Compromise of 1850. When Fillmore signed the acts, however, believing that preservation of the Union was paramount, he committed political suicide.

On September 9, 1850, California was admitted as the 31st and a free State, and the Territories of New Mexico and Utah were organized and enabled to make their own decision on slavery. The Mormons who had settled around Great Salt Lake in 1847 had set up a provisional State of Deseret, comprising the greater part of southwestern United States south of the 42d parallel and west of the Rocky Mountains in 1849, but Congress refused to recognize it and created the two territories from the Mexican cession instead.

Before adjourning on September 26, Congress also made several changes in public land laws. On September 23, Congress ceded swamp and overflowed lands to the States in which they lay with the proviso that the proceeds of the lands be applied exclusively, so far as necessary, to the reclamation of the lands by means of levees and drains. On September 26, Congress ended the distinction between agricultural and mineral lands, and hence the need for classification, in the States of Michigan and Wisconsin. The Attorney General had already made the distinction problematical by ruling that "lands that contained 'iron ore' merely" were not mineral lands. Henceforth, in these two States, mineral lands were to be offered at public sale in the same manner and subject to the same minimum price and rights of preemption as other public lands. The Office of Surveyor-General for the Territory of Oregon was established on the same day, but the distinction between mineral and agricultural lands in Oregon was retained, and both mineral and saline lands were excluded from claims.

When Congress convened in December 1850, President Fillmore urged it to extend the land laws to California, Utah, and New Mexico and recommended that the mineral lands be sold. He had in the past favored leasing, he said, as it seemed to promise the largest revenue to the government and the best security against monopolies, but experience with the lead mines had convinced him that the mineral lands should be sold. The Commissioner of the General Land Office, it might be noted, ascribed many evils to the leasing system. The lessees

> **having only a temporary connexion with the soil and that of a character calculated to stimulate every effort for their own pecuniary advantage, *** had no inducement to aid in sustaining the laws or encouraging a proper moral tone in the community.**

Congress took no action in that session, and when the new Congress convened in December 1851, Fillmore had a new recommendation. "In deference to opinions familiar with the subject," he said that the mineral lands should "be permitted to remain, as at present, a common field, open to the enterprise and industry of all our citizens, until further experience shall have developed the best policy to be ultimately adopted in regard to them." Senator William Gwin filed a bill on December 4, 1851, to extend the land laws to California; this bill was finally passed and approved on March 3, 1853. Mineral lands were excluded from the surveys, from preemption or selection by the State, and obtaining the benefits of the act by settlement or location on mineral lands was forbidden.

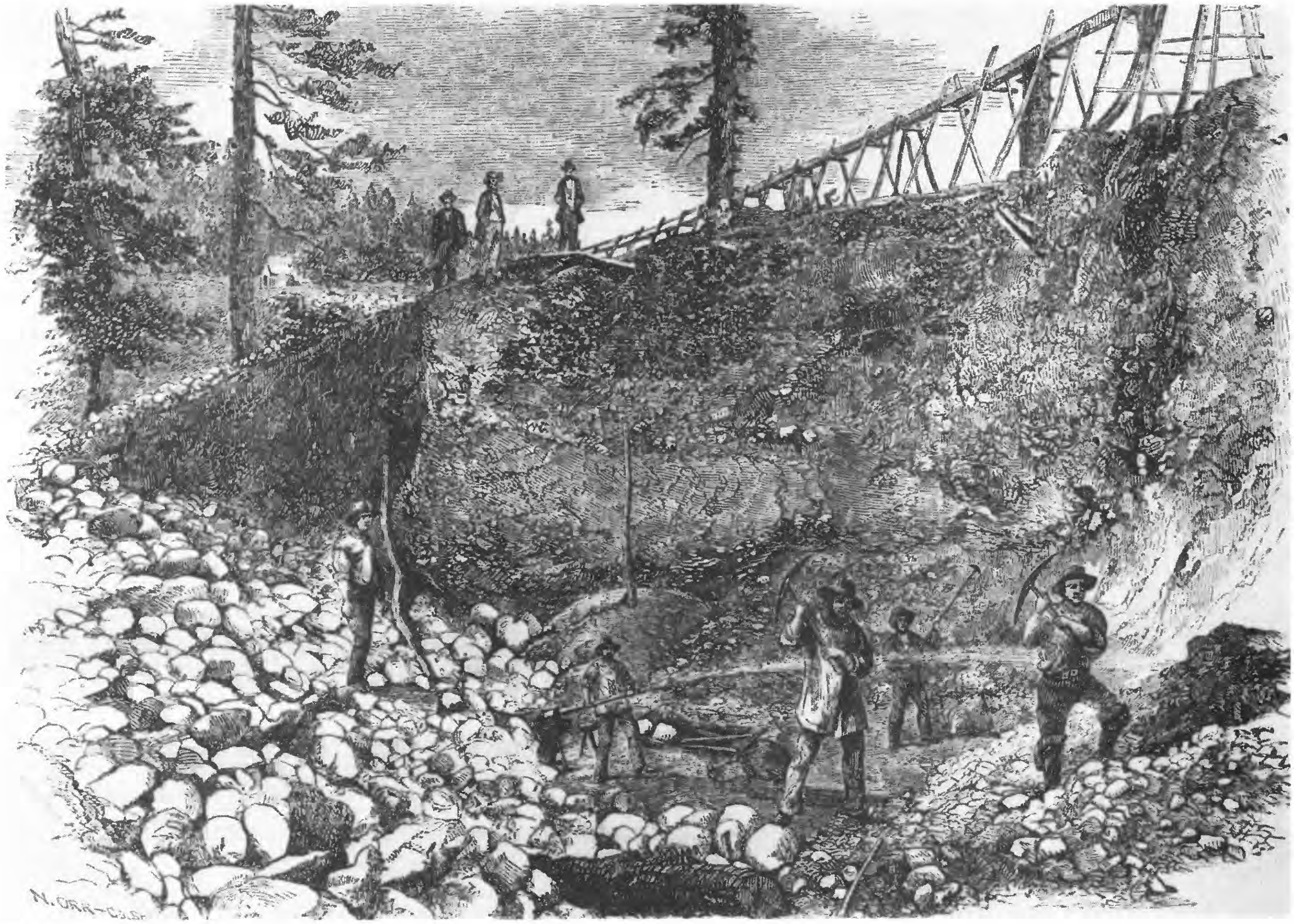
Gold mining had by then become big business. By 1853, gold mining in California was a radically different proposition from that in 1849. The first arrivals, most of them, had scant knowledge of mining, but they needed little because the placers were so rich that the gold could be simply dug out or washed out by panning. Those who had had experience in other areas, the southeastern gold fields, Mexico, or the lead mines, introduced other techniques, such as the use of quicksilver, which amalgamated with the gold. By coincidence, quicksilver had been discovered at New Almaden, a few miles south of San Francisco, in 1845. A few began to look for the veins or lodes that were the source of the gold.

The stream bottoms were quickly exhausted, but in the spring of 1850, some of the miners near Nevada City found that they could dig into the riverbanks or even into the hillsides and still find gold. The rewards were small for all the hard work involved, so by 1852, a scheme was devised to tear up the ground by directing a stream of water under pressure through a canvas hose. At first the hose was simply laid on the ground; later a tapered nozzle was added so that a jet of water could be directed against the bank. The bank was turned into mud which could be washed into and through a sluice, while the heavier gold settled behind riffle boards in the bottom of the sluice.

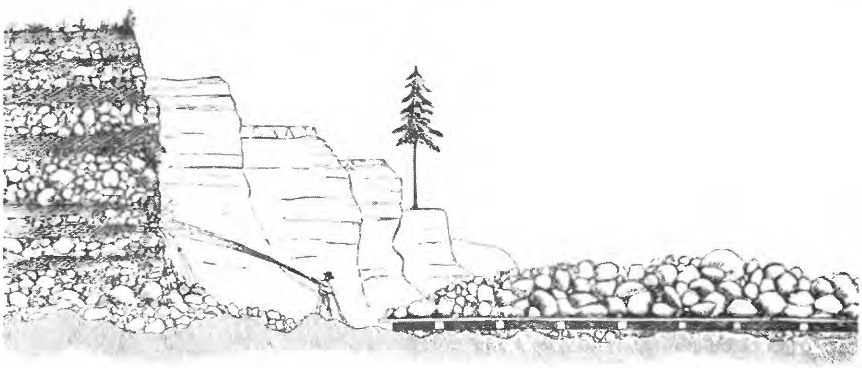
The invention of hydraulic mining revolutionized gold mining. No longer was it possible for an individual to work on his own, or even in the informal partnerships that had prevailed. The enormous quantities of water needed meant the development of the ditch and flume systems, a large labor force, and capital investment.

The discovery of gold in California had given a great impetus to mining endeavors throughout the country. Josiah Dwight Whitney, after completing his fieldwork in Michigan, had set up a private laboratory in Brookline, Massachusetts, where he made the analyses and worked on the reports of the survey, but he soon found his services in demand because of this great burst of interest in mining. Whitney said that "the Atlantic States were searched from one end to the other; many long-abandoned mines were taken up; the gold region of the Southern States suddenly became the scene of an unheard-of excitement; and the whole country seemed to swarm with the promoters of mining enterprises." Whitney became a consulting expert and soon had a clientele throughout eastern United States and Canada. In the winter of 1852–1853, he set up bachelors' quarters in Cambridge with the astronomer Benjamin Apthorp Gould, who had just become head of the longitude department of the Coast Survey, and George Martin Lane, a classics scholar, and began gathering material for a book on the metallic resources of the United States.

The excitement over the development of mineral resources was in his opinion "the mere blowing up of a prodigious bubble"; and it seemed to him that the time had come for a history of American mining operations and that American capabilities of production should be made the subject of a more comprehensive and general investigation than they had yet received. He had visited most of the important mining regions east of the Rocky Mountains,



The hydraulic method of mining was first used in the California goldfields. These two engravings, the one at the top from a daguerreotype of a claim near Michigan City, California, the other an ideal section, demonstrate the method. Instead of attacking the bank by pickaxe and shovel, a powerful jet of water, delivered through the hose from the reservoir above, is thrown against its base. The earth is soon washed away, the overhanging mass falls to the ground, and the only labor necessary is to remove the stones from the foot of the bluff as rapidly as they are washed. (From W. P. Blake, 1856.)



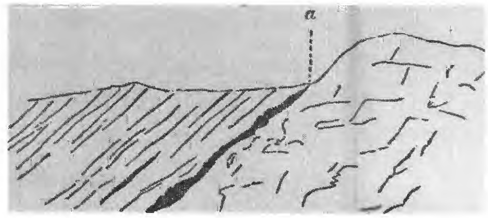
and he had also visited many of the most interesting mines in Europe and so was able to compare the metalliferous deposits of the United States with those of Great Britain and the Continent. This, he said, was an important part of the work because it was chiefly by comparison of new mining districts with those that had long been worked that light could be shed on the former. Whitney classified ore deposits as Superficial, Stratified, and Unstratified. The discovery and exploitation of superficial deposits, he said, even though valuable metals, gold, platina, and some tin were included, did not require mining operations. Stratified deposits, those in sedimentary rocks formed as part of the sedimentary process, were not valuable unless extensive. Most of the metals, except some iron and manganese ores which were found in stratified deposits, were in the Unstratified class: either irregular, masses of eruptive origin, disseminated in eruptive rocks, or contact deposits, or regular, such as segregated veins, gash veins, and true or fissure veins. *The Metallic Wealth of the United States*, a book of more than 500 pages, was published in 1854 and was the standard reference on the ore deposits of the United States for many years.

Metal mining was, in general, prosperous. The decline in iron production which had been noted in 1848 was not prolonged. It was probably due to general economic conditions and to the changing technology rather than the tariff. There is some indication that the more cheaply produced anthracite pig iron did not decline as much as charcoal pig iron. By 1850, iron production was again increasing. Copper consumption also began to increase. Most of the copper came from the Lake Superior copper mines, and there were no metallurgical problems. Copper was also discovered in Tennessee by prospectors searching for gold. The first mine at Ducktown, which was opened in August 1850, inspired an examination of the whole region and the opening of additional mines. A solution was found for the difficulties in zinc metallurgy. The chemist Samuel Wetherill joined the New Jersey Zinc Company and in 1851 invented a process for direct production of zinc oxide from the ore. Within 2 years, New York and Pennsylvania zinc ores were also being exploited, although total production remained small.

Only the lead situation was troublesome. Since 1849, the United States had been forced to import lead to meet its needs. By the mid-1850's, the lead production of southwestern Missouri began to surpass that of southeastern Missouri, but it was not sufficient to satisfy domestic needs. The Upper Mississippi Valley mines were in the doldrums, and State legislatures there began to think of geological surveys. J. D. Whitney, however, thought the western lead deposits "could never again attain the importance they once had." The deficiency would have to be made up from mines in the Eastern States or from as-yet-undiscovered deposits in the West if the country were to remain self-sufficient. As for the possibility of zinc production, Whitney stated flatly that "no one acquainted with the manufacture of zinc ores into metal or oxide would recommend the establishment of works for this purpose in the western lead region."

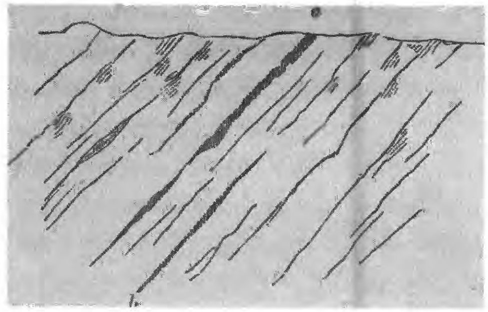
As a result of the new prosperity after the Mexican War and the great interest in mining after the discovery of gold in California, several States again became interested in geological surveys. At the second meeting of the AAAS in August 1849, a committee was appointed to memorialize the State governments on the establishment of geological surveys. The chairman of the committee was Dr. Robert W. Gibbes of Columbia, South Carolina, whose monograph on *Mosasaurus* had just been published by the Smithsonian Institution; other members were President Edward Hitchcock of Amherst College; Dr. Gerard Troost, Professors Henry D. and William B. Rogers, and Dr. Charles T. Jackson, all former State Geologists; S. G. Morton, vice president of the Academy of Natural Sciences of Philadelphia; T. Romeyn and Lewis C. Beck of New York, who had been associated with Amos Eaton; Joseph Delafield, President of the New York Lyceum of Natural History; Professor Louis Agassiz of Harvard; Professor Benjamin Silliman of Yale; Secretary Joseph Henry of the Smithsonian Institution; and J. W. Mathews, Governor of the State of Mississippi.

Six months later, in March 1850, the Mississippi legislature provided a semiannual appropriation of $3,000 for the purchase of books and apparatus and payment of salaries of professors and assistant professors of agricultural and geological sciences in the University of Mississippi with the proviso that at least half the amount be spent in making a general geological and agricultural survey of the State under the direction of the principal professor.



In the 1850's four types of ore deposits were recognized:

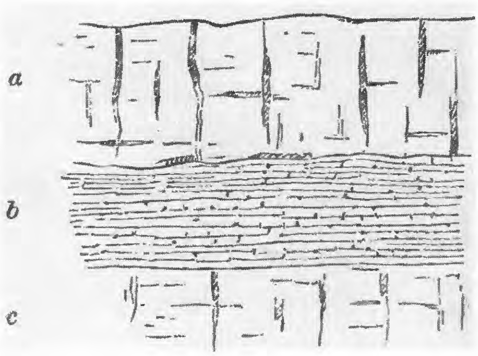
A contact deposit consisted of ore concentrated between two formations of dissimilar geological and mineralogical character.



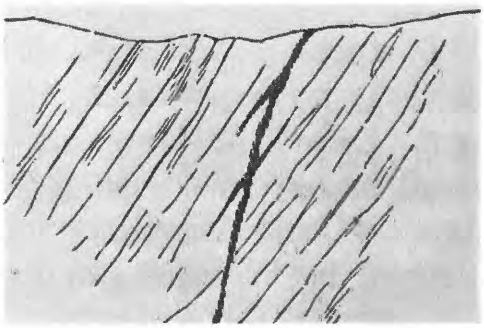
Segregated veins were veinlike masses which had a crystalline structure or a gangue differing from the adjacent mass but which did not seem to occupy a previously existing fissure. The metalliferous and mineral substances of which they were made up were the result of a chemical process which gradually eliminated the component particles from the surrounding formation and segregated them in the vein.

The University was young—it had been incorporated in 1844 and opened its doors to students in 1848—but the principal professor, John N. Millington, was already 70 and in poor health. He was unable to begin the survey himself in addition to teaching, but an assistant, B. L. C. Wailes, spent some time traveling in the eastern and southern parts of the State, making collections of fossils.

The North Carolina General Assembly authorized a survey of that State in January 1851 that was primarily economic, for agriculture was declining in the State and there was interest in the development of mineral and other resources. Although no scientific survey of the State had been undertaken since the first one was discontinued in 1828, extensive deposits of coal and iron were generally believed to exist in the central part of the State, and for several years prospectors had been searching the western part of the State for gold and, more recently, copper. In addition to determining the "nature, character, and value" of minerals, the law instructed the State Geologist to determine "the nature and character of its soils and the best method of improving same; the nature and kind of its productions and their position and relative value; its facilities for manufactories; the extent and value of its water



Gash veins occupied preexisting fissures of limited extent and were usually confined to a single member of a formation, and thus intermediate between segregated and true veins.



True veins were fissures in the solid crust of the Earth, of indefinite length or depth, which had been filled more or less perfectly with mineral substances. True veins, according to Whitney, were almost universally admitted by geologists to have originated in faults or dislocations caused by great dynamical agencies connected with extensive movements of the Earth's crust. (From J. D. Whitney, 1854.)

Henry Darwin Rogers

First State Geologist of New Jersey and Pennsylvania, and the leading structural geologist of his day. His report on the geology of Pennsylvania was the most important document on American geology to that time with the possible exception of the New York survey reports. In 1855 he was appointed Regius Professor of Natural History at the University of Glasgow, a position which he retained until his death in 1866. (From G. P. Merrill, 1924.)

power; the character and value of its botanical productions; the character and value of its timber; and all other facts connected with the subjects of geology, mineralogy, botany, and agriculture which may tend to a full development of the resources of our State." Ebenezer Emmons, formerly of the New York survey, was appointed State Geologist and began work in 1852. A report on the geology of the eastern counties and coal was published in 1852, but presumably most of Professor Emmons' energies were devoted to his major work *American Geology, Containing a Statement of the Principles of the Science with Full Illustrations of the Characteristic American Fossils*, the first volume of which was published in 1854.

The legislature of Pennsylvania appropriated funds in the spring of 1851 to revise and bring up to date H. D. Rogers' report of the first Geological Survey of Pennsylvania which had never been published. Funds were appropriated for 4 years and were sufficient for Rogers to employ a considerable corps of assistants. Among them was J. Peter Lesley who had left the survey in 1841 to enter Princeton, had been licensed as a Presbyterian minister in 1844, and since then had been trying to combine theology and geology. The reactivation of the Pennsylvania survey brought him back to geology exclusively and permanently. The final report was a monumental work of 1,631 pages, of which more than 600 were devoted to coal. Less than 75 pages were on paleontology, which brought forth the only unfavorable criticism from the *American Journal of Science*.

Illinois authorized its first geological survey in February 1851, modeling its law on that of the first Pennsylvania survey. One of the principal reasons for the survey was thus the search for mineral deposits. Dr. Joseph Granville Norwood, who had been David Dale Owen's principal assistant in the survey of the Northwest Territory from 1847 to 1851 was appointed State Geologist. His first report in 1853 listed as valuable resources iron ores, lead and zinc ore, coal, porcelain earth, fireclay, potter's clay, fuller's earth, building stones, mineral manures, quartz sand and possibly gypsum, and salt brines. Iron and coal, he said, existed in such quantity as to make them sources of wealth that would in time attract capital and an industrial population. Much attention was given to the lead mines of Hardin and Pope Counties, on which large sums of money had been spent without adequate returns. Norwood attributed this to the injudicious manner of working the mines rather than to the poverty of the deposits.

The discovery of gold had also made more urgent the development of better means of communication and transportation between the East and the western territories. The admission of California and the organization of the Territories of Utah and New Mexico left a vast area west of the 95th meridian and east of the Rocky Mountains still unorganized territory, reserved for the Indians. The United States had a population of more than 23 million, according to the Census of 1850, a gain of 35.9 percent over 1840. The urban population was 15.3 percent of the total, or twice what it had been in 1820, and the Northeastern States were the most urbanized. About 15.6 percent of the total land area, 294 million acres, was farmland. The South was almost wholly agricultural, but agriculture was increasingly important in the North-Central States, where the lands were rich and improvements in agricultural technology were making possible large-scale farming. The North-Central States were also beginning to industrialize to meet their own needs, constructing meat-slaughtering plants, flour mills, and factories to make farm machinery. An economic arrangement was in the making whereby these States disposed of their agricultural surpluses to the East, which in turn supplied them with manufactured goods. The entire western region, except in California, Oregon, and around Great Salt Lake, was sparsely settled, but both North and South wanted easy access to western wealth and western markets.

There were trails and wagon roads but the construction of a railroad to the Pacific coast became almost inevitable. Financing such an undertaking would be a formidable task, and as more than one railroad was not considered financially possible, so the location of the railroad, particularly its terminus in the Mississippi Valley, had to be determined first and there was great competition for the route and the economic advantages that would attend it. Asa Whitney had proposed building a route from Lake Michigan to the Northwest in 1844. Senator Benton naturally favored a central route, and in 1848, he persuaded three St. Louis businessmen to finance an expedition, led by his son-in-law, John C. Frémont, to explore a route from St. Louis to San Francisco. Colonel Abert, head of the Topographical Engineers, favored a southern route which could be used to help police the border as well as link the east and west coasts. In 1849 he despatched an expedition from Fort Smith, Arkansas, to explore the route to Santa Fe; somewhat later, he sent other expeditions to explore the route from Santa Fe to Los Angeles. In 1849, he also sent Captain Howard Stansbury to make a reconnaissance along the Platte River trail and across the Wasatch Mountains to Salt Lake

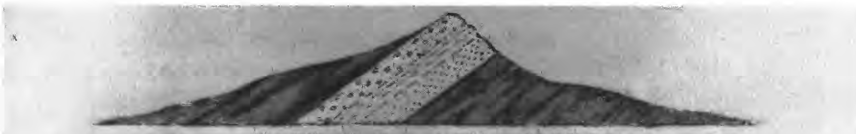


Fig. 728.—Single-crested Monoclinal Ridge.

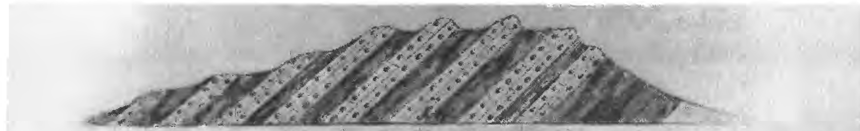


Fig. 733.—Complex Monoclinal Ridge.

Fig. 737.—Complex Monoclinal Valley.

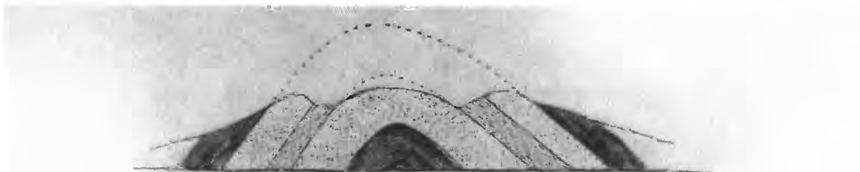


Fig. 739.—Triple-crested Anticlinal Ridge.

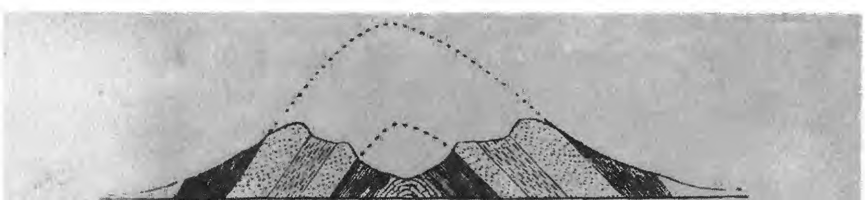
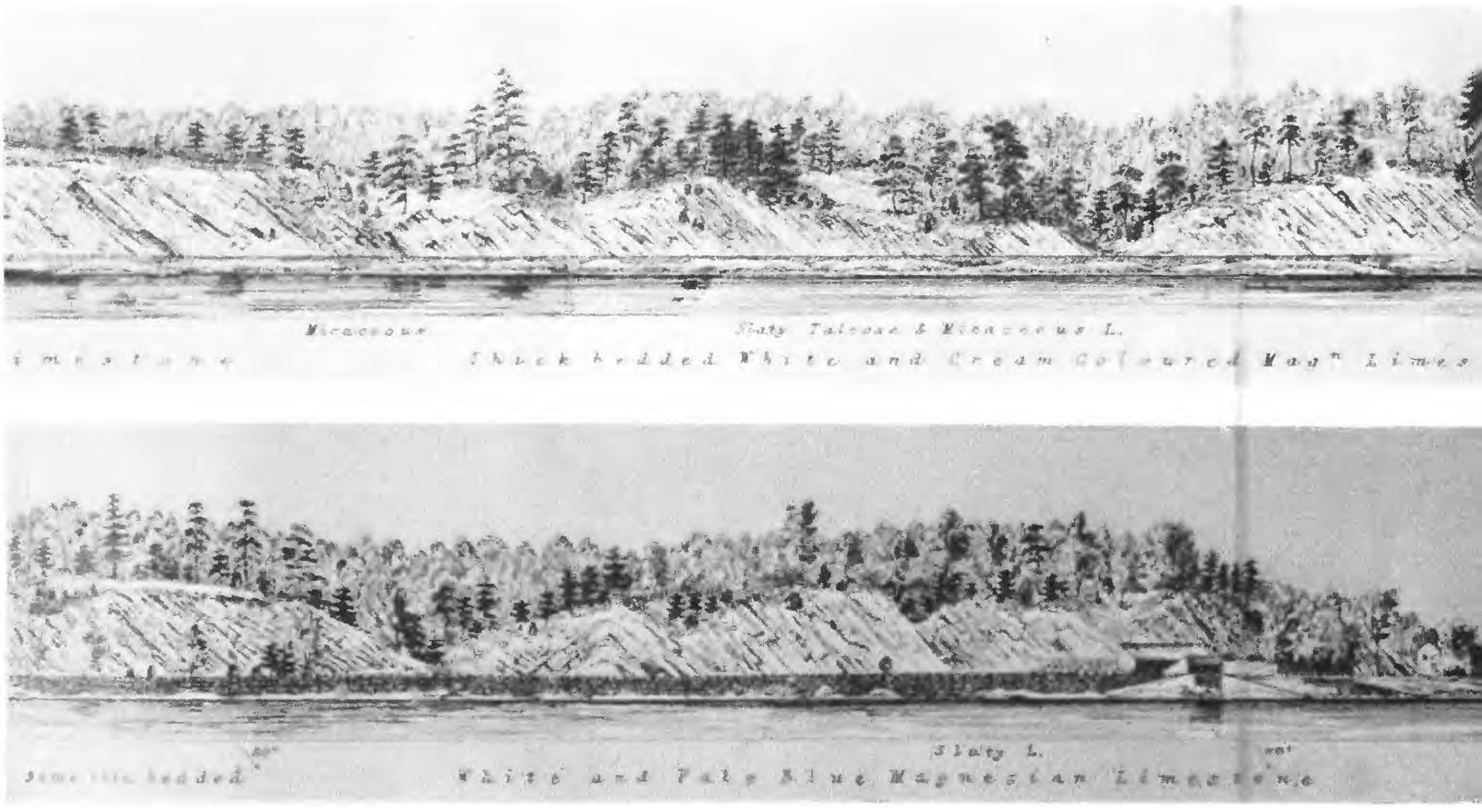


Fig. 741.—Complex Valley of Elevation.

Rogers correctly inferred that mountains were the result of erosion and not of the forcing upward of material by subterranean fires. With the assistance of his nephew, W. B. Rogers, Jr., he prepared a series of woodcuts showing the relation of structure and lithology to mountain form, some of which are reproduced here. Many of these diagrams were included in Dana's *Manual of Geology* published a few years later. (From H. D. Rogers, 1858.)



Rogers' pictorial sections relating the surface and subsurface structure, such as this one along the Schuylkill River, were a combination of art and science. (From H. D. Rogers, 1858.)

City, where the Mormons led by Brigham Young had settled 2 years before. In California, Captain W. H. Warner began a reconnaissance from the Upper Sacramento across the Sierra to the Humboldt River but was killed by Indians before completing the task.

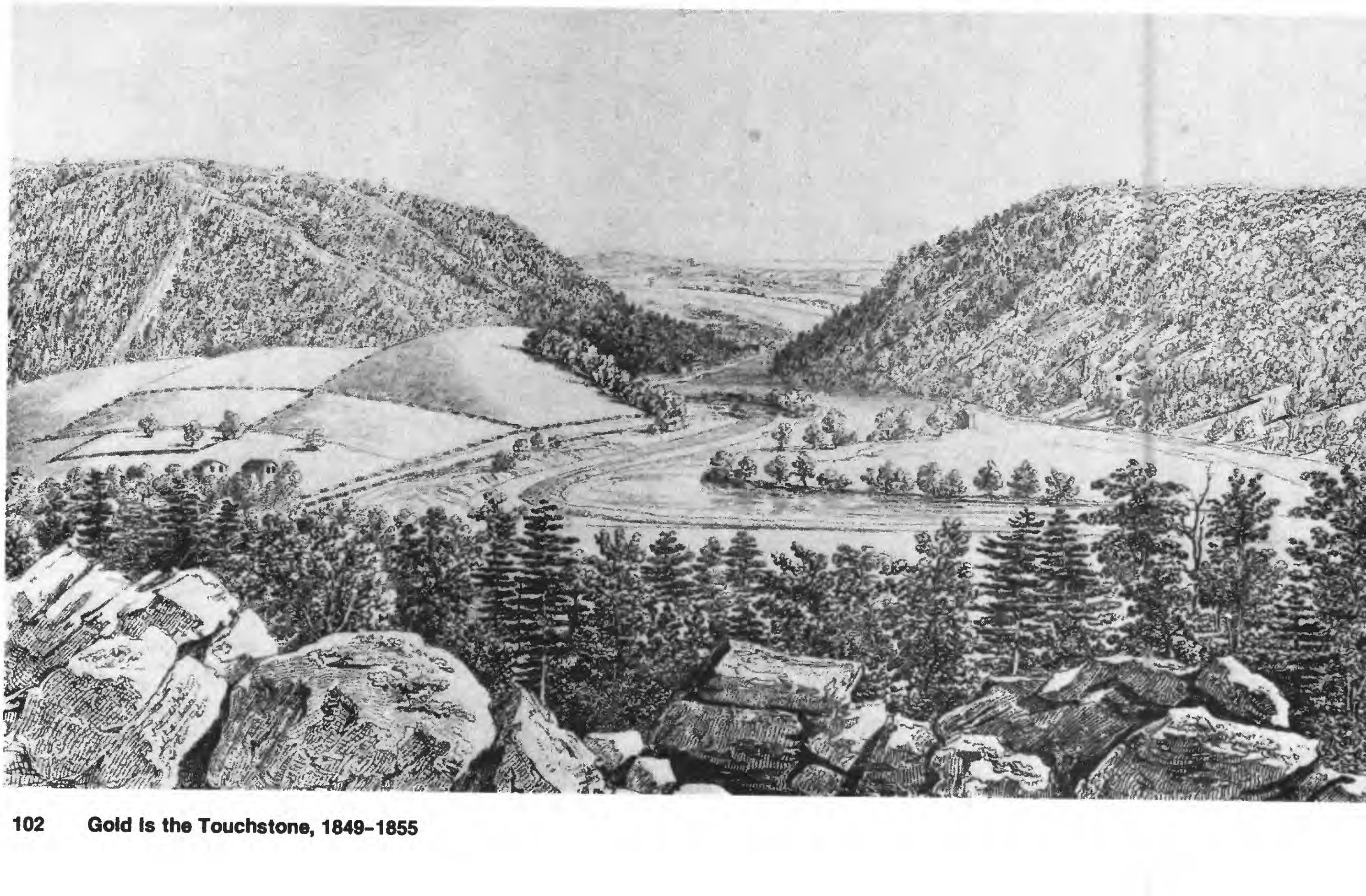
In the East, railroad building proceeded apace in an attempt to capture the eastern terminus with existing facilities. A company, which later became known as the Chicago and Rock Island, was formed in 1847 and began building toward the Mississippi. The Mobile and Ohio Railroad was chartered in the same year, and a railroad to link Hannibal on the Mississippi with St. Joseph on the Missouri was incorporated in Missouri. In 1849, the Pacific Railroad, which later became the Missouri Pacific, was chartered and began the link between St. Louis and Kansas City, and the consolidation of small lines in Illinois was the beginning of the Chicago, Burlington, and Quincy. In 1850, after completing work on the Compromise, Congress took an important step in financing railway construction by grants of public lands. Senator Douglas sought a grant for the Illinois Central Railroad and gained southern support for the measure by linking it with the Mobile and Ohio Railroad and by transferring the lands first to the States of Alabama, Mississippi, and Illinois and allowing them to grant alternate sections along the right of way to the projected railroad. As early as 1852, A. S. Hewitt became interested in the Illinois Central, and the Trenton Iron Company sold rails to it in exchange for bonds.

Finally, on March 3, 1853, Congress appropriated $150,000 for surveys to ascertain the most practical and economical route for a railroad from the Mississippi River to the Pacific Ocean. The Secretary of War was authorized "to employ such portion of the Corps of Topographical Engineers, and such other persons as may be deemed necessary, to make such explorations and surveys as he may deem advisable."

It had become apparent at least to a small group that the AAAS by itself was too unwieldy a body to be effective in promoting professionalism in science and furthering the cause of pure science over the practical. Alexander Dallas Bache, in his address as retiring president in 1851, proposed the establishment of "an institution of science, supplementary to existing one *** to guide public action in scientific matters." None of the existing organizations was well enough endowed, and committees could not work together long enough. Bache called for a council composed of members throughout the country rather than just in Washington who would be "engaged in researches self-directed, or desired by the body, called for by Congress or by the Executive, who would furnish the means for the inquiries."

Around Bache at the time there was already gathering the small group of leading scientists who became known as the Lazzaroni. Their stated purpose was only to "eat an outrageously good dinner together" and their association was informal, but by working together on committees and by correspondence with and visits to each other they hoped to exert influence in guiding public action in scientific matters, and in 1853 they had a measure of success. Three of the Lazzaroni, Joseph Henry, the Secretary of the Smithsonian Institution; Alexander Dallas Bache, Superintendent of the Coast Survey; and Professor Louis Agassiz of Harvard University were members of the committee appointed at the Cincinnati meeting of the AAAS in May 1851 to memorialize the legislatures of Ohio and Missouri on geological surveys. Serving with them were James Hall of New York, Professor Silliman, and S. G. Morton of the 1849 committee.

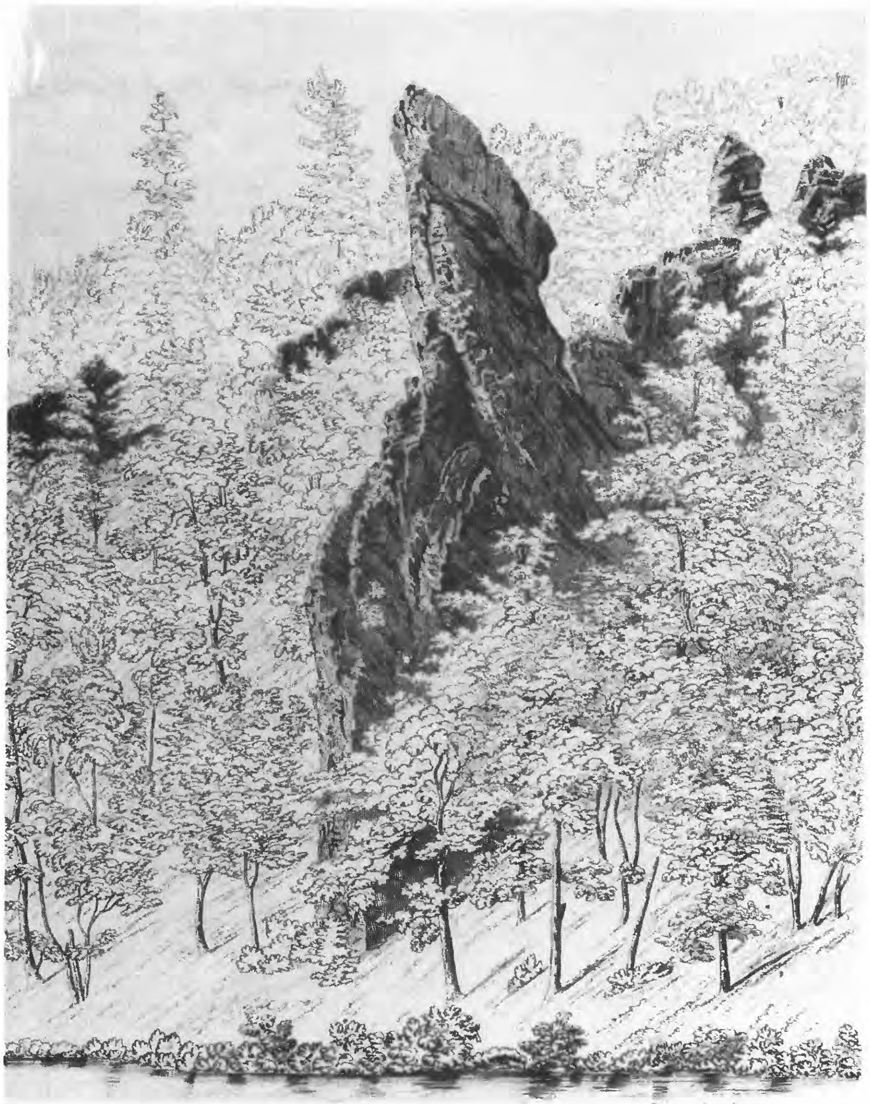
Rogers' *Geology of Pennsylvania* contains many excellent metal engravings by George Lehman, draftsman for the Pennsylvania survey in 1840, and Augustus A. Dalson, topographer, in the 1850's. These were introduced in many cases to demonstrate the intimate relationship between geology and topography and between orography and scenery. This engraving, by Dalson, of gneiss rocks near the mouth of the Wissahickon shows typical river scenery along the Atlantic slope. (From H. D. Rogers, 1858.)



This engraving of the Summit mine, by George Lehman, shows scenery that is typical of synclinal ◀ mountains. It also gives some impression of the extent of coal-mining operations. (From H. D. Rogers, 1858.)

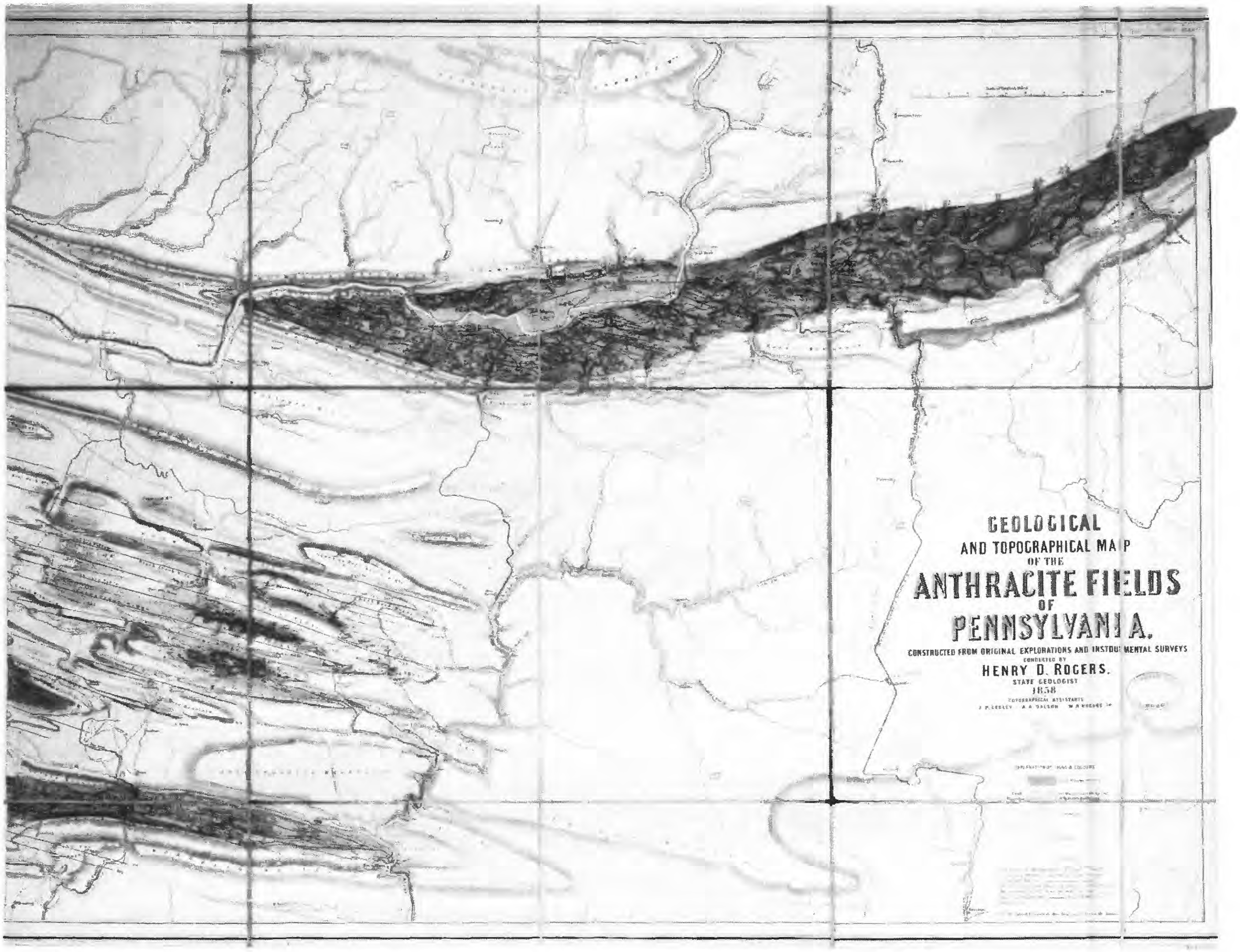
Rogers did not follow the New York System of stratigraphy but divided the Paleozoic rocks into 15 distinct series to which he assigned names corresponding to the different natural periods into which the day divides itself, from earliest dawn to twilight. Indian Chief Rock, a striking scenic feature ▶ on the Juniata River near Williamsburg, Pennsylvania, consists of alternate white cherty magnesian and blue and grey siliceous and dark-blue massive limestones, which Rogers identified as low in the Auroral series. His term "Auroral" was later replaced by the name Shenandoah limestone. (From H. D. Rogers, 1858.)

Among the local scenes characteristic of the Appalachian chain, Rogers said, none are so impressive and picturesque as the deep notches or defiles in the ridges—the wind gaps and the water gaps. The engraving of the Lehigh Water Gap, by George Lehman, shows also a broad mound which Rogers explained was formed "by whirling motion at the confluence of the great currents which here converged to pour through the breach in the Kittatinny ◀ Mountain." (From H. D. Rogers, 1858.)



Missouri established a survey in 1853 on a somewhat different basis from those established in 1850 and 1851. Missouri was unique in possessing characteristics of the North, South, and West; it was a slave State with a well-developed agriculture, but it also had commercial interests, mining enterprises, and was actively seeking the eastern terminus of the transcontinental railroad. George C. Swallow, professor of chemistry, geology, and mineralogy at the University of Missouri became director. Although the primary motivation of the legislature in establishing the survey was practical, Swallow made general geology the first objective. He assured Missourians, however, that the geological survey could not fail

> **to develop the mineral resources of our State, and place our mining interests on a more permanent basis, by inviting capital and by securing systematic and profitable operations. It will increase our mechanical and manufacturing interests, by pointing out raw materials, and the facilities for converting them into articles of domestic and foreign trade. Agriculture will be advanced by investigating the structure and chemical properties of the soils, as the results will enable us to determine the modes of culture necessary to sustain and even increase their productive energies. Commerce will also receive a new impulse, from the increased products of the farm, the mines, and the work-shop.**



England, he told them, afforded the best illustration of wealth and power resulting from a scientific development of mineral resources.

> **Our mineral wealth is probably as great as hers. She depends mostly upon her iron and coal; and still, we have more and better iron, and our Coal Measures will prove as extensive. Yet, while England annually raises from her mines $100,000,000 worth of raw materials, we raise but a few thousands. This difference is not because Nature had done less for us, but that Science has done more for her.**

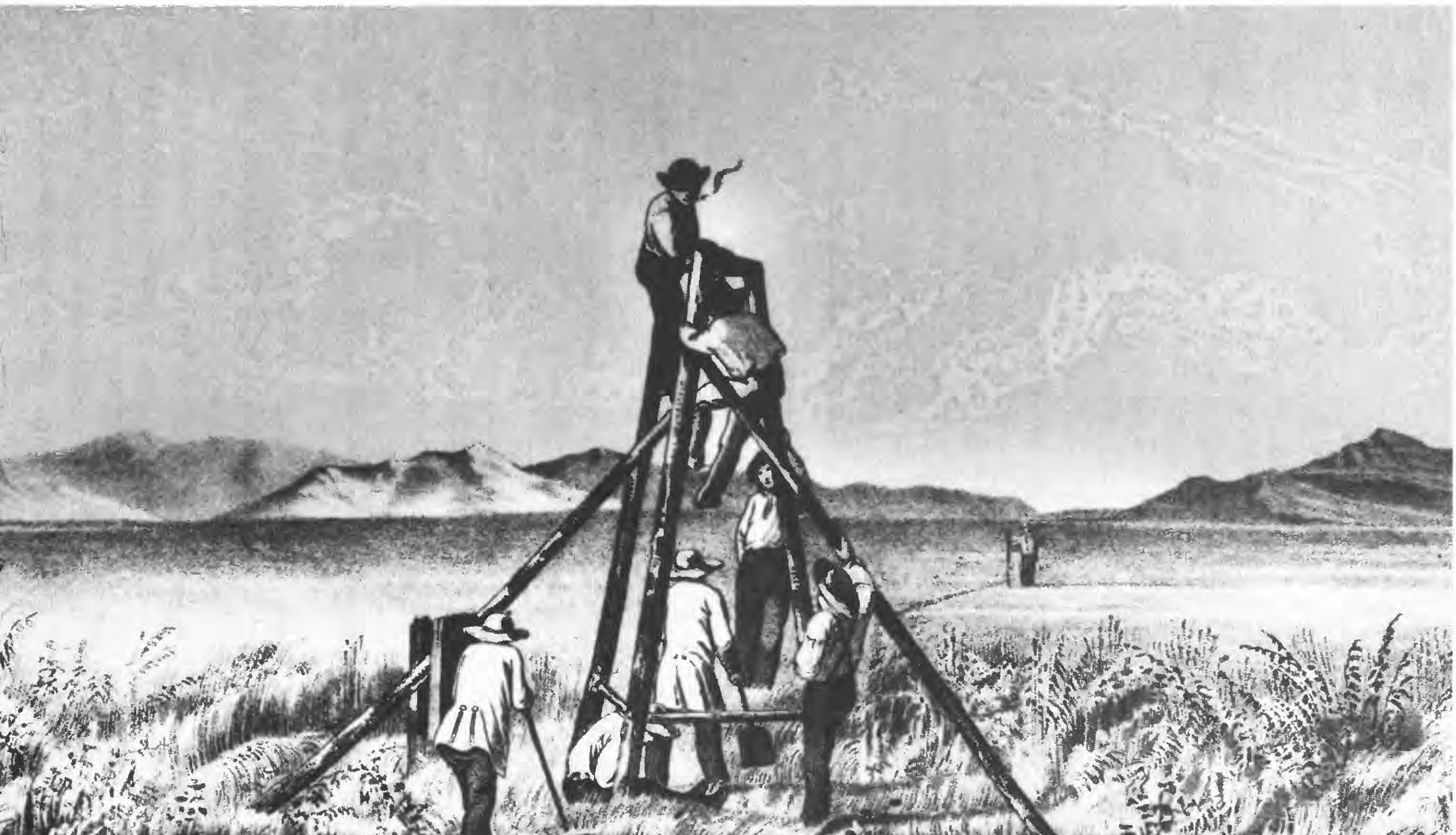
The Lazzaroni had singular success in dealing with the new Secretary of War, Jefferson Davis of Mississippi, to obtain places for scientists on the Pacific railroad surveys. Davis planned to use officers of the Topographical Corps for the assignment, but instead of placing the surveys directly under Colonel Abert, he established a separate Bureau of Explorations and Surveys under command of Major W. H. Emory, whose 1846 report had provided much of the basic information on the Southwest. In cooperation with Emory and with Captain A. A. Humphreys who succeeded him, Davis chose three routes to be explored. The northern survey, which was to explore the country between the 47th and 49th parallels (the St. Paul to Puget Sound route) was led by I. I. Stevens, who had just resigned his commission to become governor of the newly authorized Washington Territory. John Evans, whose discovery of fossils in the Dakota badlands had so excited James Hall's cu-

Conscious of the importance of accurate maps in the development of mineral resources as well as for geologic purposes, Rogers had his map of the anthracite fields of Pennsylvania prepared in great detail and published at a scale of approximately 2 miles to the inch. The coal measures are shown in dark gray. The map has been reduced for this publication. (From H. D. Rogers, 1858.)

riosity that he had despatched F. B. Meek and F. V. Hayden to investigate the country, accompanied Stevens. Hall was not one of the Lazzaroni but had been closely tied to them in the unsuccessful attempt to establish a national university in Albany. At the western end of the northern route, Captain George B. McClellan explored the Puget Sound area and central part of Washington Territory. He was accompanied by George Gibbs, brother of Oliver Wolcott Gibbs, one of the younger Lazzaroni. An expedition under Captain John Williams Gunnison was sent to explore the 38th-parallel route. W. H. Brewer who, as a graduate of the Sheffield Scientific School, might have been sponsored by Lazzaroni James Dwight Dana, was appointed to accompany the Gunnison party, but because of a delay in the mail, he missed connections. Most of the Gunnison party was killed by Indians, and Lieutenant E. G. Beckwith of the accompanying escort party completed the survey. Along the 35th-parallel route, from Fort Smith to Los Angeles, Lieutenant A. W. Whipple was in charge; he was accompanied by Jules Marcou, a protege of Louis Agassiz.

Davis did not at first consider it necessary to explore the 32d-parallel route, which the Topographical Engineers under Colonel Abert's orders had explored, or the 41st-parallel route, on which he said the Stansbury, Warner-Williamson, and Frémont expeditions had provided enough information. However, in 1854, he yielded to political pressure and sent two expeditions to survey the 32d-parallel route, one from the West led by Lieutenant J. G. Parke and the other from the East led by Captain John Pope. Thomas Antisell, a young man of French Huguenot parentage who had fled from Ireland to the United States in 1848 for political reasons, accompanied Lt.

Westward migration increased during the 1840's, less than a decade after John C. Frémont visited the Great Salt Lake. Howard Stansbury of the Topographical Engineers was sent to make a survey of the region where the Mormons had recently settled. Stansbury mapped the area in 1850, using a system of triangulation. He recognized that the area was the prehistoric bed of a vast lake or inland sea, thus anticipating the work of Clarence King and G. K. Gilbert in later years, and also prepared a lengthy report on the Mormons and their way of life. (From Howard Stansbury, 1852.)



Parke as geologist. Out in California, Lt. R. W. Williamson began the search for passes over the southern Sierra Nevada. He was accompanied by W. P. Blake, as geologist, a recent Yale graduate who had studied mineralogy with Dana.

In 1853, the Wisconsin legislature, concerned about the decline in the lead mines, authorized a geological survey, stipulating that the survey of the lead district be completed first. Edward Daniels, the first State Geologist, reported that the Wisconsin lead deposits "presented the characters of true veins," which would indicate that they were of permanent value, but said that

> **Mining, like manufacturing, requires for its successful prosecution, systematic, comprehensive, and long continued application of labor and capital. Individual mining can be profitable only for short periods. *** The mines are now in a transition state. They have passed through the period of excitement, when chance rewarded the fortunate with rapid gains, to a more quiet and settled condition, in which rude and individual attempts at mining are attended with frequent failure and occasional success. They now await the period of organization to which their full treasures are to be surrendered.**

Daniels suggested that money be invested in Wisconsin mines rather than the importation of lead and recommended that a department of mines be established at the State University. Daniels also had the zinc ores, which were generally supposed to be worthless, examined and analyzed by a Boston chemist, Dr. August Hayes, and reported that the zinc was a source of wealth second only to lead. Daniels was removed from office by the Governor on June 30, 1854, for reasons which are not clear, but which were apparently political. He was succeeded by J. G. Percival, who had been exploring for lead mines in Illinois and Wisconsin for the American Mining Company.

The Railroad surveys of the 1850's added greatly to the knowledge of the natural history, archeology, and geology of the West. Some reports were lavishly illustrated, and the lithographs which were introduced "with no purpose of representing the beauties of the scenery of the country, but to illustrate its general character, and to exhibit on a small scale the character of its mountains and cañones, and of its plains and valleys, in their respective positions and extents, as seen in nature" have become collector's items. The following six shown here are among those of continuing geologic interest.

At the Great Falls of the Missouri River in Montana, the river falls 160 feet in a little more than 11 miles of cascades and rapids. Meriwether Lewis saw the Great Falls in 1805, and his party spent a month in making a portage around the falls and rapids. Jim Bridger and members of the United States Exploring Expedition (Wilkes expedition) also visited the area, but the Blackfeet Indians discouraged visitors until Governor I. I. Stevens concluded treaties with them. (From I. I. Stevens, 1859.)

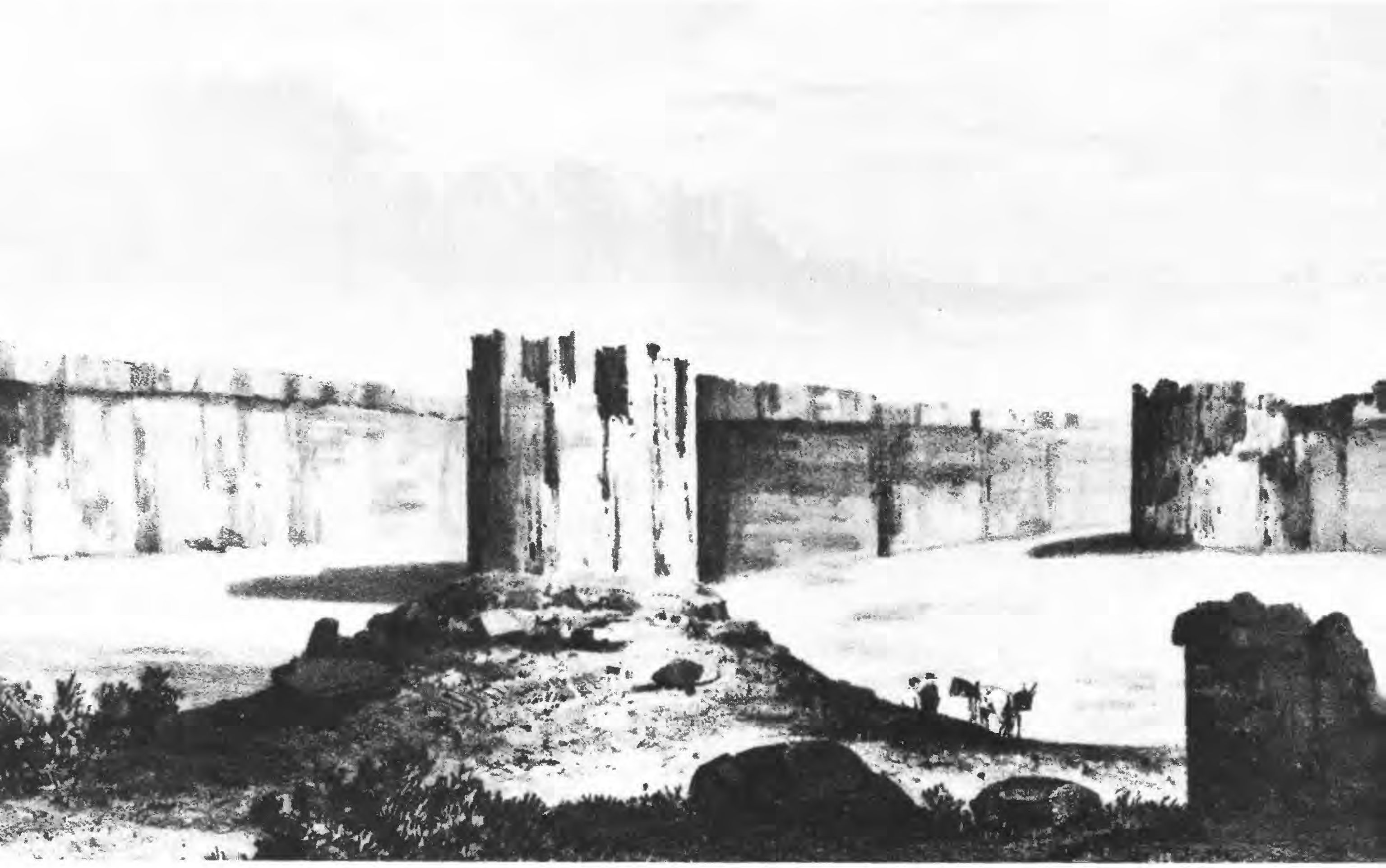
Indiana, after trying twice without success to obtain a grant of public lands to pay for a geological survey of the State for the purpose of developing its mineral resources, finally made a small appropriation in 1853, and Dr. Ryland T. Brown was appointed State Geologist. The survey was shortlived. The legislature refused to publish Brown's report on the grounds that it conveyed an erroneous and exaggerated idea of the value of the coals of Indiana and then discontinued the survey.

California was also concerned about a decline in mineral resources. In 1852, the State legislature had called on Congress for action, but when Congress did nothing beyond extending the public land surveys to the State, Dr. John B. Trask was authorized in May 1854 to make studies of the unoccupied mineral lands on the eastern borders of the Sacramento and San Joaquin valleys and an examination of the Coast Range.

The survey of New Jersey was organized for a somewhat different reason. The Governor's message to the legislature in January 1854 reflected the tenets of the Know-Nothing Party. Apparently distrustful of the growing numbers of immigrants who were increasing the working force and helping the industrialization of the area, and desirous of promoting agriculture, he told the legislature that

> **It is reported that valuable mineral deposits are frequently discovered by foreigners, and lands purchased from our landholders at nominal prices. A thorough survey of the State would doubtless discover mineral deposits to the advantage of our citizens and prevent the speculation now practiced upon them and increase the value of taxable property beyond the cost of the survey and promote the great interest of agriculture.**

The cliffs which wall the Grand Coulee in Washington are of basalt. At its northern end, the valley is about 10 miles wide, but it widens toward the south. At the northern end, the walls are about 800 feet high. (From I. I. Stevens, 1859.)



The legislature promptly authorized a survey which was organized under Dr. William Kitchell as State Geologist, but it lasted only 2 years. It did serve to provide experience for two assistants who became prominent a decade later, George H. Cook and Thomas B. Brooks.

The Alabama State legislature authorized funds for a State survey in 1854. Alabama was then second only to Mississippi in cotton production, and the State legislature specified that the first duty of the State Geologist was to make a "complete and thorough geological survey of the State, so as to determine accurately the quality and characteristics of its soils and their adaptation to agricultural purposes," and after that to determine "its mineral resources, their location and the best means of their development; its water powers and capacities; and generally everything relating to the geological and agricultural character of the State." The charter was broad, and Michael Tuomey resigned from the University to devote full time to the Survey. His first report to the legislature was laid aside, part of it was lost, and after Tuomey died in 1857, the survey was discontinued.

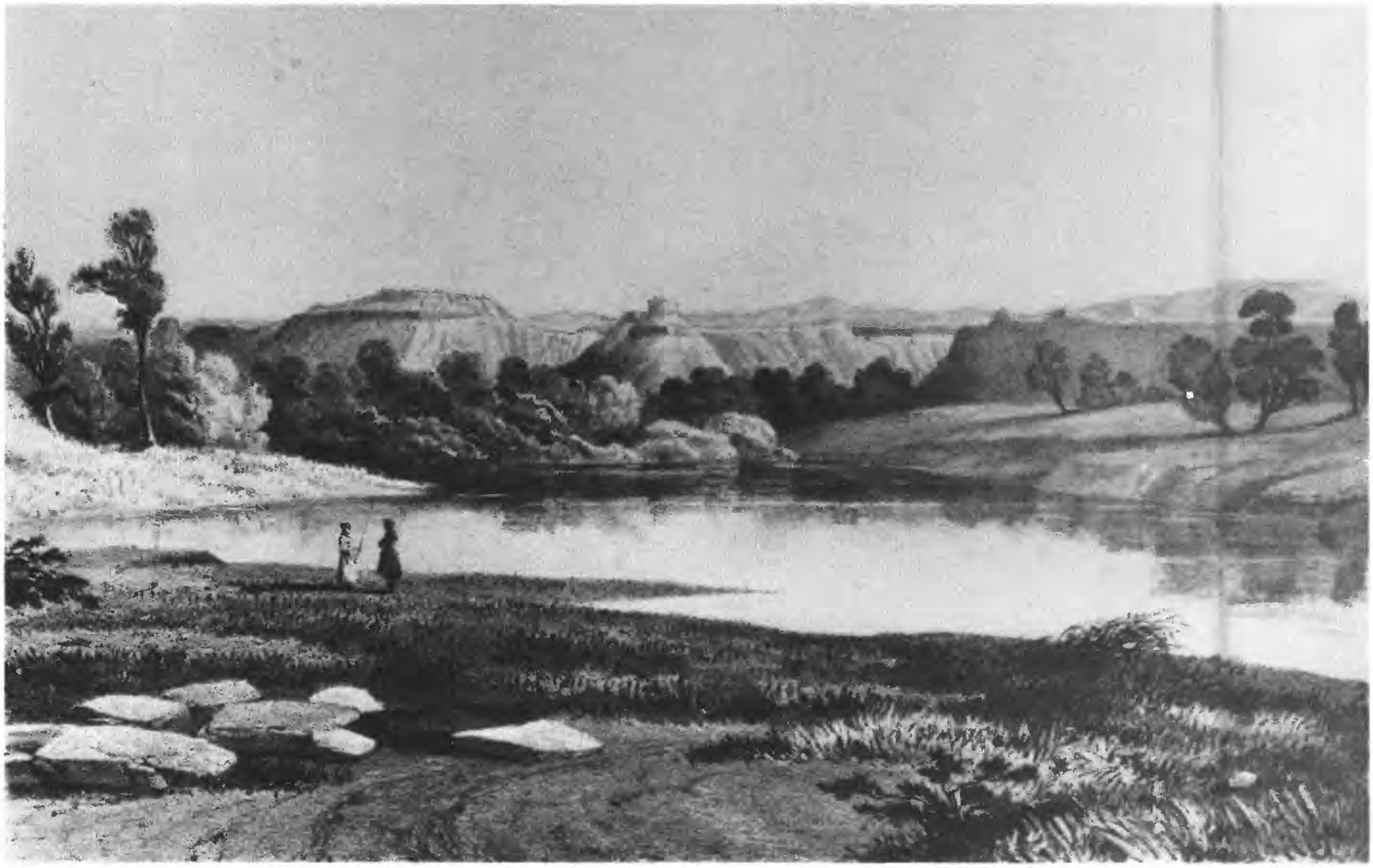
Tennessee revived its survey in 1854 after the Ducktown copper discoveries excited some interest in mineral resources. James Merrill Safford, who had studied at Yale before becoming professor of chemistry and natural history at Cumberland University, was appointed State Geologist but had to work under almost impossible conditions. The appropriation was too small to allow for purchase of equipment, and he did his fieldwork with only a compass and pocket level as tools. There were no maps, and the roads were so bad that much of his travel had to be on foot. Nevertheless, he presented a report in 1855 on the mineral resources of the State, which included not only iron, copper, lead, zinc, gold, and silver, but also aluminum, the "metal from clay," and a discussion of the geologic structure of the State.

Mount Rainier, the highest peak in the Cascade Range, had been discovered in 1792, but no one had yet climbed to its peak. Seen from a distance, the mountain appears isolated because its great height dwarfs neighboring mountains. (From I. I. Stevens, 1859.)

At the head of what Beckwith called the Grand River but which we know as the Gunnison, the banks on each side of the river rise rapidly toward precipitous sides of mesas which extend back some 15 to 30 miles to the mountains. These elevated tablelands, he thought, "were formed, doubtless, by the upheaval of large plains at the same time, and the immense cracks and crevices of these convulsions have been enlarged, in time, by the elements, and now form the cañones, gorges, ravines, gullies, and passes, which in every direction surround us." (From E. G. Beckwith, 1855.)

When the Kentucky General Assembly established a geological and mineralogical survey in 1854, the law required the State Geologist and his assistants to make the usual "thorough geological, mineralogical, and chemical survey" of the State "to discover all beds or deposits of ore, coal, and such other mineral substances as may be useful or valuable, and to analyze same," after which the State Geologist was to "deliver a written or verbal discourse" at the courthouse of each county in which valuable deposits were discovered. David Dale Owen was appointed State Geologist. Kentucky had few outstanding mineral resources, and Owen very quickly turned his attention to the support of agriculture, the basis of the State's economy. He developed a technique for sampling soils, and used chemical analyses of soils, comparing those from fields under cultivation with those from adjacent virgin land to detect loss of minerals by long-continued farming and to determine the amounts necessary to bring the soils back to their original fertility.

Several of the State geologists had realized the necessity of adequate base maps for plotting geology, especially with reference to mineral deposits. H. D. Rogers had had prepared a new map of the anthracite regions of Pennsylvania, which was a major expense to the Pennsylvania survey. Norwood, the State Geologist of Illinois, arranged to have a topographic map of Hardin County compiled, at no expense to the State, to demonstrate the importance of the base map. David Dale Owen supported him, writing "It is just the sort of map that is required to enable the geologist to lay down minutely the geology of the country." The Illinois legislature was sufficiently impressed to add $500 to the appropriation in 1853 for "accurate topographic maps." Owen then pointed out to the Kentucky legislature that a map was necessary to locate natural resources accurately, and in 1856, he was authorized to organize a topographical corps. Kentucky had never been part of the public domain and had never been surveyed on the rectangular system. Owen



As his expedition continued westward, Beckwith again noted the nearly horizontal rocks and generally level summits in the Roan, or Book, Mountains which he observed from a spot near the Spanish Trail ford on Green River. (From E. G. Beckwith, 1855.)

adopted a system of traverse surveying using compass, chain, and level, with occasional measurement of base lines and a determination of distant objects by angles of observation with a transit theodolite. The maps were reasonably accurate with respect to distance and relative locations but did not pretend to show exact elevations. The Coast Survey triangulation had provided the basis for accurate topographic mapping in some of the Atlantic Coast States, and the State of New Jersey, in 1854, appropriated funds to make a complete and accurate topographic map of that State.

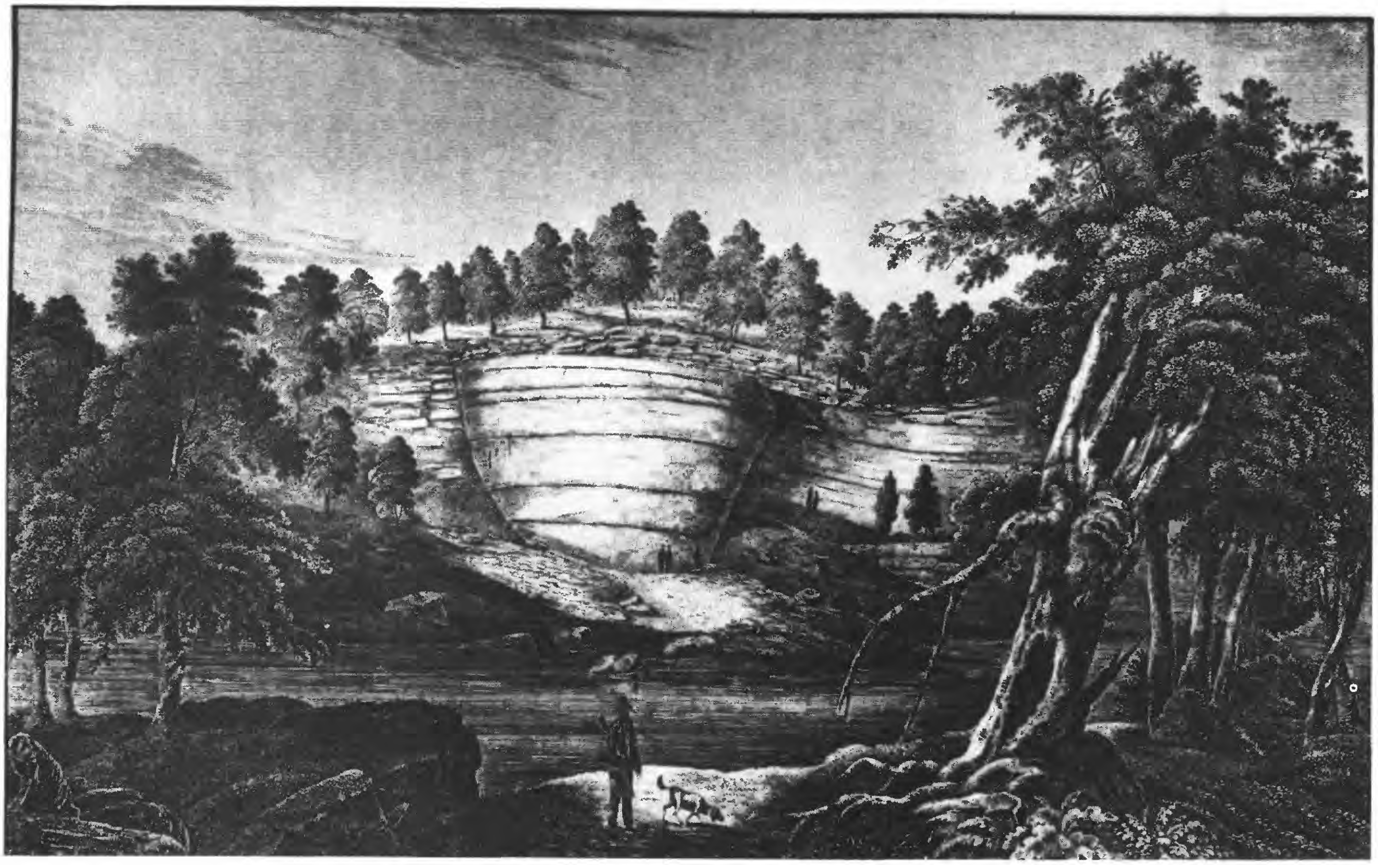
Interest in geography in the eastern part of the country had already led to the organization of the American Geographical and Statistical Society in New York. In 1853, both the American Association for the Advancement of Science and the American Geographical Society adopted resolutions favoring the establishment of a department of geography in the Library of Congress. In January 1856, a committee of the American Geographical Society, appointed to consider a resolution petitioning the New York legislature for a topographical survey, reported that probably the general Government would never supply a correct physical map of the United States. It was therefore incumbent upon the individual States to survey their own territories, and the Society should urge each of them to do so. The committee was particularly concerned that many States had made scientific surveys of geology and mineral resources but had failed in great measure to make the results of practical value for want of correct topographical maps upon which to delineate them.

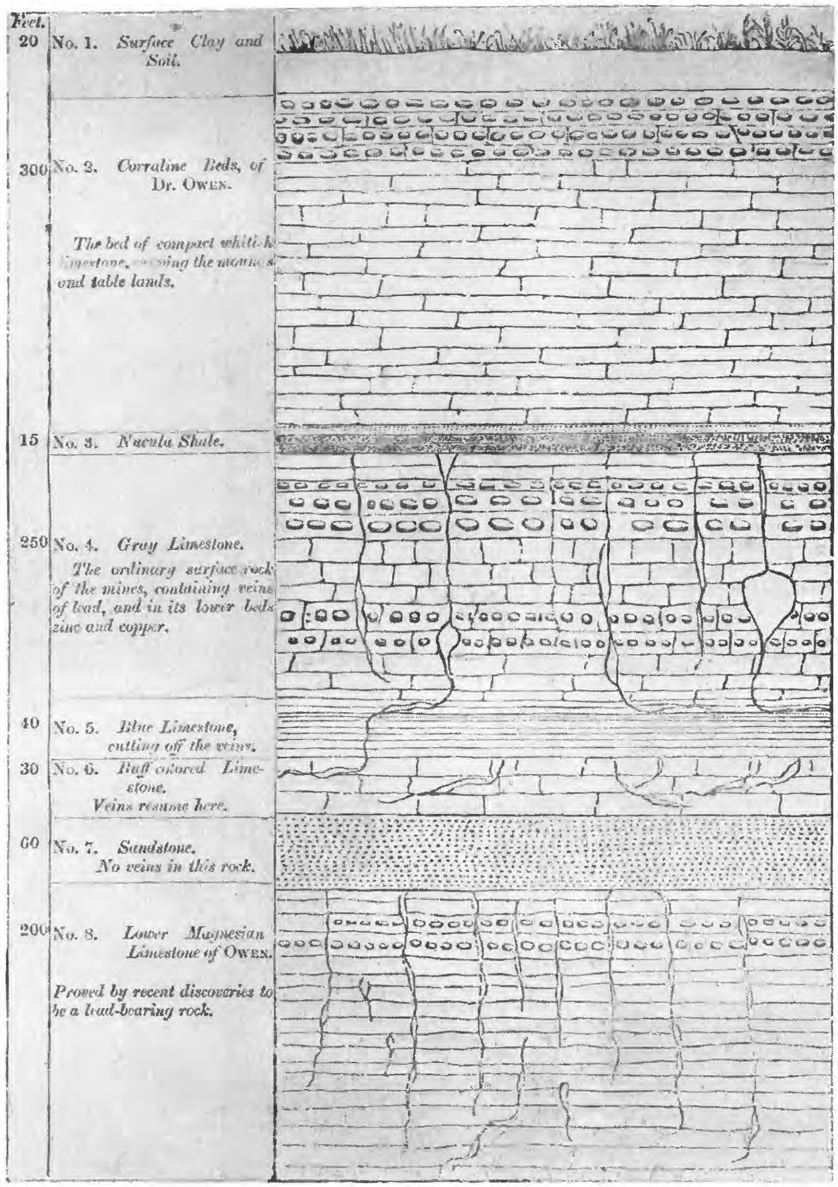
When the railroad surveys were authorized in 1853, the southernmost, or 32d-parallel route, seemed to have the best chance, but a small strip of land considered desirable was still Mexican territory. In May 1853, southern interests procured the appointment of railroad president James Gadsden of

South Carolina to negotiate with Mexico, and on December 30, a treaty was signed whereby Mexico, for $15 million, ceded to the United States a rectangular strip of territory in the Nesilla Valley, south of the Gila River. The line established at that time is still the boundary with Mexico.

To build any railroad to the Pacific other than on the southern routes required the organization of the vast Nebraska region into a territory and the cession of millions of acres of land from the Plains Indians who would then be placed on reservations. Senator Stephen Douglas of Illinois, chairman of the Senate Committee on Territories and a champion of the central route, countered the Gadsden success with a bill for territorial organization designed to win southern votes for his railroad project by opening the territory to the possibility of slavery. The Nebraska region was north of the Missouri Compromise line and hence supposedly closed to slavery. However, by invoking the principle of popular sovereignty, whereby local residents could decide for or against slavery, and by dividing the area into two territories, Kansas and Nebraska, it could be that southerners would control Kansas and northerners, Nebraska. The challenge to the Missouri Compromise encouraged the South and enraged the North. The issue was debated heatedly for 4 months but was finally passed on May 30, 1854. It was an open invitation to North and South to fight it out in the Territories, and even before the bill became law, both sides had begun marshalling their forces.

The San Francisco Mountains in central Arizona had been shown on old Spanish maps as part of a continuous range, but Whipple found them to be a huge volcanic pile with several conical peaks near the center and towering at least a mile above their base. (From A. W. Whipple, 1856.)

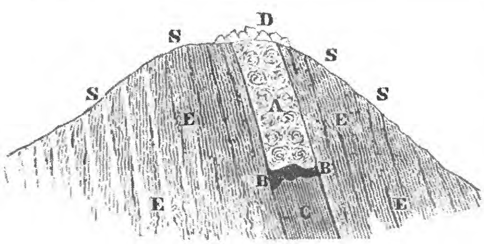




Although David Dale Owen had at first thought the lead deposits were confined to the Cliff limestone, lead ore was later found in the Lower Magnesian limestone. This vertical section shows the succession and relative thickness of the rocks which underlie the Lead Region of Wisconsin. (From Edward Daniels, 1854.)

Missouri, one of the States vying for the eastern terminus of the first trans-Mississippi railroad, was the first trans-Mississippi State to establish a State geological survey. Its first effort was to establish the geological column in the State. The State Geologist, George Swallow, sketched here the Fourth Magnesian limestone, which is observed especially well along the Niangua and Osage Rivers where erosion produced a characteristic scenery of steep bluffs rising to rounded knobs. The Magnesian limestone is the equivalent of the Calciferous sandrock of New York and the Auroral of Pennsylvania. (From G. C. Swallow, 1855.)

The Missouri Survey was also concerned with mineral resources. Pilot Knob and the nearby Iron Mountain were developed by the Missouri Iron Company, organized in 1836, and its successor, the American Iron Company, beginning in 1845, by surface excavations. They were widely believed to be solid iron and the richest masses of iron on earth. Swallow said that although a "large portion" of the Pilot Knob was pure ore, it was not easy to estimate the quantity because it was interstratified with slates. He considered the ore inexhaustible, however, and stated that the amount above the surface could not be less than 13,972,773 tons. (From G. C. Swallow, 1855.)



Another source of copper was discovered at Ducktown, Tennessee, and led to the reestablishment of a State geological survey. The copper veins were all remarkably similar in character and the State Geologist, James Safford, noted cautiously that they were called segregated veins by some. The upper part of the vein, A, was a light porous iron ore, B, the mass of black copper ore, and C, a hard arsenical rock containing iron, sulfur, and copper, which ran down indefinitely. (From J. M. Safford, 1856.)

The Kansas-Nebraska Act also converted the growing economic alliance between the Northeast and Midwest into a political alliance. Both sections were opposed to the extension of slavery, but it was southern opposition to increased Federal expenditures for internal improvements and a homestead law, which the Midwest greatly desired, on which the alliance developed.

House Bill No. 1 in that session of Congress was a homestead law, and it was debated at great length. The Public Lands Commitee proposed an amendment to the bill to combine the homestead provision and graduation of the price of lands. Instead of an amendment, however, the graduation proposal became a separate bill, which passed early in August 1854, some 30 years after Senator Benton had first proposed the idea. The Act provided that the price of all unsold public lands on the market for 10 years or more would be $1 an acre; those on the market 15 years or more would be priced at 75 cents an acre; 20 years or more, at 25 cents an acre; and 30 years or more, at only 12 ½ cents an acre. Preemption was permitted on graduated land but not on mineral land, and grants for internal improvements and railroads were forbidden. It was a small victory for the emerging alliance.

Chapter 7.
Necessary for Welfare and Progress, 1855–1861

> **Is it not incumbent on every country and every state of this Union, to adopt measures calculated, first to develop their resources in the various raw materials necessary for their welfare and progress, and having done so, to direct public attention to their stores of mineral wealth? *** What better method can a State adopt for this purpose than to institute and support with liberality a well-conducted and judiciously managed geological survey.**
>
> **—David Dale Owen**

Kansas was the scene of the physical confrontation between North and South on the slavery issue. The estrangement of the two sections increased because of other factors as well, although the basic difference was the availability of a cheap supply of labor in the South. Both the East and the Midwest were growing more rapidly than the South. The East, rapidly becoming urbanized and industrialized, needed the agricultural products of the West, and the West needed the manufactured products of the East. Railroads in the North provided a ready means of shipment between the two. Moreover, agricultural surpluses from the Midwest could be shipped to Europe more readily through Atlantic ports. As the Midwestern farms became mechanized, agricultural workers were released for industrial pursuits, and the availability of additional industrial workers expanded factory output. The economy of East and Midwest thus complemented each other. The South remained adamantly rural and agricultural and further alienated itself from other sections by its refusal to consider change. Developments in mineral resources and in the work of geological surveys at this time reflected these basic differences.

The Mississippi survey took on new direction with the arrival of E. W. Hilgard in the fall of 1855. When Millington retired, he had been succeeded by Lewis Harper, a German law student who had left his own country for political reasons and had then become interested in natural history. Harper made no attempt to go into the field until the summer of 1855 when he was ordered to do so. At the same time, Dr. F. A. P. Barnard, then professor of physics at the University, was requested to secure a competent assistant geologist during a visit to the North, which mission he accomplished at the Providence meeting of the AAAS by offering the position to Hilgard, a young Smithsonian chemist who had received a Ph.D. from Heidelberg. Hilgard promptly accepted, even though he received condolences from many of those present because there were no Paleozoic rocks in the area. Before going to Mississippi he conferred with David Dale Owen whose work in Kentucky was already more concerned with agriculture than mineral resources. By the spring of 1856, Hilgard was convinced that the Mississippi Survey also had to seek support on the basis of service to agriculture rather than mineral discoveries. He therefore began to pay more attention to surface features, vegetation, soils, the water supply, and the marls, and after observing a close connection between the vegetation and the underlying formations, he developed a technique of mapping by means of vegetation.

Emmons in North Carolina also turned his attention to agriculture, and in his later reports took up such matters as the availability of marls for fertilizing purposes. Emmons noted that North Carolina marls were of too low grade to be worth transporting very far; he also pointed out that the physical properties of soil, as well as the chemical ones, were important for fertility.

Oscar Lieber, who was appointed Director of the Geological Survey of South Carolina in 1855, was primarily interested in geognosy, which he defined as the science that treats of the existing constituents of the surface of the globe, in contradistinction to geology which seeks to explain how they were formed. Lieber, then only 25, was a protege of Michael Tuomey. His father was a political refugee from Prussia who had become professor of history and political economy at South Carolina College in 1833. As a teenager, Lieber had occasionally accompanied Tuomey on geological field trips. After studying at South Carolina College, he had gone to Berlin and Göttingen to study under Bernard von Cotta, and in 1854 and 1855, he had served as Tuomey's assistant in the Geological Survey of Alabama. Lieber did some pioneer work in petrography, although he also devoted some attention to economic geology. The South Carolina Survey was discontinued in 1860.

The Northeastern States were now largely urbanized, and State governments showed little interest in geological surveys. In 1856, Professor Edward Hitchcock, Sr., having retired as president of Amherst, was appointed State Geologist of Vermont. The Vermont survey had been plagued with misfortune. C. B. Adams, who had left Vermont in 1847 for Amherst, had died before completing his report. In December 1853, the legislature provided for completion of the survey and appointed Zadock Thompson. Thompson felt it necessary to go over much of the ground again, but he also died before completing the work. His successor lived only long enough to publish a report on the history of the survey. Then all collections were destroyed by fire. Hitchcock, assisted by his two sons, Edward, Jr., and Charles H., both of them Amherst graduates, and Albert Dorsey Hager, completed a two-volume report in 1860. The report was accompanied by three maps, one a colored geologic map, and two showing the distribution of terraces and beaches. After completion of the report, Edward Hitchcock, Jr., became a professor of hygiene and physical education at Amherst, but Charles H. Hitchcock joined the Natural History Survey of Maine under Ezekiel Holmes.

The mining industry, other than for gold, was then concentrated in the northern and middle States; Pennsylvania, with its great resources in iron and coal, was the leading mining State. Although outranked by gold in value and excitement produced, iron had become the basic mineral industry. Iron production rose steadily in the early fifties, although it remained somewhat less than 1 million tons a year. Production of anthracite pig iron increased most rapidly, and in 1855, the tonnage of anthracite pig iron exceeded that of charcoal pig iron and, in 1856, that of all other iron combined. The manufacture of wrought iron also changed, and by 1856, 95 percent of all wrought iron was being made in rolling mills. Wrought iron replaced cast iron in many uses, and wrought iron rails became so important a product, as railroad building boomed, that rail production became almost an industry in itself.

The leading iron mill in the country was Cooper & Hewitt's Trenton establishment, largely because of the initiative and enterprise of A. S. Hewitt, Trenton's ironmaster. The Trenton mill continued to make superior iron rails, but when the lower price of British rails threatened disaster, it had turned to the manufacture of wire, just as telegraph lines were being

The short-lived New Jersey survey of 1854 included the Andover mine, which was an important factor in the success of A. S. Hewitt as ironmaster, in its investigation. The mine had been opened in 1763 and much of the cast iron and nearly all the wrought iron used by the Continental Army was manufactured there. However, by 1840 the ironworks had been abandoned. Hewitt purchased the mine in 1847 for just under $9,500. A mixture of the Andover ores, hematite and magnetite, known to the miners as red ore and blue ore, made an unusually tough iron from which the Cooper and Hewitt company made railroad rails and wrought-iron beams for buildings. (From William Kitchell, 1856.)

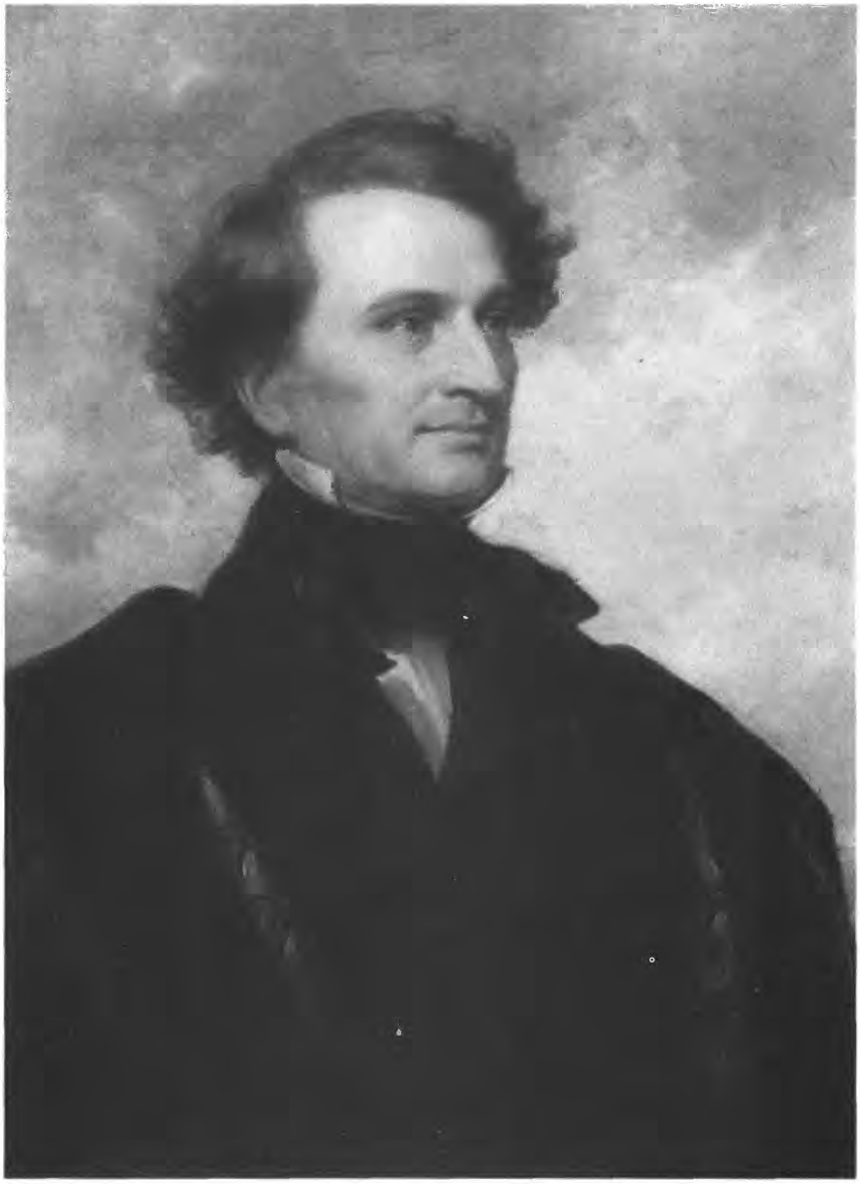
spread across the country. It had also pioneered in the manufacture of wrought iron structural beams, which made possible larger and lighter buildings, and had won several Federal contracts, including one for the new dome of the Capitol at Washington. Hewitt was optimistic about the future of the American iron industry. He told the American Geographical and Statistical Society in February 1856 that although the United States had in 1855 reached only the stage of development that Great Britain had reached in 1836, it had been handicapped by scarcity of labor and capital. These difficulties had now been overcome, and he predicted that in 20 years, American production would be 3½ million tons.

The iron industry had become important enough so that in March 1855 the American Iron Association was formed, flamboyantly proclaiming itself as having "acquired an importance in this country second only to the great agricultural interest." The primary objectives of the association were to obtain statistics on the iron trade, provide for exchange of information, collect and preserve works relating to iron, and encourage the formation of schools of mining.

In 1856, J. Peter Lesley was appointed Secretary of the Association and began the collection of statistics. His *Iron Manufacturer's Guide to the Furnaces, Forges, and Rolling Mills of the United States* listed 1,159 iron manufacturers in 25 States—614 in Pennsylvania, New York, and New Jersey. His own opinion was that the iron region in eastern Pennsylvania and northeastern Maryland was the greatest in the Union, but at the time he compiled his statistics, shipments from northern Michigan had barely begun. More than half the volume of 772 pages was devoted to a description of iron ores and their distribution, a matter of scientific as well as commercial interest. Lesley recognized five classes of ore: primary, or specular, magnetic, and red oxide; brown hematitic; fossil ore of upper Silurian rocks; carbonates; and bog ores.

Coal production had continued its spectacular increase and had more than doubled in a decade. Coal was now being produced in 24 States and Territories, but Pennsylvania continued to dominate the field, with Ohio a distant second. Coal-mine owners and operators continued to employ consulting experts. Before joining the Iron Association, Lesley, who had been one of these experts, completed a *Manual of Coal and Its Topography* on the basis of his work with the Pennsylvania survey and as consulting expert. Lesley was one of the first, if not the first, to show topography by contours rather than hachures, and his map was made for one of the coal-mine operators.

It was in this northeastern area, where the mineral industry had begun to call on science, that scientific and technical education was most advanced.



James Dwight Dana

Professor of natural history 1849-1864 and of geology and mineralogy 1864-1890 at Yale College; author of a *System of Mineralogy* (1837), *Manual of Geology* (1862), *Textbook of Geology* (1864), and numerous scientific reports. Dana is generally regarded as the outstanding American geologist of his day. Dana's 1855 presidential address to the American Association for the Advancement of Science was a declaration of independence for American geology. (Photograph of oil portrait by Daniel Huntington courtesy of the Yale University Art Gallery, Bequest of Edward Salisbury Dana.)

Brooklyn Polytechnical Institute was established in 1854. The school of applied chemistry established at Yale in 1847 became the Sheffield Scientific School in 1857. Brown, Dartmouth, and Pennsylvania all added technical courses during the 1850s. In Boston, Professor William B. Rogers was making plans for a great technical school, which eventually became the Massachusetts Institute of Technology. For advanced training, however, many students from the East went to Europe, particularly to the German universities or to Paris. The Bergakademie at Freiberg and the École des Mines at Paris had several American students.

From this northeastern area, also, came two great contributions to geologic science. In the realm of pure geology, one of the most important events of these years was the declaration of American independence of European geology by James Dwight Dana in his presidential address to the American Association for the Advancement of Science in 1855.

> It has often been said that Geology is a history, the records of which are written in the rocks, and such is its highest department. But is this appreciated? If so, why do we find text-books, even the one highest in authority in the English language, written back end foremost—like a History of England commencing with the reign of Victoria. In history, the phases of every age are deeply rooted in the preceding, and intimately dependent on the whole past. There is a literal unfolding of events as time moves on, and this is eminently true of Geology. *** From the progress of life, geological time derives its division into Ages as has been so beautifully exhibited by Agassiz. The successive phases in the progress of life are the great steps in the earth's history. What if in one country the rocks make a consecutive series without any marked interruption between two of these great ages, while there is a break or convenient starting point in another; does this alter the actuality of the ages? It is only like a book without chapters in one case, and with arbitrary sections in another. Again, what if the events characteristic of an age—that is, in Geology, the races of plants or animals—appear to some extent in the preceding and following ages, so that they thus blend with one another? It is but an illustration of the principle just stated, that *time is one*. Ages have their progressive development, flowing partly out of earlier time, and casting their lights and shadows into the far future. We distinguish the ages by the culmination of their grand characteristics, as we would mark a wave by its crest.
>
> Divisions of time subordinate to the great ages will necessarily depend on revolutions in the earth's surface, marked by abrupt transitions, either in the organic remains of the region, or in the succession of the rocks. Such divisions are not universal. Each continent has its own periods and epochs, and the geologists of New York and other States have wisely recognized this fact, disregarding European *stages* or subdivisions. This is as true a principle for the Cretaceous and Tertiary, as for the Silurian and Devonian. The usurpation of Cromwell made an epoch in English annals, not in French or Chinese. We should study most carefully the records before admitting that any physical event in America was contemporaneous with a similar one in Europe. The unity in geological history is in the progress of life and in the great physical causes of change, not in the succession of rocks.

In setting up his time scale, Dana accepted Whitney's term "Azoic" for the age without animal life. He questioned the existence of the Cambrian in North America, and proposed Age of Mollusks for the Silurian. Agassiz's Age of Fishes had been equated with the Silurian and Devonian, but the Age of Fishes properly began with the Devonian. Agassiz's Age of Reptiles had extended from the Carboniferous through the Cretaceous, but Dana suggested that Age of Acrogens (or coal plants) be used for the Carboniferous and Permian. The ages were then further divided into periods and epochs, all with American names.

In 1857, the AAAS met at Montreal, and James Hall, as retiring President, addressed the assembly on the geological history of the American continent. The principle of uniformitarianism proposed by Lyell—that existing processes acting in the same manner as at present are sufficient to explain all

James Hall

His report on the fourth district of New York, regarded as the least interesting area, became a classic in geological literature. From 1843 until his death, he dominated the field of paleontology in the United States. The bibliography of his works is among the largest of the world's men of science. Hall's presidential address to the American Association for the Advancement of Science in 1857 was the first enunciation of what became known as the American theory of mountain-building. (Photograph of oil portrait by Daniel Huntington courtesy of the National Portrait Gallery, Smithsonian Institution.)

geological changes—was then widely accepted. William Thomson, better known today as Lord Kelvin, and regarded as the leading physicist of his day, was convinced that uniformitarianism was wrong, that it had ignored the established laws of physics, but he had had little influence on geologists. Hall was perhaps referring to him when he said "I must here protest against that narrow view which has been expressed by some, that Natural History is not a science, and who perhaps believe that mathematical formulae lie at the basis of all science and that these must be used in all their minutiae to reach any valuable result." Geology, said Hall, "may assume to know something of the structure of the earth, not less than the sciences which weigh and measure it; and when the vast accumulations of geological collections in our country shall be reduced to system, and the story of their origin told, we shall learn that there are laws in operation not differing from other natural laws, though seen and studied by different modes." His protest was an early manifestation of a difference of opinion that has not been completely resolved to this day.

Hall's major contribution to geological science at this meeting was his proposal that mountains were not formed by local upthrusts but that original deposition gave direction to mountain chains and that the amount of deposition determined their elevation; in his words, "elevation is due to deposition, and there can be no great degree of elevation without a corresponding amount of previous deposition of sediments." Hall concluded that "uplifting has not produced elevation, but has rendered the strata liable to degradation, by breaking or weakening them along the line of fracture or folding." The same theory, somewhat extended, explained continent making. The currents of the Paleozoic ocean determined the directions of the sediments and consequently of mountain ranges and the outlines of continents. "The progress of the earth from the beginning of animal life to the present time" he equated to "the progress of an ocean bed to its final development as a continent." The audience was bewildered: "The idea was so entirely new, so utterly opposed to prevailing views, that it was incomprehensible even to the foremost geologists." The idea was rejected by leading geologists, but within a few decades, as developed and modified by Hall and others, it was proudly claimed as the American theory of mountain formation.

The North-Central States were increasingly interested in mineral resources, and they were the principal producers of copper and lead. Copper consumption had nearly doubled between 1845 and 1855. By the mid-fifties, 80 to 90 percent of the domestic production was coming from the Lake Superior mines. There were no metallurgical problems with the Lake Superior ores, for the first to be exploited were pure copper. The transportation problems that beset the first mines were eased by the completion of the Sault Ste. Marie Canal in 1855. The Cornwall and Devon mines in England that had been the major sources of world copper began to decline, and experienced Cornish miners began to emigrate in great numbers to the United States. Lake Superior copper commanded a premium in foreign markets, and the United States became an exporter of copper.

In 1856, a new and greater source of copper was discovered in the Lake Superior region. Until that time, most of the Michigan copper had come from the mass copper deposits in the Eagle River and Ontonagon districts. There, the veins that contained the copper cut across tilted lavas and conglomerates; most of the copper occurred where these veins cut amygdaloidal lavas. Prospectors who had moved southward toward the Portage Lake area at first concentrated on searching for vein deposits, although they noted the films of copper around the amygdules. But when the Isle Royale lode was found near Houghton in 1852, more attention was drawn to the area, and in 1856, both the Pewabic and the Quincy Mining Companies, both largely financed by Boston money, discovered the new deposits.

Lead production, however, was insufficient to meet domestic needs. By the mid-1850's, the lead production of southwestern Missouri began to surpass that of southeastern Missouri, but the Upper Mississippi Valley mines were in the doldrums. J. D. Whitney thought that the western lead deposits "could never again attain the importance they once had" and that the deficiency would have to be made up from mines in the Eastern States or from as-yet-undiscovered deposits in the West if the country were to remain self-sufficient. State legislatures in the Upper Mississippi Valley, however, began to think in terms of geological surveys.

The Iowa legislature authorized a State geological survey in January 1855, and J. D. Whitney became the assistant to James Hall. Hall, because of other commitments, did not give full time to the Iowa survey, and what time he did give was devoted to paleontological and stratigraphic matters. Whitney investigated the economic geology, and for much of the time was the acting director. The first fieldwork was done in the coal areas. Demand for Iowa coal had been small because the State was newly settled and Illinois coal was close at hand, but expectations were that as the interior counties were settled, the use of coal would increase and coal mining would become

Iowa was the second trans-Mississippi State to establish a State geological survey, and both economic and general geology were investigated. The Galena limestone was of great importance as the source of the lead ore that had been extensively mined in the vicinity of Dubuque. One of its most characteristic features, according to J. D. Whitney, was its peculiar mode of weathering, which gave to the landscape where it predominated a singularly picturesque character, as shown in this sketch of an outcrop in Catfish Valley. (From James Hall and J. D. Whitney, 1858.)

important. A search was also made for iron ore, with the conclusion that there was little probability of workable ore being discovered. Whitney devoted most of his attention to the lead ores. He concluded that in character the Upper Mississippi Valley ores most nearly approached "gash-veins," although they were in some respects peculiar and unlike anything he had observed in other mining regions. However, it was his opinion that deep mining was not likely ever to prove profitable and that horizontal excavations or drifts were the proper means of exploration. Whether the zinc ores would ever be of value, he said, was a question he was "unable to answer in the affirmative." The Iowa report was published in two volumes (the second devoted entirely to paleontology) in 1858, and the survey was thereafter discontinued. Whitney then went on to study the lead deposits of Wisconsin and Illinois.

In March 1857, the Wisconsin legislature provided for a geological and agricultural survey of the State under the joint control of James Hall, Ezra S. Carr, and Edward Daniels, the first State Geologist. J. G. Percival, who had succeeded Daniels in 1854, had died in 1856. According to Carr, Daniels had hoped to be appointed again, but his political activities had aroused so much opposition that even his own party feared to make the appointment. Carr was at the time promoting the idea of an agricultural survey of the State, so the legislature compromised on a geological and agricultural survey under the threefold direction. Whitney was employed to make a survey of the lead region, and Charles Whittlesey, to explore the country between the Menominee and Oconto Rivers.

Whitney had flatly stated in 1854 that "no one acquainted with the manufacture of zinc ores into metal or oxide would recommend the establishment of works for this purpose in the western lead region, as the business cannot be made profitable, against the competition of the Belgian and Prussian manufactories, except under the most favorable circumstances or situation, and an abundant supply of ore which can be obtained without any considerable mining cost. The zinc deposits of the west do not satisfy these conditions, either as regard quantity or quality of the ores, or the proximity of the fuel." In 1858, after further study, he was less adamant but still not optimistic. Whether there was sufficient ore was a matter which he was "unable to answer in the affirmative." At none of the localities examined in Wisconsin had he found "ore in sufficient quantity and purity to justify the erection of zinc-works."

Minnesota was admitted as a State on May 11, 1858, and the first State legislature considered the possibility of establishing a State survey but settled instead for a reprint of the parts of Daniels' report on Wisconsin that covered areas now part of Minnesota.

Whitney was engaged to make a study of the lead deposits of Illinois by Amos Worthen, who succeeded Norwood as State Geologist in 1858. Worthen was recommended for the position by Dana, Agassiz, and Hall and from his backing might have been expected to pursue pure science more than practical applications. Until 1855, he had been engaged in mercantile pursuits, and geology was an avocation; his professional experience was limited to a brief period on the Illinois survey, where he collaborated with F. B. Meek on stratigraphy and paleontology, and 2 years as Hall's assistant on the survey of Iowa. Perhaps because of his background as a businessman, Worthen thought it wise to undertake studies in both pure and applied geology, and the legislature continued to appropriate funds for the survey, though not always as much as he desired, until 1878.

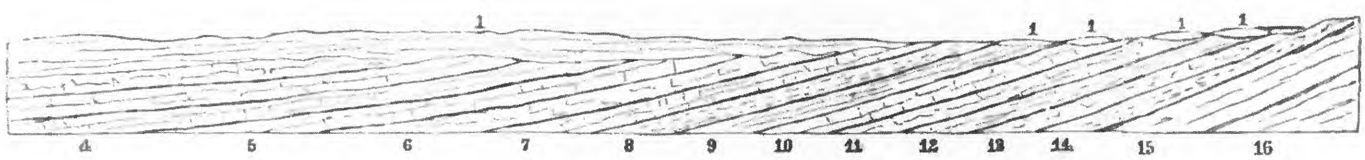
Despite Whitney's doubts about the possibility of zinc production in the Upper Mississippi Valley, a zinc plant was set up at LaSalle, Illinois, by F. W. Matthiessen and E. C. Hegeler, who had come to the United States after graduating from the School of Mines at Freiberg in 1857 and had successfully demonstrated for the Lehigh Zinc Company that zinc metal could be produced from American zinc ores. The financial crisis delayed completion of an agreement with the Lehigh Company, so the two turned their attention to the Wisconsin deposits. They selected LaSalle as the place where the Illinois coal fields were closest to the Wisconsin mines and went into production in 1860.

David Dale Owen was appointed State Geologist when the State of Arkansas established a geological survey, primarily for the investigation of mineral resources in 1857. The State Geologist was required "to make reconnaissance of the State, noting the mining and mineral lands, their geological position, extent, character, and geographical distribution; to examine and collect specimens of the ores of lead, iron, and other metals, of the marbles, granite, limestones, slates, and all other rocks of economic value, as well as the saline and mineral waters of the State." The appointment of Owen was to take effect on October 1 when presumably his Kentucky work would be concluded. The first report, on the northern counties, was published in 1858. In 1859, the law was amended so that as soon as the reconnaissance was advanced enough for the State Geologist to decide which tracts demanded a detailed survey, such surveys were to begin, starting with those that had the best prospects of valuable discoveries.

In 1858, the first attempt began at a systematic survey of Texas under State auspices. B. F. Shumard was appointed State Geologist, but served only until 1860, when he was suspended for political reasons. The only report said that a large share of attention had been devoted to agricultural capabilities and that particular search had been made for minerals of economic importance, including coal and petroleum.

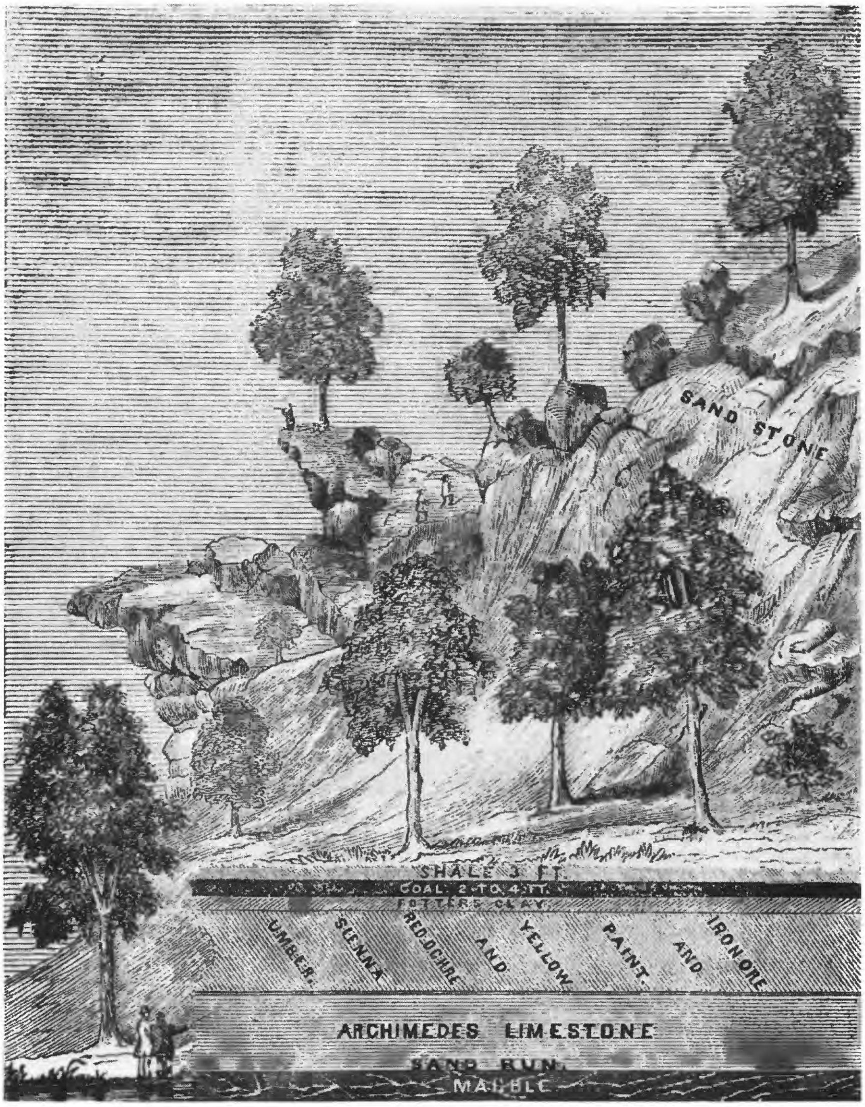
At the Baltimore meeting of the AAAS in 1858, a Committee on the Best Method of Conducting a State Geological Survey was appointed, with George C. Swallow of the Missouri Survey as Chairman, and Edward Hitch-

James Hall's study of paleontology and stratigraphy showed the existence of a major unconformity with coal measures resting directly on strata of Lower Silurian, Upper Silurian, Devonian, and Carboniferous limestone periods. Hall noted that one might expect to discover evidences of ancient denudation other than inequalities of surface filled with coal measures but for the fact that the range of subjacent rocks was so extensive and they were so easily eroded. (From James Hall and J. D. Whitney, 1858.)



1. Coal measures.
2. Kaskaskia limestone.
3. Ferruginous sandstone.
4. St. Louis limestone.
5. Warsaw limestone.
6. Keokuk limestone.
7. Burlington limestone.
8. Chemung group.
9. Hamilton and Upper Helderberg groups.
10. Leclaire limestone.
11. Niagara limestone.
12. Hudson-river group.
13. Trenton limestone.
14. St. Peters sandstone.
15. Calciferous sandstone.
16. Potsdam sandstone.

The figures 1, 1, 1, 1, towards the right hand of the section, show the relations of certain small coal basins to the strata of Lower and Upper Silurian and Devonian age.



The geological survey of Indiana began with a general reconnaissance of the coal strata by Leo Lesquereux. He noted in Martin County a bank of very soft ochrous clay in the same position as the coal, overlaid by a clay iron ore which looked as it if had been roasted, and deduced that the clay bank was the result of destruction of the coal by fire. The mingling of the iron ore with the clay formed several different tints which were then mined for paint pigments. (From Richard Owen, 1862.)

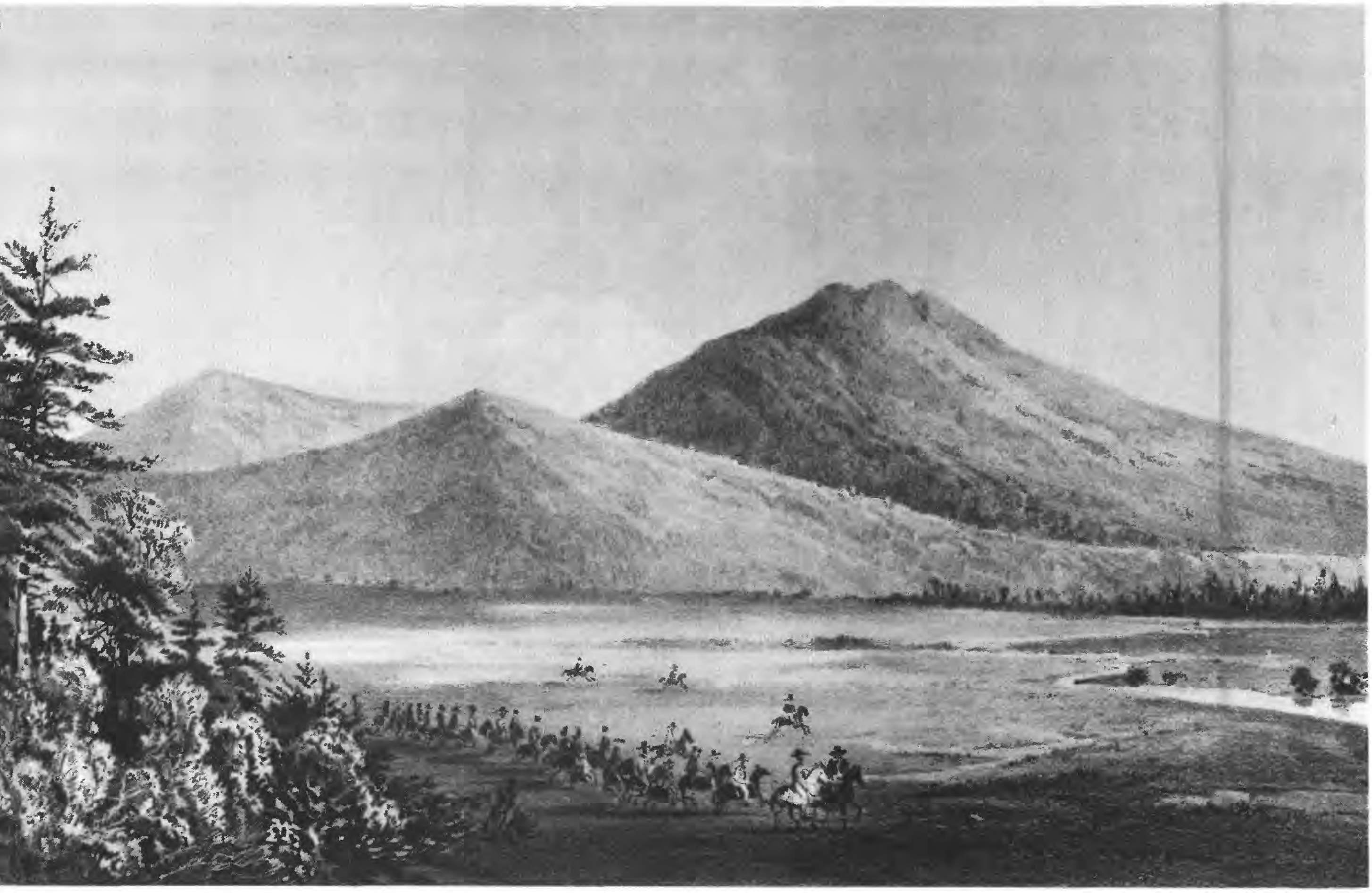
cock, James Hall, Henry D. Rogers, Philip T. Tyson, R. W. Gibbs, Charles T. Jackson, and Oscar M. Lieber as the other members. The committee never presented a report—perhaps never came to an agreement on the best method—although it included six present or former State Geologists. Their ages ranged, however, from 28 to 65, and their education and experience were as diverse as their ages. The chairman himself seemed somewhat unsure of the future of geology. At the 1858 meeting he had presented two papers, one on the rocks of Kansas, which was involved in a somewhat bitter personal controversy between Swallow, F. B. Meek, and Fred Hawn. The second was on grape culture in Missouri, which he concluded by saying that "the vine-clad hills of the beautiful Niangua will vie in wealth with the leaden veins of Potosi and Granby, the purple vintage of Arcadia will compete in golden profits with the glowing furnaces of Iron Mountain."

The two State surveys established in 1859 were primarily for economic purposes. In Michigan, petitions were presented to the legislature in 1858 asking for completion of the survey suspended in 1841, and on February 15, 1859, even though the State Treasury was reported to be in dire straits, the survey was recreated in terms that were almost exactly the same as those of the original survey. Alexander Winchell, professor of physics and civil engineering at the University of Michigan, had been instrumental in securing passage of the law and was appointed director. Winchell was a graduate of Wesleyan in Connecticut in 1847, had taught thereafter in Alabama, and during a brief term as president of the Masonic University at Selma had made geological tours and brought together large collections in natural history. He had been teaching at the University since January 1854. Winchell's first report devoted considerable attention to the salt-making industry and called attention to the gypsum, coal, iron, and other products of the State.

Indiana also wanted a survey, but it wanted its favorite son, David Dale Owen, to head it. When the legislature in 1859 provided for a geological survey under the supervision of the State Board of Agriculture, Owen was allowed to write his own terms, and he accepted the appointment as State Geologist with the understanding that until his Arkansas and Kentucky work was completed, most of the fieldwork would be done by his brother Richard. David Dale Owen died in 1860, so that most of the work fell upon Richard. The principal work was a reconnaissance of Indiana coal areas.

As the population of the North-Central States increased, settlers began eyeing the Sioux country in the northern Great Plains region, and there was a threat of a general Indian uprising. In 1855, General W. H. Harney was sent on a campaign to stop the Sioux from uniting against the settlers. He was accompanied by Lt. G. K. Warren of the Topographical Engineers. In 1856, Lt. Warren continued his exploration into the Yellowstone and Powder River country, this time accompanied by Dr. Ferdinand V. Hayden, a 27-year-old geologist who had been enthusiastically exploring the northern Great Plains region since 1853 when James Hall had sent him along with Fielding Bradford Meek to study the geology and collect fossils for him.

The continuing search for railroad routes in the Pacific coast region by the Topographical Engineers shed new light on the geology of that interesting area. Abbot described Shasta, with its double summit towering far into the region of eternal snow, as the most striking topographical feature of northern California. It was "not only the largest and grandest peak of the long range which divides the sterile interior of the country from the fertile valleys of the Pacific slope" but also "a great centre from which diverge the numerous chains that render northern California one mass of mountains." (From H. L. Abbot, 1855.)



Abbot also took a rather romantic view of Lassen's Butte which "with its snowy crest rose proudly above the surrounding mountains." The peak, previously known as Mount Joseph or Mount St. Joseph, was given the name Lassen by the Topographical Engineers for Peter Lassen, a Danish emigrant, who held a Mexican land grant in the area. (From H. L. Abbot, 1855.)

Hayden, like Newberry and many others, had obtained a scientific education through study of medicine. He was a graduate of Oberlin College in Ohio and had received his M.D. from Albany Medical College. Acquaintance with Hall had led to his interest in geology. Hayden did not have funds to carry on an independent exploration, so he obtained permission to travel part of the time with parties of the American Fur Company, and starting in the spring of 1854, he spent 2 years exploring the valley of the Missouri River from the western boundary of Iowa to Fort Benton, in what is now Montana, and the valley of the Yellowstone from its mouth to the mouth of the Big Horn River. In 1857, Hayden again accompanied Warren on an expedition to the Loup Fork-Niobrara River country of northern Nebraska and then on to the Black Hills.

In 1855, Congress appropriated funds for improvements of roads in the new territories of Kansas and Nebraska. Lt. F. T. Bryan was appointed to oversee construction of a road from Omaha to New Fort Kearney on the Platte River and from Fort Riley to Bridger's Pass through the Medicine Bow Range. Lt. Bryan surveyed the first road in 1855, and in 1856, he left Fort Riley on his expedition to the Rocky Mountains accompanied by Henry Engelmann, a young German who had just migrated to the United States after studying at Freiberg. Not much of the geology of the country along the route traveled was known, and Engelmann observed that the conclusions drawn by others, notably Marcou, were not altogether correct. The most interesting fact was the large development of the Cretaceous along the upper North Platte eastward to the Black Hills. The formation, he reported, contained coal.

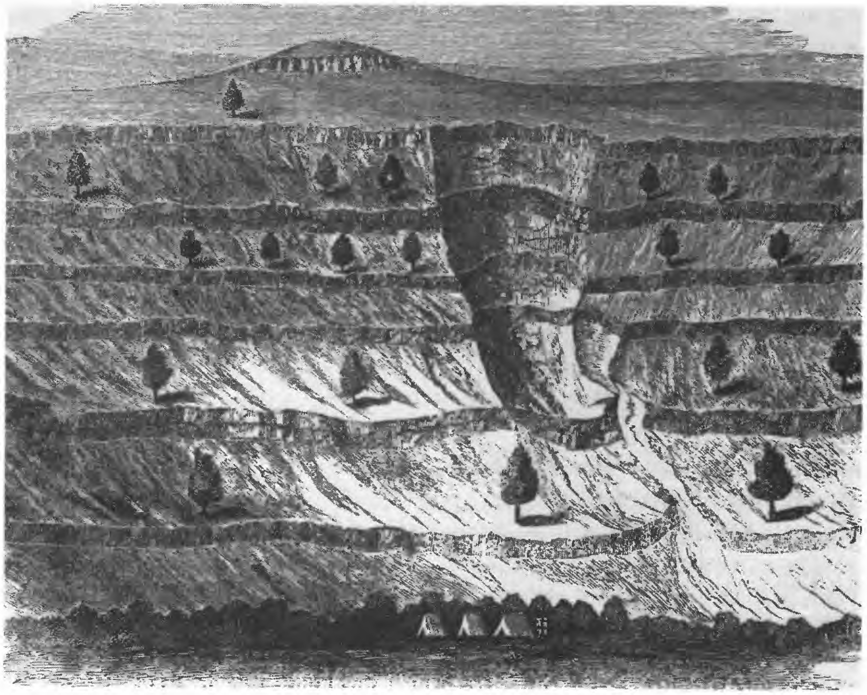
In 1855, the War Department issued a preliminary report on the evaluation of the Pacific railroad surveys. Secretary Davis and General A. A. Humphreys dismissed the Stevens, Gunnison, and Whipple reports in favor of the 32d-parallel route, which the South and the Engineers had favored all along. In the summer of 1855, Captain John Pope was sent out to bore artesian wells where water was scarce on the 32d-parallel route, and Lieutenant R. S. Williamson began a search for a connection between California and the Far Northwest. Dr. George Shumard accompanied the Pope expedition as geologist, and Dr. John Strong Newberry accompanied Williamson.

Both Shumard and Newberry were primarily interested in paleontology. Newberry had grown up in Ohio where his father was one of the pioneer coal operators. He was interested in science as a youth, an interest that was spurred by a visit of James Hall. He had graduated from Western Reserve College in 1846, received an M.D. in 1848, studied 2 years in Europe, and then set up practice in Cleveland. This practice he willingly put aside for an opportunity to do geological research.

In the summer of 1855, also, a surveying party was organized under Major William H. Emory to fix the boundary with Mexico in accordance with the treaty of 1854. Dr. C. C. Parry accompanied the expedition as geologist and botanist. Dr. Parry was primarily a botanist, and the large collection of fossils which he made were referred to James Hall and Timothy Conrad for further work. On the basis of his botanical investigations, Dr. Parry concluded that lack of rainfall made most of the boundary country west of the Rio Grande impractical for agriculture.

The Emory report included two important maps, one of the entire trans-Mississippi west on a scale of 1:6 million, the other a colored geologic map of the Mississippi Valley and the country to the west as far as the Pacific coast compiled by James Hall with the assistance of J. P. Lesley. The geologic map was not the first of the area. Jules Marcou had published, in Boston in 1853, a geological map of the United States and the British Prov-

John S. Newberry, who accompanied H. L. Abbot as geologist, found that the accumulation of modern volcanic matter completely concealed all the underlying rocks and gave "an uninteresting monotony" to the geology of the region. Lassen's Butte, he noted, was evidently a volcanic cone whose fires had not long been extinguished. Its summit was distinctly crateriform, but it was capped with perpetual snow. (From J. S. Newberry, 1856.)



Newberry was, however, interested by the effects of erosion. In the north bank of Psuc-see-que (now Seeseequa) Creek, a tributary of the Deschutes River in Oregon, heading near Mount Jefferson, a series of horizontal layers of tufa and conglomerate is exposed. The conglomerate is composed of pebbles of all varieties of volcanic rock in a matrix which Newberry said resembled Roman cement. As the "beds of concrete" were harder than the associated strata, erosion of the bank produced a series of steps, 30 or 40 feet wide. (From J. S. Newberry, 1856.)

inces of North America that extended as far west as the 106th meridian, and another edition in Europe in 1855, in which he included the whole country from the Atlantic to the Pacific Ocean. Marcou had had limited experience in the West, and he had adopted formation names established in Europe to make possible a comparison with maps of England, Germany, Russia, Scandinavia, and Bohemia. American geologists were severely critical of his maps.

Lt. G. K. Warren compiled a map of the trans-Mississippi West from the results of the Topographical Engineers' work over a period of 15 years and other sources that was a "milepost in American cartography." The scale of 1:3 million was too small, as Lt. Warren admitted, to represent the topography and character of the country except in a general way. The size of some streams and other features had to be exaggerated in order to be shown at all. Many areas were still unknown and marked "unexplored"—the area east of the Three Forks of the Missouri, the Yellowstone country, the area south of the Salmon River and parts of the Snake River Plateau, the Grand Canyon country, the Colorado Plateau region, and sections of the Great Basin and the Llano Estacado. The map was of uneven accuracy. Nonetheless, it has been said that all subsequent efforts "may properly be deemed merely the filling in of detail."

Politically, the years were troubled ones. When the 34th Congress assembled in the winter of 1855, Republicans claimed 108 members in the House, and Nathaniel Banks, Republican of Massachusetts, was elected Speaker. Kansas sent both a proslavery and a Free-State delegate to Washington, and each side drew up its own constitution and awaited admission to the Union. President Franklin Pierce gave tacit support to the South, and the Senate also favored the proslavery elements, but a brutal attack on Senator Charles Sumner of Massachusetts by a southern Congressman enraged the North. In Kansas, John Brown, seeking vengeance for northern lives lost, slaughtered proslavery settlers on Pottawatomie Creek, and thereafter, civil war raged in Kansas.

"Bleeding Kansas" became the chief campaign issue in the Presidential elections in 1856. The Republican party platform upheld Congressional authority to control slavery in the territories, favored admission of Kansas as a free State, and also endorsed a railroad to the Pacific. John C. Frémont was its candidate for President. The Democrats affirmed again the Compromise of 1850 and supported the Kansas-Nebraska Act. However, they deemed it not expedient to nominate its author, Senator Stephen Douglas but chose instead James Buchanan, who had been minister to Great Britain in 1854 and thus was not identified with the Kansas-Nebraska debates. Buchanan was elected, carrying 14 slave and 5 free States, but he received less than a majority of the popular vote, which was divided between Frémont and Fillmore, the candidate of the Whig and American parties.

Buchanan had a difficult first year in office with continuing disorders in Kansas, new problems in Utah, and a financial crisis. Two days after his inauguration, the Supreme Court issued its Dred Scott decision, holding that the Missouri Compromise was unconstitutional on the ground that under the Fifth Amendment, Congress was prohibited from depriving persons of their property, in this case, a slave, without due process of law. The decision lowered the court's prestige among northerners and widened the sectional cleavage.

In Kansas, the Territorial Governor vetoed a plan to enact a constitution guaranteeing slavery without submitting it to a popular vote and resigned on March 4. Buchanan then appointed Robert J. Walker of Mississippi as Territorial Governor, and Walker pledged that any constitution adopted would be submitted to a fair vote.

The Mormons of Utah had been blamed for the massacre of Captain Gunnison's railroad survey party in 1853, and they were distrusted by overland emigrants because of the prices they charged for their supplies. The Mormon Church controlled the local courts in Utah, and Federal judges appointed for Utah found themselves with nothing to do. When they went back to Washington in 1857, the new President decided that the time had come to assert Federal authority. On May 26, he ordered a force of 2,500 men to march against the Territory of Utah, and the Mormons thereupon rallied to protect their homes and families.

In August, the failure of the Ohio Life Insurance and Trust Company set off a severe financial panic, the result of overspeculation in railroads and real estate. Hundreds of banks and businesses were bankrupt.

Early in September, Indians attacked a group of emigrants bound for California, and a group of Mormons, who had reached the point of panic over the approach of the Army, helped the Indians massacre most of the emigrants. In late September, the Mormons began guerilla attacks against the Army itself when it was about 20 miles east of Fort Bridger, and it took until mid-November for the weary troops to accomplish those last 20 miles.

In October, the Territorial elections were held in Kansas, and after the Territorial Governor and Secretary threw out thousands of fraudulent votes, the Free State party was elected by a decisive majority. The constitutional convention, however, instead of arranging to place the constitution as a whole before the people, drafted a special article on slavery to be submitted to popular vote that guaranteed the right of property in slaves already in the Territory no matter which way the vote went. Governor Walker went to Washington to consult with the President, but he upheld the convention, and Walker resigned.

In December and again in January, Kansans voted on the constitution. In the first vote, the constitution permitting slavery won; in the second, it was overwhelmingly rejected.

In February, Buchanan submitted the constitution to Congress, recommending the admission of Kansas as a slave State, and Senator Stephen A. Douglas then led a revolt of northern Democrats against the President. The Senate voted to admit Kansas, but the House did not, so a compromise measure was finally adopted, giving Kansas the choice of accepting the constitution and becoming a State or rejecting it and remaining a territory. In

August 1858, Kansas voters rejected the constitution by an overwhelming vote and remained a territory.

A peace of sorts was also effected with the Mormons in April 1858. The Mormon leaders were offered a pardon, but Brigham Young was replaced as the Territorial Governor. The Army was allowed to enter Utah Territory but had to camp 40 miles from Salt Lake City.

After the Mormon War, several expeditions were sent out to locate trails into Utah over which supplies might be sent to the Army. Lt. J. C. Ives headed one such expedition which was to ascertain the navigability of the Colorado. The expedition first proceeded up the river from its mouth to Black Canyon. The party was then divided, and half went eastward, explored the canyon country, and eventually returned to Fort Leavenworth. Ives concluded that "the region explored after leaving the navigable portion of the Colorado—though in a scientific point of view, of the highest interest, and presenting natural features whose strange sublimity is perhaps unparalleled in any part of the world—is not of much value. Most of it is uninhabitable, and a great deal of it is impassable." John Strong Newberry, who accompanied the expedition as geologist, did not enjoy the river trip, which he described as "slowly crawling along up the muddy Colorado with nothing but the monotony of an absolute desert to feast our eyes upon," but in the canyon and plateau country, he saw what no geologist before him had ever seen. Newberry correctly inferred that the unique topography was the result of erosion and obtained the first geologic section of the area. F. W. von Egloffstein, the topographer, used a new technique of shaded relief to depict the area.

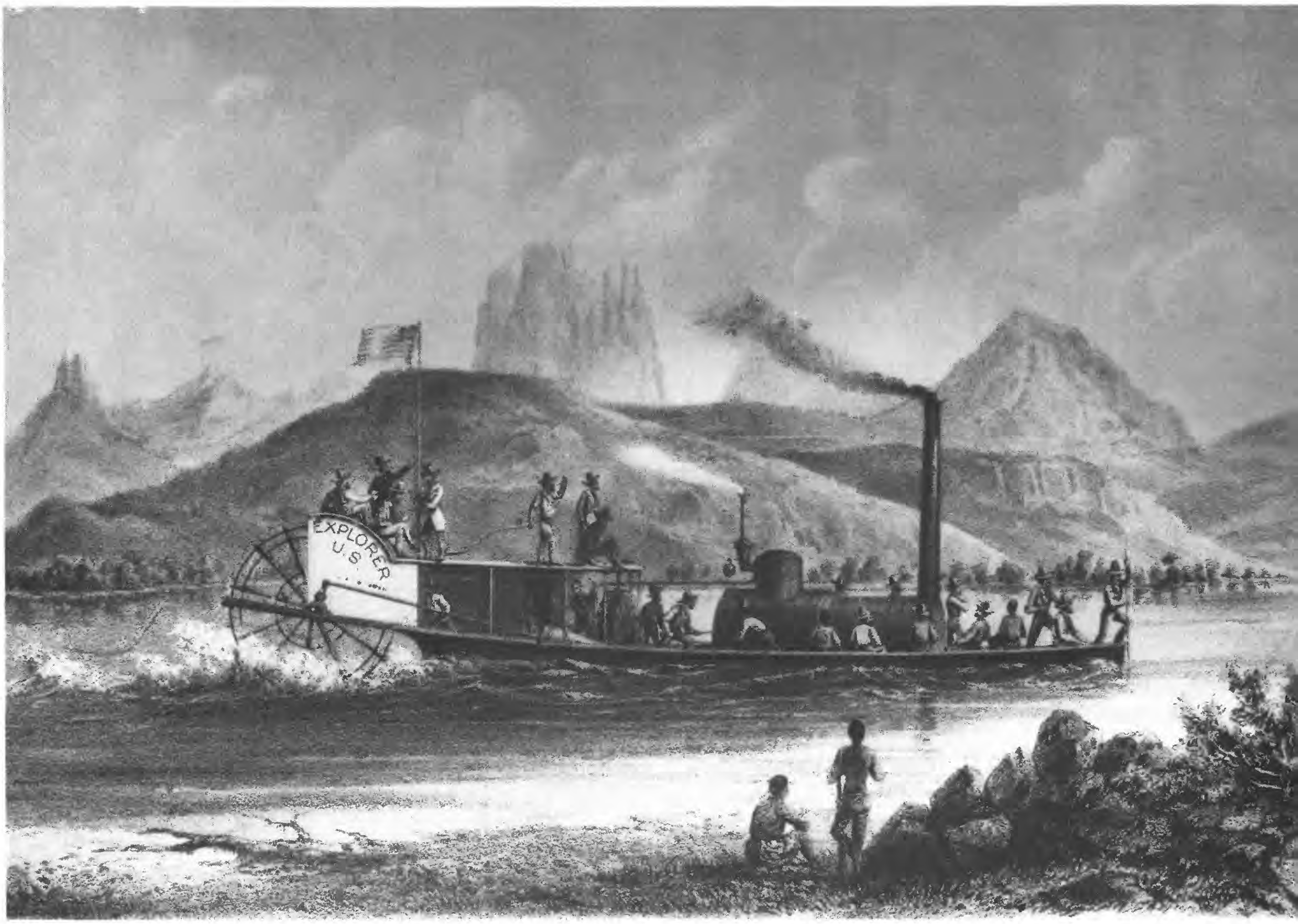
In the summer of 1858, Captain James H. Simpson led an expedition from Fort Bridger to Camp Floyd in Utah Territory, which gave Henry Engelmann a chance to continue his transcontinental profile into the Great Basin. To Engelmann, the trip was "from the western rim of the Green River basin, over the Washitah Mountains, to the eastern part of the Great Basin" and the section comprised "marine tertiary rocks; strata of the cretaceous, particularly remarkable for the coal they contain; igneous rocks of different periods; rocks of the carboniferous formation, and extensive quaternary deposits." Engelmann devoted some attention to Great Salt Lake, which had decreased in size since Stansbury's visit. The decrease he believed to be the result of evaporation.

In the summer of 1859, Newberry accompanied a topographic party under Captain J. N. Macomb, which traveled from Santa Fe to the junction of the Green and Grand Rivers, then down the Colorado River to the San Juan, and thence back to Santa Fe. Newberry was able to obtain a picture of the drainage system, to establish numerous stratigraphic columns, and to extend across a wide area his concept of the plateau country gained from the Ives expedition.

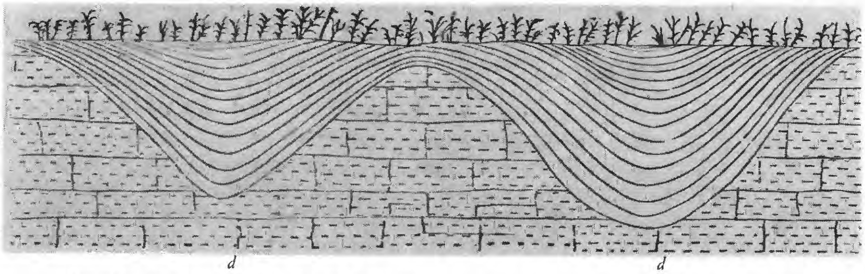
Hayden that summer accompanied an expedition led by Captain W. F. Raynolds across the Northern Plains and into the Wind River Mountains in an unsuccessful attempt to penetrate the Yellowstone country. Although the expedition was unsuccessful in that respect, Hayden added to the knowledge of the geology of the Northern Plains region.

The financial panic of 1857 was followed by a depression that was sharp but short-lived. It had, however, an unfortunate effect on the sectional rivalries. During the depression, the bottom fell out of the cotton market, and southerners were strengthened in their belief that their economic problems were the fault of the industrial East. At the same time, midwestern farmers and laborers were convinced that the spread of slavery must be curbed. Both groups were interested in 160-acre homesteads, suitable where labor was expensive and mechanization possible, but the spread of large southern plantations, based on the use of slave labor, would cut down the amount of land available. Labor was persuaded that the protective tariff, which made American factories profitable, was to its advantage. Thus, ties between the Northeast and Midwest were strengthened. Then within 2 years, the entire economic outlook of the country was altered by a series of remarkable discoveries.

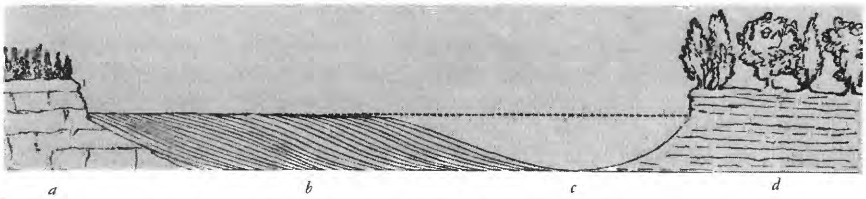
Colorado had been largely bypassed in the great transcontinental migration to the California gold fields in 1849. Most of those who crossed the country traveled along the Overland route through Wyoming or along the Santa Fe trail because the Colorado plains were Indian territory, and the routes through the mountains were not known. Among the few who did pass through Colorado in 1849 was a party of Georgians, some of whom had had experience in placer mining in the Southeastern States. They found gold along Cherry Creek, not far from the present site of Denver, but continued on their way to California where they had some success in mining near Downieville. In 1857, the Georgians sold out their California interests and returned home, but in 1858, they went back to Colorado, to the site of their earlier discovery, and started prospecting along the streams although without great success. A rumor of rich diggings swept the Missouri Valley about this time, and many who were searching for new enterprises because of the depression headed for Colorado. By fall so many converged on the area that townsites were laid out.



John S. Newberry was also a member of the expedition, under J. C. Ives of the Topographical Engineers, that made the first scientific exploration of the canyon of the Colorado, traveling up the river from its mouth in a 54-foot paddle-wheel steamboat, the *Explorer*. (From J. C. Ives, 1861.)



a Surface of bottom lands covered with grass and canes
b Beds of clay and sand horizontally stratified
c Water line of Colorado
dd Channels eroded in *b*, subsequently filled with curved layers of clay and sand



a Old bank covered with small willows, receiving additions from receding channel
b New bank, or sand bar, cross stratified, being added to *a*
c Present channel moving from *a* to *d*; the dotted line representing the surface of the stream
d Oldest bank, being now cut away by current, covered with large cottonwood and willows

Although Newberry did not enjoy the trip upstream on the *Explorer*, he noted that the course of the Colorado "is exceedingly tortuous; and as the water level is subject to great oscillations the channel is constantly changing, and the sediment, with which its current is always loaded, undergoing deposition or removal. The sections of these alluvial deposits formed along the channel afforded me, at the time we passed—the water then being at its lowest stage—many instructive examples of the mode of formation of false bedding and cross stratification so frequently observed in older rocks." The woodcuts shown were based on sketches in Newberry's notebook. (From J. S. Newberry, 1861.)

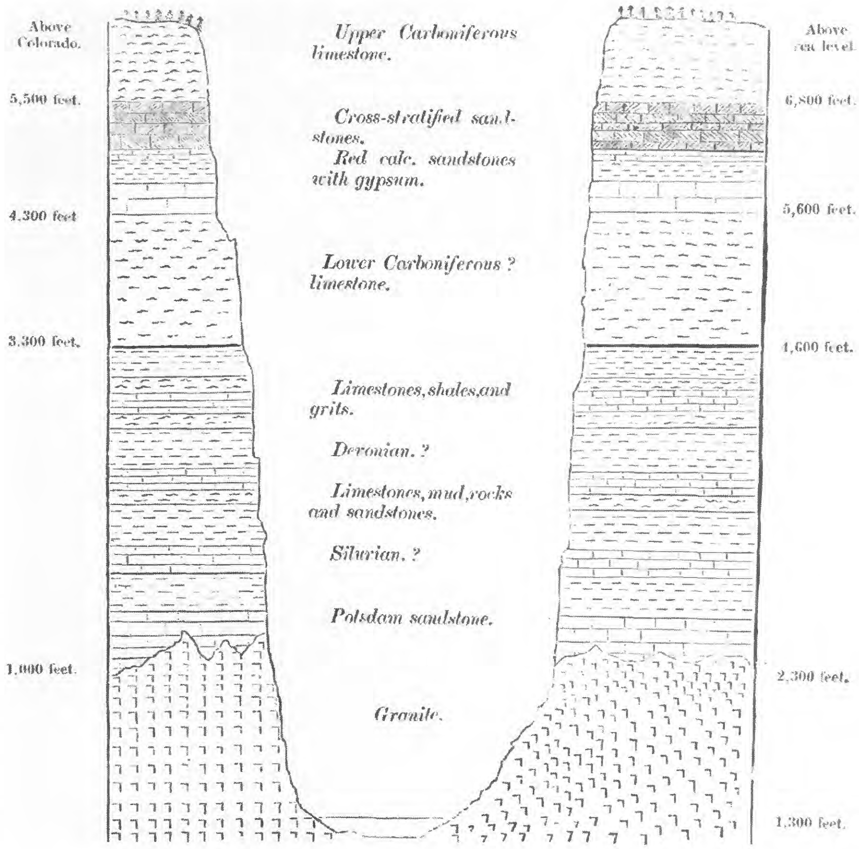
In the spring of 1859, gold was found almost simultaneously on the branches of Clear Creek, at what are now Idaho Springs and Black Hawk; soon afterwards, other veins were discovered. In May, easily worked surface deposits were found. In June, the pattern of mining districts and miners' laws were outlined and adopted, and in July, a provisional local government was formed. Later in the summer, gold was found in South Park, and the rush that followed that discovery was even bigger.

Discovery of the fabulous Comstock Lode on Sun Peak (now Mount Davidson) in western Nevada inaugurated silver mining in the Western States. Prospectors on their way to California in May 1849 had found gold in Carson Valley but not in sufficient quantity to beguile most of them to tarry. The few who stayed on worked their way up the gulches, but by 1857 had pretty well exhausted the gravel in the lower parts of the canyons and in the bars of the Carson River. Though some of the gold was pale in color and worth less than the going rate of $18 an ounce, apparently few thought of the possibility of silver. Among those who did were the brothers Grosch, who had made some assays but who died in 1857 before developing any claim.

The Comstock itself was discovered by other, more picturesque, individuals. James Finney, more commonly known as "Old Virginny," in 1858 fancied the appearance of a ledge of rock on the northeastern slope of the highest peak and claimed it. Two Irishmen, Patrick McLaughlin and Peter O'Riley, who had been working the canyon to the north, crossed over and in May 1859, found gold in a waterhole they dug. Henry Comstock talked his way into a share of the discovery claim by claiming that the area was part of a 160-acre tract he had taken up for a ranch, and the deposit was named for him. When assays made in California in June 1859 showed the ore was rich in silver, the stampede was on.

Rumors of fabulous lost mines in the Southwest had persisted since the days of the Spanish occupation, but the warlike reputation of the Apache and Navajo Indians had been sufficient to keep prospectors away from the area until Federal forts were built in the early 1850's. After Fort Yuma was built at the junction of the Gila and the Colorado, prospectors arrived and found gold about 10 miles upstream on the Gila. When Fort Buchanan was built, 20 miles east of Tubac, Arizona, prospectors swarmed in. Mines in the Santa Rita and Cerro Colorado Mountains were profitable enough to draw a large amount of eastern capital, and Raphael Pumpelly, fresh from the Bergakademie at Freiberg, was employed as a mining engineer. Army officers discovered other deposits, and Lieutenant Sylvester Mowry, who bought a mining property in the Santa Cruz Mountains from them, succeeded in producing silver-lead bullion, which he shipped to England. In 1859, application was made to organize the southern part of the Territory of New Mexico as the Territory of Arizona.

In August 1859, the first oil well in the United States was successfully drilled at Titusville, Crawford County, northwestern Pennsylvania. In the late 1850's, a safe, efficient, and reasonably priced illuminant was greatly desired. Whale oil, commonly used, was unsatisfactory unless refined, and, when refined, was expensive. Oil had long been known on streams in northwestern Pennsylvania and had been found when salt-water wells were drilled. The early settlers thought the oil a nuisance, but the Indians had valued it as a medicine, and of late, the oil had been bottled in small vials for use by country doctors and dealers in patent medicines, among them William Avery Rockefeller. In 1855, Benjamin Silliman, Jr., had prepared a report on the rock oil of Venango County in which he described the first analysis of crude oil, the method of fractional distillation into several components, and the superior usefulness of various components for lubrication, illumination, and the manufacture of paraffin. On the basis of the report, a group of investors was interested in the possibility of obtaining oil in quantity for illumination and decided to try drilling for it. The Titusville well set off a stampede into the area very like the stampede into mining regions. Forests of rickety derricks soon dotted the horizon, wildcat fires burned day and



Newberry also made the first geologic section of the canyon of the Colorado, a section which is remarkable, considering the conditions under which he worked and the state of general knowledge at the time. His Upper Carboniferous is now known to be Permian, the rocks he called Silurian? and Devonian? are now classed as Cambrian and Devonian, but the ages of his Lower Carboniferous? and Potsdam sandstone were correctly identified. (From J. S. Newberry, 1861.)

night, and teams carrying the oil to refineries clogged the roads. The drilling of the Titusville changed the course of world history. Gold with its promise of riches might retain first place in men's dreams for many years, but it now had a rival in "black gold."

By this time, gold mining in California had become difficult and costly. The value of gold produced declined from $81 million in 1852 to less than $46 million in 1859. River mining reached a peak in 1855 and 1856, aided by favorable weather, but thereafter declined, and progress in devising and adapting equipment to quartz mining was painfully slow. News of the Comstock discovery provoked an immediate stampede toward the new diggings, and sentiment began to grow for a State-supported geological survey in California. Newspapers went on record as favoring the idea, and the *North San Juan Hydraulic Press* said,

> **It is generally held that a thorough geological report, from a competent person would place the immense resources of California in a more commanding position before the world's eye, besides resulting in a more systematic method of developing them.**

At this critical time, J. D. Whitney, long interested in California, had completed his work on the lead deposits of the Iowa-Wisconsin-Illinois region and was free to undertake something new. With the support of leading scientists and the aid of his brother-in-law, S. Osgood Putnam, secretary of the California Steam Navigation Company, Judge Stephen J. Field, a family friend and then a powerful figure in California politics, and John Conness, a member of the California State legislature, a bill appointing Whitney State Geologist was passed on April 21, 1860. The law, which Whitney drafted, did not stress the investigation of mineral resources but required him "to make an accurate and complete geological survey of the state, and to furnish *** proper maps, and diagrams thereof, and with a full and scientific description of its rocks, fossils, soils, and minerals, and of its botanical and zoological productions."

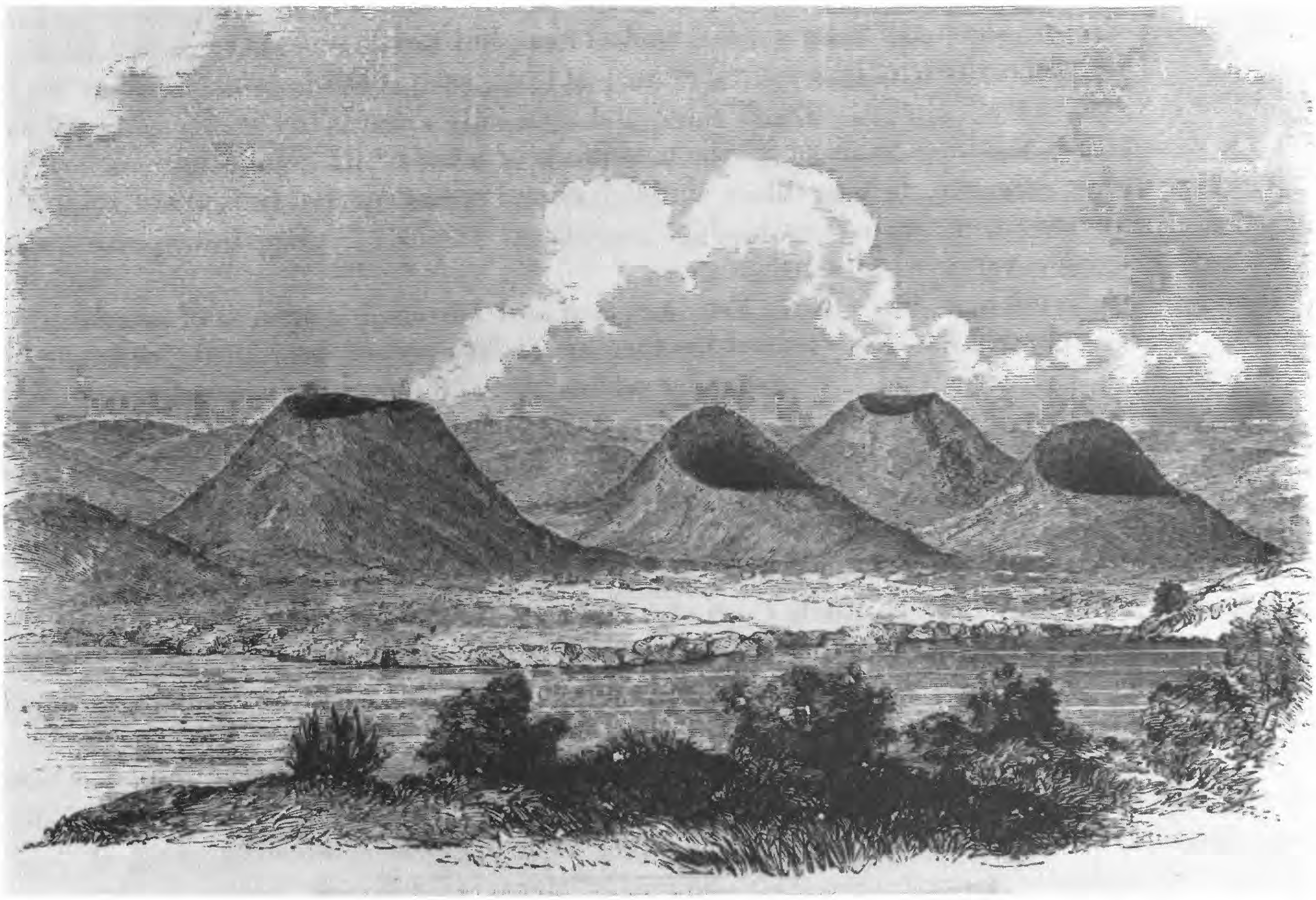
The year of the Comstock, Colorado, and the first oil well was also the year in which, for the first time, the value of the products of U.S. industry exceeded the value of agricultural products. The Middle Atlantic States ranked first in terms of annual value of manufactured products, followed by New England, and the Middle Western States. The Southern States produced less than 4 percent of the total value of manufactured products. In terms of gross value, flour milling was first, but it was followed by the iron industry.

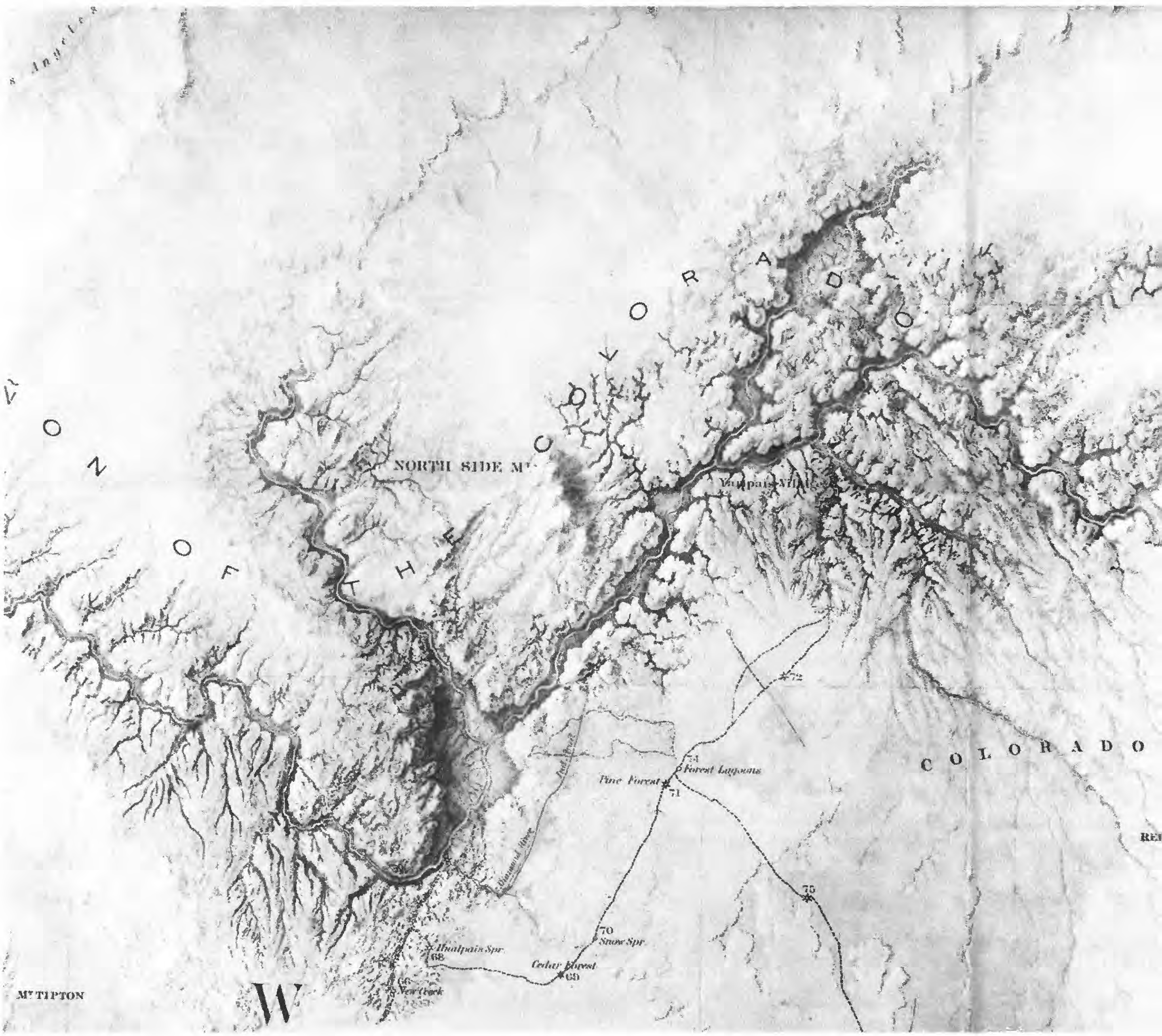
It was also the year that Charles Darwin's *Origin of Species* was published and split the civilized world, not excluding scientists, into opposing camps. Agassiz promptly labelled the idea monstrous, Asa Gray defended it, and William Barton Rogers thought that scientific men should consider it but withhold judgment until all the facts had been assembled. There began then some 20 years of controversy, during which most scientists gradually came to accept at least the major parts of the thesis.

The developments following the events of the climactic year of 1859 were overshadowed by the Civil War and the events leading up to it. The sectional rivalries were very evident in the last session of the 35th Congress, and southern Congressmen, with the aid of the President, were able to thwart some of the greatest desires of the North and West. A bill providing aid to a Pacific railroad by a northern route was resoundingly defeated in the Senate. The President vetoed a bill to make more easily navigable the difficult waters connecting Lakes Huron and Erie, which would have made transportation of western farm products to the East more economical. A bill to raise the level of the tariff failed. The President vetoed a bill to grant public lands to the States for use in establishing colleges of agriculture and the mechanical arts. Southern objections were based on constitutional grounds, but the grants were to have been made in proportion to Congressional representation, so that more would have gone to the more populous Northern States than to the South. A similar succession of events took place in the first session of the 36th Congress which convened in December 1859. Southern legislatures began to talk openly of secession.

On April 23, 1860, two days after California established its State survey, the Democrats met in a national nominating convention, but the southern delegates walked out, and the convention adjourned without nominating a candidate. The Constitutional Union party, made up of remnants of the Whig and Know-Nothing parties, nominated John Bell of Tennessee on a platform upholding the Constitution, the Union, and the enforcement of law. The Republicans nominated Abraham Lincoln of Illinois, generally regarded as a moderate on the slavery question. The Republican platform, written to appeal to both East and West and to radicals and conservatives, supported the principles of the Wilmot Proviso, internal improvements, a railroad to the Pacific coast, a homestead law, liberal immigration laws, and a tariff adjustment to encourage industrial development. The Democrats reassembled in June and nominated Stephen A. Douglas for President. Radical delegates from eight Southern States thereupon walked out again and in a separate convention nominated Vice President John C. Breckenridge of Kentucky for President. Given the division among the parties, Lincoln's election was almost inevitable, and in the voting he carried 18 free States and received 180 electoral votes.

East of the San Francisco Mountains, Newberry found "at intervals the sedimentary rock is covered with erupted materials, basaltic trap, scoria or ashes, and at several points are cones, once minor volcanic vents, and the sources from which these igneous rocks were derived." The sketch shows the most interesting group of these craters on their route. The area is now included in the Sunset Crater National Monument. (From J. S. Newberry, 1861.)





On receiving word of Lincoln's election, the South Carolina legislature called a special State convention to meet on December 20. President Buchanan in his annual message to Congress in December deplored disruption of the Union but stated, after consultation with Attorney General Jeremiah S. Black, that the Federal Government had no legal power to prevent it by force. On December 20, by unanimous vote of the special convention, South Carolina seceded from the Union. Mississippi, Florida, Alabama, Georgia, Louisiana, and Texas followed suit within a few weeks. Delegates from these seven States met in early February, and on February 8, the provisional government for the Confederate States of America was set up, and on February 9, Senator Jefferson Davis was elected President. The Confederate Constitution differed from the 1787 Constitution in a few essential ways on matters other than slavery. The Confederate Congress was forbidden to grant boun-

F. W. von Egloffstein's map of the Colorado Plateau was drawn directly on the plates, thus avoiding the expense of engraving. The system in which light is supposed to fall at an oblique angle upon the objects represented was not new, but von Egloffstein modified it by drawing fine parallel lines on the plate with a ruling machine and exposing the plate to acid in order to obtain different tints by which relief on the light side of mountains and comparative altitudes could be shown. (From J. C. Ives, 1861.)

ties, to pass protective tariffs, or to appropriate money for internal improvements.

On March 2, the United States Congress reestablished protection of industry by enacting the Morrill Tariff, which substituted specific for ad valorem duties and raised duties generally. Kansas had been admitted as a free State on January 29. Colorado, Dakota, and Nevada Territories were organized on March 2, 1861.

On March 4, 1861, Abraham Lincoln became President. On the day following his inauguration, he discovered that the garrison at Fort Sumter in Charleston Harbor would be starved out if not provisioned and, after long hesitation, ordered a relief expedition. On April 12, the Confederates opened fire on Fort Sumter, and on the 14th it was forced to surrender. On the 15th, Lincoln called for 75,000 militia to suppress the insurrection, and on the 17th, Virginia seceded. The western counties of Virginia, tied economically to the Ohio Valley and traditionally opposed to the eastern counties, refused to recognize the secession and formed a provisional State government loyal to the Union; these counties ultimately became the State of West Virginia. Arkansas, Tennessee, and North Carolina also seceded, but the other border States of Maryland, Delaware, Kentucky, and Missouri remained loyal to the Union. By the end of May, all had taken a stand, and the Union was divided.

Most of the State geological surveys were suspended shortly after the war began. The State Geologist of Indiana, Richard Owen, and the State Geologist of South Carolina, Oscar Lieber, joined the armed forces, and Lieber was killed in action. The survey of Maine, established in March 1861, continued through two brief field seasons but was then suspended. Only the surveys of Illinois and California (and California was too far away to become deeply involved in the war) continued beyond 1862.

Most of the Topographical Engineers were recalled from the West and reassigned to armies in the field, where they worked under great difficulties. Dr. Hayden joined the Army Medical Corps, and Dr. Newberry, the Sanitation Corps.

When the military left the Southwest after the beginning of the Civil War, prospectors and miners, with no defense against the Indians, left hastily, and all mining in that area ceased. The Colorado boom petered out early in the war because of difficulties in transportation and the hostile attitude of the Indians.

Chapter 8.
Not From our Permanent Part, 1861–1867

Our national strife springs not from our permanent part; not from the land we inhabit; not from our national homestead. There is no possible severing of this but would multiply and not mitigate evils among us. * Our strife pertains to ourselves—to the passing generations of men—and it can without convulsion be hushed forever with the passing of one generation.**

—Abraham Lincoln

The belligerents were not evenly matched. The South had the greater commitment to the struggle and a great number of able Army officers. The South was also convinced that the North would not fight to maintain the Union and that it could afford to wait, even to lose battles, until the North was worn down. It also believed that the control of the mouth of the Mississippi would swing the entire Mississippi Valley to the Southern cause, although in fact, the building of the railroads had altered the importance of that control. Moreover, the South believed that both Great Britain and France, which were dependent on Southern cotton, would recognize Confederate independence and supply material aid. The North had the greater population and wealth, a balanced economy, better communications and transportation systems, a merchant marine, and a navy. In order to win, however, it had to invade and conquer the South. Many Northerners were convinced that with one good thrust, the Confederacy would be overthrown, and it would all be over in 90 days. A strong minority in the Northern States and many European observers, however, fully expected the Confederacy to win.

The South underrated the North and overrated its own advantages. British sentiment, for example, was actually divided. The working class and most of the middle class favored the North, although the upper classes and commercial interests favored the South. The British Government realized that if substantial aid were offered to the South, Canada might be invaded. On May 13, 1861, therefore, Great Britain declared its neutrality, and other European states followed the British lead.

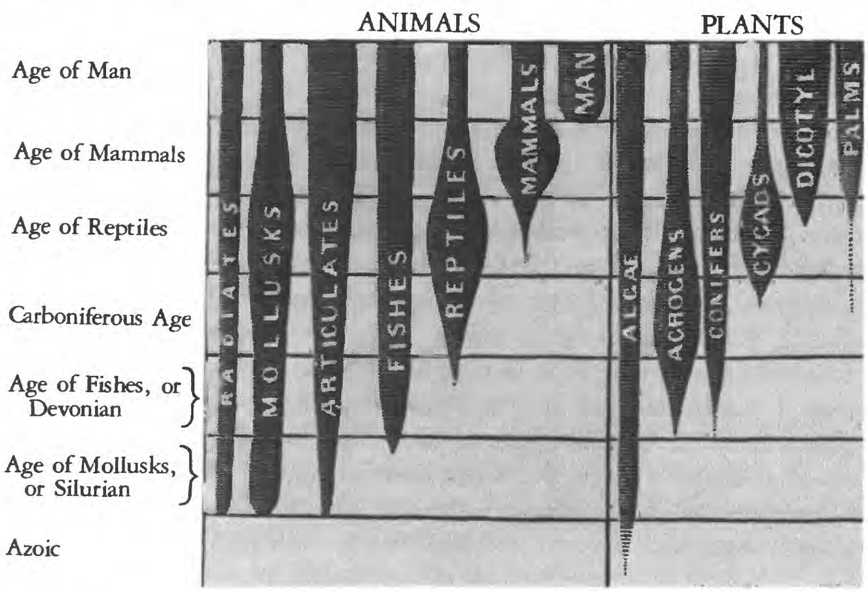
The North had an immense advantage over the South in the development of basic mineral resources. Pennsylvania was still the leading producer of iron, but the rich iron fields of Michigan were also coming into production. Pennsylvania dominated the coal industry and produced nearly three-fourths of the Nation's coal. Michigan was the largest copper producer. Lead was the only problem. Southwestern Missouri was contested territory, and mining there was completely halted at times. Southeastern Missouri was outside the zone of active hostilities, but there were raids and some of the furnaces were destroyed. The price of lead rose from 5.25 to 12.8 cents a pound, but lead production remained insufficient, and in the North, lead was in such short supply that the Union troops made bullets by melting lead gutters of roofs or pewter pots. The precious metals from the Western States and Territories also remained in Union hands, although the Confederate States attempted to gain access to California gold by occupying the southernmost part of the Territory of New Mexico.

At the start of the war, the United States was dependent on Great Britain for a superior iron for gun metal, for although iron ore was abundant, American iron fabrication was inferior to that of Europe. Metallurgy was not yet a science, and improvements were more a matter of experimentation and good fortune than basic knowledge. A. S. Hewitt had experimented with Bessemer steel after Bessemer obtained his patents in 1856 but had abandoned the project when the first attempts were unsuccessful. He had then become interested in the cast steel being made by the Krupp works in Essen, Prussia, and had been experimenting with cast steel bars, hoping to develop fluxing process for making steel at the Trenton mill. Hewitt realized early in the war that if Great Britain intervened on behalf of the South, the arms of the Union troops would be inferior to those of the Confederate troops and decided to combine his experimentation with war work by attempting to produce a superior American gun metal. He gave up all thoughts of steel and concentrated on producing a tough wrought iron similar to the English iron. He was encouraged in this by the War Department, but early efforts met with failure.

Unable to solve the problem of producing an iron equal to the British iron, Hewitt went to England in March 1862, armed with an order for a large amount of iron and a commission from Secretary of the Navy Gideon Welles to examine the principal iron establishments. While in England, he discovered most of the secret British process; just how, his biographer Allan Nevins says, is somewhat of a mystery—whether by use of money, astute detective work in the plants he visited, or by conversing with workmen. According to family tradition, he spent much time in the local pubs making friends with the workmen. In any event, the experiments continued after his return and by fall were so successful that new orders for gun metal were no longer sent to England but to Cooper Hewitt, and Cooper Hewitt supplied all the gun metal for the Union troops for the rest of the war. Secretary Edwin M. Stanton in his annual report for 1863 said:

> **This country, until the present year, has relied upon Sweden, Norway, and England for material to make gun-barrels, bridle-bits, car-wheel tires, and other articles requiring iron of finest quality. The iron of our own production is now superior to that obtained abroad for all these purposes.**

The problem of metal for armament also took Alexander L. Holley to England in 1862, and that trip led to the successful production of Bessemer



James Dwight Dana prepared a *Manual of Geology,* issued late in 1862, which gave for the first time an authoritative summary of the geology of North America. The book was profusely illustrated with woodcuts from various American publications. In this diagram, Dana uses the progress of life as the basis of the subdivision into geological ages. (From J. D. Dana, 1864.)

steel in the United States a few years later. Although Holley is now accounted largely responsible for laying the foundation of the steel industry in the United States, until his trip to England, his chief interest had been railroad engineering. He was a native of Connecticut and a graduate of Brown College in 1853. Since 1853, he had worked for companies engaged in the manufacture of railroad locomotives, published *Holley's Railroad Advocate*, written technical material for the *New York Times*, and served as technical editor of the *American Railway Review*. While in England, Holley made friends with Bessemer and on his return he persuaded Messrs. John A. Griswold and John F. Winslow of Troy to join him in obtaining Bessemer's American patents. The Winslow, Griswold & Holley experimental plant at Troy began operation on February 16, 1865. It was not the first to manufacture steel in the United States. An American company had been formed in 1863 to make steel using patents by William Kelly in conjunction with Mushet's patent on recarburization, and steel was made at an experimental plant in Wyandotte, Michigan, in the fall of 1864. However, the Winslow, Griswold & Holley Company later obtained the Kelly patents, and the Troy plant was the first to be commercially successful.

Neither the United States nor the Confederate Government made any great effort to use science in the war effort, but significant advances were made by the Union forces in surveying and mapping. At the start of the war, the two most powerful men of science in Washington were Joseph Henry, Secretary of the Smithsonian Institution, and Alexander Dallas Bache, Superintendent of the Coast Survey. Although both recognized the connection between science and war, they took their agencies in opposite directions. Henry tried to continue the normal operation of the Smithsonian as far as possible while devoting his personal attention to war-connected problems. Bache proposed the setting up of a military commission to condense information in the Government archives useful to blockading squadrons and to choose objectives for amphibious operation. By this maneuver, the Army and Navy were both given access to the Coast Survey's information and introduced at the same time to an organization that, particularly because of Bache's military background, was capable of aiding the formulation of military decisions. The result was a large and valuable series of maps and charts of rivers and harbors on the Atlantic and Gulf coasts. The Union Army made use of the camera to make multiple copies of maps for use in the field and accumulated a great amount of cartographic and pictorial information that made possible reasonably accurate small- and intermediate-scale maps.

In 1862, without the southern members to cast negative votes, the 37th Congress passed several measures, desired by East or West, which proved to be of great significance for the future of science in the Federal Government. On May 15, 1862, the Department of Agriculture was established, under a commissioner, to "acquire and diffuse *** useful information on subjects connected with agriculture." The law specifically authorized "practical and scientific experiments" as a means of obtaining this information and provided for the services of "chemists, botanists, entomologists, and other persons skilled in the natural sciences pertaining to agriculture." Five days later, on May 20, the Homestead Act offered to any citizen or intending citizen who was the head of a family and over 21 years of age, 160 acres of surveyed public domain after 5 years of continued residence and payment of a registration fee, or after 6 months' residence for $1.25 an acre. On July 1, the Union Pacific Railroad was authorized to build a line westward from Nebraska to Utah to meet the Central Pacific, which was being built eastward from California. And on July 2, the Morrill Act granted to each loyal State and to the Territories 30,000 acres of public land for each senator and representative then in Congress to "provide colleges for the benefit of agriculture and the mechanic arts."

The Secretary of the Interior, Caleb Smith, had proposed establishment of a bureau of agricultural statistics, and Lincoln had endorsed the proposal. The Commissioner of Patents had a more elaborate proposal. Congress went farther than either in setting up an independent bureau which encompassed far more than statistics, and, as A. H. Dupree has pointed out, proceeded for the first time on the assumption that its power to provide for the common defense and general welfare warranted Federal sponsorship of scientific research.

The Homestead Act enormously increased the work and complicated the problems of the General Land Office. There was an immediate expansion of the farming frontier westward, and between 1863 and 1865 about 2½ million acres of farmland were taken up. Most of them, however, were lands that the pioneers had passed over in their westward trek, unforested lands of the great plains where rainfall was insufficient for the familiar methods of farming.

The Secretary of the Interior had also asked Congress to do something about the mineral lands. "The valuable and extensive mineral lands owned by the Government in California and New Mexico have hitherto produced no revenue," he wrote. "All who chose to do so have been permitted to work them without limitation. It is believed that no other government owning valuable mineral lands has ever refused to avail itself of the opportunity of deriving a revenue from the privilege of mining such lands. They are the property of the whole people, and it would be obviously just and proper to require those who reap the advantage of mining them to pay a reasonable amount as a consideration for the advantages enjoyed." The Commissioner of the General Land Office, J. M. Edmunds, proposed that a small appropriation be made for exploration of the interior and western mineral regions. As such an appropriation was not founded on the organic act, he submitted it "to the enlightened judgment of Congress as to the propriety and necessity of affording governmental aid in the development of the mineral wealth of the public domain." Congress did not act on either recommendation.

The 37th Congress in its first session also abolished slavery in the District of Columbia and in the territories. Lincoln at first resisted the demands of radical Republicans for the abolition of slavery, seeking to retain the loyalty of the border States and appealing to them to enact statutes for gradual and compensated emancipation of slaves. On January 1, 1863, however, aware of the public shift toward the radical position on slavery and the need to influence European opinion, he issued a proclamation declaring all slaves in areas still in rebellion "then, thenceforward, and forever free."

In the second session, the 37th Congress faced up to some of the exigencies of war. To finance the war, a national banking system was established, and national banks were required to have one-third of their capital invested in U.S. securities and were in turn authorized to issue notes for as much as 90 percent of such bond holdings. On March 3, the first Conscription Act was enacted, requiring all men between 20 and 45 to register for military service. On the same day, a concurrent resolution branded as "foreign intervention" an offer by Napoleon III to mediate the conflict.

The Secretary of the Interior had again asked for a decision on the mineral lands. The Commissioner of the General Land Office pointed out that an immense revenue could be obtained by subjecting the public mines either to lease under quarterly payments or to a quarterly tax as seigniorage on the actual product, and that such payments "would relieve the necessities of the Republic." Congress did not get around to doing anything about the mineral lands in California or New Mexico. It did, however, organize the Territory of Arizona from the western half of New Mexico on February 24, 1863. When the Civil War began, Confederate territory reached to El Paso, and the Confederate Government was anxious to extend it westward to the Pacific coast and thereby increase its resources by access to the California gold mines. Confederate forces from Texas occupied Mesilla, proclaimed all New Mexico south of the 34th parallel as the Territory of Arizona, and the Confederate Congress recognized the Territory. There were several battles between North and South, but after the summer of 1862, the Union forces were in command. By setting up the Territory of Arizona as the western half of New Mexico, Congress provided a barrier zone between the Confederate States and California gold.

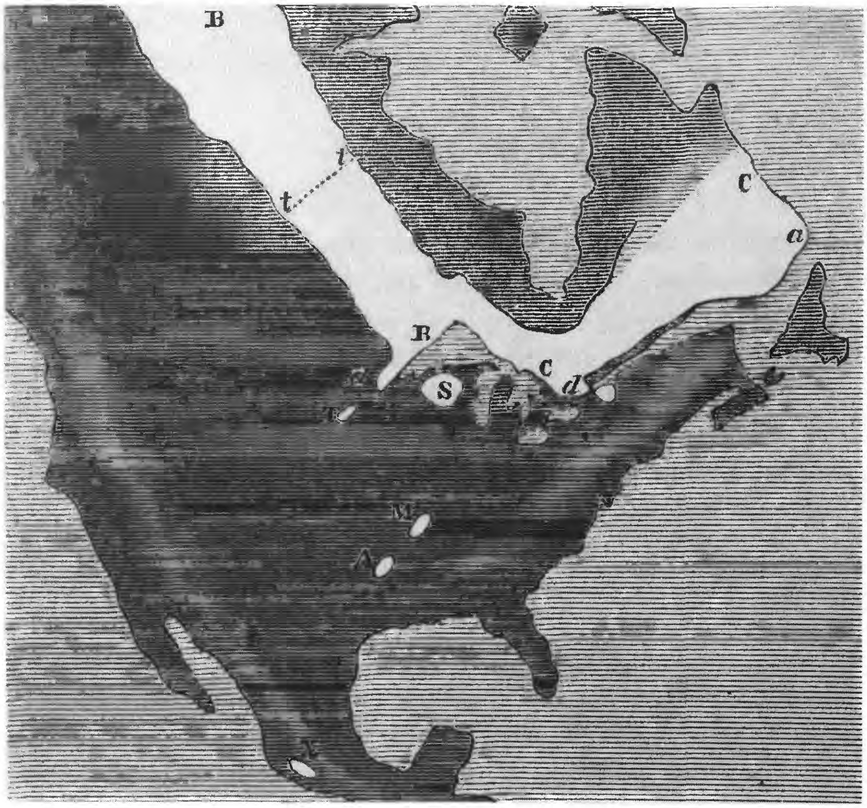
A week later, the Territory of Idaho was organized from parts of Washington, Dakota, Utah, and Nebraska Territories in the flush of early mining successes. When gold mining became difficult in California, prospectors had moved north in search of more easily worked deposits. Gold was discovered near Fort Colville on the Columbia River in 1854, but the Indians halted the rush that followed the discovery. The region was opened up after the Indians were defeated in 1858, but the deposits were soon exhausted, and the miners moved on into British Columbia. The Fraser River deposits in British Columbia were also a disappointment.

The mines at Virginia City in Nevada had also proved to be beyond the capabilities of the individual miner, so the restless pioneers had moved on, hoping to strike it rich elsewhere. Miners moving northeastward from Virginia City met those returning from British Columbia, and together they searched the Northern Rockies for gold. Gold was discovered on the Clearwater in 1860, on the Salmon in 1861, and on the Boise in 1862. Each discovery was followed by an influx of those hoping to capitalize on it, a period of prosperity, and then a decline, but before the decline set in, the Territory of Nevada was established in 1861.

Several new mining towns were also set up in Nevada by miners heading east from Virginia City. Silver was found at Esmeralda in 1860, and the town of Aurora was established. In 1862, ore was found where the overland mail route crossed the Reese River, and the town of Austin was built. Those who arrived later at Austin moved on eastward to establish mining districts at Ione and Cortez. In 1863, Nevada applied for statehood.

During 1863, the National Academy of Sciences was established. Early in the year, Alexander Dallas Bache, Joseph Henry, and Charles Henry Davis, the head of the Navy's Bureau of Navigation, had had some discussion on setting up a "National Association under an act of Congress" which would serve as a central organization for science, but Henry had reservations about getting science involved with politics and politicians; they agreed instead to get as much of an advisory organization into the government as was possible without calling on Congress. On February 11, Secretary of the Navy Gideon Welles set up a "permanent commission to which all subjects of a scientific character on which the Government may require information may be referred" and appointed to this commission Bache, Henry, and Davis.

Bache and Davis, however, were still bent on their "National Association," and three of the Cambridge Lazzaroni came to their aid. On February 19, Louis Agassiz, Benjamin Peirce, and Benjamin Apthorp Gould met with Bache and Senator Henry Wilson of Massachusetts, and out of that meeting came the draft of a bill that established the National Academy of Sciences. The bill was introduced on February 21, and in the midst of debate over financing, conscription, and foreign intervention, and with adjournment im-



In Dana's Azoic map of North America, the white represents dry land during Precambrian time, and the dark areas the submerged portions of the continent. Dana thought that some other areas of dry land might have existed in the Appalachian and Rocky Mountains and that future study would bring them to light. The term "Azoic" used here he later abandoned. (From J. D. Dana, 1864.)

minent, Congress gave it scant attention. It was passed and approved by President Lincoln on March 3.

In addition to naming the 50 original members and giving them power over their own rules and membership, the bill provided that

> **the Academy shall, whenever called upon by any Department of the Government, investigate, examine, experiment, and report upon any subject of science or art, the actual expense of such investigations, examinations, experiments, and reports to be paid from appropriations which may be made for the purpose, but the Academy shall receive no compensation whatever for any service to the Government of the United States.**

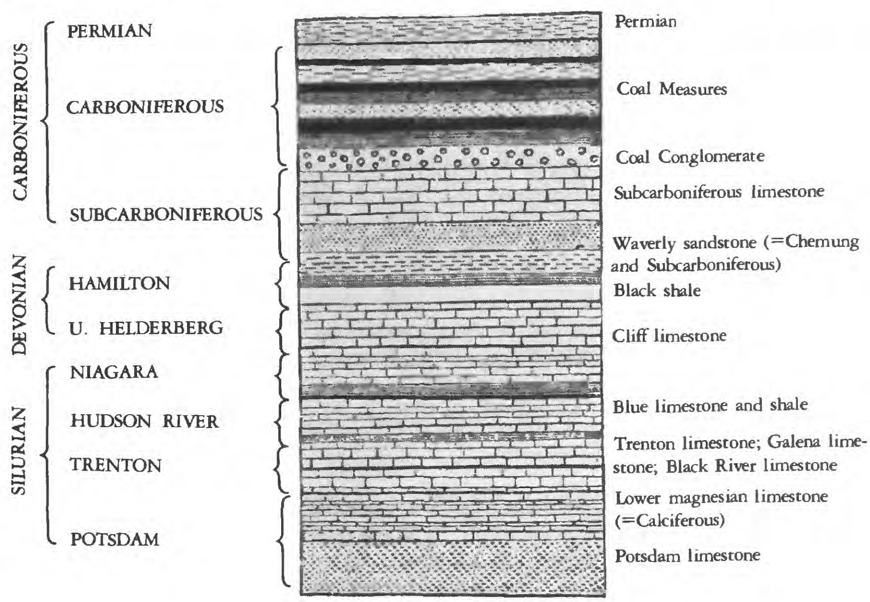
Among the 50 incorporators were several who had been associated with the development of geology and mineral resources. Included, of course, was Benjamin Silliman, then 84, and his son, Benjamin Silliman, Jr., and son-in-law, James Dwight Dana, who, though both Yale professors, typified two different trends in American science. Included also were some of Professor Silliman's students: Edward Hitchcock, the first State Geologist of Massachusetts, and Josiah Dwight Whitney, the most recently appointed State Geologist (California). James Hall of the New York Survey; W. B. Rogers of the Virginia Survey, then President of the new Boston Institute of Technology; and John Henry Alexander of the Maryland Survey who had written the first American book on iron metallurgy were also among the incorporators. Among the younger men were J. S. Newberry, Joseph Leidy, and J. P. Lesley.

Out in California, the Whitney survey had settled down in San Francisco. Brewer had more and more assumed command of field parties, while Whitney divided his time between field and office. Whitney was also busy lecturing the legislature on the value of his work and conferring with State officials about the establishment of a new college to be dedicated to the useful sciences. Charles F. Hoffmann, a young German engineer, had joined the Survey as topographer and was preparing a map of the San Francisco Bay area.

The problem of mapping in California was crucial. Whitney believed that a geologic map must be based on accurate topography. At the time, three different kinds of maps were being prepared. The Coast Survey maps were accurate to a few inches in a hundred miles, but they were made by elaborate triangulation, which sometimes involved a whole season's work at a single station, and were correspondingly expensive. Obviously, California could not afford maps prepared after the manner of the Coast Survey. The General Land Office prepared maps by ordinary chain and compass survey. They were cheaply prepared, one could not count on repeating a determination, and in any event they were not suitable for mountainous topography. Many of the western exploring expeditions used the meander method, measuring distance from a base more or less accurately located. Whitney found these maps least usable. He therefore fell back on a method with which he had experimented in his Lake Superior days, involving triangulation on sharp mountain peaks rather than special signal stations, and then mapping in the intervening country by eye. Hoffmann took Whitney's idea and made it practical, starting a process that revolutionized topographic mapping.

In the early days of July 1863, the tide of war turned. On July 4, the city of Vicksburg, after a long siege, surrendered. Five days later, when Port Hudson, Louisiana, was captured, the entire Mississippi was under Union control. And on July 4, the Confederate army under General Lee had been turned back at Gettysburg. The victories at Vicksburg and Gettysburg also tipped the diplomatic balance toward the North, and by the end of the year, Confederate hopes for foreign recognition and intervention were shattered. At home, the breakdown of the railway system brought hardship and near starvation to some southern cities.

In his annual message to Congress on December 8, Lincoln announced his plan of reconstruction: amnesty, with certain exceptions, to southerners taking a prescribed loyalty oath, and executive recognition of State governments when 10 percent of the electorate of 1860 took the oath and the States agreed to emancipation. Congress had other ideas about reconstruction. Both Arkansas and Louisiana applied for restoration to the Union, but Congress refused to seat their representatives. Instead, shortly before adjourning, it passed the Wade-Davis bill which required a majority of the electorate in



Dana's section of Paleozoic rocks in the Mississippi basin shows the geologic time terms on the left, formation names on the right. When his *Manual of Geology* was published, and for several years thereafter, Dana doubted that Cambrian rocks existed in North America. The term "Ordovician" was not proposed until 1879. (From J. D. Dana, 1864.)

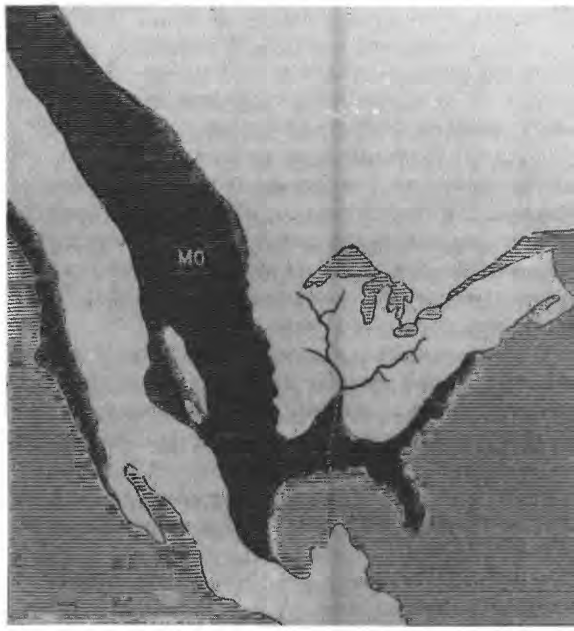
each Confederate State to take an oath of past as well as future loyalty as a condition for restoration. Lincoln pocket vetoed the bill, thereby incurring the wrath of the Radical Republicans.

The Secretary of the Interior, in his report of 1863, stated:

> **At the time of the discovery of the great mineral wealth of portions of the public domain the nation was in the enjoyment of domestic tranquillity and unrivalled prosperity, and could well afford to throw open her rich mine of the precious metals to the unrestricted enterprise of the world; but having now been forced into a war for the preservation of our national existence, as unexampled in expense as in magnitude, the question whether we can, in justice to other branches of industry and enterprise, longer exempt this immense source of individual revenue from its equitable share of the public burden, becomes of much importance.**

There were by then many more mines on the public lands, but the miners were running into problems. The mining frontier had continued to move inland. In 1863, the prospectors crossed the mountains from Idaho into western Montana, and in the following year, gold was found in Summit Valley just west of the Continental Divide. The new camp was named Butte, and $1½ million worth of gold would be washed out of the gravels there in the next 2 years. Montana was organized as a separate Territory on May 26, 1864. Miners continued to move eastward in Nevada, and mining camps were set up at Eureka, Ruby, and Diamond. The Eureka ores were discovered in 1864 but were found to have too much lead for successful milling, so the prospectors continued eastward. The Third California Volunteer Infantry made the first discoveries in Utah. Mining had been slow to develop in Utah because there were no easily worked placers, and the Mormon leaders took a cautious view of mining. Many of the soldiers who were stationed at Camp Douglas overlooking Salt Lake City had seen something of gold mining in California, and their commanding officer, General Patrick E. Connor, encouraged them, whenever they were not busy keeping an eye on Indians or Mormons, in a systematic prospecting of the hillsides. Ore was found at Bingham Canyon in the fall of 1863 and a little later at Little Cottonwood Canyon. Early operations languished, however, because of the difficulty of mining and smelting the ores, the lack of transportation, and the high cost of all supplies.

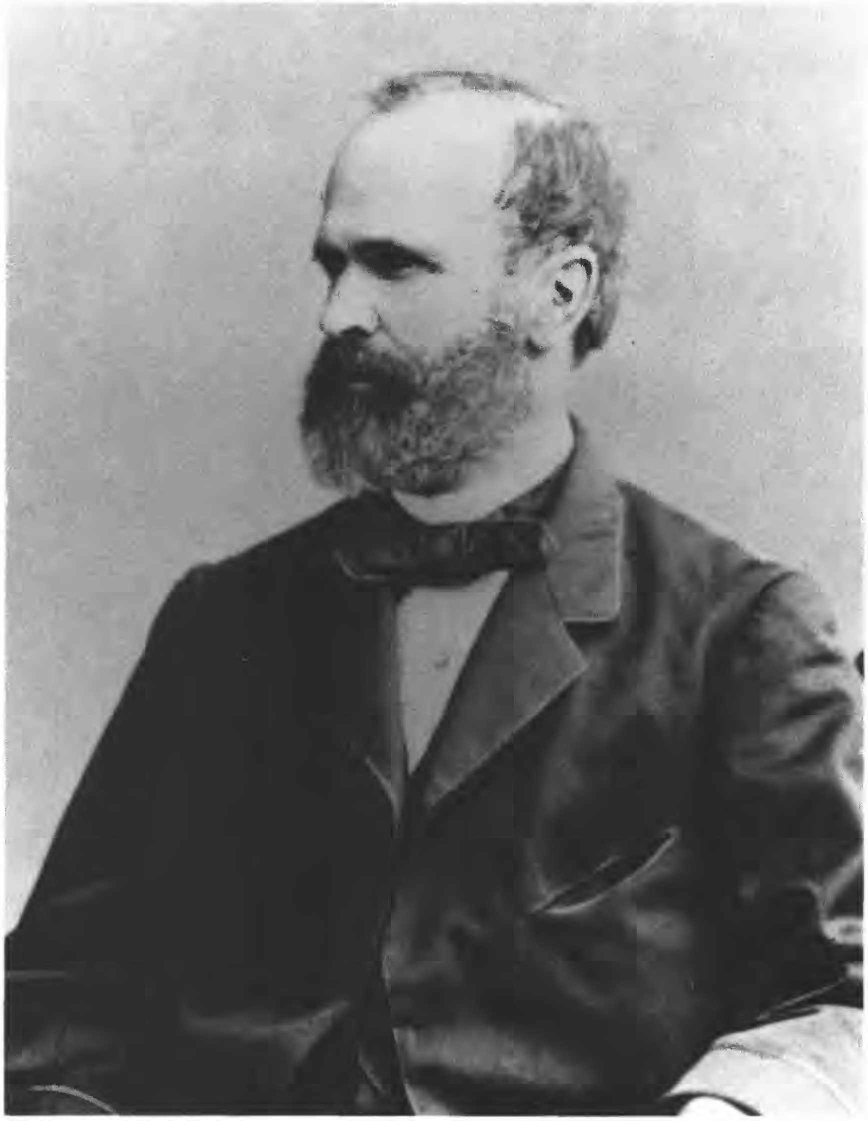
Dana's map of North America in the Cretaceous period shows the great extent of rocks of Cretaceous age believed to exist in the American West. Here the white is dry land, the shaded areas the submerged part of the continent where sediments of Cretaceous age were deposited. (From J. D. Dana, 1864.)



Congress spent some time debating the mineral lands problems. Revenue was needed to pay mounting war costs. The possibility of taxing mine production was considered, but those who opposed taxation said that investment in expensive mining techniques was discouraged by the insecurity of land titles, and anyway the profits were greatly exaggerated. Some proposals were made that the Government appropriate the mines and operate them or supervise their operation. Some thought was given to reserving title to minerals and requiring the claim holders to pay an established tax on profits. None of these measures was passed.

Early in June, the Senate passed unanimously a bill for the disposal of townsites and coal lands on the public lands. Some small discussion took place when the bill reached the House, but when the Chairman of the House Committee on Public Lands explained that coal lands were not to be considered as mineral lands, the House also passed the bill. Sale of coal lands, which had been excluded from sale by the preemption act of 1841, was authorized to the highest bidder, but for not less than $20 an acre. Lands not disposed of in this way were thereafter to be subject to private entry at this minimum price.

By this time, enthusiasm for the California survey had dwindled. No new mineral resources had been discovered, and Whitney had discouraged capital from coming into the State by his negative reports on about half the reported

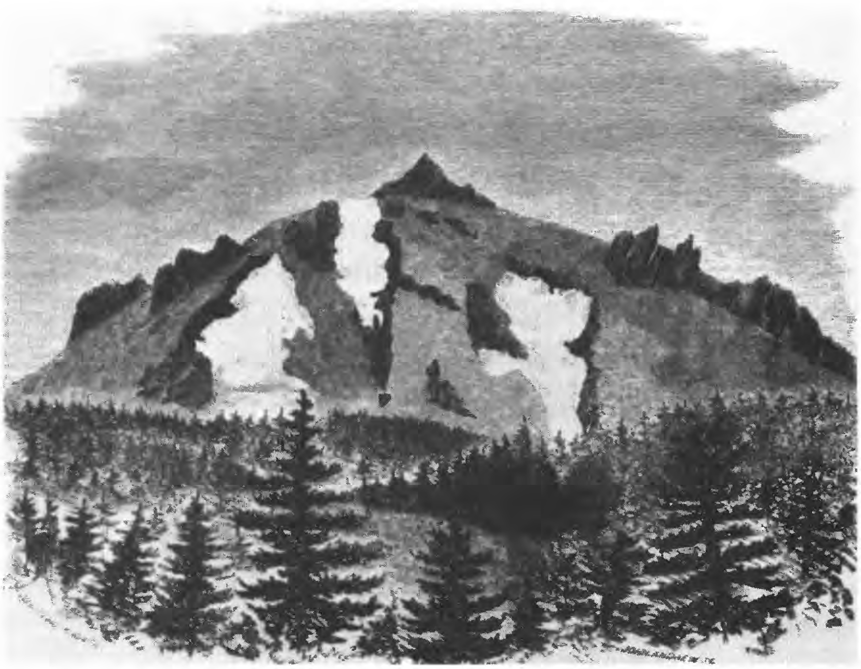


Josiah Dwight Whitney

Whitney's work in the mineral lands of northern Michigan and the lead district of the Upper Mississippi Valley, together with his book, *The Metallic Wealth of the United States*, gave a powerful stimulus to the scientific study of ore deposits in the United States. In the California survey, however, he placed greater stress on basic research and mapping. (Courtesy of the Smithsonian Archives, Merrill Collection.)

strikes he had examined. Some thought that too many easterners were on the Survey and wanted W. P. Blake, the geologist for the State agricultural department, to be made director. According to the California constitution, all offices created by the legislature expired automatically after 4 years. Whitney, therefore, spent only part of the 1863 season in the field, when work began on the western slope of the Sierra, and then headed back to San Francisco to prepare for the forthcoming legislative session. Brewer continued in the field until September and then, his funds low, started back. On the way he met two young men, Clarence King and James Gardner, who had started off on a transcontinental trip, been stranded in Virginia City by a fire in which they lost everything except the clothes they were wearing, and had worked in a quartz mill to gain funds enough to finish their trip. King was a graduate of the Sheffield Scientific School at Yale, and Brewer was easily persuaded to take him on as a volunteer assistant.

When the renewal of the California survey came up for consideration in the spring of 1864, San Francisco was in the midst of a speculative frenzy over Comstock stocks. Almost from the beginning, the Virginia City mines had proved to be beyond the capabilities of the individual miner, for most of those who came lacked experience in lode mining, and almost no one had



W. H. Brewer and Clarence King, who had joined the California survey as a volunteer assistant, twice climbed to the top of Lassen Peak in September 1863. They found that the upper part is an imperfect flattened cone with an elliptical base whose longer axis is at right angles to that of the Sierra. Thus from the valley, Lassen Peak appears to be a very steep cone and from the north and south it looks dome shaped. The sketch was made by King. (From J. D. Whitney, 1865.)

experience in silver extraction. There were, in addition, some unusual difficulties. Underground water flooded the claims, and pumps had to be installed. At somewhat greater depths, the timbers used as simple pillars began to break, and there were cave-ins. Philip Deidesheimer, a young German mining engineer who had previously worked in the quartz mines of California, devised a square set scheme of timbering that solved that problem. It was difficult to extract silver from the complex ores, but in time, the Mexican processes were mechanized into what became known as the Washoe pan process. Then toward the end of 1863, the mines began running out of rich ore and into barren rock. The best apprised stockholders tried to dispose of their shares quietly, but before long, selling became general.

The first report, other than brief progress reports, of the California survey was published in 1864, a volume on paleontology. Some clergymen considered the work blasphemous. A member of the legislature who opposed the survey read random extracts from it as samples of the character of the work being done at public expense. When the new bill was passed, the survey survived, but Whitney's salary and the appropriation for expenses were both cut in half; the agricultural, botanical, and zoological work was discontinued; and Whitney was ordered to devote his time to "a thorough and scientific examination of the gold, silver, and copper producing districts of this State, and to make such scientific and practical experiments as will be of value in the discovery of mines and the working and reduction of ores."

Whitney ignored the restrictions on his work and took King with him on a trip to inspect the Comstock and to help study the rock formations of western Nevada for comparison with those of California. He then left for the East. During the summer of 1864, King, Hoffmann, and Gardner worked under W. H. Brewer's direction in making a systematic survey of the High Sierra. At the end of the season, Brewer left for New Haven where he had been appointed to a professorship in the Sheffield Scientific School.

When King and Gardner returned to San Francisco in September, they were immediately engaged to run a boundary line for a new State park in the Yosemite Valley. On June 30, 1864, President Lincoln had signed a bill granting to the State of California the Yosemite Valley and the Mariposa Grove of Big Trees with the proviso that they be held "for public use, resort, and recreation" and that they "be inalienable for all times." Senator John

Conness, who introduced the bill, said the scheme had been presented to him by several California gentlemen whom he did not identify. One was certainly Israel Ward Raymond, a San Francisco businessman who had been inspired by the beauty of the Yosemite and dismayed by the threatened destruction of the Big Trees for timber; another was Frederick Law Olmstead, who had been largely responsible for the creation of Central Park in New York City and who had come to California in 1863 to manage the Mariposa Estate.

Governor Frederic F. Low appointed a Board of Commissioners, including Olmsted and Raymond and also J. D. Whitney and W. A. Ashburner of the State geological survey. Olmsted prepared a report for his fellow commissioners on the problems involved in which he stressed "the preservation and maintenance as exactly as is possible of the natural scenery; the restriction, that is to say, within the narrowest limits consistent with the necessary accommodation of visitors, of all artificial constructions markedly inharmonious with the scenery or which would unnecessarily obscure, distort or distract from the dignity of the scenery." The report elaborated the policy underlying reservation by the government of a scenic area and provided a philosophic base for the establishment of State and national parks.

In the year that Yosemite Park was created, George Perkins Marsh, then the American Ambassador to Italy, published a volume entitled *Man and Nature* to show that man was fast making the earth uninhabitable by his wanton destruction, waste, and neglect. As a young man, Marsh had seen the damage done in his native Vermont by misuse of the land. He was elected to Congress in 1842 and in Washington had come to know John Quincy Adams during his last years in Congress. Marsh had become an advocate of Government support for science, and Adams had praised his plea for a research-oriented Smithsonian Institution as one of the best speeches ever delivered in the House. In 1849, President Taylor had appointed Marsh Minister to Turkey, which gave him a firsthand opportunity to study the geography of the Middle East. His appointment to Italy gave him the opportunity to set down his observations and conclusions.

Marsh pointed out that there was still "an immense extent of North American soil where the industry and folly of man have as yet produced little appreciable change." It was to be hoped that there, "with the present in-

W. H. Brewer and Charles Hoffmann climbed an unnamed peak in 1864 and named it Mount Silliman after Yale's famous professor. This sketch was made by Hoffmann. (From J. D. Whitney, 1865.)

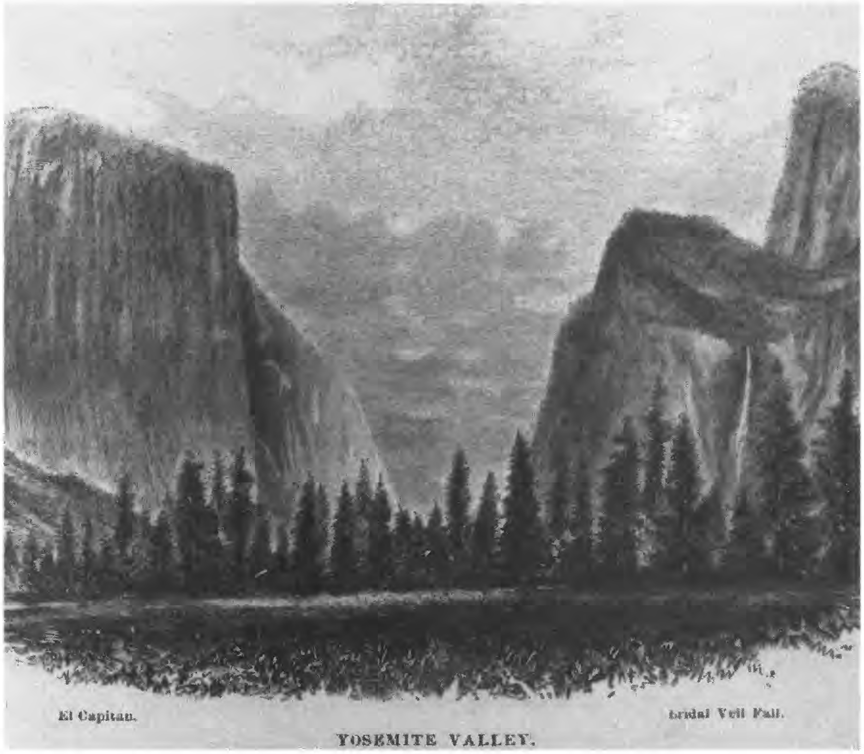
In 1864, Yosemite State Park was created, and Clarence King and his friend James T. Gardner were sent to map it. The two surveyors gazing at Cathedral Peak, in this sketch by Whitney, are not identified but one can imagine them to be King and Gardner. (From J. D. Whitney, 1865 and 1868.)

creased facilities for scientific observations, the future effects, direct and contingent, of man's labors can be measured and such precautions taken in the rural processes we call improvements, as to mitigate evils, perhaps, in some degree, inseparable from every attempt to control the action of natural laws." A more exact knowledge of the topography and climatic conditions of countries where the surface was yet unbroken was urgently needed, but the geological, hydrographical, and topographical surveys already being made in civilized countries were making such important contributions that within a short time there should be enough facts from which "to reason upon all the relations of of action and reaction between man and external nature."

Marsh has been called the fountainhead of the conservation movement, but his contribution was largely doctrinal, whereas Olmsted and Raymond in the same year were attempting to put conservation into practice. In the city of New York, in that same year of 1864, a first step in another form of conservation was taken when the first school of mines in the United States was established. Its founder was Thomas Egleston, a 32-year-old graduate of Yale who had had advanced training at the École des Mines in Paris. Egleston had taken special work in chemistry at Yale, from which he graduated in 1854, and had then gone to Paris. There he attracted the attention of some of the faculty of the École des Mines and eventually took the full course before returning to the United States in 1861. For a while he was employed in sorting and arranging geological specimens at the Smithsonian Institution, work which helped him realize the need and opportunity for schools like the École des Mines in this country. The existing scientific schools were either too general or too specialized to provide adequate training in mining and metallurgy. In March 1863, he published a *Proposed Plan for a School of Mines and Metallurgy in New York City,* which he submitted to the trustees of Columbia College. F. A. P. Barnard, another Yale graduate, who had very progressive ideas on education, became President of Columbia in 1864, and on November 15, 1864, the Columbia School of Mines was opened.

The first dean of the School of Mines was Charles F. Chandler, who had had intensive training in chemistry in Germany, where he received a Ph.D.

This shaded woodcut is an effort to show the grandeur of Yosemite Valley. The distance between the inner edges of the talus on each side was measured by King as a little less than one-half mile. (From J. D. Whitney, 1865.)

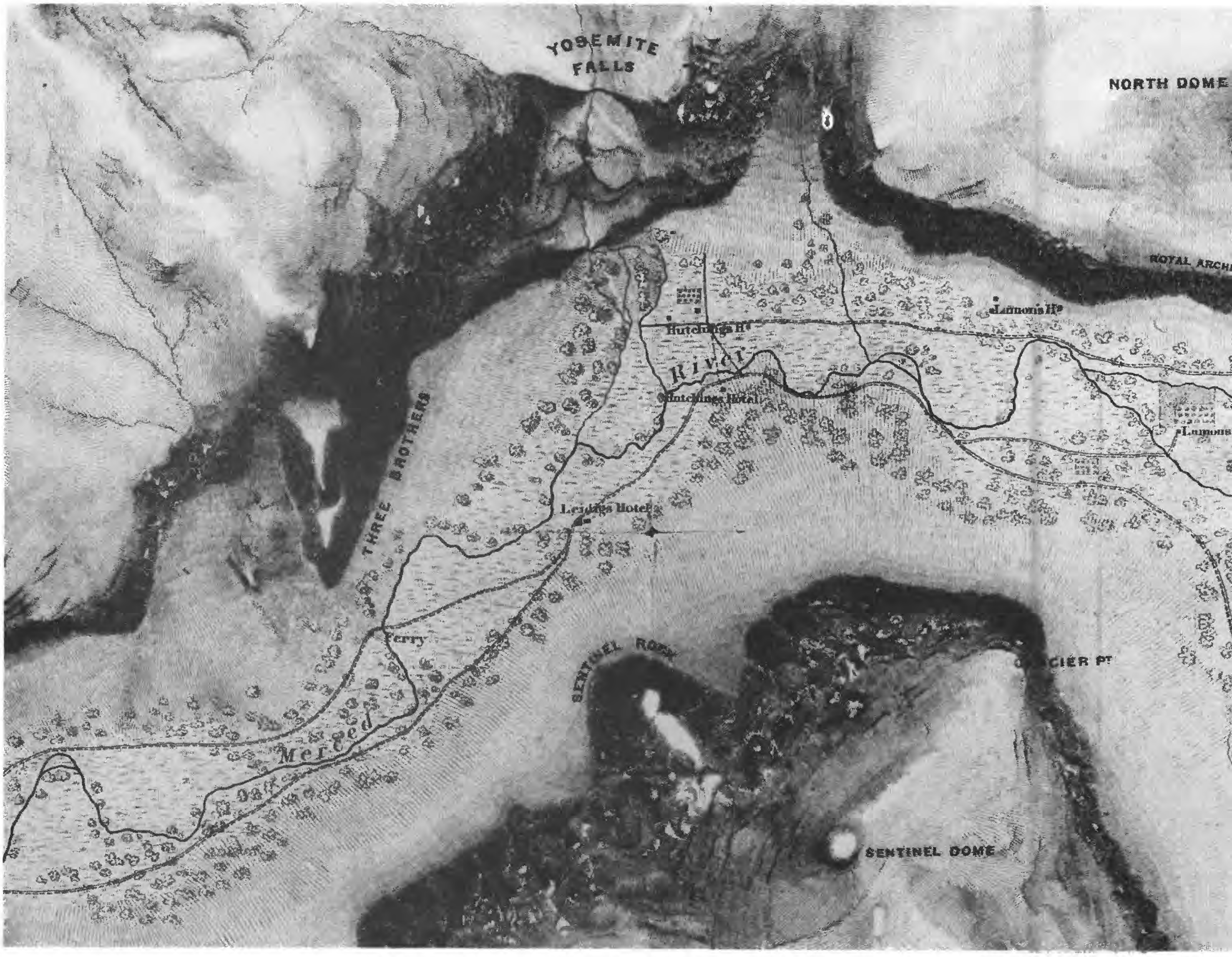


from Göttingen when he was only 20. While he was in Germany, his studies of the distillation of oil from Scotch shales by German chemists led him to suggest that oil from the earth might be used as a substitute for whale oil for lighting. The editor of the *Scientific American* had refused, however, to publish the paper as too improbable. Chandler returned to the United States in 1856, to become an assistant and then professor at Union College, 3 years before Drake drilled his well at Titusville, Pennsylvania.

The School of Mines was an immediate success. By 1871, a writer in the *North American Review* characterized it as "already more scientific than Freiberg, more practical than Paris." Its graduates would play an important role in the development of mineral resources of the country in the next few decades. The Columbia School of Mines was, however, only the beginning. After the Civil War ended, technical education improved rapidly through the operation of the Morrill Act or through private grants. Mining and railroad interests, for example, aided in the development of several mining departments and even the establishment of some colleges.

In the last years of the war, three States took up geologic work, again with emphasis on development of natural resources. The New Jersey survey was a resumption of previous work. Kitchell had felt that his scientific reputation had been injured by the abrupt closing of the survey in 1856. In 1860, he had offered, under the auspices of the State Agricultural Society, to complete and publish at his own expense a geological report and map of the State, obtaining his recompense from sale of the work, but he died in 1861 before completing it. In 1863, George Cook, who had been the assistant geologist, obtained from the legislature authorization to finish the survey on the same terms as those granted Kitchell. Cook presented a report to the legislature in 1864, stressing that the undeveloped resources of New Jersey were immense and only needed to be understood to be appreciated. The legislature requested that the survey be completed within 4 years at a cost not to exceed $20,000, exclusive of publication.

The Kansas legislature in 1864 invited B. F. Mudge, a teacher in Kansas City, to deliver a course of lectures on the geological resources of the State.



Part of the first map of Yosemite Valley made by James T. Gardner and Clarence King in 1864. (From J. D. Whitney, 1868.)

Mudge, who had graduated from Wesleyan College in Connecticut in 1840 and had practiced law in the East until 1859 before moving to Kansas, was deeply interested in natural sciences. After his lectures to the legislature, he was unanimously elected State Geologist. Mudge's first report devoted 10 pages to general geology, 41 to economic geology. He did not foresee much in the way of metal mining in Kansas, gave attention to coal and structural materials, mentioned the petroleum deposits, but gave most of his attention to the salt deposits. Mudge was succeeded in 1865 by George C. Swallow, formerly of the Missouri survey, whose program for the Kansas Geological Survey was first, determination of what rocks occupy the State, then of the mineral and fossil contents of each, character and position of each mineral deposit that might be useful, value and uses to which each mineral deposit might be applied, and suggestions of improvements in mining and working the valuable rocks and minerals.

The State of Minnesota authorized a geological survey in 1864, and the Governor appointed A. Hanchett as State Geologist. Hanchett was replaced in 1865 by Henry Eames, who presented two reports almost wholly devoted to economic matters. Coal was greatly desired in Minnesota, but Eames found no workable coal beds. He noted the immense bodies of iron ores in the northern part of the State, and Richard Eames prepared a report on the Mesabi iron range, which was not published. The Governor said that the region was so remote from transportation it could wait for another generation, and the survey was discontinued after 2 years.

In the election of November 1864, Lincoln won with an overwhelming electoral vote, although his popular majority was only 400,000 out of 4 million votes. The end of the war was a matter of time, and plans were being made for the future. The Secretary of the Interior in his annual report in December 1864 announced that the initial point of the main line of railroad from the Missouri River westward had been fixed at Omaha, Nebraska, and that the definite location of the road for 100 miles west from that point had been approved by the President. The route of the Pacific railroad of California had been selected, and a map of the preliminary location, from Sacramento eastward to the great bend of the Truckee River in Nevada, had been filed in the Department. During the past year, the Secretary said, additional discoveries of precious metals had been made in the region east of the extended ranges of the Sierra Nevada. Because of the remote localities and the difficulty of transportation, little machinery for reduction of ores had been introduced. In the part of Nevada through which the railroad would pass, many rich veins had been found, and it was estimated that with the use of proper machinery, the yield might be $10 million a month. The Secretary asked for an appropriation to enable the Department to have a scientific examination made of the principal mining localities and of the mineral regions generally, and repeated his recommendations of 1863 on the disposition of the mineral lands. Establishment of a bureau of mines he was satisfied would come about in due time. President Lincoln in his annual message on December 4 called the attention of Congress to these recommendations.

By Inauguration Day, the war was almost over. In his very brief second inaugural address, Lincoln said "Neither party expected for the war the magnitude or the duration which it has already attained. Neither anticipated that the cause of the conflict might cease with or even before the conflict itself should cease. Each looked for an easier triumph, and a result less fundamental and astounding" and called on all "with malice toward none, with charity for all, with firmness in the right as God gives to see the right, let us strive on to finish the work we are in ***"

A month later, Lee abandoned Petersburg and Richmond and headed toward Lynchburg, whence he hoped to move by rail to North Carolina to join forces with General Johnston. However, the Confederate forces were virtually surrounded, rations were scarce, and on April 9, Lee surrendered to Grant at Appomattox Court House. On April 11, Lincoln repeated his plea for conciliation. Three days later he was assassinated, and Andrew Johnson became President.

Johnson adopted Lincoln's reconstruction plan with only minor changes, and during the Congressional recess, he recognized the loyal governments of Arkansas, Louisiana, Tennessee, and Virginia, and organized provisional governments for the other seven. Provisional governors were empowered to convene conventions of delegates elected by "loyal" citizens to amend the State constitutions, abolish slavery, and repudiate the State war debt. By December 1865, every Confederate State except Texas had fulfilled these requirements, and in his annual message to Congress on December 6, Johnson announced that the Union was restored.

He reckoned, however, without the Radical Republicans. The 39th Congress refused to endorse Johnson's actions, and appointed a joint committee of six Senators and nine Representatives to examine the issues of suffrage and southern representation in Congress. The joint committee declared that the

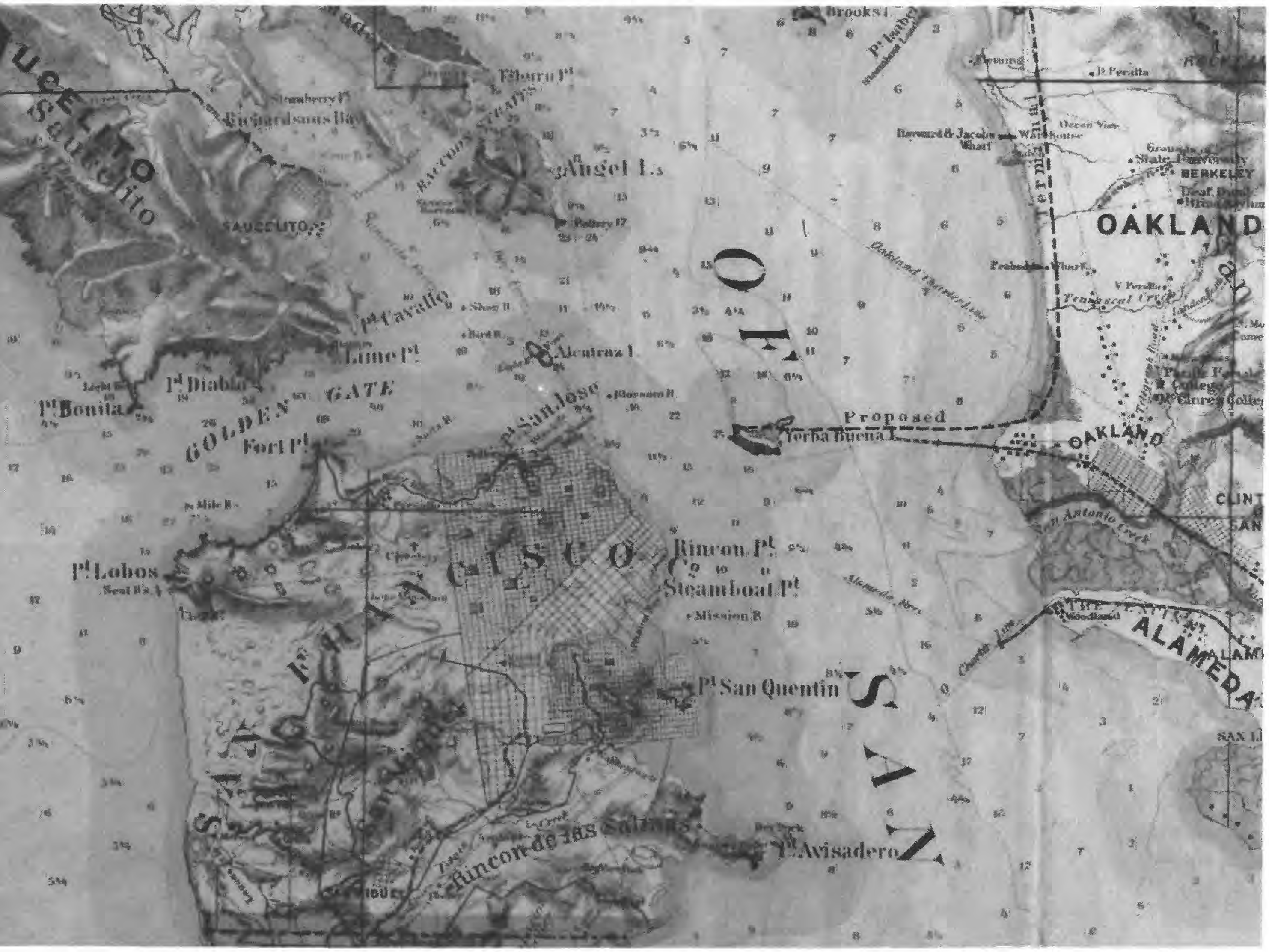
South had no State governments and that Congress alone could restore them and impose such conditions for readmission as it deemed necessary. A Civil Rights Act was passed on April 9, and then the Fourteenth Amendment, formulated by the committee because of widespread doubt as to the constitutionality of the Civil Rights Act, was passed on June 13 and submitted to the States for ratification. Ratification was made a condition for restoration to the Union, but only Tennessee did so. The other States rejected ratification, counting on the Congressional elections to repudiate the Radical program.

In 1865, Secretary of the Interior John P. Usher again asked for the establishment of a bureau of mining, sale of all mineral lands except those bearing the precious metals, and a decision by Congress on means of securing an income from the product of the precious metals from the public domain. "Individual proprietorship," he said, "it is conceded, would stimulate the development of coal fields, petroleum, deposits of iron, lead, and of other gross metals, and mineral formations. There can, therefore, be no sufficient reason for withholding such mineral lands from market." He estimated that 200,000 or 300,000 men were engaged in mining precious metals on the public lands, "without authority of law," paying nothing for the privilege. "The existing financial condition of the Nation obviously requires that all our national resources and the product of every industrial pursuit should contribute to the payment of the public debt. The wisdom of Congress must decide whether the public interest would be better promoted by a sale in fee of these mineral lands, or by raising a revenue from their annual product."

Western mining was in a parlous state after the War, and both houses of Congress established Committees on Mines and Mining. Senator Conness of California, who had been a gold miner for a brief time, was chairman of the Senate Committee; Mr. William Higby, also of California, was chairman of the House Committee. The best known, and perhaps the most highly qualified, member of either committee was undoubtedly Senator William Stewart, Nevada's first Senator. Stewart had entered Yale in 1848 but left in 1850, lured to California by thoughts of gold. Like Conness, he indulged in mining for a time, amassed $8,000, and then abandoned mining for law, which, in his case, proved more profitable. He was admitted to practice in 1852 and was elected district attorney of Nevada County in 1853, where he helped write the first regulations for quartz mining. After the Comstock was discovered, he left California for Virginia City. There he gained fame, or notoriety, for his legal and other tactics during 4 years litigation over Comstock claims, for which it has been reported his annual income was $200,000.

On July 26, 1866, the mineral lands were opened to appropriation and occupation by a bit of fast legislative footwork on the part of the new senator from Nevada. In April, once the Civil Rights Act had been passed, Senator John Sherman introduced a bill to regulate the occupation of and extend the right of preemption to the mineral lands. It was referred to the Committee on Mines and Mining, which reported it out in May with one amendment, and then was passed by the Senate. When the bill reached the House, it was referred to the Committee on Public Lands, where no action was taken on it, as Chairman George Julian preferred the sale of mineral lands at public auction.

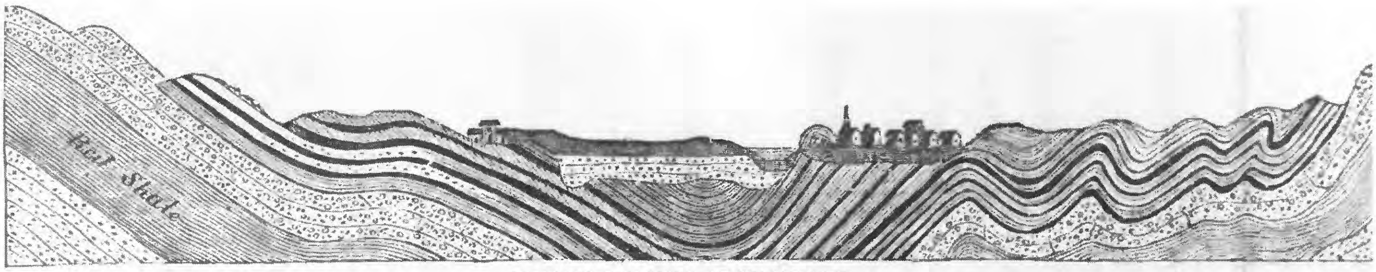
As the end of the session approached, the House passed a bill to authorize a right-of-way over the public lands in California to ditch and canal owners. When this bill reached the Senate, it was referred to the Committee on Public Lands, of which, as it happened, Senator Stewart was also a member. The Senate Committee reported the bill out promptly, with one amendment—the previously passed Senate bill on mineral lands. In the new form the bill was passed by the Senate and referred back to the House for consid-



Charles Hoffmann's map of San Francisco Bay region, on a scale of one-half inch to the mile, is 4 by 3 feet. J. D. Whitney said it had "all the topography correctly represented on it, in as much detail as the scale will allow." (California Geological Survey, 1868.)

eration of the amendment. This time it was referred to the Committee on Mines and Mining, which had sponsored the right-of-way bill, was reported out favorably, and was passed.

The "Act granting the Right of Way to Ditch and Canal Owners over the Public Lands, and for other Purposes" declared the mineral lands of the public domain, both surveyed and unsurveyed, were free and open to exploration and occupation, subject to the local customs or rules of miners in the several mining districts that were not in conflict with the laws of the United States. Patenting of lode-mining claims containing veins bearing gold, silver, cinnabar, or copper was authorized if the claimant had occupied the land and improved it according to the miners' customs and had expended not less than $1,000 in actual labor or improvements. The patent granted the mine "together with the right to follow such vein or lode with its dips, angles, and variations, to any depth." The price was set as $5 an acre; the title was to include no more than one vein or lode, and claims were limited to 200 feet along the vein. The uncertainty of success in mining was noted by a provision that if homesteads had been established and no mines discovered on any lands that had been designated as mineral lands, and therefore excluded from survey or sale, settlers were given the right to preemption and were entitled to purchase the land at $1.25 an acre.



TRANSVERSE SECTION AT WILKESBARRE.

At the beginning of the session, Senator Stewart had also introduced a bill to establish a national bureau of mining. No action was taken on that bill, but on July 28, 1866, Congress had appropriated $10,000 for the collection of "reliable statistical information concerning the gold and silver mines of the Western States and Territories." As it happened, J. Ross Browne, traveler and author, and one of the more colorful figures of mid-19th century America, arrived in Washington in the spring of 1866 to lobby for the California grape growers against a bill to tax domestic wines and, incidentally, to look for a position for himself, perhaps as Indian Commissioner or as an ambassador. Browne had no scientific knowledge of mining or of geology, but he had had some practical experience in the mines and had written articles for *Harper's Magazine* on mining in California, Nevada, and Arizona, which had given him a reputation as an authority. He joined forces with Stewart in promoting the bureau of mining, and when the appropriation for gathering statistics became available, he received the appointment from the Secretary of the Treasury. He was to include in his report a brief historical review of the origin of gold and silver mining, the geological formation of the great mineral belts, the general character of the placer diggings and quartz ledges, the different systems of mining, machinery, processes of reduction, percentage of waste, net profits, population engaged in mining, capital and labor employed, climate, cost of living, number of banks, communications facilities available—and much more. Browne left promptly for San Francisco and by the middle of November had compiled a preliminary report of 321 pages on the mines of California, Nevada, and Arizona.

The North Carolina survey was revived in April 1866. W. C. Kerr had been named State Geologist in 1864, but because of the disorganized conditions in the State, no work could be done. Kerr was a graduate of the State University at Chapel Hill in 1850 and had studied at the Lawrence Scientific School at Harvard while he served as a computer in the Nautical Almanac Office. North Carolina was one of the first of the Southern States to declare its secession ordinance null and void and had abolished slavery on October 7, 1865, as a prerequisite to restoration to the Union. Congress, of course, decreed otherwise, and for several years the survey had to be conducted under unfavorable conditions. Kerr nonetheless investigated agricultural and mineral resources and attempted to advertize them, although much of his work was reconnaissance. Drainage and topography also received attention.

The geological survey of Iowa was reinstituted in April 1866 also, with Charles A. White as director "to give the people of the State the greatest amount of practical information in relation to its resources." White was a New Englander, transplanted to Iowa in 1838 at the age of 12. Opportunities for education in Iowa were almost completely lacking at that time, and White was a self-educated naturalist of the old school, learning by making large collections. His fossil collections served to introduce him to James Hall, F. B. Meek, and Amos Worthen. In 1860, he took up the study of medicine and was graduated from Rush Medical College in 1864. After his

A dozen years after Whitney's book on metallic deposits was published, S. H. Daddow and Benjamin Bannan published a treatise on *Coal, Iron, and Oil.* Daddow was a practical miner and engineer of mines, Bannan the editor and proprietor of the Miner's Journal, and their book was subtitled *The Practical American Miner. A plain and popular work on our mines and mineral resources, and a textbook or guide to their economical development.* The next four illustrations are from their book.

▲

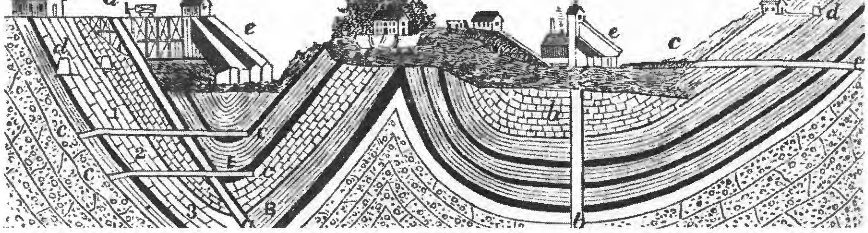
Their ideal section at Wilkesbarre, Pennsylvania, is of the same area as that depicted by Silliman in 1830 (page 35). The growth of Wilkesbarre as well as the increased knowledge of geologic structure is evident by comparing the two, even though Daddow and Bannan said that their illustration "gives a good general impression" but "is by no means exact in proportion or measurement." They also noted certain errors—"the number of basins between Wilkesbarre and the mountain is uncertain, but they run deeper, in all probability, than the section indicates," and the artist had transposed the seams in crossing the basin, and placed more veins on the south than the north side. (From S. H. Daddow and Benjamin Bannan, 1866.)

Iowa appointment, however, he gave up the practice of medicine. White began with a review of the geology of the eastern part of the State so that the coal-bearing strata could be studied with the greatest precision, and he made examinations of the coal deposits of neighboring States before beginning an intensive study of the western part of Iowa and its resources.

In California, funds for the State survey were again running short. In December 1865, King and Gardner were loaned to General McDowell's command in Arizona to make a survey across the Mojave Desert to the Colorado River and on to Prescott to find routes for military roads. In the summer of 1866, King and Gardner were assigned to a survey of the Upper San Joaquin-Merced-Mount Ritter area. During the summer, King received word that his stepfather had died, leaving him responsible for the welfare of 11 people, so he decided it was time for him to strike out on his own. Ever since his transcontinental trip in 1863, he had been planning a survey of his own across the Rocky Mountains and the deserts at their widest. The possibility of making such a survey along the route of the railroads then being built he realized would aid him in getting congressional support. Whitney thought the scheme impractical and offered to put him in charge of the economic geology of the California survey, but he declined and submitted his resignation.

It is evident that in this case the pupil was shrewder than the master. As the result of the Army Act of 1866, the army had a force of only 45,000 men to garrison the South and guard the western frontier where the Indians were on the warpath; three railroads, and several wagon roads were being built; and both settlers and prospectors were headed west in increasing numbers. Manpower was not available to send out expeditions as had been done in the decade before the war to gain the needed information. The Corps of Topographical Engineers had been merged with the Corps of Engineers, and the best the Chief of Engineers could do was assign one of his officers to each of the military departments in the West to make maps, mineral surveys, and wagon-road estimates. Reconnaissances of this sort had been made in the last year of the war in the Department of the Pacific where Colonel R. S. Williamson had laid out military roads in northern California and Oregon. In 1866, he had moved into the Great Basin in an attempt to keep up with the prospectors. King's proposed survey would provide information needed by the Engineers, and they had the funds though not the manpower. When King left for the East, he carried with him a written endorsement from Colonel Williamson.

Colonel Williamson's letter interested General A. A. Humphreys, Chief of Engineers, in King's plan. Professor W. H. Brewer wrote to Secretary of War Stanton endorsing the plan and stressing the lack of reliable knowledge on the region to be spanned by the railroad. After Secretary Edwin M. Stanton consulted General Humphreys, the War Department endorsed the plan. Senator Conness then took up the cause and added an item to an appropriation bill.

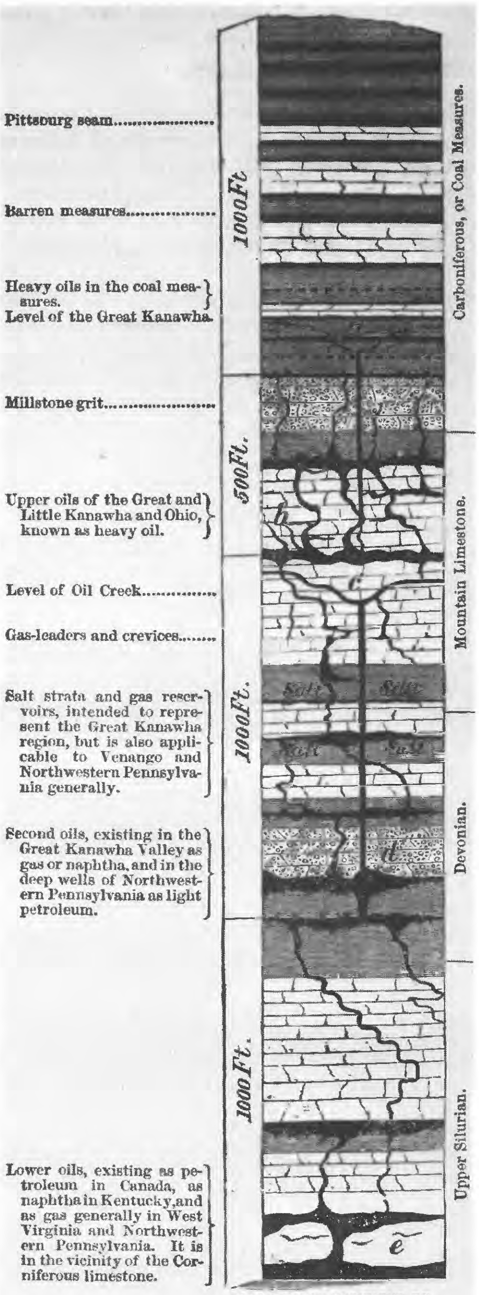


According to Daddow and Bannan, methods of mining in the anthracite coal fields were determined by geological structure. In the deep abrupt basin on the left, a coal seam is opened by slope *a,a.* and the seams above and below are reached by tunnels. The wider and more shallow basin on the right, where the bottom is comparatively horizontal, can be mined more economically by a shaft. (From S. H. Daddow and Benjamin Bannan, 1866.)

This depiction of coal flora reflects the attempt to reconcile geology and theology. Daddow and Bannan suggest that toward the close of the third day in the Biblical account of creation, the air was full of vapor and dust from distant eruptions, carbonic acid was present in water and air, and both air and water were heated by the cooling lava and condensing earth. Such conditions were unfavorable for animal life but produced a vegetation "of the most vast and magnificent description." (From S. H. Daddow and Benjamin Bannan, 1866.)

Congress was occupied during most of the short session with reconstruction legislation. In the 1866 elections, the Republicans captured two-thirds of each house in Congress, giving the Radicals effective control of reconstruction. As all Southern States except Tennessee had rejected the Fourteenth Amendment, Congress acted on the premise that there were no legal governments in the South. On March 2, the next to the last day of the session, the First Reconstruction Act was passed over the President's veto, dividing the South into five military districts subject to martial law and setting the requirements for restoration to the Union. The Command of the Army Act, passed on the same day, virtually deprived the President of command of the army by requiring that he issue all military orders through the General of the Army. The Tenure of Office Act, also passed on March 2, forbade the President to remove officials appointed by and with the advice and consent of the Senate without Senatorial approval.

Congress was so involved in reconstructing the South and battling the President that it gave only scant attention to other matters. Browne's report on western mining was sent to Congress on January 8. Professor G. J. Brush, who reviewed the volume for the *American Journal of Science*, said that it contained "a large mass of important and interesting information" but that "as Mr. Brown is neither a mineralogist, geologist nor miner, we can fairly look in this document only for such information as an industrious collector of facts and an experienced traveler may amass upon almost any subject to which he brings zeal and intelligence." Browne himself recommended that the work be continued but that an experienced geologist be appointed in each State and Territory to send annual reports to a supervising commissioner



GEOLOGICAL POSITIONS OF ROCK-OIL.

Oil was of much more recent interest than coal but according to Daddow and Bannan, oil produced coal, and therefore oil and coal would be found in the same positions, lithological structures, and topographical features. They stated that both petroleum and coal were produced in and from granitic formations as well as volcanic regions and in the stratified fossiliferous rocks of the Paleozoic, but noted that they were, however, limited in volcanic regions. (From S. H. Daddow and Benjamin Bannan, 1866.)

who would visit each mining district and confer with these associates before preparing the report for the Secretary of the Treasury. Congress took no action on the recommendation, and Browne's investigation was simply continued for another year.

Several bills were rushed through in the last days of the session. In the Legislative, Executive, and Judicial bill, approved on March 2, 1867, the Secretary of War was authorized "to direct a geological and topographical exploration of the territory between the Rocky Mountains and the Sierra Nevada mountains; Provided, that the same can be done out of existing appropriations." For the first time, geology would be the principal objective of an exploration of the West under the sponsorship of Congress. As Clarence King later put it,

> **Eighteen sixty-seven, therefore, marks, in the history of national geological work, a turning point, when the science ceased to be dragged in the dust of rapid exploration and took a commanding position in the professional work of the country.**

In the Deficiency Appropriations bill approved the same day, Congress authorized "the unexpended balance of the appropriations heretofore made for defraying the expenses of the legislative assembly of the Territory of Nebraska" to be "diverted and set aside for the purpose of procuring a geological survey" of the natural resources of the new State of Nebraska under the direction of the General Land Office. The appropriation was requested by P. W. Hitchcock, the Territorial delegate, who later became Surveyor-General for Nebraska and Iowa.

Five days later, King received a letter naming him United States Geologist in charge of the Geological Exploration of the Fortieth Parallel. He was told he could expect to receive $100,000 to finance the work for 3 years and was authorized to engage two assistant geologists, three topographic aides, two collectors, a photographer, and necessary camp men. He was also advised by Secretary of War Stanton to leave Washington as soon as possible, for there were four major-generals who wanted his place.

Spencer Baird of the Smithsonian Institution told Hayden of the opportunity in Nebraska, and on April 29, Professor Hayden was appointed to make the geological survey. The amount of funds that would be available was $5,000. The beginning of these two surveys created a new chapter in the history of geology in the United States.

Chapter 9.
The Matter of Highest Concern, 1867–1870

The proper development of the geological characteristics and mineral wealth of the country is a matter of the highest concern to our people.
—Joseph S. Wilson

By 1867, the development of the industrial era was already making radical demands on natural resources. The Commissioner of the General Land Office, Joseph S. Wilson, in his report in the fall of 1866, made a lengthy assessment of the mineral resources of the public domain, considering first, coal, which he called "this element of power and progress." Coal was distributed in the public domain in large quantities. It had long been known, and in many places mined, in Michigan, Ohio, Indiana, Illinois, Missouri, Iowa, and Alabama; deposits had been discovered in Arkansas, Louisiana, Kansas, and California; and traces had been found in Nevada and Oregon, and in the Territories of Washington, Idaho, Montana, Utah, Colorado, Dakota, New Mexico, and Nebraska. Beyond the Plains, along the base of the Rocky Mountains, were the Tertiary coal measures, containing many varieties of brown coal, useful for fuel and steam navigation. These deposits, Wilson said, were destined to be of immense importance in the future settlement of those extensive regions. The wealth of this country in coal was, in fact, beyond estimate. The aggregate of the coal fields of British North America, Great Britain, France, Belgium, Rhenish Prussia, Westphalia, Bohemia, Saxony, Spain, and Russia were reported to be 16,494 square miles, whereas the extent of those discovered in the United States was estimated at 200,000 square miles. Possession of such a deposit led an English writer to forecast a future of almost boundless enterprise and production in America.

Iron, "the most useful of all metals," was also the most generally distributed through the public land States and Territories, and copper was present in immense quantities east of the Mississippi and to a greater or lesser degree west of the Mississippi Valley; lead, zinc, and tin had also been found in several States and Territories. The precious metals, scattered over an area of a million square miles, now yielded an annual product in gold and silver of more than $100 million.

Commissioner Wilson also noted that from a semiofficial report from the Surveyor-General of California it appeared that the petroleum belt in that State extended from Humboldt county on the north to Los Angeles on the south, that in fact, "the sandstone and shale of the whole coast range of mountains in most of these counties is so strongly saturated with petroleum oil as to burn in a furnace." In some localities, especially in the southern counties, oil flowed out of the shale rocks in small rills, one of the most remarkable of which was under the ocean opposite San Luis Obispo and north of Point Concepcion; in calm weather, this rill was said to cover the surface of the sea with oil for 20 miles. Drilling experiments had as yet met with only partial success but sufficient to warrant belief that when adequate capital and machinery were available a full supply would be obtained.

Whitney, the State Geologist, had a different view. He had sent samples of oil to a New Haven chemist in 1862 and had concluded that oil was not present in commercial quantities. In 1864, Benjamin Silliman, Jr., began promoting the sale of stock in companies to develop California oil. Both Whitney and W. H. Brewer attacked Silliman's scheme as fraudulent, and an intensive study by S. F. Peckham of samples from the oil regions that indicated Silliman's samples had been falsified seemed to bear them out.

In the spring of 1867, the United States gained a vast new territory when Alaska was purchased from Russia for $7,200,000. At the time the acquisition was regarded as of little immediate value except as a step in extending the nation's manifest destiny northward.

It was during this highly optimistic era that the Geological Exploration of the Fortieth Parallel received its orders from General A. A. Humphreys. These orders called for a comprehensive survey of both general and economic geology and natural history. The Fortieth Parallel survey was "to examine and describe the geological structure, geographical condition and natural resources of a belt of country extending from the 120th meridian eastward to the 105th meridian, along the 40th parallel of latitude with sufficient expansion north and south to include the line of the Central and Union Pacific railroads and as much more as may be consistent with accuracy and proper progress, which would be not less than five degrees of longitude yearly." They were also to examine all rock formations, mountain ranges, detrital plains, coal deposits, soils, minerals, ores, saline and alkaline deposits, to collect material for a topographic map, and to make collections in botany and zoology with a view to preparation of a memoir illustrating the occurrence and distribution of plants and animals. King was reported well pleased with the orders, as he had written most of them himself.

The Geological Exploration of the Fortieth Parallel was, by reason of the

Clarence King

King, only 25 and 5 years out of Yale, in 1867 led a small group of young men into an area almost unknown geologically to begin the first modern geological survey. (From the files of the U.S. Geological Survey.)

The King survey began its work near Pyramid Lake in western Nevada, which John C. Frémont had sketched in 1842 (page 74). This engraving of the lake with its tufa-encrusted island was made from a photograph by Timothy O'Sullivan, photographer of the King survey, as the halftone process was not yet developed. (From Arnold Hague and S. F. Emmons, 1877.)

training and to a degree experience of its members, a step in advance of any previous expedition or survey. Its chief, Clarence King, was only 25, but he had a degree from Yale's Sheffield Scientific School and 3 years' experience in the California survey under Whitney. As first assistant in geology, King chose James D. Hague, on the advice of Professor Dana. Hague had been graduated from Harvard and had also studied at Göttingen and at the Freiberg Academy of Mines, where he was a contemporary of Raphael Pumpelly. He had been superintendent of the Albany and Boston copper mine in Michigan and was currently professor of mining geology at the Boston Institute of Technology. The second assistant was Arnold Hague, James Hague's younger brother, who had been at Sheffield when King was a student and who had recently returned from 3 years' study at Göttingen, Heidelberg, and the Freiberg Academy. Arnold Hague introduced King to Samuel Franklin Emmons, who had become his friend at Freiberg. King had no authority to hire a third assistant in geology, but Emmons agreed to work without salary, and before long, with biblical certitude, the last became first. Emmons was about 9 months older than King, and his father, like King's father, had been engaged in the East India trade. Emmons had graduated from Harvard in 1861 and then had accompanied his mother and brother to Europe, still undecided on a career. He was strongly attracted to the outdoor life, but his father wanted him to be a professional man. While he was in Paris, he met Eckley B. Coxe, scion of the Coxe family which had extensive coal properties in Pennsylvania, and he had decided on a career in

During the winter of 1867-1868, the King survey investigated the Virginia City mines. Timothy O'Sullivan made the first photographs underground in a mine, burning magnesium wire as a source of light. (Photograph from the files of the U.S. Geological Survey.)

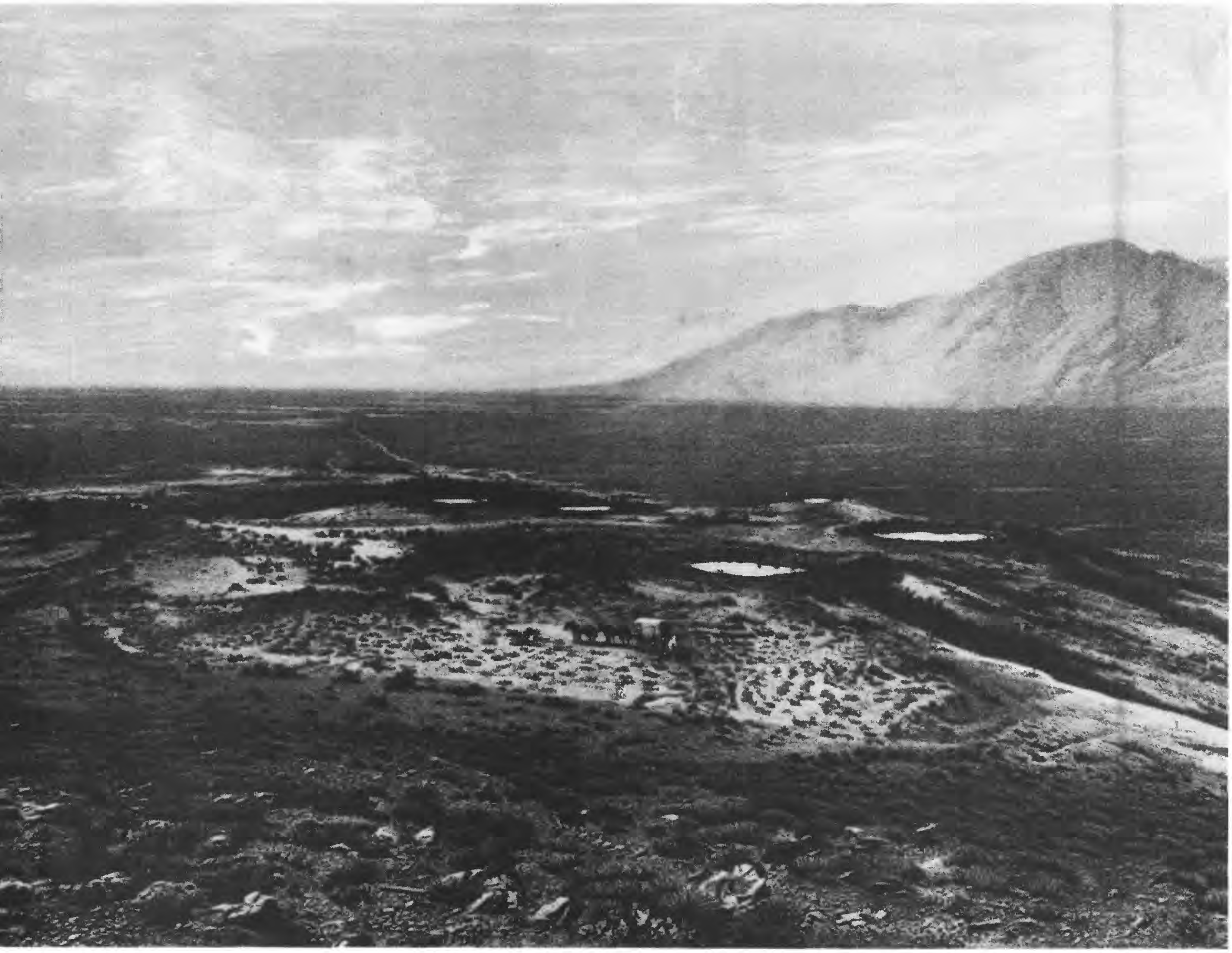
mining engineering. Emmons had then spent 2 years at the Paris Ecole des Mines and another 2 years at the Freiberg Academy. James Gardner, King's long-time friend, who had learned the art of mapping under Hoffmann in the California survey, became the first assistant in topography. The second topographer was Henry Custer, who had worked with the Northwest Boundary Commission, and the third, F. A. Clark, who had done surveying in the Yosemite. The zoologist of the party was Robert Ridgway, an ornithologist who had been recommended by Professor Baird of the Smithsonian Institution, and the botanist, W. W. Bailey, came with the recommendation of Professor Asa Gray of Harvard. For photographer, King chose Timothy H. O'Sullivan, who had helped Mathew Brady photograph the war.

King's plan, Emmons later remarked, "contained much that was novel and startling, especially in consideration of the desert character of the region in which it was to be carried out." It included a topographic map, controlled by systems of primary and secondary triangulation with relative elevations to be determined by frequent observations of cistern barometers, as a base for the geologic map. The area to be surveyed, which was always to include the line of the projected railroad, was divided into rectangular blocks, each about 165 miles long by more than 100 miles wide, which were to be mapped on a scale of 4 miles to the inch.

The party began work at the east base of the Sierra Nevada in 1867 and spent the following winter in Virginia City in a study of the Comstock where the mines were then about 1,000 feet deep. O'Sullivan made the first photographs ever taken in an underground mine. In the summer of 1868, the work was more systematized. King divided the work among several parties, each consisting of a geologist and a topographer, all of whom worked an unusually long season, and the Survey was carried across the Great Basin to the western shore of Great Salt Lake. There remained the survey of the desert ranges of Utah, the Wasatch Range, and the western end of the Uinta Mountains to complete the work as planned. The Chief of Engineers was so pleased with the efforts of the first 2 years that he raised King's salary to $360 a month, the highest of any civilian employed by the Engineers and the equivalent of a full colonel on field duty.

During the 1869 season, the work was again divided up, and three parties took the field, one to study the desert area south of Great Salt Lake, one to make a marine survey of the lake itself, which had risen 9 feet since Stansbury's survey of 1850 and now had a completely new outline, and the third, led by King himself, to search the ranges north of the lake for the outlet of ancient Lake Bonneville. Later they moved eastward, and one party proceeded through the northern Wasatch, another by way of the Provo River to the canyons of the Duchesne and northward to the crest of the Uintas. King himself took the middle course, following the railroad route through Echo Canyon to study the coal measures and thence to the Bear River and along it to its headwaters in the Uintas, where the spectacular scenery of the glaciated mountains made a profound impression on him.

In what is now the Trinity Range, the King expedition geologists observed a series of high ridges of eruptive rocks exhibiting a variety of rhyolitic forms. To one ridge they gave the name Karnak from its resemblance to the ruins of the many-columned Egyptian temple. (From Arnold Hague and S. F. Emmons, 1877.)



In Dixie Valley (which the King survey called Osobb Valley), on the east slope of the Stillwater Range in Churchill County, Nevada, the party observed a group of hot springs, each of which had a rim of calcareous tufa around it. The temperature of the hottest spring was 160° to 185° F., but several were reported to have temperatures agreeable for bathing. Timothy O'Sullivan's photographic outfit is near the center of the picture. (From Arnold Hague and S. F. Emmons, 1877.)

In mid-August the new fieldwork was completed, and the party moved back to Salt Lake City, auctioned off their surplus equipment, and continued westward across the Utah basin, reviewing their previous work, until at the end of September, the season was officially closed. Ahead of them there remained, or so they thought, only the preparation of reports. They settled in Washington to prepare the reports, which King hoped with his usual optimism would be completed in 2 years. The volumes on ornithology and on mining industry were completed that winter. Then King obtained permission to relocate the work at Yale, where laboratory and library facilities, missing in the Capital, would be available.

The first report to be published was that on the mining industry, first because its subject was "most directly applicable to the material development of that great extent of mountain territory opened up by the Pacific Railroad." It was a volume of more than 650 pages, with an accompanying atlas of maps, about half of it a description of the principal mining districts of the West, which James Hague had compiled with the help of his brother Arnold and S. F. Emmons. James Hague also prepared a long report on the Comstock mines and the treatment of the Comstock ores, a report which included a dissertation by Arnold Hague on the chemistry of the Washoe process. King contributed three chapters, one on the distribution of mining districts and their geological mode of occurrence, one on the geology of the Comstock lode, and a third on the Green River coal field. The *American Journal of Science* said that the book "should be studied by every one interested in the development of our western mining regions" and called it the "most valuable contribution yet made to the literature on the Mining Industry in the United States." J. D. Whitney called it "a superb piece of work, and far in advance of anything previously done in this country in the same line, and we know of nothing published in Europe superior to it."

King's description of the Comstock geology was the first widely available report on the subject. Baron von Richthofen had written a report in 1865, but for distribution primarily to stockholders of the Sutro Company. His history of the Comstock postulated an ancient Virginia Range, formed in the Jurassic and then eroded, which was deluged in the late Tertiary by successive volcanic flows, first of propylite or trachytic greenstone and then andesite, which in the beginning penetrated a newly formed fissure on the contact plane of the ancient rocks and the propylite. The andesite period gave birth to solfataras which rapidly decomposed the surrounding rocks and gradually filled the fissures of the Comstock with metal-bearing quartz. Later, flows of andesite covered the propylite, but the solfataric activity continued within the mass. At the close of the volcanic period, the eruptions exerted pressure

In the Humboldt Range of northwestern Nevada, geologists of the King survey recognized the effects of glacial erosion in the steep escarpments of the summit, the narrow lateral ridges, and the sharp angular fracture with which the Archean quartzites that formed the summits splits. (From Arnold Hague and S. F. Emmons, 1877.)

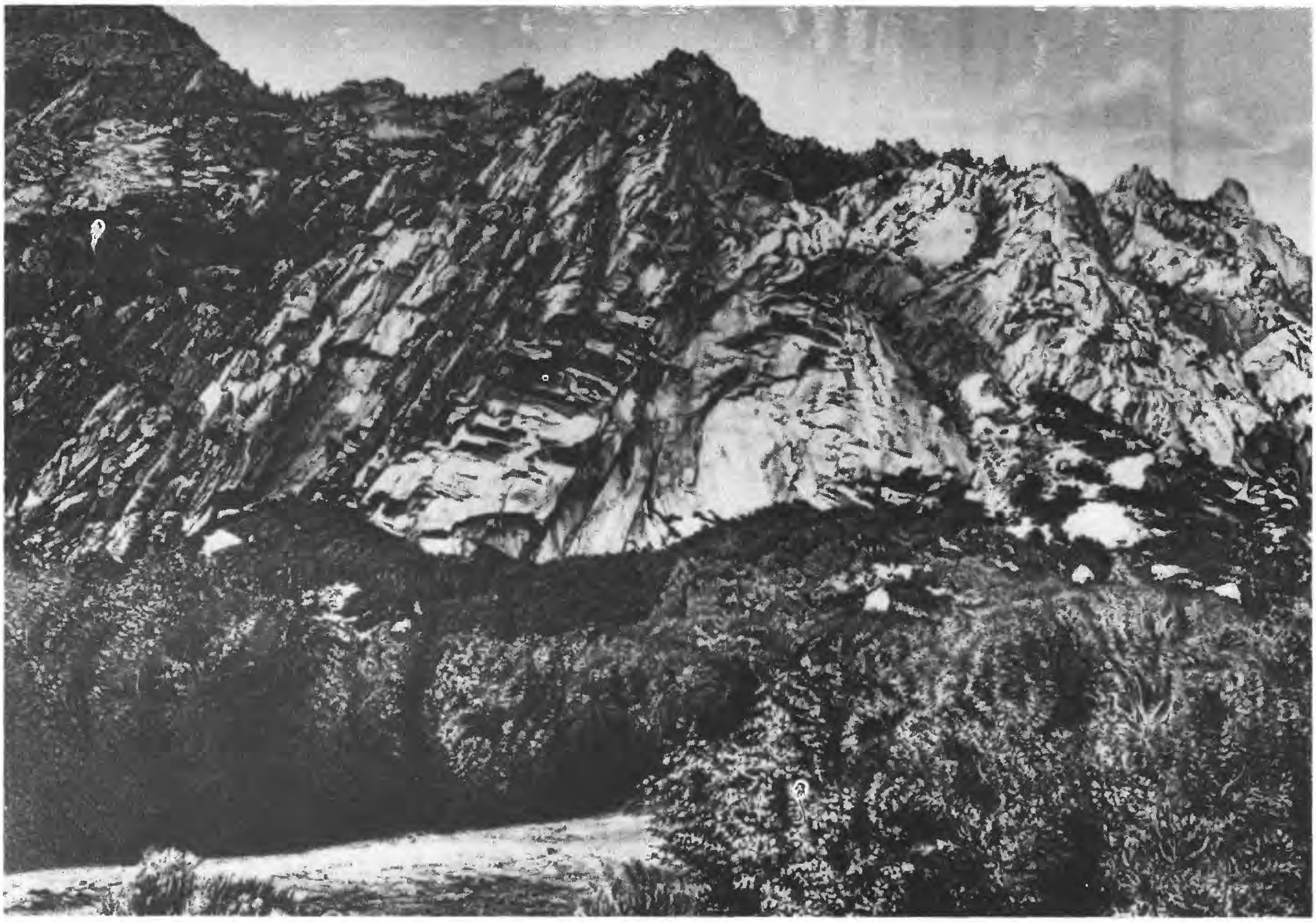
in the veins, which crushed the quartz. King accepted the term "propylite" that von Richthofen had used, although he noted similarities between this rock and some of the andesites and thought that in the end the two might prove to be different forms of the same rock. He offered no theory for the origin of the quartz and the metals. Such a theory, he said, should come from a study of veins, not from the study of a single district.

In the report on the Green River coal, King noted that coal had been known in the region for some years but had been mined for only a few years because of the demand for railroad fuel. The coal was of very wide geographical extent, from New Mexico certainly as far north as Dakota, and, in all probability, into Canada, and from the Wasatch Mountains as far east as central Colorado. The report included a description of the mines and several analyses of the coal.

Perhaps most interesting were King's generalizations on the relation of mining districts to the geological history of the continent. He suggested that from west to east there were seven longitudinal zones of mineral deposits; these included one in the Pacific Coast ranges which carried quicksilver, tin, and chromic iron; two zones in the Sierra Nevada-Oregon Cascades, one of copper and one of gold; and a zone in New Mexico-Colorado-Wyoming-Montana which contained a chain of gold deposits. Two periods of mountain-making, he said, favored the formation of metalliferous deposits, the first culminating in the Jurassic, the other in the Tertiary.

Because of his length of experience, Professor Hayden had an advantage over those conducting the Fortieth Parallel Survey, but he was handicapped by the limited funds at his disposal. His own salary was set at $2,000 a year,

In Little Cottonwood Canyon, in the Wasatch Mountains, 20 miles southeast of Salt Lake City, a massive granite is exposed. Large masses tend to flake off, leaving rounded surfaces, which to members of the King survey gave the appearance of having been worn smooth by glacial action. Immense boulders of this granite scattered through the canyon were being quarried for the Mormon Temple in Salt Lake City. Soldier-prospectors had found ore in the canyon during the Civil War, but mining did not prosper until after the discovery of the vein on which the famous Emma mine was developed. (From Arnold Hague and S. F. Emmons, 1877.)



Provo Canyon is a straight, deep gorge that cuts into the Wasatch Mountains at nearly right angles to the main trend of the mountains about 40 miles southeast of Salt Lake City. Emmons suggested that the straightness of the walls and their general parallelism to the southern line of the Cottonwood granite body indicated that the course of the canyon had been determined by, and its shape was largely due to, fracturing of the strata. (From Arnold Hague and S. F. Emmons, 1877.)

and he was allowed an assistant at $1,000 a year and three collectors and laborers at a maximum of $700 a year, which left no funds for expenses. For this sum, he was instructed "to ascertain the order of succession, arrangement, relative position, dip, and comparative thickness of the several strata and geological formations in the State, to search for and examine all the beds, veins, and other deposits of ores, coals, clays, marls, peat, and other like mineral substances, as well as the fossil remains of the various formations; to obtain chemical analyses of such of those substances, and of the different varieties of soil, whereof it may be deemed desirable to ascertain the elementary constituents"; he was also required "to determine by careful barometrical observations the relative elevations and depressions of the different parts of the State of Nebraska, and to gather in the field of his explorations collections on geology, mineralogy, and paleontology, to illustrate

In 1869 Timothy O'Sullivan photographed the Canyon of Lodore on the Green River; the river here cuts through the main body of the Uinta Range at nearly right angles to its trend and exposes a section of the southern side of the main anticlinal fold. In its deepest part, the walls of the canyon are about 3,000 feet high, and on the western side particularly, they are almost vertical. The engraving shown here was made from O'Sullivan's photograph. (From Arnold Hague and S. F. Emmons, 1877.)

the notes taken in the field." Fielding Bradford Meek joined Professor Hayden as the assistant, and James Stevenson, as one of the collectors. Stevenson, however, was really the executive officer of the Hayden survey. He had been associated with Professor Hayden ever since as a boy of 16 he had accompanied him on the Warren expedition, though he was more interested in the study of Indian customs and dialects than geology. After serving in the Civil War, he had resumed his interrupted studies in 1866 and had accompanied Hayden on his Bad Lands expedition.

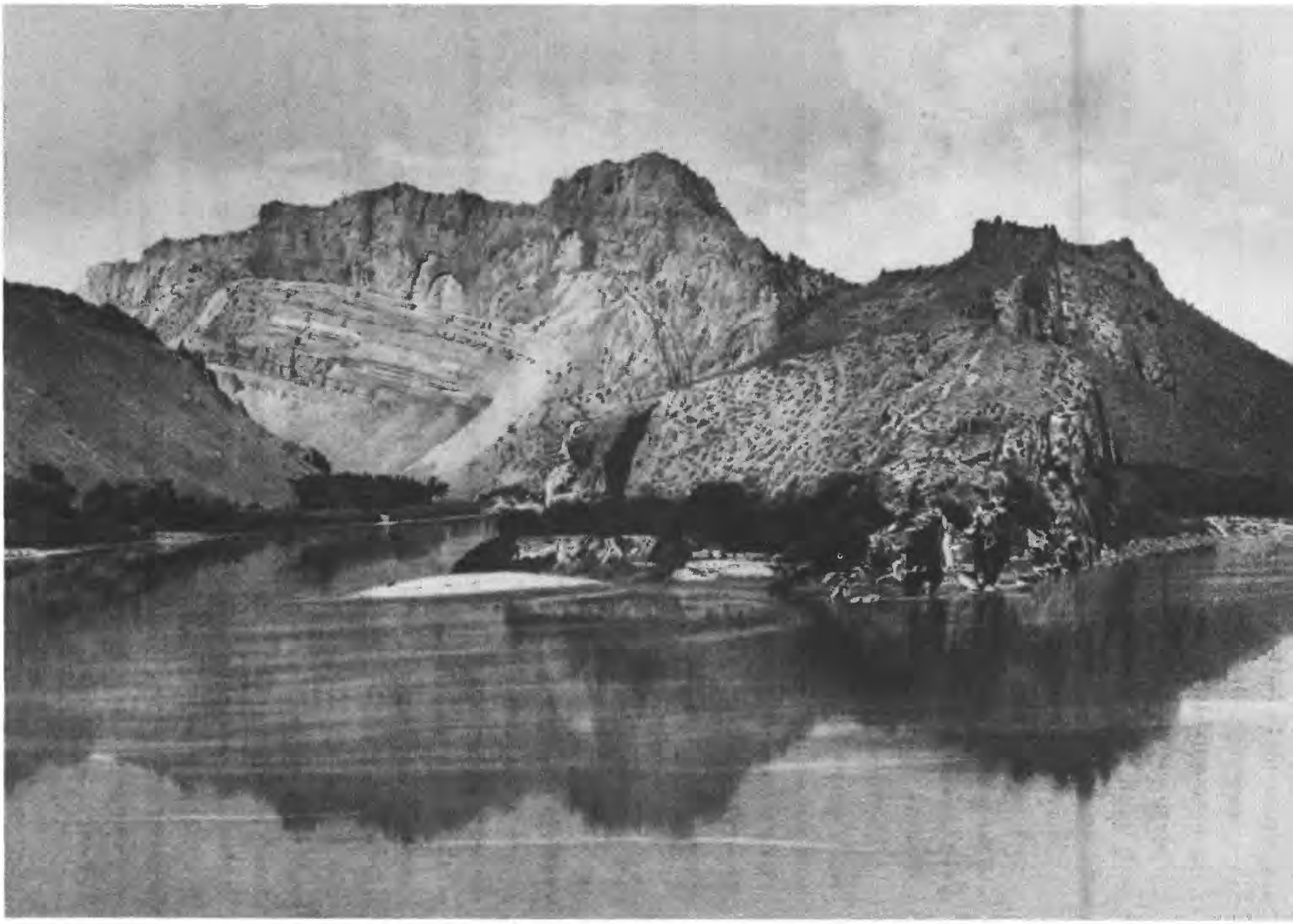
Hayden's first order of business was the investigation of the coal measures. Meek, accompanied by C. A. White of the Iowa survey, made a traverse across Iowa so he might connect the geologic formations of Iowa and Nebraska and trace out the coal beds in their western extension. For the rest of the season, the work was a county-by-county examination of resources, agricultural as well as mineral.

Hayden's first report was so well received that in 1868 he received a second appropriation, this time in the Sundry Civil bill, to extend the surveys beyond Nebraska to the new Territory of Wyoming. In general, he followed the line of the Union Pacific Railroad, beginning at Cheyenne and working west toward Fort Bridger.

In 1869, Hayden's appropriation was doubled; he was removed from the jurisdiction of the General Land Office, placed directly under the Secretary of the Interior, and ordered to make a survey of the Territory of Colorado. With the increased appropriation, he was able to organize a much larger party, including, in addition to Stevenson, Persifor Frazer, mining engineer; E. C. Carrington, zoologist; the Reverend Cyrus Thomas, entomologist; B. H. Cheever; and Henry W. Elliott as artist. Young Frazer was the son of John Fries Frazer, professor of chemistry and natural philosophy at the University of Pennsylvania, one of the original members of the National Academy of Sciences, and one of the assistants on the first Pennsylvania survey. Frazer was a graduate of the university at 18 and had had advanced training in Europe. The 1869 party set out to explore the Front Range from Fort Bridger through Colorado and over the Raton Pass into Santa Fe.

Professor Hayden's report for the year included not only his own observations on the geology of the region but also special reports by Persifor Frazer on the mines and minerals of Colorado and by Cyrus Thomas on the agricul-

This view of the canyon of the Yampa is taken from the northern wall of the canyon at its junction with the Green River. In the foreground, the Yampa is emerging into an opening that Powell called Echo Park. (From Arnold Hague and S. F. Emmons, 1877.)



tural resources. Frazer complained that "Any report of the condition of mining affairs in the Territories of Colorado and New Mexico, (each of which is larger than all the New England States put together,) and in particular of the former, which counts its discovered lodes, the varieties of its minerals, and its mining enterprises, by thousands and in which energetic capital and intelligence, 'ever striving through darkness to the light,' are working such incessant changes, must represent things as a telescope represents the stars, not as they are or ever were, but this as it was last week and that as it was last year." Frazer reported as a general impression that valuable ores abounded almost everywhere in the granite and gneiss of the Rocky Mountains and the question was not to find ore but the capital and labor with which to work it. Speculators had ruined many mines by their greed to obtain profits, and thousands of dollars worth of gold had been thrown away in the haste to rush ore through the mill.

The concern of both King and Hayden in 1870 with western mining reflected changed conditions in 3 years. In the more settled parts of the country, the mineral industry was flourishing, for the most part with large capital investment and the aid of science.

The third Bessemer ironworks in the United States was started in June 1867 and two more, in 1868. During 1867, according to the reports of the American Iron and Steel Association, a total of only 3,000 net tons of Bessemer steel ingots was produced.

Flaming Gorge on the Green River in Wyoming is at one extremity of a semicircular or bow-shaped ridge of Triassic sandstones. Emmons noted that the great variety of strikes and dips in the strata of which the ridge is composed illustrated how easily apparent nonconformities could be caused by secondary lateral flexures along the flanks of a great anticlinal fold. (From Arnold Hague and S. F. Emmons, 1877.)

A. S. Hewitt was one of the commissioners to the Paris Universal Exposition in 1867, and he took advantage of the opportunity to study the great iron and steel establishments of Europe. His study of the iron and steel section at the Exposition indicated that Europe was still far ahead of the United States; this observation was confirmed in visits to the mills and furnaces. He found that the Bessemer process was making steady progress and that chemistry had made its quality more certain, but he became convinced that the open-hearth process was better. Bessemer furnaces required a pig iron almost completely free of sulfur and phosphorus, which was hard to obtain, whereas the open-hearth or crucible methods could use any kind of pig iron. Hewitt made two great contributions to iron technology on that trip. He hired a Swedish chemist, and he obtained the American rights for the Martin process of making steel. The first open-hearth furnace was built for Cooper Hewitt in 1868, and the first steel was made in December of that year.

The bluffs on the west bank of the Green River near Green River City, Wyoming, which Timothy O'Sullivan photographed for the King survey, are of the Green River formation, which Hayden named in 1869 after observing it a little east of Rock Spring Station in Wyoming. Where Hayden observed it, he noted that it contained a great amount of combustible, or petroleum, slates. At Green River City, the formation is about 2,000 feet thick and includes 800 to 1,200 feet of calcareous shales so thinly and regularly laminated that they have been called paper shales. (From Arnold Hague and S. F. Emmons, 1877.)

In 1865, young Andrew Carnegie resigned from the Pennsylvania Railroad, where he had done notable service for the Union forces as superintendent of the eastern military and telegraph lines, to devote himself to iron, oil, and other businesses. In 1868, he established the Union iron mills, the first step along the road to concentration of power.

The copper industry had at first resorted to the protective tariff to maintain its prosperity after the war. The Michigan legislature launched a drive in February 1869. The immediate effect was to cut off imports of foreign ores and to deal a death blow to the smelting industry on the eastern seaboard. Consumption of copper began to increase during the late 1860's because of railroad construction and the use of copper in rifle and pistol cartridges, the use of bronze, and an increase in canned goods. The conglomerate deposits that had been discovered in 1864 were more difficult to work than the mass copper or the amygdaloid, and a large investment was needed. Finally, Alexander Agassiz, son of Professor Louis Agassiz, took over the management in 1867 and soon put the mining on a practical basis. The Hecla Mining Company paid its first dividend in December 1869, and the Calumet 6 months later. Within the next 18 months, the two paid more than $2.8 million in dividends.

The Missouri lead mines were in sad shape when Charles B. Parson became superintendent for the St. Joseph Lead Company in 1867. In 1869, a diamond drill was used to prospect at depth, and almost immediately, immense deposits of disseminated ore were discovered at a depth of about 120 feet. Although they were of low grade, the deposits were of such great extent that

Emmons pointed out that the more clayey beds in the badlands of the Washakie Basin in Wyoming disintegrate in the dry air and as the result of expansion and contraction produced by great diurnal changes of temperature, except where isolated remnants are preserved under a bed of coarse sandstone. O. C. Marsh later obtained from these beds in the badlands great quantities of vertebrate remains which were described in the last of the reports of the King survey. (From Arnold Hague and S. F. Emmons, 1877.)

Ferdinand V. Hayden

Hayden, 38, had already established his reputation as a master of reconnaissance in the area beyond the Mississippi when he began his work for the General Land Office in 1867. Many stratigraphic units in the area were familiar to him and had been named by him in his earlier explorations. (Courtesy of the Smithsonian Archives, Merrill Collection.)

their total lead content completely overshadowed that of the shallow deposits. New mining and milling methods had to be devised to exploit the deposits, and these took time, but the output steadily increased.

The young petroleum industry was thriving without the aid of science. Oil was carried from the Pennsylvania fields to Pittsburgh and New York for refining, and after the Atlantic and Great Western Railroad ran its first trains into Cleveland, refineries also sprang up there. In 1863, young John D. Rockefeller became a partner in an oil-refining business of Andrews, Clark and Company. In 1865, he had bought out the business, and renamed it Rockefeller and Andrews. It soon became the largest refinery in Cleveland.

Four States had established geological surveys in 1868 and 1869, all concerned with mineral resources, and all conducted with a high degree of professionalism. The second survey of New Hampshire was directed by C. H. Hitchcock, who had been associated with his father in the survey of Vermont just before the war and had then been engaged in the short-lived survey of Maine. After the war, he had studied at the Royal School of Mines in London and had then become an instructor at Lafayette College in Pennsylvania, which had close ties with the mineral industry. Hitchcock made his first order of business an investigation of the Ammonoosuc gold fields and then of copper and zinc minerals, slate, and peat, although he also pressed the legislature to provide for an adequate map of the State. In 1869, the legislature appropriated a small sum for preparation of a map. As this sum was not sufficient for a program of accurate mapping, Hitchcock for the most part had to be content with revising existing county maps.

The second geological survey of Ohio began its work on June 1, 1869, with legislative instructions to make "a complete and thorough geological, agricultural, and mineralogical survey of each and every county in the state." Professor John Strong Newberry of the Columbia School of Mines was appointed Chief Geologist; he had three assistant geologists: E. B. Andrews, Edward Orton, and John H. Klippart. Klippart, who was secretary of the State Board of Agriculture, was assigned responsibility for the agricultural part of the survey. Andrews had published several papers on Ohio geology and had done some of the earliest work on the geological relations of petroleum, but for Orton, an ordained minister of the Presbyterian Church who had turned to teaching, this was a first assignment in geology. There were also several volunteer assistants, most of them recent college graduates. Among them were G. K. Gilbert, a graduate of the University of Rochester, who had been an assistant at Ward's Natural History Museum for several years, and Roland D. Irving, who had been one of Newberry's students at the Columbia School of Mines.

The coal industry was moving westward, and coal was a special interest of the Ohio Survey. Newberry himself became almost lyrical on the subject. Coal, he said, was

> **entitled to be considered as the mainspring of our civilization. By the power developed in its combustion, all the wheels of industry are kept in motion, commerce is carried with rapidity and certainty over all portions of the earth's surface, the useful metals are brought from the deep caves in which they have hidden themselves, and are purified and wrought to serve the purposes of man. By coal, night is in one sense converted into day, winter into summer, and the life of man, measured by its fruits, greatly prolonged. Wealth, with all the comforts, the luxuries and the triumphs it brings, is its gift. Though black, sooty and often repulsive in its aspects, it is the embodiment of a power more potent than that attributed to the genii in oriental tales. Its possession is, therefore, the highest material boon that can be craved by a community or nation.**

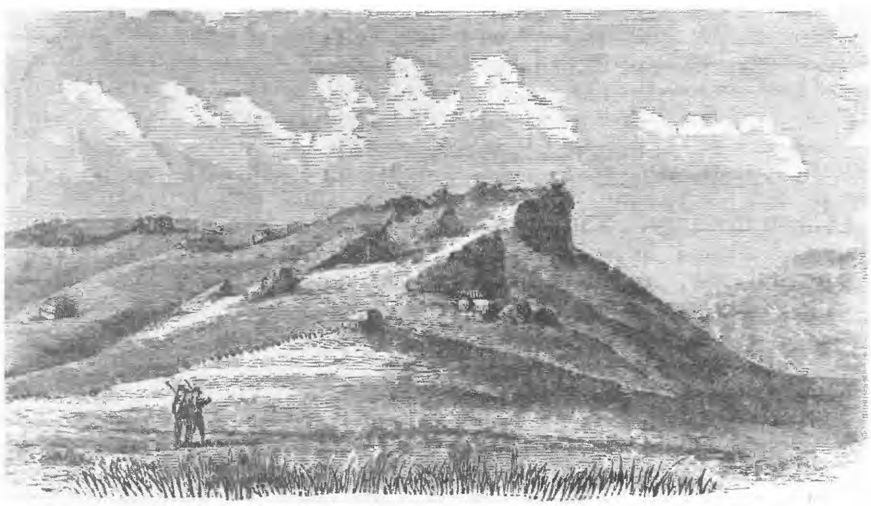
Coal was also of special interest to the State Geologist of Indiana. The Indiana General Assembly created the Office of State Geologist in 1869 "at the head of a Geological and Scientific Department, to act in connection with and under the control and management of the Indiana State Board of Agriculture for the purpose of collecting information designed to promote the interests of agriculture, arts, manufactures and mining." E. T. Cox, who had been a student of David Dale Owen's in New Harmony and had assisted him in the surveys of Kentucky and Arkansas, was appointed State Geologist. Cox had gone to Mexico in 1864 to examine some mining properties there, but he had also investigated coal deposits and had prepared a full report, which was published by the Government in 1865. In 1865, Amos Worthen invited Cox to join the Illinois survey. For the Illinois survey, Cox examined the coal measures of Gallatin County, establishing their place in the geological column, and later made a similar examination of the coals of southern Illinois. Though mining was the last purpose mentioned in the legislation, it became the first interest of the Indiana survey.

The geological survey of Michigan was also revived in 1869. Alexander Winchell, who was again made director, undertook the investigations of the Lower Peninsula, while T. B. Brooks began a survey of the iron regions, and Raphael Pumpelly, of the copper regions.

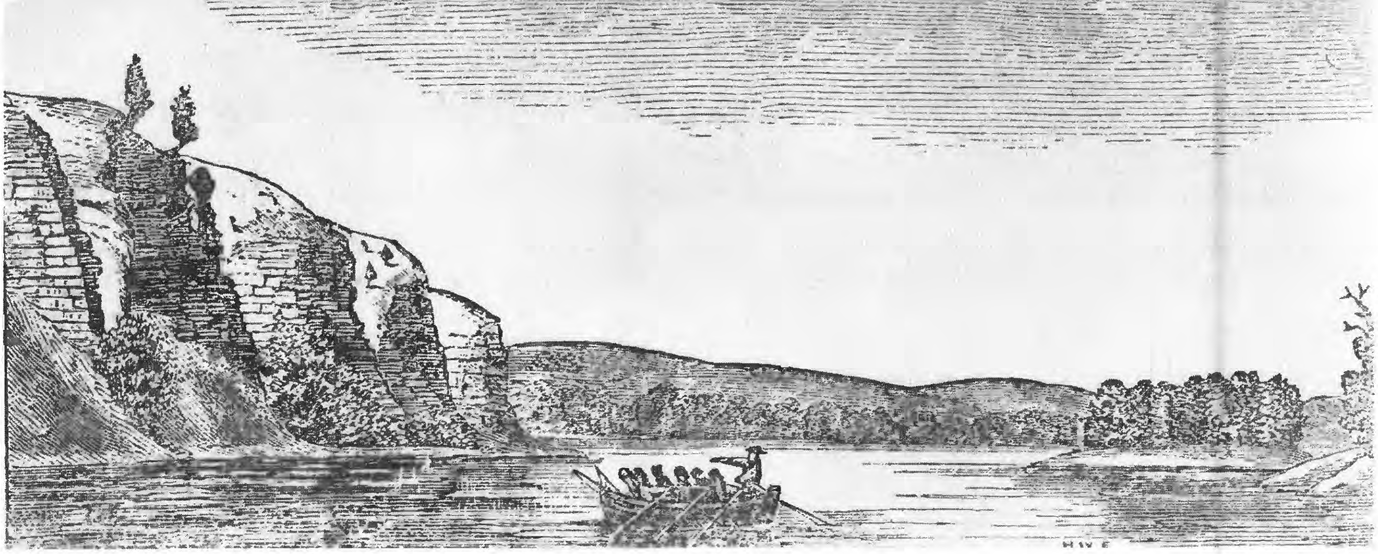
Brooks had retired from the army in the fall of 1864 and thereafter served for a year on the geological survey of New Jersey under Cook. Then, in 1865, he had become vice president and general manager of the Iron Cliff mine in the Marquette district in Michigan.

Pumpelly had spent most of the war years in Japan and China, first as an expert appointed by the United States Government in response to a request from the Government of Japan for a geologist and mining engineer to explore certain lands in southern Yesso (Hokkaido) and to introduce foreign methods of mining and smelting. Then, after having been driven out of Japan by anti-foreign feeling, Pumpelly worked on his own in China. After his return, he had been offered the Chair of Mining at Harvard under the Sturgis-Hooper Endowment and had accepted, although he did not do much teaching because the income of the endowment was not large enough to pay him a salary. In the summer of 1866, he made a trip to the Lake Superior region to report on a copper property and there became acquainted with Major Brooks. In 1867, a company headed by H. S. Welles was given two land grants in Michigan to build a ship canal across the peninsula of Keeweenaw Point to shorten the distance for shipping from the western to the eastern end of the lake. One grant was along the line of canal; the other sections were to be selected from unoccupied government land in northern Michigan. The company asked Pumpelly to select the lands of the second grant, and he convinced them that the greatest opportunity was not in finding gold or silver but in white pine and iron ore. Pumpelly hired men to explore for white pine, and he himself took on the iron project.

Both Brooks and Pumpelly were innovative in their methods. The iron country was still heavily wooded, and much of it was swampy. Most of the few outcrops were obscured by drift or undergrowth. The only maps available were those of the Land Office. Nonetheless, Brooks produced a report in 1873 in which he explained he had tried to produce "as complete a manual as possible of information relating to the finding, extracting, transporting, and smelting of the iron ores of the Lake Superior region." The report included an historical sketch of the discovery and development of the iron mines; the geology of the Upper Peninsula; the geology of the Marquette, Menominee, Lake Gogebic, and Montreal River iron regions; a chapter on exploration and prospecting for ore; a chapter on the magnetism of rocks and the use of the magnetic needle in exploration; the method and cost of mining; and the chemical composition of the ores. Pumpelly chose to make a detailed study of the stratigraphy and mineralogy of selected areas rather



With the exception of a small portion of Douglas and Sarpy Counties, bordering on the Missouri and Platte Rivers, the whole State of Nebraska north of the Platte River is underlain by rocks of Cretaceous and Tertiary age. Cretaceous No. 1, or the Dakota formation, shown here on Little Blue River, was described by Hayden as a yellowish, reddish, and occasionally white sandstone with alternations of clay and lignites in places. No rock in the State, he said, would be so unyielding and durable for the abutments of railroad bridges, provided enough could be found. (From F. V. Hayden, 1871.)



than a general reconnaissance of the entire copper district. Much of his work consisted of microscope study of hundreds of thin sections (which he ground himself) to determine the paragenesis of the copper, a totally new line of research.

Precious-metal mining in the West was far from prosperous. The Comstock was plagued with water problems, the Idaho and Montana rushes had slackened off, and Colorado was in the doldrums. Then silver was discovered at Treasure Hill, just east of White Pine Mountain in Nevada, and the ore assayed as high as $27,000 a ton. The discoveries were cause for great rejoicing, and eager miners began arriving before snow was off the ground in the spring of 1868. An estimated $1½ million worth of silver was produced in 1868. The extraordinarily rich ore was silver chloride, horn silver, but the nature of the deposits was uncertain. Were they a true fissure vein, and therefore likely to persist at depth, or were they horizontal deposits of sedimentary origin and limited extent? The State Mineralogist, after three visits, could not be sure, and James Hague of the 40th Parallel survey, after visiting the site, observed cautiously that the Eberhardt deposit was "probably the most remarkable occurrence of horn silver on Record," but the depth of the mine was not clearly established. At the end of 1868, the *Mining and Scientific Press* of San Francisco reported that the richness of the chloride deposits was "nothing very wonderful." Many capitalists who visited the mines had expressed the opinion that the deposits, being horizontal, could not be depended upon, and the peak soon passed.

In the West, there were only three States and no State survey. The California survey had come to an untimely end. In the summer of 1867, parties had mapped in the central and high Sierra, W. M. Gabb led a party half way across the Nevada desert to 116° W., and Whitney himself spent the field season in Oregon. The legislature that winter was unimpressed and inclined to listen to the disappointed oil promoters, and it adjourned without providing any funds for the continuance of the survey. Whitney attributed the action solely to the oil issue, but the reason was probably the lack of any practical results and the stress on pure science as much or more than on oil.

Senator Stewart asked Congress in 1868 to establish a great mining university, patterned after the mining academies in Europe, somewhere west of the Rockies on the Pacific railroad line, but Congress still wanted no part in a national university, mining or any other kind. Although the first of the great western State universities was established in 1868 at Oakland, California, partly as a land-grant college, mining education remained very much an eastern and privately endowed affair. The Columbia School of Mines was flourishing, several colleges in Pennsylvania had added courses or departments of mining and metallurgy, and the Massachusetts Institute of Technology was beginning to expand.

Hayden described the Niobrara group, or Cretaceous No. 3 as "one of the most interesting of the Cretaceous divisions. It is found in some form wherever the Cretaceous beds occur, from the north line to New Mexico, and probably much farther. As it is developed on the Lower Missouri, and southwest through Nebraska, Kansas, into Texas and the Indian Territory, it contains thick, massive beds of chalky limestone * * * but along the flanks of the mountains, or in the far West, it never reveals its chalky character." (From F. V. Hayden, 1872.)

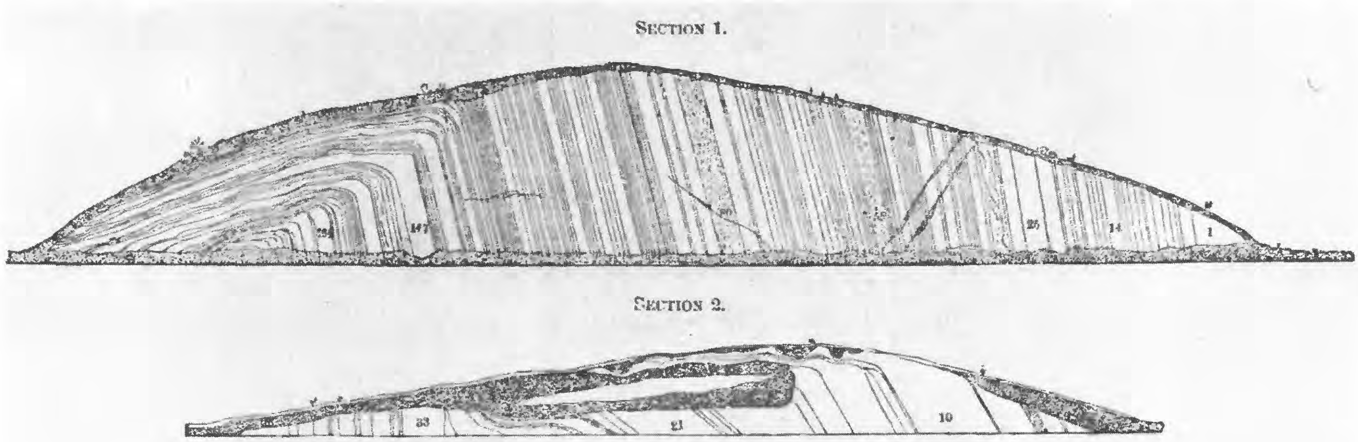
The collection of mineral statistics, however, became a more professional endeavor. In 1868, J. Ross Browne achieved his goal and was appointed Ambassador to China, and Rossiter W. Raymond was appointed Commissioner of Mining Statistics in the Treasury Department. Raymond was a graduate of Brooklyn Polytechnic School and had also studied at Heidelberg, Munich, and Freiberg. During the Civil War, he had served as aide-de-camp to General Frémont. When appointed to his new position, the 28-year-old Raymond was employed as a consulting mining engineer and was editor and proprietor of the *American Journal of Mining* (which later became the *Engineering and Mining Journal*).

The Treasury was particularly concerned with mining statistics because of the importance of the currency issue. The war had been largely financed by the issue of notes, greenbacks. Specie payments had been discontinued by the banks, and a special gold market had been established in New York, where gold for transactions in which its use was required (in payment of international obligations, customs duties, or interest on Government bonds) could be bought and sold for paper money. In December 1865, Congress had pledged itself to withdraw the greenbacks from circulation, and in April 1866, it passed the Funding Act, which required the Secretary of the Treasury to retire $10 million worth of greenbacks immediately and as much as $4 million worth each month thereafter. The program ran into difficulties, and in 1868, the authority to retire greenbacks was repealed. Pressure was immediately exerted to put the retired notes back into circulation, and pressure also came from both farmer and labor groups for payment of interest on government bonds in greenbacks rather than gold. Greenbacks were worth considerably less than gold, so payment in gold meant a very high rate of interest.

Reconstruction and the currency were the major platform issues in the presidential election campaign of 1868. The Republicans endorsed radical reconstruction and advocated payment of the national debt in gold. The Democrats attacked radical reconstruction and endorsed the Ohio Plan for payment of the national debt in greenbacks. In the campaign itself, however, the Republicans made "the bloody shirt of the rebellion" the chief issue, and in November, General Grant, the Republican nominee, carried 26 of the 34 States.

In his inaugural address, Grant took a firm stand on the payment of the national debt in gold, saying "It looks as though Providence had bestowed upon us a strong box in the precious metals locked up in the sterile mountains of the far west and which we are now forging the key to unlock, to

West of Bear River City, Hayden noted a series of freshwater beds which had been tilted and flexed in a most remarkable manner. The sides of the railroad cut in which they were exposed he described as so peculiarly banded that they looked like the stripes of a zebra. The sections were drawn for Hayden by H. R. Durkee, a civil engineer, who distinguished 173 beds, ranging in thickness from 1 inch to 10 feet, in Section 1 and 39 beds, ranging in thickness from 5 inches to 15 feet, in Section 2. Many of them were so crowded with fossil shells that they could be gathered by the bushel, mostly land and freshwater species, many of them previously undescribed. F. B. Meek concluded that they were all Tertiary. (From F. V. Hayden, 1871.)



Sections taken at Bear River City, Union Pacific Railroad.

meet the very contingency that is now upon us. Ultimately it may be necessary to insure the facilities to these riches, and it may be necessary also that the general government should give its aid to secure this access." The statement is somewhat ambiguous, and he did not elaborate, but presumably he was referring to the railroad, then nearing completion, as the key to unlock the western deposits.

The completion of the railroad, appropriately celebrated with the driving of the golden spike at Promontory, Utah, on May 10, had completely altered the conditions under which the civilized population came in contact with the Indians. Instead of a slowly advancing tide of settlers gradually pushing the Indians back, the very heartland of Indian country had been pierced, and every station along the railroad was a nucleus for settlement and a base from which prospectors and miners could fan out in all directions. The Indians' food supply was being diminished as the buffalo were killed, and as the Secretary of the Interior observed "If he is in want he will rob, as white men do in like circumstances, and robbery is but the beginning of war." By 1869, exploration of the Colorado River and location of north-south routes across the Great Basin had become the most important projects of the Army's Department of the Pacific.

Army exploration of the Colorado was postponed when it was learned that Professor John W. Powell of Illinois State Normal University planned an expedition down the Green and Colorado Rivers by boat. Powell was 35, the son of an itinerant Methodist preacher, and his formal schooling had ceased when he was twelve. His life thereafter had been a succession of farming, studying, teaching, and exploring in the Midwest until the outbreak of the Civil War. He had enlisted in the Union Army in May 1861, been wounded at the Battle of Shiloh as a result of which his right forearm had been amputated, but continued to serve until 1865, achieving the rank of Major by the end of the war. After the war he became professor of geology at Illinois Wesleyan University and then at Illinois State Normal University, both in Bloomington. Though an excellent teacher and popular with students, Powell did not enjoy the sedentary life of a teacher. He made his first trip west in the summer of 1867 and explored the Colorado Rockies as far south as the Grand River. In 1868, he requested aid from General Grant to organize a larger exploration party, mentioning as one reason the value to the War Department of a survey of a region "inhabited *** by powerful tribes of Indians that will doubtless become hostile as the prospector and the pioneer encroach upon their hunting grounds." Grant was willing, but it took an act of Congress to get Army rations as Powell's only support. During the second expedition, Powell explored the White River to its junction with the Green and around the eastern base of the Uinta Mountains.

These expeditions convinced him that the unknown canyon land to the south and west, exceedingly difficult to explore by land, could be traversed in boats. Again he sought support from the Government, hoping to obtain more now that General Grant was President, but again he received only an authorization to draw Army rations. Determined to make the exploration, he used his own salary, a grant from the Illinois Natural History Society of whose museum he was curator, and small contributions from Illinois Industrial University and the Chicago Academy of Sciences to finance the trip. He designed the boats himself and had them built by a master boatbuilder in Chicago. As members of the expedition, Powell chose his youngest brother; four mountain guides who had been with him in the summer of 1868 and the younger brother of one of them; an army sergeant who claimed to be willing to explore the river Styx in order to get out of the army; an 18-year-old veteran mule driver, bullwhacker, and Indian scout; and an Englishman

Hayden could do little mining geology with the funds available to him. The elaborate and elegantly illustrated report prepared under the direction of Clarence King, he remarked, covered the ground far more efficiently than his incidental labors could do. The dike in Colorado shown is the site of the Gregory lode, where gold had been discovered in 1859. (From F. V. Hayden, 1871.)

John Wesley Powell

In 1869, Powell, a 35-year-old professor from Illinois, made his historic trip down the Green and Colorado Rivers through an area until then almost unknown. In the spirit of the old naturalists, he proposed to make collections to add to the sum of human knowledge. (From the files of the U.S. Geological Survey.)

in search of adventure. With this crew, Powell proposed "to make collections in geology, natural history, antiquities, and ethnology" and "to add a mite to the great sum of human knowledge."

The Powell expedition left Green River, Wyoming, in three small boats on May 24. All went well until June 8, when one of the boats capsized and was dashed to pieces against the rocks in the Canyon of Lodore. The crew escaped, but all their clothing, one-third of the rations, half the mess kit, and some of the instruments were lost. Nine days later, they lost most of the rest of the mess kit in a mad dash to get away from a fire. One June 28, they reached the mouth of the Uinta, within reach of settlements, and the Englishman left. On July 6, they started down the river again and on the 16th, arrived at the junction of the Green and the Grand but stopped only long enough to make an astronomic determination of their position. By this time, their rations were in very poor condition, and they were short of everything except flour, coffee, and dried apples. The hunting and fishing had been poor, and rain added to their discomfort. The crew was discontented and grumbling, but Professor Powell seemed not to notice. The eclipse on August 7 gave them a brief rest and a chance to repair the boats while the Professor and his brother climbed to a summit to make observations, but at the last minute, clouds obscured their view. On Friday, August 13, they started into the Grand Canyon and almost immediately encountered long and difficult rapids. After 2 weeks in the canyon, with only 5 days' rations left, with difficult rapids ahead of them and the end not in sight, three of the men refused to go on. They climbed the cliffs to go overland and try to reach settlements at the head of the Virgin River; they were never seen again and were later found to have been killed by Indians. The rest continued in two boats, and on Monday, August 30, a little after noon, they arrived at the mouth of the Virgin, where they met three Mormon fishermen and a small boy. The expedition officially disbanded 2 days later, and Professor Powell and his brother went on to Salt Lake City, where on September 16 the Professor regaled a large and appreciative audience with an account of his exploration.

Professor Powell realized that the scientific results of his first exploration of the Colorado River were inadequate and again went to Washington seeking support for another study of the river and its canyons and plateaus. This time, however, he was a national hero instead of an obscure professor. Congressman Garfield sponsored a bill to appropriate $10,000 for a geographical and topographical survey of the Colorado River of the West.

Early in June 1869, Lieutenant George Wheeler received orders to organize and equip a party to make a "thorough and careful reconnaissance" of the country south and east of White Pine, Nevada, as far as the head of navigation on the Colorado River, if practicable, to obtain data for a military map, survey the possibility of a road, and select sites for military posts to protect the mining country from the Indians. In addition, he was instructed "as convenient" to investigate the physical geography of the country and its resources and the character, habits, and numbers of Indian tribes and their disposition toward settlers and miners. Lieutenant Wheeler was the Engineer Officer of the Department of the Pacific. He was not quite 27, born in Massachusetts, and a graduate of West Point in 1866, where he ranked sixth in his class and won a commission in the elite Engineer Corps.

The Wheeler survey, comprising 36 persons, 8 wagons, 48 mules, and 31 horses, got underway in mid-July. From a camp in the White Pine district of Nevada, Wheeler planned to move eastward, then south along a meridian toward the Colorado, and back by a more westerly route. They left camp on the 31st and marched east to Steptoe Valley; then after a few days making observations in the Robinson district, they went south along the western side of the valley to Ice Creek, where they remained to observe the eclipse of the sun on August 7. They continued then into Cave Valley, where they made camp again and sent the wagons back for supplies. On September 1, they started out again, through unfamiliar territory, for the Colorado River. A small detachment was sent to march through the Pahranagat Valley to the settlements on the Muddy River; Lieutenant Wheeler and the main party continued farther to the east where he believed there would be a better route for the wagon train. They had great difficulty, however, in finding a route by which the wagon train could travel, and on September 14, with the animals nearly exhausted and almost no water or grass available, Lieutenant Wheeler and one companion left the rest in camp and struck out for the settlements on Muddy River. About noon the next day, one of the horses gave out, and the two men began to walk, but at three o'clock, they came within sight of the other party, and another 18 miles brought them to St. Joseph where supplies were purchased. The reunited party then settled into camp near West Point, not far from where the old Los Angeles and Salt Lake Road crosses the Muddy. From this point, the wagons were sent directly to Las Vegas Ranch where the animals would have a chance to recuperate, while Lieutenant Wheeler and nine others, with a pack train of six animals, set out on the morning of September 29 for the Colorado River. In 2 days, they reached the mouth of the Virgin, where they found two Mormon fishermen and learned of Professor Powell's arrival a month earlier. The Wheeler party continued down the river to El Dorado Canyon, from which point there was a road to Las Vegas Springs and then rejoined the main group. Although by this time almost everyone wanted to take the Salt Lake Road to Los Angeles, Lieutenant Wheeler stubbornly insisted on trying to carry out the original plan. Even though some of his men deserted and some of the animals were lost, they marched northward, through extreme hardship, and arrived at their starting point in the midst of a severe snowstorm on November 25.

There had been further developments in the currency problem during the year. Supporting Grant's stand on hard money, Congress had passed the Public Credit Act on March 18, providing for the payment of government obligations in gold. Then during the summer, Jay Gould and James Fisk, stock manipulators, attempted to corner the gold market in New York. They persuaded the President's brother-in-law to ask him to keep the Government from selling gold. Grant refused, but the rumor was spread that he opposed the sale, and Grant lent credence to the rumor by social contacts with the schemers. The price of gold soared, and then on September 24, the Secretary of the Treasury ordered the sale of $4 million of Treasury gold, the price dropped, and many speculators were ruined.

George M. Wheeler

In 1869, Wheeler, 27 years old and 3 years out of West Point, began a reconnaissance south and east of White Pine, Nevada, to obtain data for a military map and revived the interest of the Army Engineers in mapping. (From an article by William Rideing in *Harper's New Monthly Magazine,* May 1876, p. 807.)

In the Treasury Department at the time were many young Army officers who had been drawn to Washington by the opportunity for public service after the war. Henry Adams described them as "full of faith, greedy for work, eager for reform, energetic, confident, capable, quick of study, charmed with a fight, equally ready to defend or attack." Among them was Francis A. Walker, son of Amasa Walker, one of America's first political economists, and a protege of David Wells, the special commissioner of U.S. revenue. Walker had graduated from Amherst College in 1860, just before his 20th birthday, and had then studied law. At the outbreak of the Civil War, he joined the Union Army and proved to be such a capable staff officer that when he was discharged in the spring of 1865, not yet 25, he was brevet brigadier general. Wells had persuaded him to come to Washington to take the position of Chief of the Bureau of Statistics.

When the plans were being made for the Ninth Census in 1870, an attempt was made to take the collection of technical information, including mineral statistics, away from the Federal marshals and place it in the hands of a new force under the Superintendent of the Census. Walker told a House committee that

> **The fullest examination which I have been able to give the subject inclines me to the belief that our mining industries, in part if not altogether, deserve a special treatment in the coming census. Coal mining and iron mining, indeed, dealing as they do with heavy products and being carried on almost exclusively within the limits of settlement and civilization, are susceptible of treatment like any other form of industry. I do not, however, regard it as possible to make an enumeration of the gold and silver mining of the United States by the ordinary machinery *** which shall be in any way satisfactory. On the contrary, the probability is that the result under such a system would either be deceptive in the highest degree or else depart so manifestly from the real truth of the case as to become simply grotesque.**

Many of the reformers soon lost their jobs, and David Wells was among the first—banished for advocating free trade rather than the protective tariff. Secretary Jacob Cox rescued some of those who were dismissed from the Treasury, including Walker, who was appointed Superintendent of the Ninth Census. The bill to reform the method of census taking failed, however, and the census was conducted by the methods specified in the 1850 law.

The census figures showed that production of pig iron had more than doubled in the decade between 1860 and 1870. Sixteen States now produced iron ore. Pennsylvania was still first, as it had been since 1750, but Michigan was now second, followed by New York, New Jersey, Ohio, and Missouri in that order. The iron industry was moving westward. Coal production had also just about doubled. Pennsylvania's production was nearly twice what it had been in 1860 and still dominated the industry, but percentage-wise, greater gains had been made in Illinois, which now ranked second, in Indiana, which now ranked seventh, and in Iowa, which now ranked eighth. The coal industry was also moving westward. As far as the figures on gold and silver were concerned, however, Walker said they were "published in conformity with what is understood to be the requirement of law; but it would be wholly unjustifiable were the figures to be put forth without a distinct and emphatic disclaimer of their validity and authority."

Walker resigned from the Federal Government in 1872 to become professor of political economy and history at Yale's Sheffield School and there completed the *Statistical Atlas of the Ninth Census*. In that volume, statistical data were presented for the first time in maps and charts, and this new method of graphic presentation won him international acclaim.

A geologic map of the United States compiled by C. H. Hitchcock and W. P. Blake for the Ninth Census was less well received. The map was small, only 34 by 22 inches, and the *American Journal of Science* commented that

> **It is not a little discreditable to the United States for the government to publish so meagre a production. A general U.S. geological chart ought to be published by the General Government, and it should combine all that is contained in the maps that have been made in the course of the various State surveys, and be issued in the best possible style. It would be a great thing for the nation's industry as well as its science if the work could be soon begun and the best of American art and science be engaged upon it.**

Rossiter Raymond, the U.S. Commissioner of Mining Statistics, also had difficulty in obtaining data. The figures in his annual report he described as "estimates rather than statistics," but because of the small appropriation, there was little chance of obtaining more accurate figures. In March 1870, Raymond submitted to the Secretary of the Treasury his second report on the condition of the mining industry in the several Western States and Territories. He included with it a proposed revision of the United States mining law, an outline of a classification of mineral deposits, which he said was substantially that of the late Professor Lottner of Berlin, a description of the mechanical appliances of mining by William Phipps Blake, and a discussion of metallurgical processes.

At Raymond's request, Judge E. F. Dunne of White Pine County, Nevada, "whose legal knowledge, as well as long familiarity with the conditions of title, etc., of mines on the public lands, entitle his views to the most respectful consideration," had prepared a list of objections to the present law and proposed remedies. Dunne's 16 objections ranged from not fixing the size of the tract to not providing for a national mining university; they included: not determining in places where two veins cross at depth, who shall have the ore in the space of intersection; not determining in places where two veins unite at depth, how the same shall be held; not providing some means of settling the question of whether a mineral deposit is a vein or only a deposit; and not extending the law to placer mines, river diggings, gravel claims, and cement deposits. On the basis of such of Judge Dunne's suggestions and a few of his own that he considered feasible, Raymond prepared the draft of a law entitled "An act to amend an act granting the rights of way *** passed July 26, 1866."

In the summer of 1870, Chairman George Julian of the Public Lands Committee of the House made an effort to bring about repeal of the Mining Act of 1866 and to substitute sale of the mineral lands, but instead, the Mining Act was extended to cover claims that had been omitted in 1866. When the Julian bill reached the Senate, Senator Aaron A. Sargent of California countered with an amendment to the Mining Act authorizing the patenting of placer claims. Most of the debate involved the amount of land that should be patentable under a placer claim. Senator Sargent's amendment was finally passed and approved on July 9. It defined placer claims as "all forms of deposit, excepting veins of quartz, and other rock in place," made placers subject to entry, patent, and preemption, as were vein and lode deposits, but limited placer locations to not more than 160 acres. It also extended the public land surveys to the mineral lands of California, which had been excluded in 1853.

The key to unlock western mineral resources was not the railroad or law but a solution to the metallurgical difficulties at Eureka, Nevada. Interest in the Eureka district was renewed after the discoveries at White Pine. The Eureka ore consisted of masses of oxidized silver-lead minerals embedded in limestone, in a form that has been described as comparable to that of a cuttle-fish, with a large central body and tentacles extending in many directions. The Scotch hearth or reverberatory furnaces used in the Missouri and

Wisconsin lead districts were not adapted to the treatment of the ore. As a last resort, a blast furnace was erected, and it was immediately successful, as the Eureka ores were self-fluxing. The Eureka district became a regular producer in December 1869.

Development of the Eureka district, once the smelting problem was solved, was rapid, and Eureka mines became the largest suppliers of domestic pig lead. The Eureka Consolidated Company was formed in San Francisco in 1870, and the Richmond Mining Company of London took over another set of claims in 1871. Both companies secured the best metallurgical services available and aggressively pursued the development of the Eureka mines.

In 1870, Utah became a mining State. Successful treatment of Eureka ores had made mining profitable, and the Mormons ceased to discourage mining. The Emma mine in Little Cottonwood Canyon began to ship fabulously rich ore—in its first year almost $1 million worth. A great influx of prospectors, miners, and speculators followed a year later. The Flagstaff mine, nearby, began to produce rich ore, and there was considerable activity in American Fork Canyon, Bingham Canyon, the Tintic district, and the Ophir and Rush Valley districts as well.

Chapter 10.
Subservient to the Interests of a Civilized Community, 1870–1873

> **It gives me the greatest pleasure to have an opportunity of laying before you some statements and reflections, which I trust will satisfy you that geology and natural history can be made subservient to the great interests of a civilized community to a far greater extent than is generally admitted.**
>
> **—Louis Agassiz to Benjamin Peirce**

In the spring of 1870, on the basis of his 3 years' experience, Professor Hayden presented to the Committee on Appropriations in the House of Representatives a plan for the geological and geographical exploration of the Territories of the United States that looked forward to the gradual preparation of a series of geographical and geological maps of each of the Territories on a uniform scale.

The appropriations bills were late in 1870, delayed by the debate over the annexation of Santo Domingo. President Grant was anxious to annex the island, but in the fall of 1869 the Cabinet unanimously rejected his proposed treaty of annexation. He nevertheless submitted it to the Senate in January 1870, where it was ultimately defeated on June 30.

Hayden's plan for mapping the western Territories was accepted, and when the appropriation bill was passed in late July, his appropriation was increased to $25,000. The lateness of the appropriation, however, delayed the start of the field season until early August. Hayden assembled his party, the largest yet, at Camp Carlin, near Fort D. A. Russell, and from there he followed the line of the Union Pacific Railroad westward from Cheyenne through South Pass to Fort Bridger and back along the north slope of the Uinta Mountains. He did not feel that his appropriation was large enough to hire a topographer so his maps could be improved, but he did take along, in addition to his usual assistants, Sanford Robinson Gifford, a landscape painter of the Hudson River school, and William Henry Jackson, the photographer.

With the acceptance of his plan for a geological and geographical survey of the Territories, Hayden was able to make long-term plans. In his report for 1870, he defined his position as publicist and promoter of western development as well as scientist.

> **Never has my faith in the grand future that awaits the entire West been so strong as it is at the present time and it is my earnest desire to devote the remainder of the working days of my life to the development of its scientific and material interests, until I shall see every Territory which is now organized, a State of the Union. Out of the portions of the continent which lie to the northward and southward of the great central mass, other Territories will, in the mean time, be carved, until we shall embrace within our limits the entire country from the Arctic Circle to the Isthmus of Darien.**

His report for 1870 includes, in addition to the observations on geology of the country traversed during the field season, several special papers. Hayden explained that he thought it best to make the preliminary reports the vehicle of much detailed matter which he believed to be useful, upon which he would base many generalizations, but which could not be repeated in the more elaborate final report. These special papers included F. B. Meek's report on paleontology, a paper on the Tertiary coals of the West by James T. Hodge, a paper by J. S. Newberry on ancient lakes, a paper by Joseph Leidy on vertebrate fossils, another by Leo Lesquereux on fossil plants, two by E. D. Cope on fossil reptiles and fishes, and one by R. S. Elliott on the industrial resources of western Kansas and eastern Colorado. Most of these papers were written by men of national repute, but E. D. Cope was a younger man, a protege of sorts of Joseph Leidy. Cope's parents were wealthy members of the Society of Friends, and he had been educated in part privately and in Europe. He had studied under both Spencer Baird at the Smithsonian and Leidy at the Philadelphia Academy of Natural Sciences. This was his first venture into public service.

In 1870, Professor Powell, having received the $10,000 requested for his second expedition, went west to prepare for the expedition by finding ways to bring supplies down to the river so that he and his men would not face starvation as they had the first time, and also to learn what had happened to the three men who had been lost, so that precautions could be taken to avoid another such incident. With Jacob Hamblin, recommended by Brigham Young as a guide, he set up a base camp on the upper Kanab, from which he made trips in different directions. Friends were made of the Indians who named him Kapurats (one-arm-off) and assured him he could travel in their country without harm; the three men had been killed by mistake. After locating several supply points, Powell crossed the river and spent 2 months studying the Indians and their way of life and climaxed the trip in November by a trip to Fort Defiance, New Mexico, where he helped Hamblin conclude the first treaty between the Navajos and the Mormon towns.

In the summer of 1870, Professor Othniel C. Marsh of Yale University led an expedition of 12 Yale students to the Rocky Mountain country to collect fossil bones. Marsh had been professor of paleontology at Yale since 1866. He was a graduate of Yale in 1860, at the somewhat advanced age of 29, and had then studied at the Sheffield School for 2 years and in Europe for 3 additional years. It was during his student days at Berlin that he first met E. D. Cope. Marsh had made his first trip to the West after the AAAS meeting in 1868. Having made a small collection of fossil bones at Antelope Station, Nebraska, including those of a diminutive horse, which he promptly described to the National Academy of Sciences and in the *American Journal of Science,* he began immediately to make plans for a systematic exploration of the western plains. He had been unable to take a party into the field in 1869 because of the Indian troubles, but the expedition of 1870, the first of four such student expeditions, started off in June. Marsh sought and obtained aid from General William T. Sherman, then Commanding General of the Army, including a military escort. Three collecting trips were made in the Nebraska-Wyoming-Colorado area, one out of Fort McPherson, one out of Fort D. A. Russell, and the third out of Fort Bridger in southwestern Wyoming, which took them to the junction of the Green and White Rivers through the Uinta Mountains. On the way home, after a trip to Salt Lake City and California, the group stopped in western Kansas, where giant mosasaur bones were discovered, and also a small bone from which Marsh identified the first known American pterodactyl, and a giant one at that.

The King survey had hardly settled in New Haven to continue preparation of reports when word was received that a new appropriation had been made for continuation of the work. It was too late in the season to mount a full-scale campaign, so King secured permission to study the volcanoes along the Pacific coast. Taking with him the topographers Clark and A. D. Wilson, and Arnold Hague and S. F. Emmons, he set off for the Pacific coast. On

September 11, King, Emmons, and Clark climbed to the top of the lesser Shasta, a conical secondary crater jutting out from the main mass of Mount Shasta on its northwest side, and discovered, between the secondary crater and the main mass, a glacier, the first actual glacier discovered in the United States. On the following day, they climbed the main summit, and three glaciers were observed on its north side. Whitney, Dana, and Agassiz had all believed there were no true glaciers within the United States, exclusive of Alaska, but they had all climbed the peak from the south side where there was less snow. Emmons was sent on to Mount Rainier where he also discovered glaciers, and Hague found them on Mount Hood in Oregon. King wanted to continue and extend the study of the glaciers, but General A. A. Humphreys thought the proposal could "hardly be considered authorized under any existing act or appropriation." The Engineers were not about to support any such purely scientific venture.

In the more settled parts of the country, the work of the State surveys continued to be primarily the search for and development of mineral resources, but some of the work became a little more sophisticated. U.S. lead production had been close to its lowest point in 1870—the disseminated deposits in Missouri were not yet in production, and Eureka, which would soon dominate the field, was just coming into production—and both Wisconsin and Missouri, where lead had been important, undertook State work in 1870. The Wisconsin work was completely practical and confined to a survey of the lead district. John Murrish was appointed commissioner and prepared three reports on the area. The legislature of Missouri, in reactivating its State survey, however, changed it to a mining, metallurgical, and geological bureau, in sharp contrast to the predecessor survey, which had placed its emphasis on general geology. Albert D. Hager was appointed State Geologist, but his term of service was short, and he was succeeded in 1871 by Raphael Pumpelly. Pumpelly's plan of work called for study of the general stratigraphy and the distribution and manner of occurrence of the various important mineral deposits, the latter study to be made by specialists or those who had special qualifications for the work. The economic investigations were organized in three divisions: iron ores and metallurgy, ores other than iron, and fuels and construction materials. Among the several assistants were G. C. Broadhead, who became director of the survey in 1873, W. B. Potter, who later became a professor of mining geology at Washington University in St. Louis, and Regis Chauvenet, who became one of the leading industrial chemists in the country.

The Coast Survey also became involved in a study of a mineral resource. None of the Lazzaroni had been more assiduous than Benjamin Peirce in efforts to raise the standards of pure science, and when he became Superintendent of the Coast Survey after the death of Alexander Dallas Bache in 1867, he consulted Louis Agassiz, who suggested a program in which geology and zoology could be applied to the purposes of the Coast Survey, both onshore and offshore. Peirce therefore planned to have the geology of the belt of country within the limits of the Coast Survey maps carefully determined so that they might be shaped in a way that would better serve the commercial interests of the country and also have a greater scientific value. In 1870, he sent Professor N. S. Shaler of Harvard University to examine the phosphate beds of South Carolina, to determine the limits of the field, and to ascertain, if possible, the conditions that led to the formation of the deposits. It turned out, however, that there were legal obstacles to onshore geologic work by the Coast Survey. Superintendent Peirce hoped to get the law amended but did not succeed in doing so. In 1870, he also asked for a small appropriation to extend the Coast Survey triangulation so as to form a geodetic connection

between the Atlantic and Pacific coasts, calling the work "of inestimable importance to the scientific accomplishment of the survey" and one that would "give the best possible basis for all accurate surveys which may hereafter be required." That appropriation was made, with the proviso "that the triangulation shall determine points in each State of the Union which shall make requisite provisions for its own typographical [sic!] and geological surveys."

In 1871, the American Institute of Mining Engineers was established officially because "the great development of the mines and metallurgical works of this country during the last few years, accompanied as it has been by the investment of enormous sums of money in purchasing lands, and in the erection of improvements, requires that advantage should be taken of the accumulated knowledge of engineers, superintendents, and others, in mastering the problems which are constantly presenting themselves for our action." E. C. Pechin, one of the engineers, put it more bluntly:

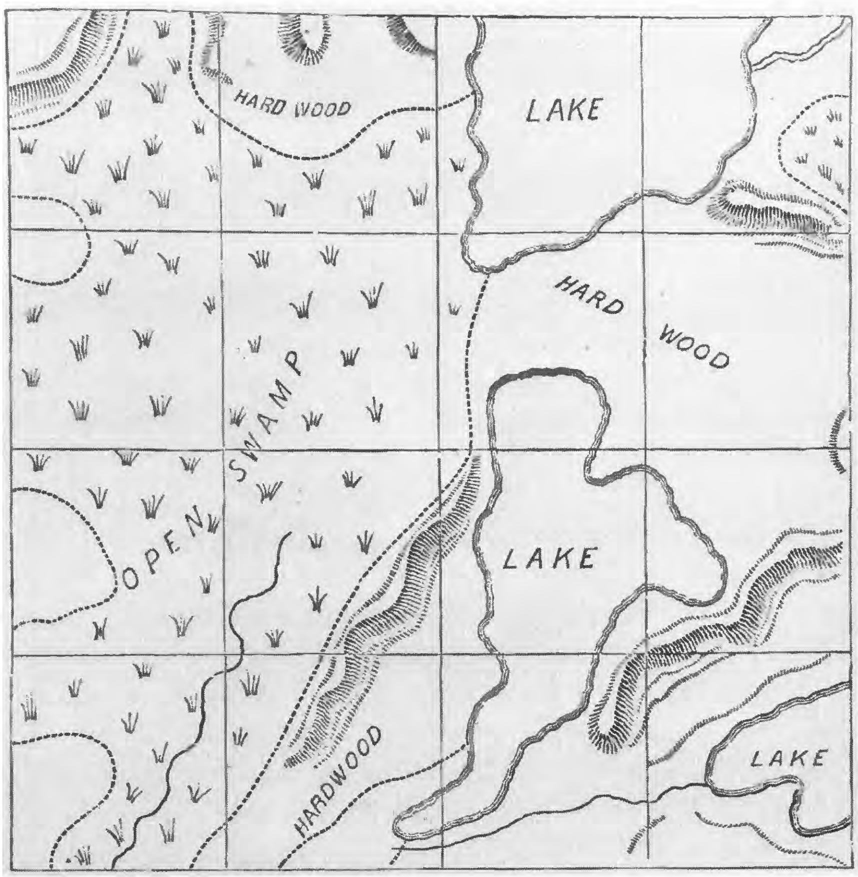
> **The time has come when scientific research is to assume its true position—the day of 'sheer force and blind stupidity,' whose only protection was a high tariff, has gone by forever. *** the physicist, the geologist and mineralogist, the chemist, the engineer and mechanic, are as essential to success as the furnace itself, or the labor that works it.**

Active glaciers were first observed in the United States on September 11, 1870, when members of the King survey climbed to the top of Shastina, the lesser cone on Mount Shasta, and saw directly beneath them a fine glacier flowing toward them and curving around the circular base of the cone. In this photograph, King is shown examining the crevasses on the glacier which was named for J. D. Whitney. (Photograph by C. Watkins from the files of the U.S. Geological Survey.)

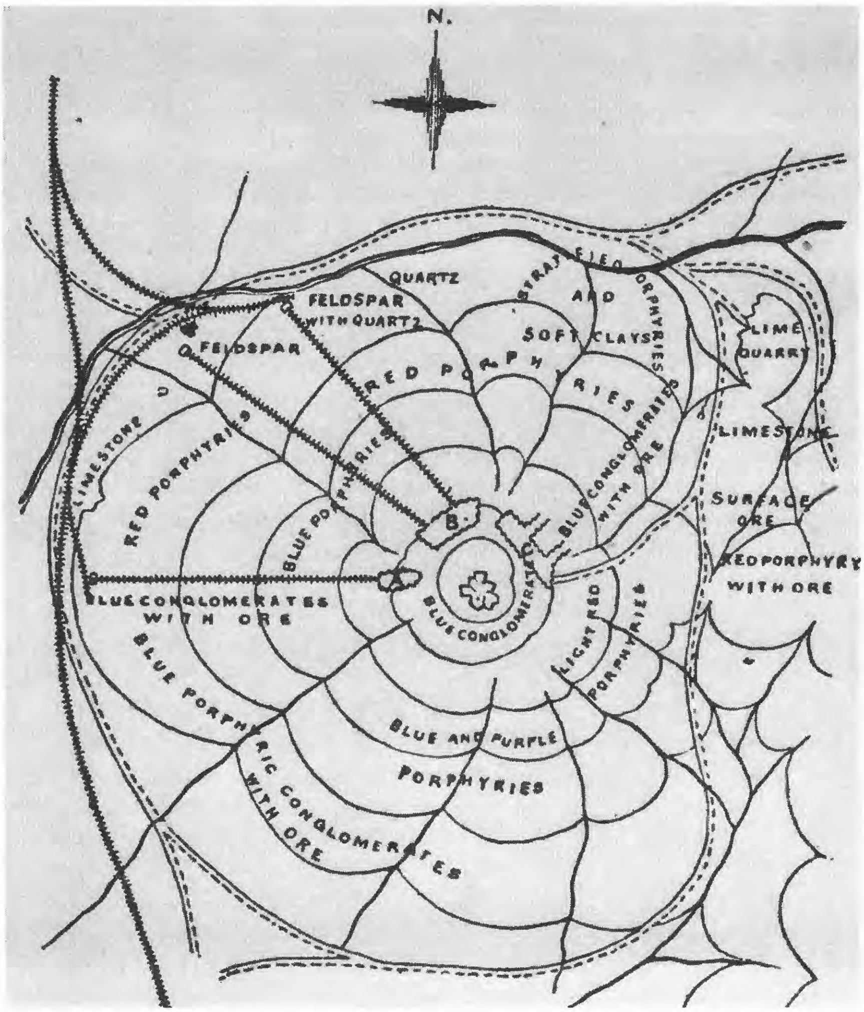
The initial impetus came from iron and coal operators in Pennsylvania (among them Eckley B. Coxe, S. F. Emmons' friend), and most of the members came from those industries. The initial circular had mentioned consideration of

> **more economical systems of mining in our coal and metalliferous mines, improved methods of transportation above and below ground, unwatering and ventilating mines, the mechanical preparation of coal and other minerals, the various metallurgical processes, and, in fact, every question tending to the attainment of two great objects: 1st. The more economical production of the useful minerals and metals. 2nd. The greater safety and welfare of those employed in these industries.**

Benjamin Apthorp Gould, youngest of the Lazzaroni, viewed with alarm the tendency to use science for mundane purposes in his presidential address to the AAAS in 1869. "The omens are less favorable for science in our own land than elsewhere," he said, "since there are peculiar obstacles to be encountered. These chiefly arise, directly or indirectly, from that characteristic in our national development, which assigns an exaggerated value to immediate utility, and a low estimate to what real utility is. It cannot be denied that the attainment of riches is becoming with us more and more the chief aim of existence." Gould thought that matters should be arranged "so as to allow the ablest minds to labor in those fields for which they are best adapted, and to guide the most versatile, so far as possible, into such channels that their energies may promote the highest welfare of society." As the scientist was the man to whom indirectly the world owed its material progress, civilized communities should encourage and protect him. Instead, in America, institutions of science were "dependent upon subsidies and gifts from individuals" and the "governance and guidance of intellectual agencies" had been placed "in the hands of men who are not well fitted for their



The surveys of those States where studies of mineral resources were important realized the need for careful mapping. T. B. Brooks of the Michigan survey said that an explorer should make a careful sketch or map of each section examined, at a scale of 4 inches to 1 mile, and on it should mark "in their proper places all streams, lakes, swamps, hills, etc., and all outcrops, with name or sign indicating the kind of rock." Opposite each such sketch he should write a full description of the rocks and minerals found, as well as notes on timber and soil. Brooks also remarked that surveys by the U.S. General Land Office Survey, valuable as they were "and reliable, so far as the section lines go," were often "considerably in error in their representation of the interior of the section," as evidenced by the two maps reproduced here. (From T. B. Brooks, 1873.)

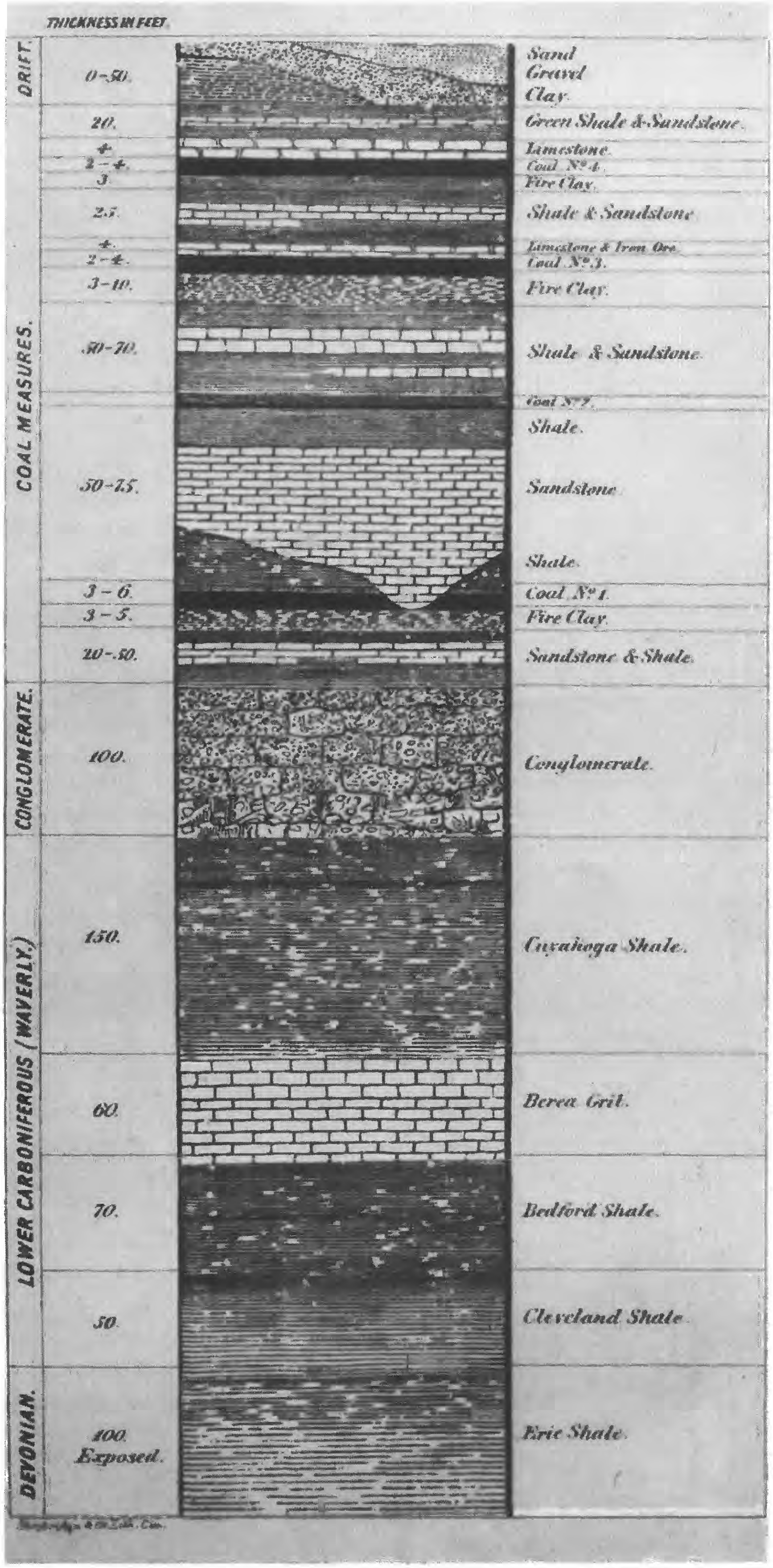


Pumpelly's "topographical plan," made for the Missouri Geological Survey, shows the surface geology and three mining cuts (A, B, and C) at Pilot Knob, Missouri. The knob was still being actively mined in 1873 although there were indications that it was not inexhaustible as had once been believed. (From Raphael Pumpelly, 1873.)

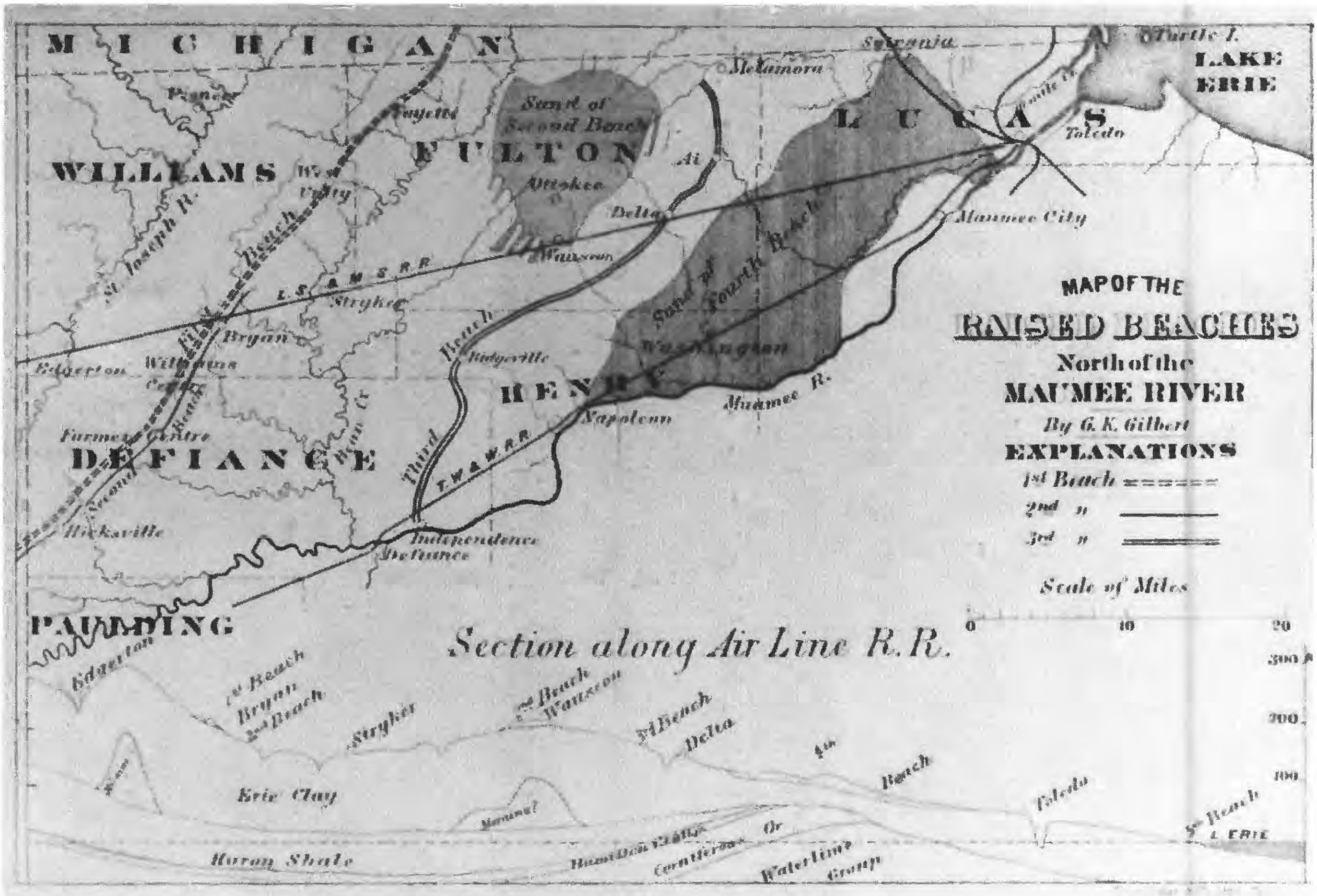
exercise." He called for adequate financial support for scientific research so that the scientist would not be compelled "to earn his bread *** by work other than scientific research" and a change in public sentiment "as may lead to deference in scientific matters to the judgment of experts, together with the maintenance and encouragement of institutions which may serve to develop experts and indicate who they are!"

From the very beginning, the Institute did not confine itself to applied science. Rossiter Raymond, who was one of the founding members of the American Institute of Mining Engineers and secretary of the organizational meeting in 1871, discussed King's ideas at some length at that meeting in a paper on the distribution of mining districts in the United States. The distribution of mineral deposits east of the Rocky Mountains, he pointed out, followed different laws. The striking feature in the eastern region was the peculiar relative position of the coal and iron deposits, which Hewitt had described as a gigantic bowl filled with treasure and rimmed with metal. Although the description was geographical rather than geological, Raymond said, it was none the less connected with the underlying geological facts. Iron and coal were "the prime elements" in the "universe of industry," so the relation between them was of special economic significance.

The Institute served a distinct need in the growing profession, and by the time of its second (first annual) meeting in May 1872, it had more than 200 members, among them Raphael Pumpelly, State geologist of Missouri; Persifor Frazer of the University of Pennsylvania; James D. Hague of the For-



Ohio State Geologist John S. Newberry was particularly interested in coal. The first mineral coal to be used on the lake shore came from Summit County, and it had been sent to Cleveland by his father, Henry Newberry, in 1828. Mines had been worked actively since 1838, and all the southern part of the county was underlaid by productive coal measures. As indicated on this section of rocks in Summit County, however, Coal No. 1 was not as widespread as had been believed because extensive stream channels had been cut in it after it was deposited. (From J. S. Newberry, 1873.)



Careful mapping also provided information primarily of scientific interest. G. K. Gilbert, one of the young assistants on the survey of Ohio, noted that small brooks converging northeastward toward Lake Erie were gathered together into streams that flowed along the base of two low concentric ridges in northwestern Ohio and then were united in the Maumee River which flowed lakeward through open gaps. Gilbert suggested that the ridges were the surface representation of a buried terminal moraine, now completely covered by lacustrine clays deposited in an expanded predecessor of Lake Erie but still exerting an influence on the hydrography, and concluded that the margin of the continental ice sheet, shown at two stages of its recession, was lobed or digitate. (From G. K. Gilbert, 1873.)

tieth Parallel survey; Professor John S. Newberry of the Columbia School of Mines and State geologist of Ohio; as well as those from industry.

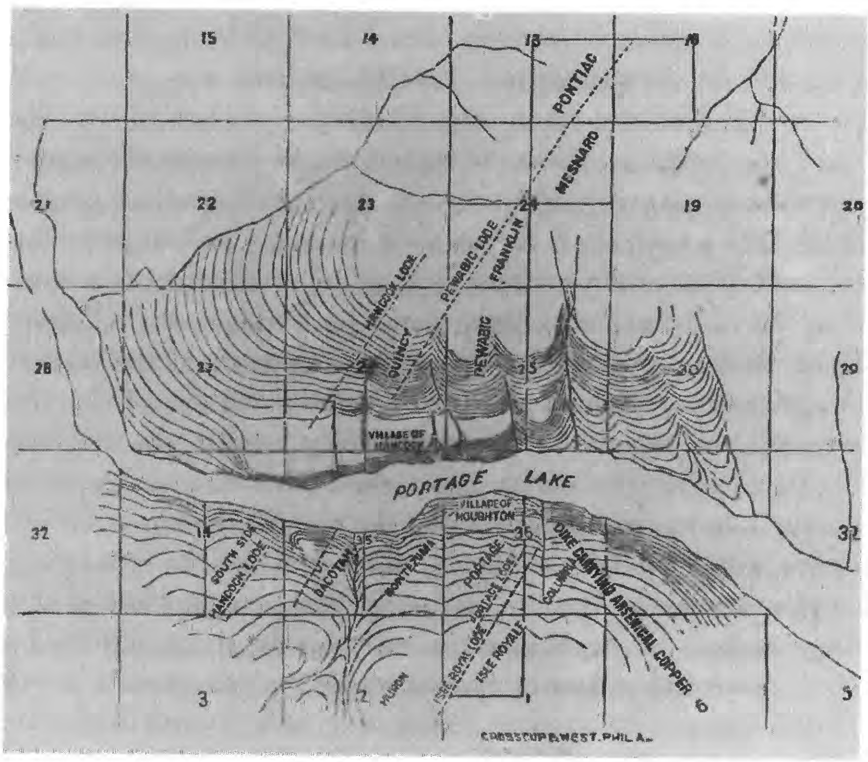
At the May 1872 meeting, A. S. Hewitt presented some further thoughts on the role of science in the mineral industry. No body of men understood better than the engineers, he said, that "capital is essential to the development of natural resources on the scale demanded by modern civilization, but capital does not always comprehend as fully that science and experience are essential for the profitable use of money in the vast undertakings of our day." Hence, there had been great waste of resources and disastrous failures. However, the growth of population and the spread of civilization meant that there would be an increase in comsumption and production of iron. In 1856, Hewitt had predicted that production would reach 14 million tons in 1875; in point of fact, that figure would be surpassed in 1872. Ultimately, he predicted a total annual world production of more than 70 million tons of iron; by 1900, it would be more than 40 million tons, and a large part of the increase had to come from the United States. Before the close of the century, the United States would be producing annually at least 10 million and probably 15 million tons of iron, which meant mining yearly 25 million to 40 million tons of iron ore and more than 100 million tons of coal, and investing at least $500 million and probably $1 billion in opening mines, erecting works, and supplying machinery. Productive results would depend mainly on the judgment and skill used in the expenditure of this vast sum of money, and that was "the common ground on which capital and science must meet."

Science, however, had yet another role—to reconcile capital and labor. Iron had been made at too low a cost in foreign countries to allow the workmen engaged in its production a fair share of the necessities and comforts of life. Cheap iron was a blessing to mankind; to deprive the world of it was a "calamity so serious that no one could contemplate it without a feeling of reluctance." Science could satisfy both needs by devising cheaper processes.

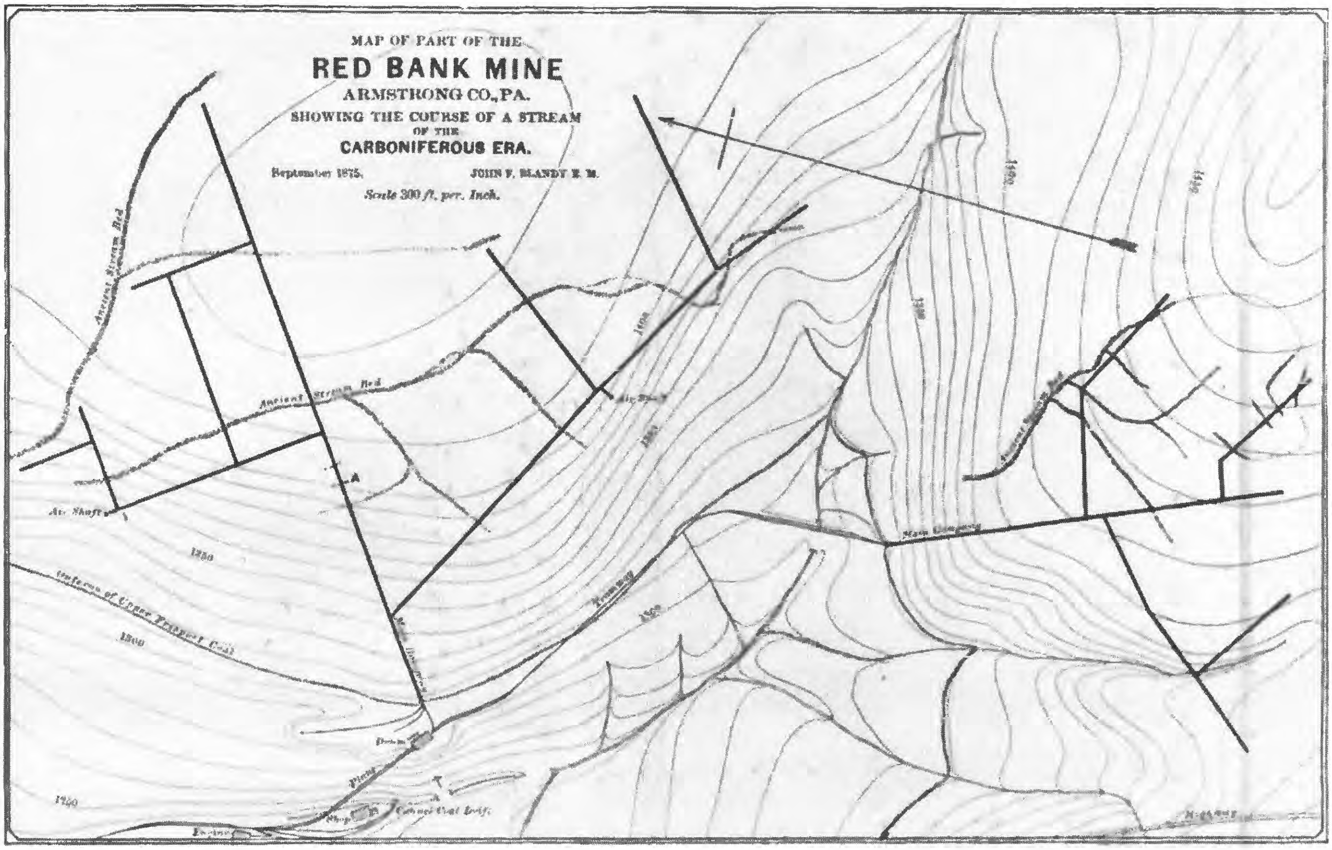
In the summer of 1871, the work of the Fortieth Parallel Survey was carried eastward toward the Great Plains. In August 1871, King led a party into North Park and the Elk Head Mountains of Colorado, while Emmons entered the Uinta Mountains near the head of Black's Fork, intending to work eastward to the Green River Canyon. Extensive forest fires throughout the entire Rocky Mountain region filled the air with such volumes of smoke that it was impossible for either party to do any topographic work.

Captain W. A. Jones, the engineer officer of the Department of the Platte, was also instructed to make surveys in the Uinta Mountains in the summer of 1871, and at one point Captain Jones marched his party through a burning area where the Indians had set the forest ablaze to stop them. Captain Jones' instructions were to ascertain the character and extent of the stream valleys and their adaptability to cultivation or grazing; to ascertain the character of the timber, its amount, location, and the feasibility of getting it to the railroad; if possible, to find a practicable wagon road from Fort Bridger to the Uintah Indian Agency; if possible, to examine the Green River country with reference to the large mineral deposits reported there; and generally, to obtain all useful information concerning the country. As far as mineral resources were concerned, the Captain reported:

> **From my own observation, as well as that of Mr. Emmons who was in charge of one of Mr. Clarence King's parties which made a thorough examination of the whole Uintah range, I am of the opinion that, except near the eastern extremity, there is little probability of the occurrence of metalliferous veins carrying the precious metals in the Uinta Mountains.**



Mining engineers were among the first to point out a mutual relationship between economic and general geology. John F. Blandy pointed out, for example, that along the Lake Superior shore, ancient lake shores are shown as terraces (on the north side from the middle of section 27 to the middle of section 25 and on the south side from Dacotah Creek eastward to the east side of section 31). As the terrace on the north side is higher than that on the south and both rise toward the east, the presence of structural changes is a possibility and these structural changes could be related to the location of mineral veins. (From J. F. Blandy, 1872.)



Conversely, Blandy suggested, detailed economic studies in mining regions might yield results of scientific interest. He believed his studies at the Red Bank mine in Pennsylvania showed evidence of the stream channel of a Carboniferous stream in the coal. (From J. F. Blandy, 1875.)

In 1871, under orders from General A. A. Humphreys, Lieutenant Wheeler was sent to explore and map "those portions of the United States territory lying south of the Central Pacific Railroad, embracing parts of Eastern Nevada and Arizona." The main object was to obtain information for maps, but there were the usual admonitions to observe the physical features of the country, the Indians, to obtain information for selection of sites for military operations, facilities for roads, as well as to survey the mineral resources, geology, vegetation, weather, and suitability of the land for agriculture.

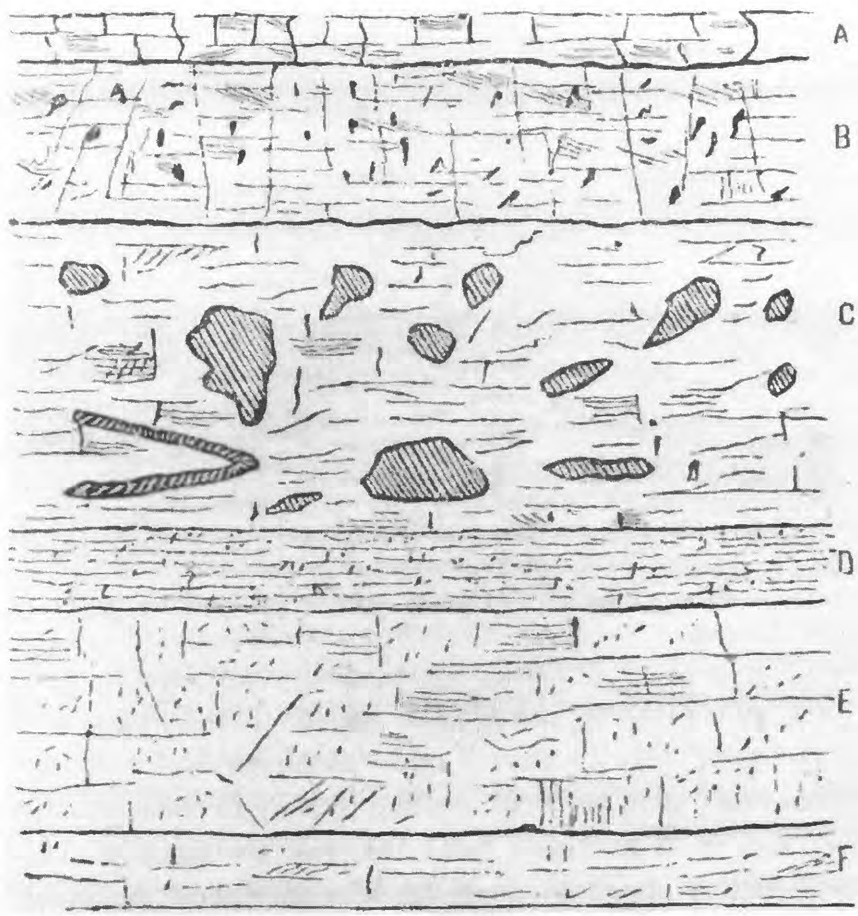
Wheeler included in this expedition two geologists, Grove Karl Gilbert, who had been with the Ohio survey, and his friend, Archibald Marvine; Timothy O'Sullivan, who had been the photographer with the King survey; and Frederick W. Loring, a reporter from Boston. The entire party numbered 80 to 90 persons. The survey got underway early in May, and from Carlin, Nevada, parties zigzagged southward across Nevada, visiting mining districts. In July, they converged on and explored Death Valley. Then Wheeler turned to his main objective, the exploration of the Colorado River upstream from Camp Mojave. Gilbert accompanied one of the parties establishing supply bases along the river and became acquainted with the plateau country. The trip up the river from Camp Mojave to Diamond Creek took from September 16 to October 18 and was accomplished with great hardships.

In 1871, Hayden went to the Yellowstone country which he had attempted to reach just before the beginning of the Civil War. Shortly after the war ended, some of the citizens of Montana began to talk of an expedition, but early efforts failed because of difficulties with the Indians. In 1869, however, a small party succeeded in reaching the headwaters of the Yellowstone River and then crossed over the divide to the Madison River and reached the area that is now Yellowstone Park. A larger follow-up expedition was planned for 1870, and the commanding general of the Department of the Dakotas was asked to provide a military escort. The combined military-civilian party left Fort Ellis on August 22 and reached Yellowstone Lake within a few days. At the suggestion of one member of the party, they agreed to work together in an effort to persuade the Federal Government to set aside the region as a national park. Lt. G. C. Doane, head of the escort party, made an official report to the Commanding General, who sent it to the Secretary of War, who sent it along to Congress. N. P. Langford, a member of the party, described the region in articles in the May and June 1871 *Scribner's Magazine.*

Proposals for further scientific exploration were backed by the Speaker of the House, and Congress appropriated $40,000 for F. V. Hayden to undertake the work. Hayden was instructed by the Secretary of the Interior "to make such instrumental observations, astronomical and barometrical, as are necessary for the construction of an accurate geographical map of the district explored, upon which the different geological formations may be represented with suitable colors." Further,

> as the object of the expedition is to secure as much information as possible, both scientific and practical, you will give your attention to the geological, mineralogical, zoological, botanical and agricultural resources of the country. You will collect as ample material as possible for the illustration of your final report, such as sketches, sections, photographs &c. Should your route lead you in the vicinity of any of our Indian tribes you will secure such information in regard to them as will be useful to this department or the country.

James Stevenson was made "managing director" of the expedition, and several new men were added to the corps, among them A. C. Peale, who had



Mining engineers used much larger scales in mapping in connection with the development of mineral resources than did geologists. In this section showing the disseminated lead deposits of Missouri, B represents a 10-inch-thick limestone with small blotches of galena, and C, the true lead-bearing rock 19 inches thick. (From J. R. Gage, 1874.)

just received his M.D. from the University of Pennsylvania, as mineralogist; Anton Schonborn, a topographer and artist; and Thomas Moran, the landscape painter. The party spent 38 days in the Yellowstone wonderland, during which Moran made sketches and Jackson obtained about 400 negatives. Schonborn committed suicide on the return trip, so some of the topographic material was lost, although the Coast Survey attempted to work up his notes.

Hayden joined the enthusiasts who were promoting the idea of a national park. He contributed an article to *Scribner's* and two to the *American Journal of Science* and distributed Jackson's photographs widely. On December 18, 1871, a bill was introduced simultaneously in the Senate and the House of Representatives for the establishment of a park at the headwaters of the Yellowstone River. Both bills were referred to the Committees on Public Lands. The Senate bill was reported back first, and on January 22, 1872, Senator S. C. Pomeroy said that "Professor Hayden and party have been there, and this bill is drawn on the recommendation of that gentleman to consecrate for public uses this country for a public park." The bill was passed on January 30 with only limited floor discussion and with a comfortable margin. The House considered the bill on February 27; again there was little debate, and the bill was passed 115 to 60. President Grant signed the bill into law on March 1, 1872, creating the first national park.

With his usual enthusiasm, Hayden said:

> **That our legislators, at a time when public opinion is so strong against appropriating the public domain for any purpose, however laudable, should reserve for the benefit and instruction of the people a tract of 3,575 square miles, is an act that should cause universal satisfaction through the land. This noble deed may be regarded as a tribute from our legislators to science, and the gratitude of a nation, and of men of science in all parts of the world, is due them for this munificent donation.**

Cyrus Thomas prepared a 65-page article on the agricultural resources of the Territories for Hayden's annual report. Thomas called for some plan to conserve timber resources and also a planned system of irrigation in dry regions, the Government controlling irrigation and water rights. The annual report included extensive papers by Lesquereux, Cope, Leidy, and Meek on paleontology and reports on zoology, botany, and meteorology. In one of his papers, Cope described a flying saurian which he claimed he had discovered before Marsh.

Professor Marsh had also had a small party in the field, dividing its time between Kansas and Wyoming. The Kansas trip was especially successful, as Marsh found a specimen of the great diving bird *Hesperornis regalis* with its skull, which proved the existence of teeth in this form. Later in the year, Marsh charged that Cope was predating some of his publications in order to insure priority under the rules of nomenclature, and the great Cope-Marsh paleontological war got underway.

Powell began his second expedition down the Colorado on May 22, 1871. Again, Powell ignored professional scientists in choosing his crew, and except for Jack Sumner, none of the 1869 crew was recalled. In the end, Sumner was unable to go, being snowbound, and Jack Hillers of Salt Lake City as a last-minute substitute began a long association with Major Powell. In addition to A. H. Thompson, F. M. Bishop, and W. H. Graves, who had accompanied him in 1870, the new crew included E. O. Beaman, a professional photographer; Fred Dellenbaugh, a young man with artistic abilities; S. V. Jones, a student; J. F. Steward and Andrew Hattan, Army friends; Walter Clement Powell, Major Powell's cousin; and Frank Richardson, a family friend.

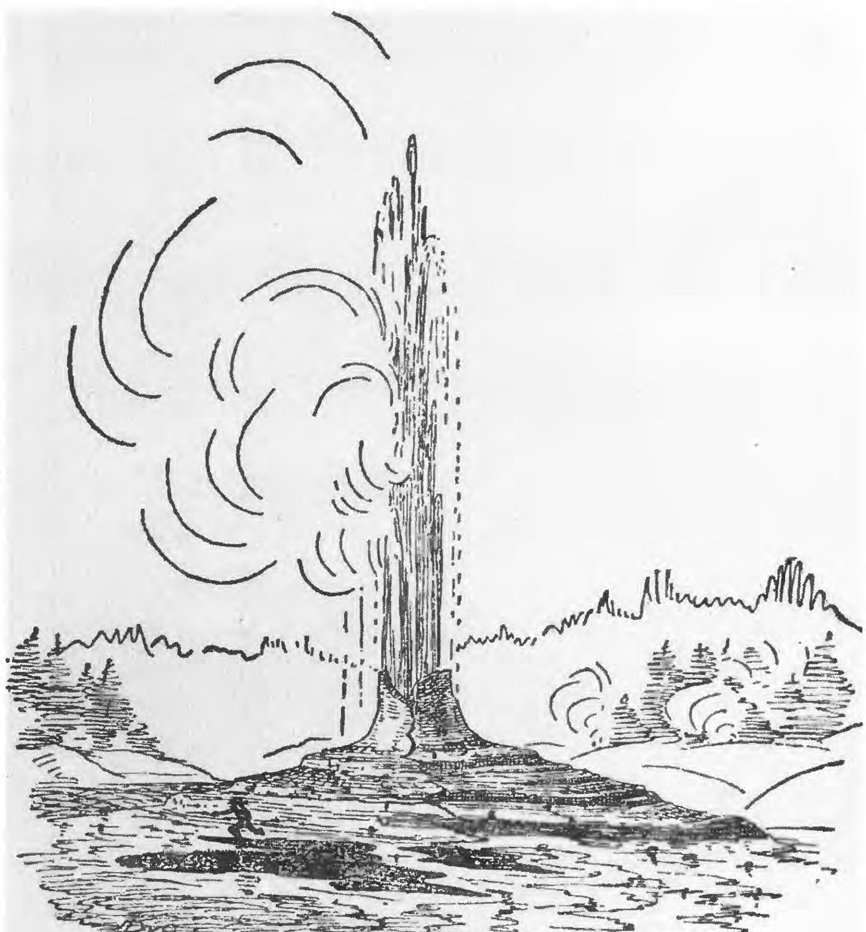
Major Powell himself made only part of the river trip. When they reached the Uintah Indian Agency a message was received that it was not possible to

▲
Hayden, who spent the seasons of 1871 and 1872 studying the first national park, said the most formidable impediments to traveling were encountered around Yellowstone Lake and the mountains bordering it because fallen tall pines, destroyed in autumnal fires and laid down in every direction by strong winds, formed a network 6 feet high in some places. (From F. V. Hayden, 1872.)

take supplies to the mouth of the Dirty Devil, so Powell took off overland for Salt Lake City, returned briefly to report that the river which Hamblin had thought was the Dirty Devil was actually the San Rafael, put Thompson in charge of the river party, and took off again, determined to find a route down the Dirty Devil. He rejoined the river party at Gunnison's Crossing at the end of August, his mission unaccomplished. Supplies were already getting short, so the party pressed on without time for observations and reached the Crossing of the Fathers on October 6. There Powell left them to make arrangements for winter camp at Kanab, and the rest went on to the mouth of the Paria where they cached the boats.

While they were in winter camp, Thompson began preparation for the topographic map of the Kaibab and Kanab Plateaus, measuring a 9-mile base line and setting up monuments for triangulation, which took until February 21. Major Powell and another party found a trail by which a pack train could reach the Grand Canyon at the mouth of the Kanab, thus assuring supplies for the river party of the following summer. Early in February, he left for the East to seek a new appropriation.

Major Powell made his first appearance at the newly formed Philosophical Society of Washington in the spring of 1872 and presented an elaborate classification of valleys into two orders and six varieties, with appropriate names derived from Greek, on the basis of his studies in the Colorado region. During this trip Powell sold his house in Illinois, purchased one in Washington, and resigned from the University. He, like Hayden 20 years earlier, had decided to make his life's work a study of the West.



As Hayden's party was leaving in 1871, Old Faithful, so named by N. P. Langford and Gustavus Doane because of the regularity of its eruption, gave them a magnificent parting display. With little or no preliminary warning, Hayden said, it shot a column of water about 6 feet in diameter to a height of 100 to 150 feet and by a succession of impulses seemed to hold it up steadily for 15 minutes. (From F. V. Hayden, 1872.)

While Powell was in the East, A. H. Thompson completed the preliminary map of the Grand Canyon region and had another try at finding the Dirty Devil route to the Colorado, which he succeeded in doing. In the process, he discovered a hitherto unknown river which he named the Escalante in honor of the Spanish padre who had led an expedition from New Mexico to Great Salt Lake in 1776.

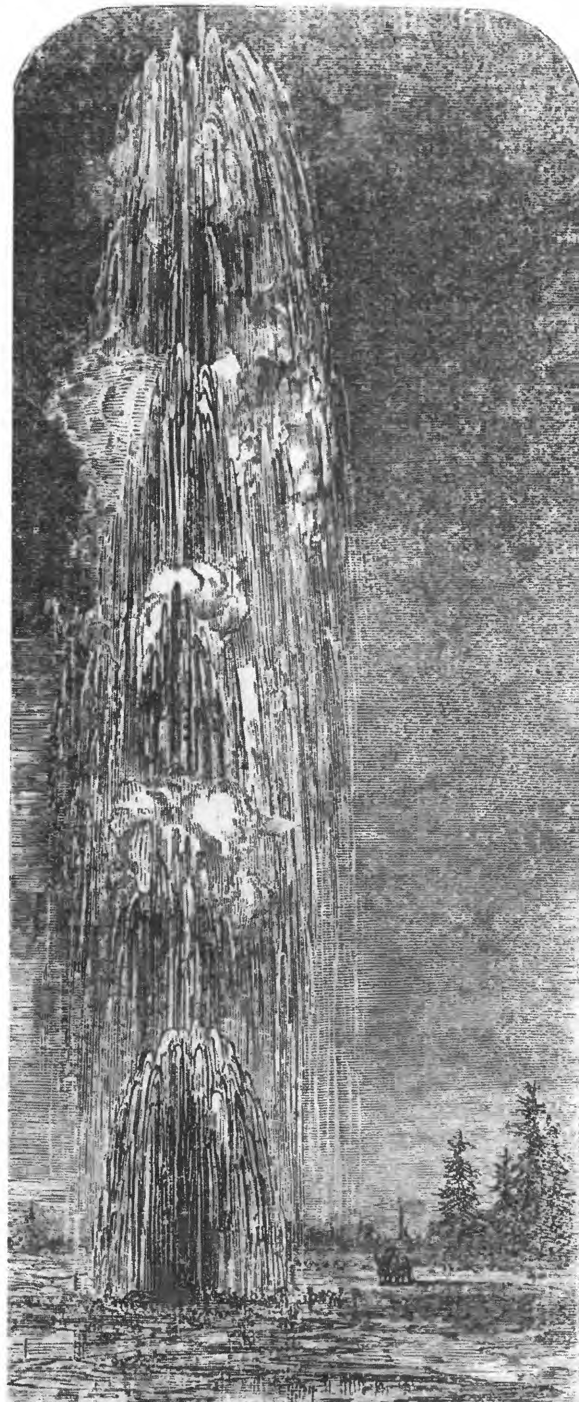
Wheeler and his corps were delayed by snow and the loss of three members of the expedition, including the chief topographer, to the Apaches, but returned to Washington in late January. Wheeler was convinced that "the day of the path-finder has sensibly ended" and proposed a broad plan for construction of a map of the Western Territories. The mapping was to be done on a scale of 8 miles to the inch, and an atlas of 85 rectangles was to be prepared. The mapping and associated natural history observations were intended in the main as an aid to military administration and operations. The survey was expected to take about 15 years and to cost in all as much as $2.5 million.

The plan for a detailed topographic survey of the entire territory of the United States west of the 100th meridian received the specific sanction of Congress in an act approved June 10, 1872. In the summer of 1872, Wheeler had two parties in the field; they mapped 50,000 square miles in western and southwestern Utah, parts of eastern and southeastern Nevada, and northern and northwestern Arizona. Parts of the Great Salt Lake, Sevier Lake, and other basins, and the valley and basin of the Colorado in and around the lower end of the main canyon were covered. The mapping was connected on the north with that of the King survey.

On March 25, 1872, Major Powell presented a brief report to Secretary Henry. He mentioned that he had discovered much mineral coal, which had been carefully examined, and other mineral deposits, which had not been thoroughly examined. He reported that the extent and character of such valleys as might be redeemed by irrigation had been noted, and that the forests had been examined. Ruins of ancient communal houses and some relics of Indian pottery had been discovered, and vocabularies of several Indian languages had been compiled. More information was promised in the final report. Secretary Henry sent the report to Congress with a letter saying "The region mentioned is one of the most interesting, in a geological point of view, in this or any country. The Colorado of the West, and its tributaries, traverse chasms in some places over a mile below the general surface of the country, presenting in many places, at one view, sections of the greater number of all known geological formations of America. The importance of the exploration, however, is not confined to the advance of science, but is also associated with practical results of value, such as the discovery of coal, salt, the metals, and other resources of the country." Congress on June 10, appropriated $20,000 for the completion of the survey.

Major Powell resumed the river trip early in August, but the Colorado was much higher than it had been the year before, and the boats were almost impossible to control, so at Kanab Wash, on September 7, the second expedition ended. For the rest of the season, Thompson continued the systematic mapping of the lower canyons, but Major Powell, after a brief study of Long Valley, went off with the new Indian agent to ride around the district. He had already acquired a reputation for being able to deal with the Indians.

In 1872, Hayden's appropriation was increased to $75,000, with an additional $10,000 for preparation of illustrations. The expedition was enlarged to 61 men and divided into two parties, each of which included a geologist, topographer, astronomer, and meteorologist. Hayden led one party that took the usual route from Bozeman through Fort Ellis and Boe-

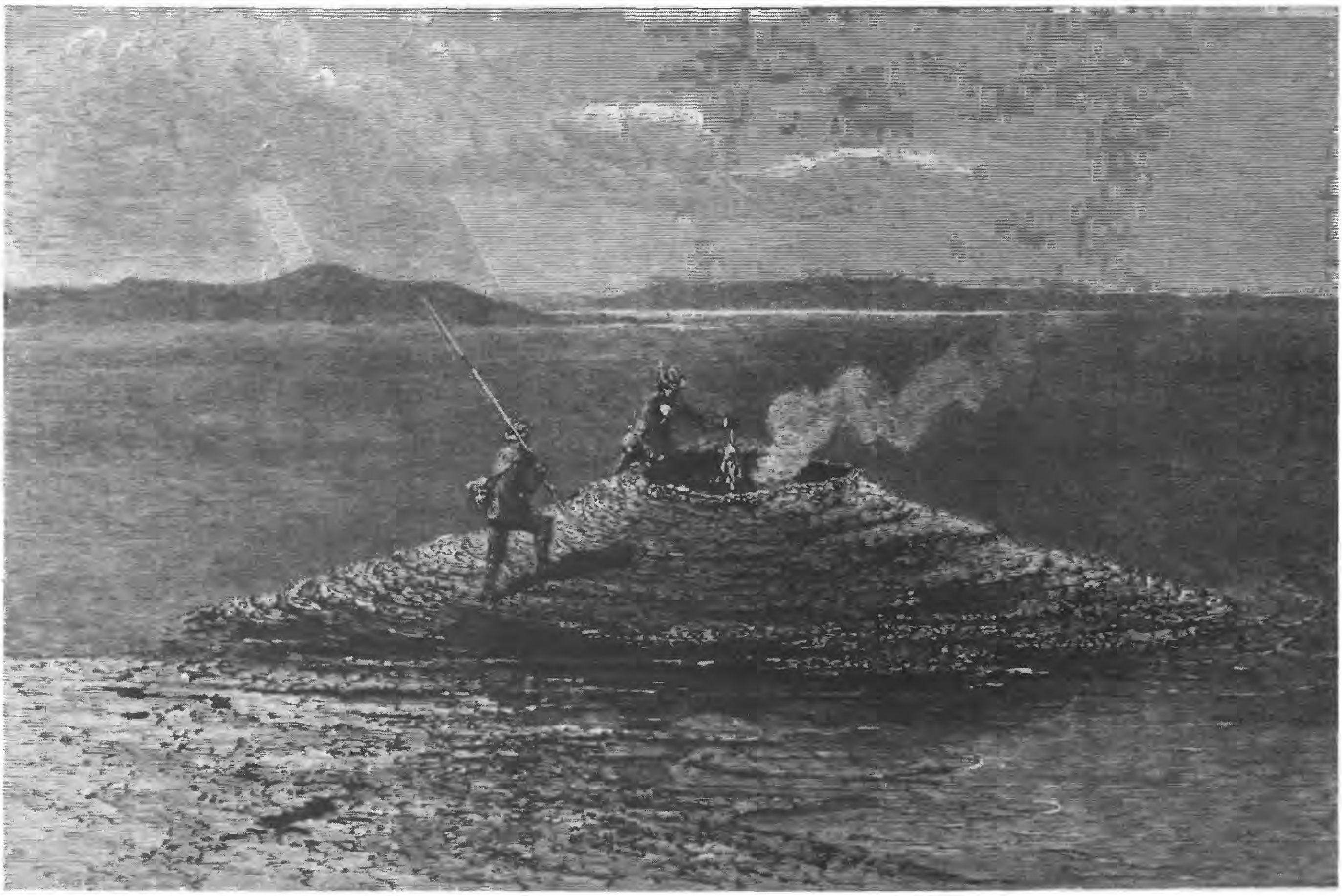


The Hayden party observed two eruptions of the Giantess in the 22 hours they remained in Yellowstone. The eruption continued for 20 minutes and was, said Hayden, "the most magnificent sight we ever witnessed." The illustration drawn by Thomas Moran, better known as a painter, shows the succession of impulses by which the column is held up apparently so steadily for so long a time. (From F. V. Hayden, 1873.)

tler's Ranch into the Yellowstone. James Stevenson led the other from Ogden, Utah, by way of Fort Hall, Idaho, and the Grand Tetons to a rendezvous in Yellowstone. The Stevenson party made a careful survey of the Snake River Valley and the Tetons and found that Madison Lake was the source of the Snake, not the Madison River. Hayden mapped the Gallatin and Madison Rivers. Together they examined the park in detail.

The Hayden party included Henry Gannett as astronomer and W. H. Holmes as artist. Gannett had been graduated from the Lawrence Scientific School at Harvard in 1869 and was one of the four students that Whitney and Hoffmann had taken to the Colorado Rockies to learn topographic mapping (whence Mount Harvard). Holmes was a graduate of McNeely Normal College in Ohio in 1870, and he had been an instructor in physical geography and drawing there and a scientific illustrator at the Smithsonian Institution for F. B. Meek and W. H. Dall. Gannett assumed charge of all astronomical, hypsometrical, and meteorological work. The astronomical position of 34 locations were determined as well as the western, southern, and eastern boundaries of the park. Gannett reported that he also "paid some attention to elevations of the water level of streams not only for getting the rate of fall, which may be of use for purposes of irrigation but as indicating what may be called the water-contour of the country, which certainly expresses the general elevation better than any other class of elevation." Gannett and Rudolf Hering, who was his counterpart in the Stevenson party, also considered possible routes for a railroad connection from the Central Pacific to the settled parts of Montana, a subject of much interest at the time.

There were attractions for sportsmen also. Hayden reported that a person might stand on one of the siliceous mounds that extend into Yellowstone Lake from the shore, catch trout weighing from 1 to 2 pounds from the lake, and cook them in the boiling springs without removing the fish from the hook. His friend, William Blackmore, repeatedly performed this experiment on the southwest shore of the lake. (From F. V. Hayden, 1873.)



In the trip up the Colorado from Mojave to Diamond Creek, Wheeler found the scenery less interesting than he had been led to expect from von Egloffstein's illustrations in the J. C. Ives report of 1861. Timothy O'Sullivan's photograph looking south into Grand Canyon from a point high on the walls, which in some reproductions suggests a satellite photograph and from which this engraving was made, is as dramatic a view as one could wish. (From G. M. Wheeler, 1874.)

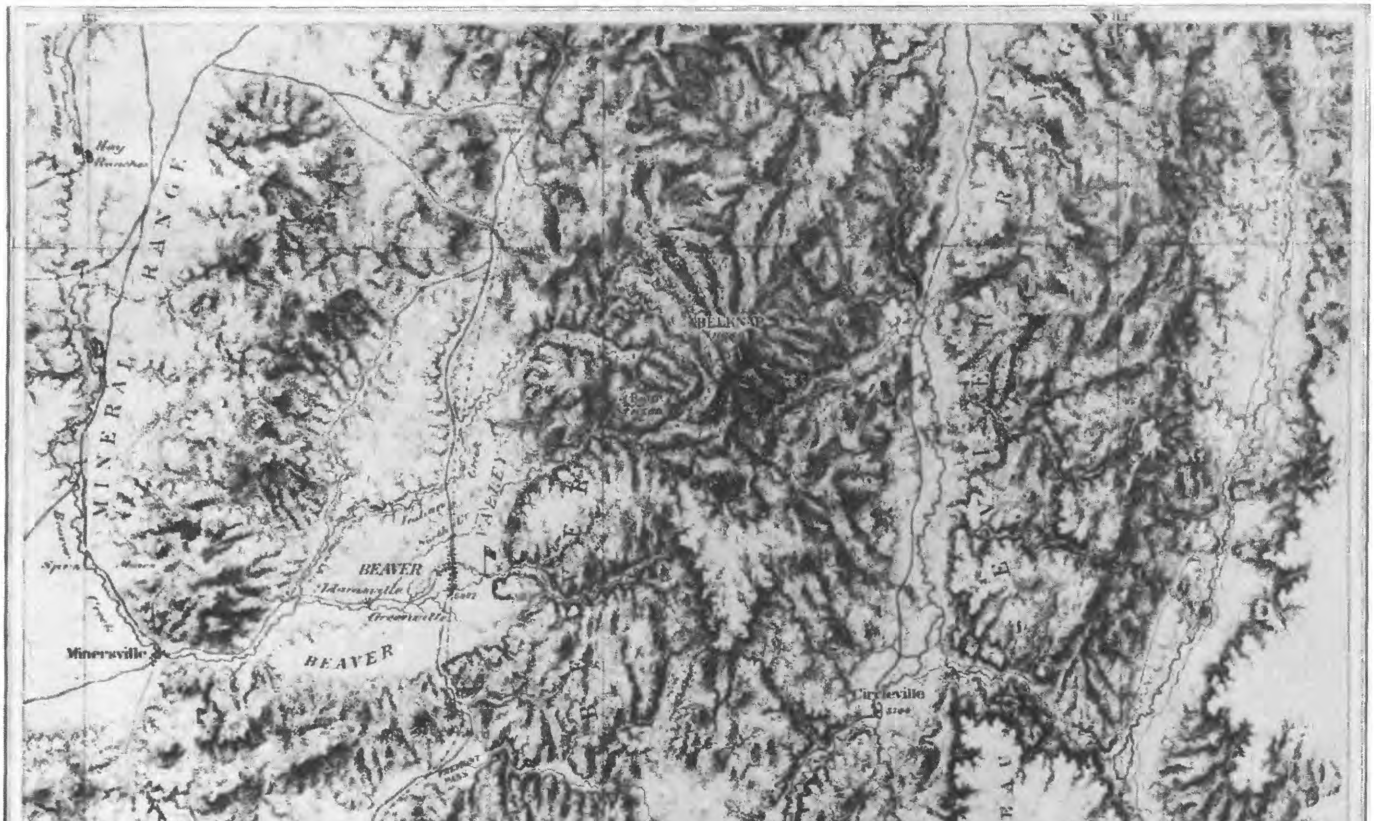
Five small parties made special examinations in various parts of the West under the auspices of the Hayden survey during that summer of 1872. There had long been some differences of opinion on the exact age of some parts of the Cretaceous and Tertiary groups, so Joseph Leidy and E. D. Cope spent a large part of the summer studying ancient lake basins where vertebrate fossils abounded. F. B. Meek, accompanied by H. M. Bannister, spent about 2 months in a reconnaissance of the coal-bearing formations along the line of the Union Pacific Railroad. Leo Lesquereux made a careful study of the Dakota group and the Lignitic formation to determine the age of the Lignitic.

Cyrus Thomas spent the summer examining the agricultural resources of Dakota Territory and adjacent parts of Minnesota and Nebraska. In his report on their physical geography and agricultural resources, Thomas said:

> **I may state that, although in some respects the portion of our country visited did not meet entirely my expectations, founded on the exaggerated and glowing descriptions of speculators and others interested, yet it presents a bread-producing area equaled by but few and surpassed by none on the continent. Its capacity as a wheat-growing section is immense; so great, in fact, that the figures stagger our belief when first presented. As a beef-producing section its resources are great, the grazing-excellent throughout the entire area.**

Thomas urged, however, that climatological studies be undertaken in the region. The real dividing line between the eastern and western parts of the continent, he said, was not the Rocky Mountains, where the streams divided, but a north-south line, approximately the 100th meridian, which divided regions of very different climate. The two questions that deserved special consideration were the temperature and rainfall. A statement that the mean lines of summer temperature made a rapid bend northward after passing west of Lake Michigan had been used in efforts to induce emigration to Wisconsin, Minnesota, and Dakota. Such a flexure would have an important bearing on agriculture, if true. He thought there was a flexure, but nowhere near so pronounced as had been advertised. With regard to rainfall, Thomas observed that it was well known that on the east side of the plains, the average rainfall was sufficient to supply the moisture necessary for growing grains, and almost as well known that irrigation was necessary at all points on the plains along the east base of the Rocky Mountains. It therefore was very important to determine the boundary between the two. The valleys, the weathering of bluffs, and detritus at the base of the Rocky Mountains all showed that at some very recent period, in a geological sense, the amount of rainfall had been greater and that a profound change had taken place.

The fieldwork of the Fortieth Parallel survey was completed in 1872. Emmons' party, with Allen D. Wilson as chief topographer, began by mapping a belt about 30 miles wide north of the Humboldt River in Nevada as far as Humboldt Wells, so that geologic sections through the whole belt of country surveyed might be on a great circle; they then moved on to Wyoming to complete the mapping of the western half of the block of unfinished



Wheeler's special pride was in his efficiency at mapmaking. This map, on a scale of 1:506,880, of an area in Utah south of that mapped by the King survey, was the result of Wheeler's work in 1872. (From G. M. Wheeler, 1874a.)

ground. Another party under Gardner spent the entire season east of the North Platte in Wyoming. Arnold Hague led a third party reexamining the Paleozoic and Triassic beds associated with silver deposits. Hague also made excursions north of the actual boundary of the survey to see if Hayden's discoveries of the Carboniferous were real. "I ought not to characterize his statements," King reported to General A. A. Humphreys, "but Mr. Hague saw enough to forbid our accepting any data from that source."

King himself spent most of the summer in a study of the ancient glacier system of the Sierra Nevada, but he also established methodically the geological connections between the work of Hague and Emmons. In late October, King, Emmons, and Wilson met and went via Brown's Hole and Vermilion Creek to Uinta Canyon, where they made sections which assured them that the ideas advanced by Hayden and others as to Silurian developments there were erroneous.

King and others of the 40th Parallel survey had been suspicious of rumors about a great diamond discovery which flooded the west in 1872 after two prospectors deposited some uncut diamonds for safekeeping in a San Francisco bank. William Ralston, a director of the bank, and George D. Roberts, a mining engineer who was associated with him, persuaded the two to take a representative to the site; the representative, who was blindfolded so the location would remain a secret, found more diamonds as well as rubies and other precious stones. Charles Tiffany of New York pronounced the gems genuine. A nationwide syndicate was then formed that bought the rights to the diamond fields. Henry Janin, a distinguished mining engineer, who was sent to confirm the value of the discovery, found more diamonds along with rubies, emeralds, and sapphires. Janin's report, quoted in the *Engineering and Mining Journal* for September 3, 1872, said the discovery was wonderfully rich and one that would prove extremely profitable.

However, in all their work in the West, none of the 40th Parallel men had ever found diamonds or had even seen a formation that looked as if it might contain such gems. Early in November, after their investigations in Uinta Canyon had been completed, King, Emmons, and Wilson went north. The location of the diamond fields had been variously located by rumor in Arizona, or Nevada, or Colorado, but King, Emmons, and Wilson had individually concluded that they must be north of Brown's Hole. They found the site in Wyoming, a small sandstone mesa, and they found diamonds, but curiously the diamonds were only on the mesa, in a fixed ratio of rubies to diamonds, and most of them were in anthills. The deposit was obviously a fraud.

King and Wilson left immediately for San Francisco, riding all day through the badlands to Black Butte Station where they caught the train for San Francisco. In San Francisco, King sought out Janin and showed him the evidence. Together they went to the company directors, who begged King to keep quiet until they could sell out. King refused but was persuaded to take Janin and others to the diamond fields for a final check. When they returned, the fraud was announced, and Ralston and his partners repaid the stockholders. King was the hero of the hour, but General Humphreys was not pleased. It was proper that King make the investigation, but he should have gone through channels to announce his discovery. Scientists, however, rejoiced at his success, and Whitney said, "Who's King of Diamonds now? And isn't he trumps?"

Chapter 11.
The Shifting Times, 1873–1874

Thus times do shift, each thing his turn does hold; New things succeed, as former things grow old.

—Robert Herrick

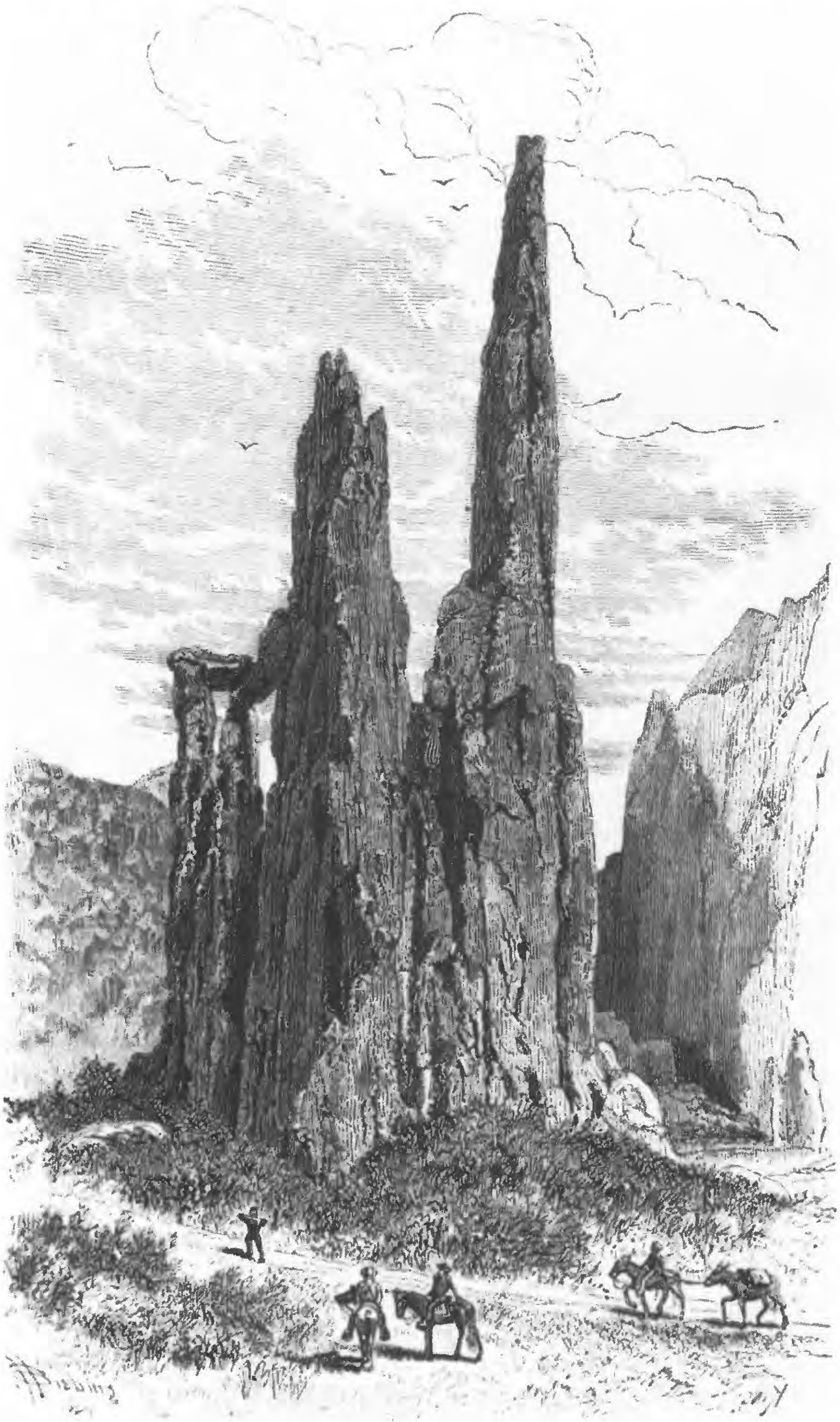
The year 1873 divides the dozen years following the Civil War into two distinct parts. The financial and economic crisis in September 1873 had great consequences in American life. Allan Nevins describes the change as "on the one side lies the sunshine of buoyant commercial prosperity; on the other the gloom of depression, economy and poverty." Inevitably, these changed conditions had an effect on science and the surveys.

Hayden shifted his operations to Colorado in 1873. In late January, he wrote to Secretary Delano suggesting that he begin work in the Territory of Colorado immediately south of the area mapped by the King survey. "There is probably no portion of our continent, at the present time," he wrote, "which promises to yield more useful results, both of a practical and scientific character. This region seems to be unoccupied at this time, as far as I am aware, by any other survey under the Government, and the prospect of its rapid development within the next five years, by some of the most important railroads in the West, renders it very desirable that its resources be made known to the world at as early a date as possible." The northern work could wait until the railroads opened of that country. Besides, the Indians there were becoming hostile. Congress appropriated $75,000 for "continuation of the geographical and geological survey of the Territories," and Hayden planned to begin the survey of Colorado in the eastern part of the mountainous region.

James Gardner, chief topographer of the King survey, joined the Hayden survey as chief geographer and, apparently in his mind at least, co-director with responsibility for the geographical part of the survey. Gardner insisted that "for making maps suited to geological purposes it is necessary to carry over the country a systematic trigonometric and topographical survey, checked by astronomical observations." He himself headed the chief triangulation party, which went ahead of the others, and accomplished almost 17,000 square miles of primary triangulation. Holmes accompanied Gardner and made numerous sketches from the high peaks used as primary stations.

The area to be surveyed was divided into three districts, North, Middle, and South, and three combined topographic and geologic parties were organized, one for each district. The party in the North district, which became known as Middle Park was headed by A. R. Marvine, who had transferred from the Wheeler survey. Both a geologic and a topographic map were prepared, and S. B. Ladd, the assistant topographer, and Marvine also prepared a report on means of communication, distribution or timber, grasslands, and population. Henry Gannett, who had been the astronomer in Yellowstone, was in charge of the Middle district, which became known as South Park, and was accompanied by A. C. Peale as geologist. Allen Wilson, who had been with Emmons' party of the King survey as topographer, was in charge of the South district, or San Luis district, with F. M. Endlich as geologist.

The Engineers despatched a party under Captain William A. Jones to make a reconnaissance of the northwestern part of the Territory of Wyoming which Hayden had abandoned. The official orders were to make a reconnaissance of the country about the headwaters of the Snake, Green, Big Horn, Grey Bull, Clark's Fork, and Yellowstone Rivers, but General E. O. C. Ord added oral directions to find, if possible, a good route from the south, via the Wind River valley and Upper Yellowstone, into Montana. Both Hayden and N. P. Langford maintained that Yellowstone Park was accessible only from Montana.



The Triassic sandstones along the eastern base of the Rocky Mountains in Colorado, in every shade of red, have weathered into fantastic shapes, in places standing in walls or columns 50 to 250 feet high. The Cathedral Rocks in the Garden of the Gods are among the most celebrated scenic features in Colorado, and Hayden chose this illustration more for popular appeal than scientific exposition. (From F. V. Hayden, 1874.)

Captain Jones' party included a young geologist, Theodore Comstock, a graduate of Cornell in 1870 who had been teaching natural history in private schools. The party was in the field from June 12 to September 19 and traversed the entire western part of the Territory from south to north and from 108° to 111° W. Jones found a wagon route into the park from the south, a route that General A. A. Humphreys said "whatever may be the advantages of the Missouri River route, would tend to keep down rates, and would prove advantageous to the Government in the transportation of military and Indian supplies." By the following spring, Comstock produced a 100-page report on the geology of the area, complete with a colored geologic map.

Lieutenant Wheeler had three divisions in the field in the summer of 1873. The main party operated out of Santa Fe and mapped in the basins of the Rio Grande, de Chelly, Little Colorado, Gila, San Francisco, and Salt Rivers. G. K. Gilbert was the geologist with this party. O'Sullivan took many spectacular photographs of the Indian ruins in Canyon de Chelly. A section under Lieutenant R. L. Hoxie operated out of Salt Lake City, mapping in the basins of Great Salt Lake, Sevier, Green, Little Colorado, and Colorado Rivers. E. E. Howell was geologist with the Hoxie party, and Gilbert Thompson accompanied it as topographer. Lieutenant Hoxie's party encountered considerable hardship. They were frequently without good water, and sometimes without any. At one time they subsisted for 7 days on hard corn brought along for the mules. The third section, under Lieutenant W. L. Marshall, set out from Denver, confining itself to the basins of the Arkansas, Gunnison, and Rio Grande. J. J. Stevenson, professor of geology at New York University and former aid with the Ohio survey, accompanied this party as geologist. It was almost inevitable that Lieutenant Marshall would run into parties of the Hayden survey.

On January 17, 1873, Major Powell had presented a brief report to Secretary Henry on his work during 1872 and asked for continuation of his survey. Much of the report was devoted to ethnology, for Powell had been interested in studying the languages, habits and customs, and the state of arts among the Indians. He had sent Jack Hillers and a small party to the seven ancient towns known to the Spaniards as the Province of Tusayan to make a collection of works of art and a series of photographs. The collection had been made, but owing to an unfortunate accident to the photographic apparatus, only a few pictures were obtained.

The chief reason given for continuing the work, however, was Powell's discovery of a series of faults and folds, which Henry called "most remarkable" in his letter to Congress. "The faulting and folding of the rocks have, together with erosion, produced long lines of cliffs of a magnitude that is believed to be elsewhere unknown," Powell reported. "These cliffs are bold escarpments, often hundreds or even thousands of feet high, great geographical steps, scores or hundreds of miles in length, presenting steep faces of rock, often quite vertical." Some of these he named: Shinarump, Vermillion, Gray, and Pink Cliffs. Transverse to them, another series of cliffs marked lines of a great system of faults, and these he also named: Grand Wash, Hurricane, Toroweap.

To complete the survey properly, he estimated would take 2 years at $20,000 a year, or 1 year at $45,000. If that were not approved, he suggested that a system of triangles be run from the valley of the Sevier to the junction of the Grand and Green in order to fix with approximate accuracy the head of the Colorado and to complete the survey of the valley of the San Rafael and of the mountains and plateaus in which it had it sources, and then to complete the reconnaissance of the upper country and trace his great system of faults to where they were lost in the mountains to the north. That

could be done in 1 year at a cost of $20,000. Secretary Henry sent the request to Congress but made no special request for an appropriation. Congress, on March 3, appropriated "the sum of ten thousand dollars, or as much thereof as may be necessary *** to enable Professor J. W. Powell to prepare his materials, and to present to Congress at its next session a report on the Colorado River of the West and its tributaries."

In the summer of 1873, Major Powell sent A. H. Thompson to continue mapping while he himself was engaged in a study of the Indians. He had been appointed a special commissioner by the Department of the Interior to visit the Indians of Utah and eastern Nevada and to help them get established on reservations. Between July and November, he visited all the bands known to live in the area, making a careful census of their numbers and condition and adding to his store of knowledge of their languages and customs. The report of the special commissioners disclosed the unexpected fact that there were only 5,500 Indians in the whole territory. Because of the influx of white settlers who had occupied the best areas, the Indians had had to split into smaller and smaller bands in order to obtain the barest subsistence, and they were on the verge of extinction.

Settlers on the Middle Western Plains and prairies were handicapped by lack of wood and in some places, water. The lack of trees had been one of the reasons why the pioneers had traveled through the area to reach the Oregon country 30 or 40 years earlier. Now that they were settling the

The sandstone walls of Canyon de Chelly in Arizona were photographed by Timothy O'Sullivan in 1873. The isolated shafts near the center of the canyon (right of the picture) were estimated to be 742 feet high. The Indian ruins of Canyon de Chelly, some of them 400 feet above the river bed, were first brought to notice through James H. Simpson's reconnaissance of 1849. (From G. M. Wheeler, 1889.)

country, wood had to be imported for construction purposes, and precipitation was sometimes so low as to make farming without irrigation hazardous. Forests would obviously supply wood, and at the time many people believed that forests would increase rainfall, so planting trees would serve a dual purpose. The Commissioner of the General Land Office in 1866 had suggested that all homesteaders in localities where trees were scarce should be required to plant trees. Finally, on March 3, 1873, Congress passed the Timber Culture Act providing that any person who planted, protected, and kept in healthy growing condition for 10 years 20 acres of timber trees spaced no more than 12 feet apart on any quarter section of public lands was entitled to a patent for the whole quarter section.

At the same time, Congress began to look into more direct ways of solving the problem of irrigation. Senator Stewart for the Committee on Public lands brought up a bill late in the session to enable the President to appoint a commission to determine the best method of irrigation for the San Joaquin, Tulare, and Sacramento Valleys of California. Legislation was constantly being pressed on them, the Senator said, and the Committee on Public Lands wanted an investigation and report. Several Senators immediately concluded that the report would be accompanied or followed by a recommendation for the appropriation of a large sum of money but Senator Stewart insisted information was all that was sought, and the bill also became law on March 3, 1873.

Changes were also made in the mineral land laws. The Mining Acts of 1866 and 1870 were amended by the Mining Act of May 10, 1872. The mineral lands were still free and open to exploration and purchase but "under regulations prescribed by law, and according to the local customs or rules of miners, in the several mining districts, so far as the same are applicable and not inconsistent with the laws of the United States." Claims made after passage of the act were not to exceed 1,500 feet along the lode or 300 feet in width, and the sides were limited by vertical planes. In introducing the bill, Mr. Aaron A. Sargent of California said that it did not make any important changes in previous laws and that the changes were principally those related to the legal questions involved and were meant to facilitate the obtaining of titles. J. D. Whitney rather caustically observed that it bore "all the marks of having been drawn up by lawyers with an eye to their own business, rather than to the good of the miner or of the country in general: certainly no

The Hayden survey began systematic topographic mapping in Colorado in 1873. W. H. Holmes accompanied the triangulation party and used his artistic ability and geologic knowledge in making panoramic sketches from the high peaks used as primary stations. This sketch shows the eruptive rocks in two table mountains near Golden as viewed from Bear Creek Station, about 6 miles to the south, and also the characteristic appearance of the plains to the east of the mountain front. (From F. V. Hayden, 1874.)

competent mining engineers could have been consulted in its preparation."

A new Coal Lands Act was enacted on March 3, 1873. Again, as in 1864, it was made clear that coal lands were not considered mineral lands; Section 6 stated that the act could not be construed to authorize sale of lands valuable for mines of gold, silver, or copper. The Coal Lands Act provided that a citizen, or one who indicated an intention to become one, might enter any quantity of vacant and unreserved coal lands of not more than 160 acres, described according to the government survey. An association of individuals was permitted to enter a 320-acre tract. The minimum price was $10 an acre for land more than 15 miles from a completed railroad and $20 an acre for land within 15 miles of the railroad. An association of not less than four persons could obtain as much as 640 acres if not less than $5,000 had been expended in work and improvements.

In the Coinage Act of February 12, 1873, Congress demonetized silver. This was not a formal adoption of the gold standard, although several European countries were adopting the gold standard, and Great Britain, which dominated international monetary affairs, had been on the gold standard since 1821. The U.S. Congress dropped silver coins from the list of official coinage because the world price of silver was high, and little was being offered to the Mint at the official price. The act was almost unnoticed at the time but soon became a source of contention between the East and West.

King settled in San Francisco to complete the 40th Parallel reports and atlas. Several mining commissions came his way and he took advantage of them, combining mine inspection with a review of 40th Parallel geology. In May 1873, he was summoned to testify before the court as an expert witness in the battle between the Richmond and Consolidated Eureka Companies over a cavern which both had tapped. In June 1873, he was commissioned to examine the Emma mine in Utah which had been sold to British investors for nearly $5 million. The new manager retained King to make an investigation, and King told him that "The great Emma 'bonanza' *** is with insignificant exceptions worked out***."

During the winter, the 40th Parallel survey moved east to New York, where headquarters were set up not far from Cooper Union. Rossiter Raymond, the U.S. Commissioner of Mining Statistics, was then an aide to A. S. Hewitt in the Cooper-Hewitt enterprises, so Cooper Union was a center for mining and metals studies. The atlas was finished and sent to the printer, and on February 25, 1874, King wrote to General A. A. Humphreys:

> **The day has passed in Geological Science when it is either decent or tolerable to rush into print with undigested field observations, ignoring the methods and appliances in use among advanced investigators. It is my intention to give this work a finish which will place it on an equal footing with the best European productions and those few which have redeemed the wavering reputations of our American investigators.**

One of the special studies undertaken was based on the chemistry and microstructure of western rocks. C. E. Wright, who had become acquainted with the new methods in microscopic work as a student in Germany, was hired on his return to the United States in 1873. Wright had already made some determinations for the Michigan survey, which had sent the specimens to Europe. Emmons was also sent to Europe to observe methods developed by British and Continental surveys, to collect books of reference not available in the United States, and to buy microscopes in Germany. Emmons did even more; he induced Professor Ferdinand Zirkel, one of the pioneers in microscopic petrography whose *Mikroskopische Beschaffenheit der Mineralien and Gesteine* had just been published, to come to New York to oversee the work.

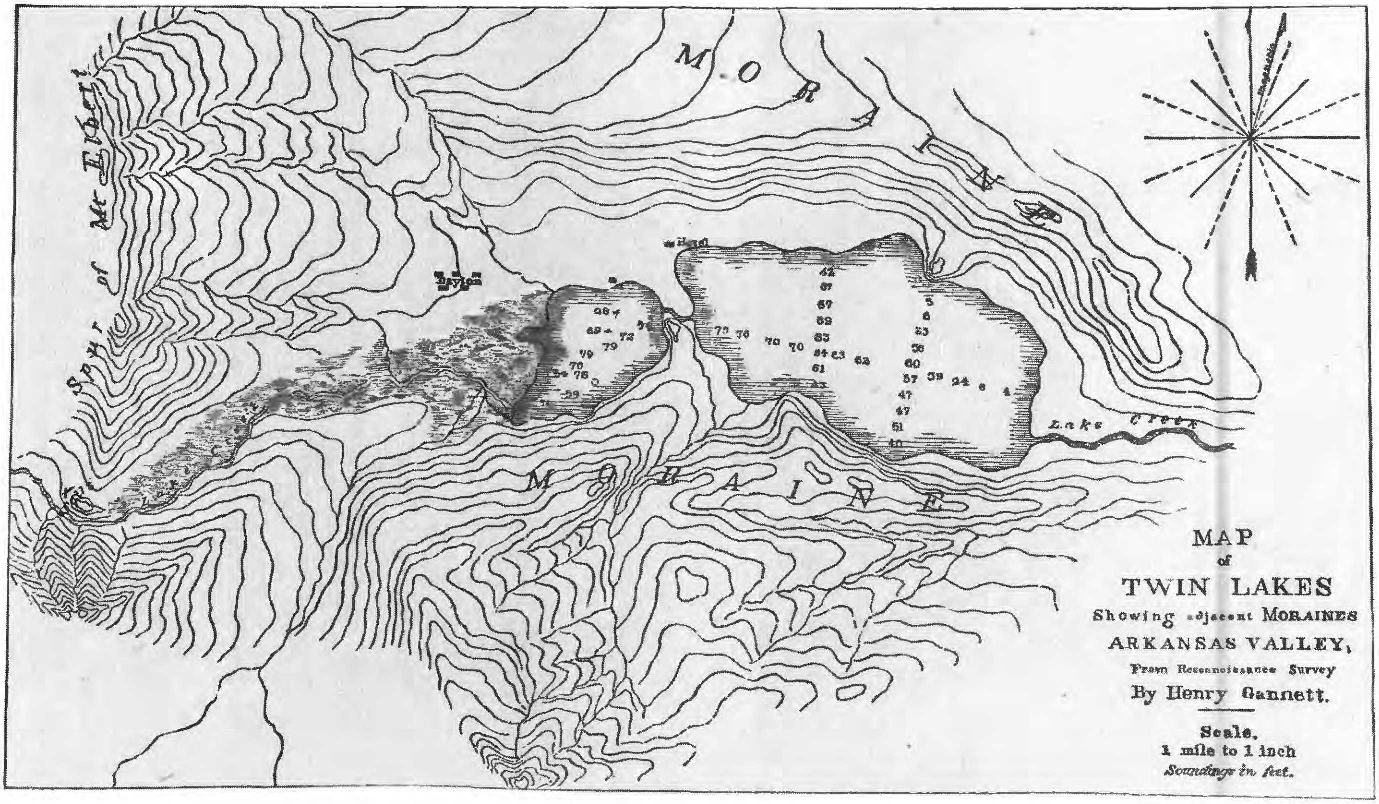
Five State surveys were reactivated in the early 1870's, all of them staffed largely or wholly by young men trained in the newer ways of science. In most of them, the development of mineral resources was the primary motive. In 1873, the Alabama legislature provided funds to continue the work left incomplete by the death of Michael Tuomey. Eugene A. Smith, professor of geology at the University of Alabama, who became the State Geologist, was then 32, a graduate of the University in 1862, and had a doctorate from Heidelberg in 1868. Whereas Tuomey had concentrated on Alabama coal, Smith began with a study of copper-bearing rocks and afterwards began a study of iron ores.

The Kentucky legislature in 1873 ordered a continuation of the Owen survey, left incomplete by his death in 1860. Nathaniel S. Shaler, also 32, a native of Kentucky, but then professor of paleontology in the Lawrence Scientific School at Harvard, was named Chief Geologist and Director. The records of the previous survey had been destroyed during a fire in the State offices in 1867, so Shaler planned a general reconnaissance, an accurate topographic map of the State on the scale of 1 inch to the mile, and a geologic map. The first assistants were Dr. Robert Peter, who had been Owen's assistant, as chemist, and A. R. Crandell as geological assistant.

Wisconsin also reestablished its geological survey in 1873, and Increase A. Lapham was appointed State Geologist. Lapham was a naturalist of the old school, but he was assisted by three young men, all still in their twenties: Thomas Chrowder Chamberlin, a graduate of Beloit in 1866; Roland Duer Irving, a graduate of the Columbia School of Mines in 1869, who had since served under Newberry on the Ohio survey; and Moses Strong, a graduate of Yale with advanced study in Europe. Irving was assigned to begin a survey of the iron and copper ranges of Ashland and Douglas Counties, Strong, a survey of the lead region, and Chamberlin, of the southwestern part of the State.

The Minnesota survey, established under the act of March 1, 1872, began in somewhat different fashion. The Minnesota law was drawn up by the President of the University of Minnesota, one of his prime motives being to make the university the center of information on natural features of the State and its museum the center for natural history collections. Newton Horace Winchell, younger brother of Alexander Winchell, who had been State Geologist of Michigan, was appointed State Geologist. N. H. Winchell had received an A. B. from Michigan in 1866, an A. M. in 1869, and had served as assistant on the Michigan and Ohio surveys. The first annual appropriation for the Minnesota survey was only $1,000, but the State Geologist gained acceptance for the survey by undertaking work on the salt-spring lands, on which private industry was then making inroads, as the result of which a new law was passed in 1873, which transferred custody of the salt lands to the Board of Regents of the University. Winchell shrewdly stressed the economic applications of the work and put the reports of the survey in semiscientific language so that they could be widely understood, and the State survey had an exceptionally long life.

The rapid development of the economic resources of Pennsylvania, particularly coal, iron, and petroleum, led to the establishment of the second geological survey of Pennsylvania in 1874. The immediate motive for the survey was probably the clamor of the oil men in 1873 for a survey of the oil regions, for in that year, the annual production of petroleum increased from 6 million to 10 million barrels and the price dropped from $4 to $2 a barrel, throwing western Pennsylvania into a state of intense excitement and the stock markets of the world into confusion. The law provided for the appointment of 10 commissioners with authority to appoint a State Geologist, who,



The Twin Lakes area in Colorado at the base of the Sawatch Range near the mouth of Lake Creek gorge shows evidence of glacial action in the valleys. Hayden pointed out that the rounded form and cover of grass and vegetation on the ridges indicated the deposits were of loose materials, or moraines, and suggested that the valleys had been cut through the detrital mass after the end of the glacial period. (From F. V. Hayden, 1874.)

with competent assistants, was to make such investigations as might be required to elucidate the geology of the State and put the results of this and previous work into convenient form. The commissioners appointed J. Peter Lesley, professor of geology at the University of Pennsylvania, as State Geologist, and the legislature provided sufficient funds ($105,000 for the first biennium) for a large staff. Among the assistants were Charles Allen, C. A. Ashburner, J. F. Carll, H. M. Chance, Persifor Frazer, F. A. Genth, and F. Prime, Jr. Systematic work began in the northwestern part of the State—the oil regions.

The Economic conditions were at this time changing. In the fall of 1837, the nation was plunged into a financial panic of disaster proportions. Unbridled railroad speculation, especially in the field of construction; overexpansion in industry, agriculture, and commerce; and a contraction of European demand for U.S. farm products were all underlying causes, but the panic itself was triggered by the failure of the powerful banking firm of Jay Cooke. The panic was followed by half a dozen years of as dark depression as the country had known to that time.

Farmers and laborers were especially hard hit, and both these groups had grievances against the monetary system. For some time, the Treasury had been retiring greenbacks issued during the war, but national bank notes were allocated on the basis of population and existing bank facilities which meant that most of them went to the Northeastern States. Greenbacks were the only real bank reserves available in the West. To cope with the depression, several measures were tried, including a reissue of some greenbacks. In April, Congress passed a bill to raise the amount of greenbacks and national bank notes to $400 million each, but Grant vetoed the measure. In a reversal of form, Congress then placed a ceiling on the greenbacks at the number then outstanding.

Congress was bombarded with information about irrigation in the spring of 1874. The commissioners appointed under the act of March 3, 1873, Lt.

Col. B. S. Alexander and Major George H. Mendell of the Corps of Engineers and George Davidson of the Coast Survey, prepared a 91-page report.

"Irrigation is but little understood in this country," the commissioners concluded "either by our engineers, who must design, plan, lay out, and execute the works for that purpose, or by the farmers who are to use the water when it is brought alongside their farms." They found

> that the experience of other countries appears to prove that no extensive system of irrigation can ever be devised or executed by the farmers themselves, in consequence of the impossibility of forming proper combinations or associations for that purpose; that while small enterprises may be undertaken by farmers in particular cases, it would not be in accordance with the experience of the world to expect of them the means or inclination to that co-operation which would be necessary to construct irrigating-works, involving large expenditures; that enterprises of this character, if built at all, must be built by the State or by private capital.

No comprehensive system for irrigation could be made without a complete instrumental survey made for that special purpose, so that the proper location, size, and height of the dams across the different rivers and streams could be determined as well as the alinement, size, and slope of the canals, and distributing ditches, and the country divided into different irrigating districts which would be more or less independent of each other.

The Commissioners remarked that

> all such natural districts, because they are natural, cannot be altered by legislation, and their boundaries are independent of the artificial boundaries of a State, county, or township unless those boundaries follow the natural lines of drainage, or the divisions of drainage areas into different water-sheds.

The commissioners also thought

> that it is the duty of the government, both State and national, to encourage irrigation, and the first step in that direction ought to be to make a complete instrumental reconnaissance of the country to be irrigated, embracing the sources from whence the irrigating-canals ought to commence, gauging the flow of the rivers and streams, and defining the boundaries of the natural districts of irrigation into which the country is divided. Then, when it is proposed to irrigate any particular district, an accurate topographical survey of that district should be made, so that the canal and other necessary works for its irrigation may be designed on an intelligent and comprehensive system, and in harmony with the neighboring canals, and these works executed in the most economical manner.

The commissioners proposed that

> as a matter of public policy, it is desirable that the land and water should be joined together, never to be cut asunder; that the farmers should enjoy in perpetuity the use of water necessary for the irrigation of their respective lands; that when the land is sold the right to water shall be sold with it, and that neither should be sold separately.

Congress had already been warned that irrigation was no panacea for the arid West. On February 10. 1874, the Commissioner of Agriculture had supplied a report by George Perkins Marsh on *Irrigation: Its Evils, the Remedies, and the Compensations,* and by Senate resolution, 10,000 copies had been printed. The report was based on Marsh's new edition of *The Earth and Man.* Irrigation, Marsh said, was not cheap or easy, and it posed problems. Irrigation required reservoirs and artificial lakes, which sometimes burst their barriers and flooded the country below. Irrigation often exhausted the soil, produced hardpan, or concentrated lethal salts at the surface. Irrigation might multiply yields at the expense of nutritive value and flavor. Knowledge of western climates and soils was virtually nonexistent; no one knew how much land was irrigable, or whether enough water was available to make irrigation profitable. Water used for irrigation deprived adjacent lands of their normal supply, thus disturbing the balance of nature. Before any major irrigation works were begun, a comprehensive hydrographical survey should be made, which would show how much water each river basin received from rain, melting snow, and ground water; how much would be needed for agricultural, industrial, and domestic purposes; how much the supply could be augmented by water diverted from other areas; and the probable effects of such diversions.

Marsh also warned them that "acquisition of the control of abundant sources of water by private individuals may often result in the establishment of vested rights and monopolies liable to great abuse." Irrigation required large amounts of capital and thus tended to promote the accumulation of large tracts of land in the hands of single proprietors and to dispossess the smaller landholders. "We must look to our rulers for such legislation as shall prevent the greatest amount of evil and secure the greatest amount of good, from the introduction of a system so new to us." Marsh thought that a new water code was necessary to protect the rights of all and that only public ownership could solve western water problems.

On April 10, 1874, Senator John W. Stevenson of Kentucky filed a bill in the Senate to provide aid for geological and other surveys in the States by detailing Army officers to them. The bill was referred to the Committee on Military Affairs, which reported it adversely on April 28. Senator John A. Logan said that the Committee deemed it improper for the general Government to tender aid to the States until they requested it, and in fact that it was not "aware" that detailing officers would in any way aid the surveys, "as it is not to be presumed that their education for and duties as Army officers prepares them to compete with or furnish any valuable aid to those civilians in charge of these surveys who have devoted years of patient study to geology and the cognate sciences." The committee considered that such positions would be simple sinecures which would draw a number of officers from duties they were required by law to perform, and it expressed its firm conviction that it was detrimental to the usefulness and efficiency of the officers of the Army to have them constantly detailed for work not in their line of duty. Moreover, placing them in charge of works and surveys of a scientific character had a tendency to deter civilians from devoting their time and talent to investigations which, "if left to their own control, will not only redound to their own honor, but will be of great benefit to the public." The Committee also observed that if there were too many Army officers, other ways could be found to solve that problem.

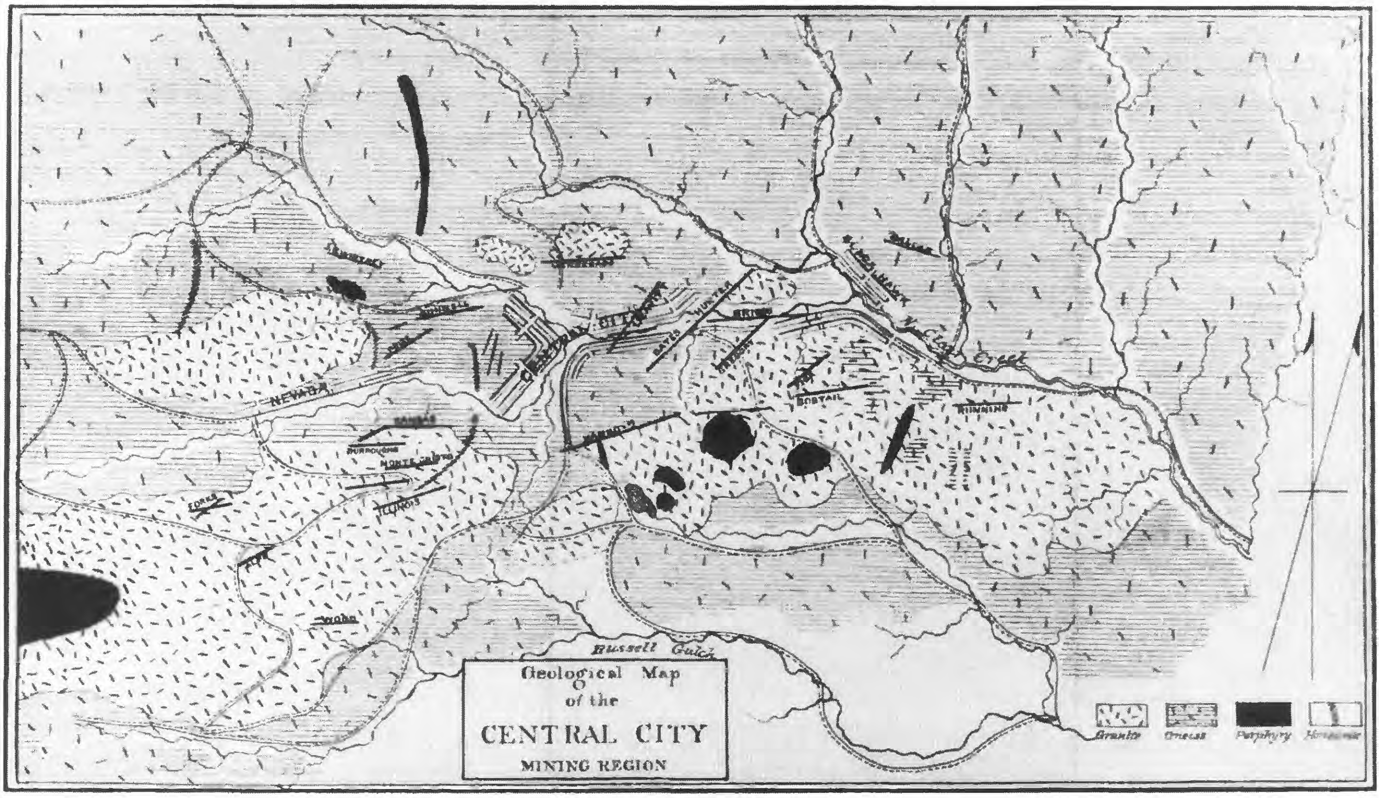
On April 15, Mr. Lazarus Shoemaker of Pennsylvania proposed a resolution, which the House promptly passed, asking President Grant to supply information about the surveys operating west of the Mississippi and the practicability of consolidating them or of defining the geographic limits to be embraced by each.

The President replied on May 2, sending a message with his own views as well as the views of officers of the War and Interior Departments. Everyone was in favor of some sort of consolidation, although they did not agree under which department. The President said that there was no question that surveys for sectioning the public lands should be under the control of the Interior Department. Where the objective was to complete the map of the country or to collect information on the unexplored parts of the country, it mattered little which department had control; the choice should depend first on which department could do the work best and then on which one could do it most expeditiously and economically. Exploring expeditions needed military escorts, the Engineer Corps was composed of scientific gentlemen who had to be paid whether exploring or not, and so the President thought that his conditions could be best fulfilled by having the Army make the surveys. The Secretary of War naturally concurred—efficiency and economy would be the result of consolidating all such surveys, except the surveys under the General Land Office, under the War Department.

General A. A. Humphreys, the Chief of Engineers, said: "By placing all these surveys under one Department, there would be unity of plan, greater economy, and greater efficiency, and, as a consequence, more useful results for the same expediture." His main argument was a repetition of what he had written to Congressman Garfield, Chairman of the House Appropriations Committee, in February 1873, that the War Department had "superior claims" because "it has usually been intrusted with them, and possesses officers skilled in the operations which form the chief labors of the party—skilled, too, in the application of the results of all the labors of the party to the great practical ends had in view in making the explorations, and trained to the command of men and of the troops that always form a part of such expeditions."

In the judgment of the Secretary of the Interior, Colmbus Delano, however, "all surveys which are made for the purpose of ascertaining the geological character, natural history, climatology, and mineral, agricultural, and other resources of the public domain, come entirely within the province and should be conducted under the direction of the Department of the Interior, as contradistinguished from those surveys which may be found necessary for purely military purposes, and which, from their very nature, should properly be conducted under the supervision of the War Department." Secretary Delano included under the purview of the Interior Department "Topography, so far as the latter may be necessary for the construction of accurate maps, whereon the several features above enumerated could be properly illustrated for the information of the people."

Professor Hayden also agreed that 'If the language of the resolution is designed to include only scientific and geographical surveys, which are intended to ascertain the value of the public lands, and to determine their character by ascertaining their geological features, mineral and agricultural



The geologic map of the Central City mining district in the Gilpin County area of Colorado shows that gneiss is the principal rock in area, except in the immediate vicinity of the mines, and that there are two sets of lodes, the more numerous striking east-west. Hayden commented that the small district was limitable at a glance by the perfect bareness of the hills in which the precious metals were found. Every particle of timber had been stripped from them whereas the surrounding hills were still forest covered. (From F. V. Hayden, 1874.)

resources, productions, and climate, in that case, as the land department is under the Department of the Interior and is one of the chief objects for which this Department was originally created, it certainly is proper that such surveys should be placed under its control and supervision." He was not as sure, however, that all the surveys should be under one head, or one bureau of that Department.

> **If a geologist is placed in charge of this bureau, which must necessarily be done if it is to be of any value, it at once gives him a feeling of security and ease, and he no longer looks upon his continuance in office as depending upon the results of his surveys. Such a system tends very strongly to crush out and destroy that scientific individuality from which the greater results have always been derived. It also destroys that healthy emulation which produces extra exertion, gives stimulus to energy, and a proper regard for expenses. There is no necessity for such a system *in order to prevent conflict or duplication*, if all the surveys of this character are placed under the supervision and control of the Secretary of the Interior.**

Major Powell, whose survey was then under the Smithsonian Institution, took a more detached view. "There is now left within the territory of the United States no great unexplored region, and exploring expeditions are no longer needed for general purposes; their methods do not produce results sufficiently accurate to warrant their continuance for economic purposes, as the industrial interests of the country are not greatly subserved by them; nor are the results for scientific purposes of an importance commensurate with their expense. A more thorough method, or a survey proper, is now demanded." Such a survey would be important in connection with the construction of railroads and in determining the mineral resources of the country, but especially for determining areas that could be redeemed by irrigation. He had "no hesitancy" in saying that all surveys made for these general purposes should be under one Department, though he carefully expressed no preference. However, he said that if military explorations were needed for special reason, "It might be well to carry them on without regard to the general survey." Because opinion was divided, the House Committee on Public Lands held hearings, which lasted the better part of 2 weeks in May. Lt. Wheeler, who appeared first, said that his personal opinion was that the surveys could be consolidated under the War Department, but that he doubted whether the surveys could be limited geographically. "You can say that certain persons shall go here, and certain persons shall go there, but certain persons will always be doing different, and there never will be any harmony between them."

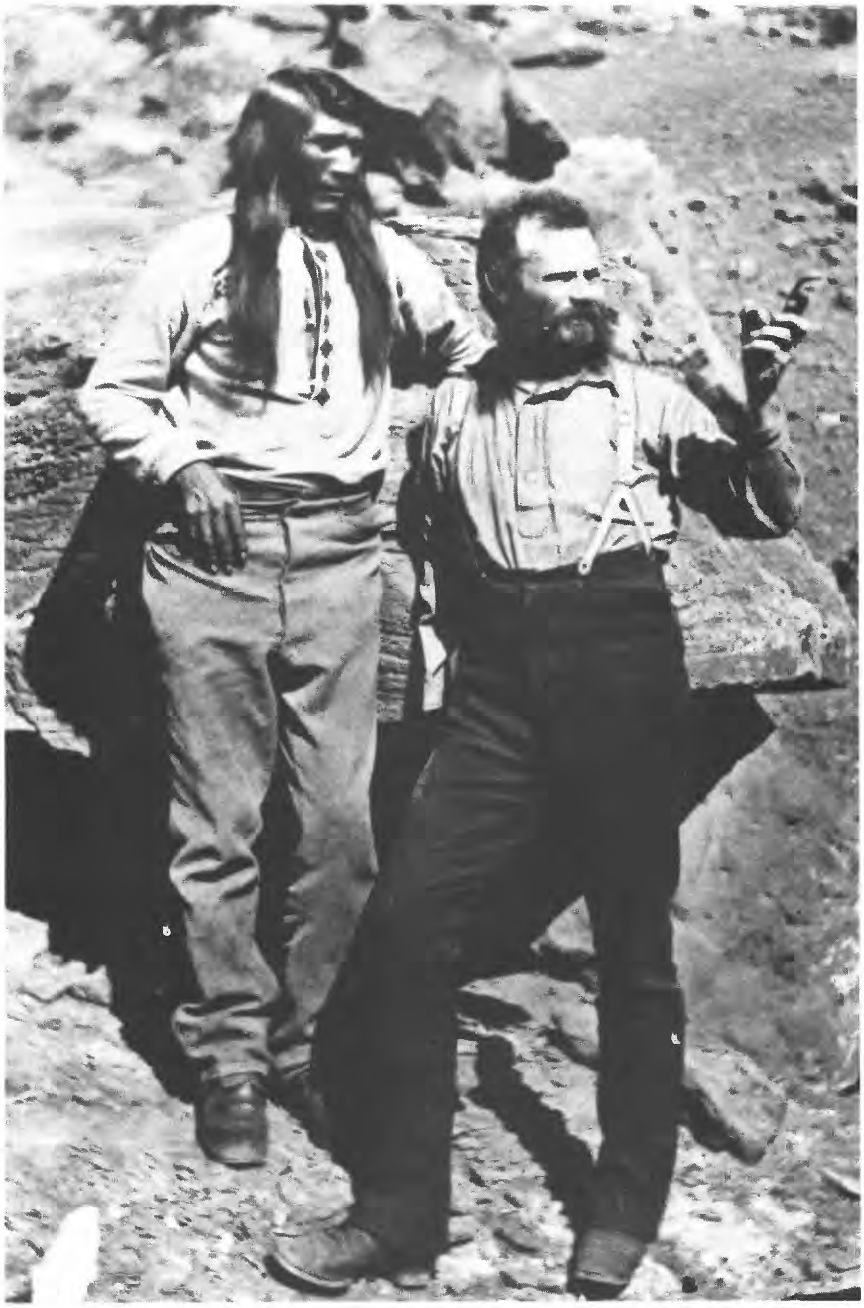
Professor Hayden said: "as a matter of course, that comparing the results, (which ought to be taken into consideration,) the civilian organization can do the work far more economically than the Army organization; *** As to defining the limits of each, that is a matter that I have never taken into consideration, neither do I very much care one way or the other." Hayden also thought that the land surveys of the Interior Department were more in detail and more accurate than other maps and said that there was "not a single square mile of the Rocky Mountain region sufficiently accurate and in detail on the engineer maps that we could use for geological purposes."

General Humphreys, in his appearance, said: "The geological survey is based upon surveys which determine the position and form of the surface of the earth. That is the more exact scientific survey which precedes the geological survey, and without which the geological survey would be of comparatively little value." In General Humphreys' opinion, the War Department was better prepared than any other for conducting the complete surveys, and he included as part of the War Department, the "gentlemen from civil life who are engaged with it." General Humphreys insisted that "The War Department and the officers of the Army are not in antagonism with the

Wheeler considered that photographs had few uses, chiefly to show scenic features. The material data gathered from photographs, he remarked, applied only to geology and natural history in which "as is well understood, we are obliged to leave the field of exact science." He believed, however, that it might be possible to refine instruments and develop methods so that values could be given to measurements on photographs, and so wanted a photographic party permanently attached to his survey. The photograph of the canyon of Kanab Wash, from which this engraving was made, was offered as evidence of what could be accomplished in securing local profiles of peculiar structures. (From G. M. Wheeler, 1874.)

science of the country, but have always maintained friendly and intimate relations with it, and Army officers have always been associated with the various scientific societies, and are not in an attitude of hostility toward them or the scientific institutions of the country; and I repudiate any intimation on the part of any one that the Engineer Department holds that position because it may not accede to the pretensions of a few who are not recognized as exponents of or authorities in the branches of science they are engaged upon." General Humphreys thought that if Congress directed that geographical limits be set, the heads of the War and Interior Departments could make the divisions of territory.

King did not testify. General Humphreys reported that he had "telegraphed Mr. Clarence King to ascertain if he could come here at once, but he has been quite unwell for some months past, and is absent by authority. He is now in San Francisco. Will be here toward the close of the month ***." Humphreys went on, with some enthusiasm: "I have recently examined the maps and results of Mr. King's surveys, and if he were here he could give you a very interesting account of them. I mean those portions that are in an unfinished condition, but inasmuch as they are incomplete, and as gentlemen engaged in scientific investigations do not like to have their un-



Powell, more than any of the other leaders of the territorial surveys, displayed a facility for getting along with the Indians, as is shown in this photograph taken by J. K. Hillers in 1872. (From the files of the U.S. Geological Survey.)

finished partial results made known, I prefer to abstain from any statement in regard to them, except that I was very much impressed by the admirable manner in which he has executed his duties, and that I consider his work as of very high order."

Major Powell was called as the hearings went into the second week, and he tried to remain a little aloof from the main argument. His chief concern was with the methods or, rather, the efficiency of mapping. He had brought along a blackboard on which he could draw diagrams and proceeded to instruct the committee. The meander method, used by the Army, he dismissed as not accurate enough for geological purposes. There were two methods based on triangulation from a base line. Clarence King had used a base line determined by astronomic methods in the early part of the Fortieth Parallel survey but had abandoned it as not sufficiently accurate. The better method was triangulation from a measured base line, which had been King's final method, Powell's own method in northern Arizona and southern Utah, and Hayden's method during the past year. When questioned about the advisability of confining these expeditions under one head and the practicability of limiting them geographically, Powell finally took sides. The surveys made for scientific and economic purposes should be under one department, "and it seems to me that as these surveys relate to the lands and to the mineral resources of the country, they should be under the management of the Interior Department. I think they should be made by civilians rather than by military men. Even in those under military management civilians do the work. I think that the history of all these explorations will show that the major part of the work was done by civilians, and I think that those who do the work and who are responsible to the scientific men of the country should have charge and control of the work."

Major Powell in his testimony made a special plea for determining the areas that could be redeemed by irrigation. "All of the country west of the 100th or 99th meridian, except a little in California, Oregon, and Washington Territory, is arid, and no part of that country can be cultivated, with the exceptions that I have mentioned; no part of it can be redeemed for agriculture, except by irrigation. When every spring, and stream, and body of water in all that region of country is taken out and used, less than three per cent. of the entire area will be under cultivation, so that, under the best circumstances, I believe that of more than two-fifths of the whole area of the United States not more than three per cent. can eventually be cultivated. Now, the extent and position of those areas that can be redeemed should be known." Then he gave warning that "Already the land surveys are being extended over broad districts of country which can never be settled, on which no drop of water can be had. Over the country which I have surveyed I have carefully noted the extent of the streams and the extent of the valleys that can be redeemed, and I have the data necessary for the construction of a map showing these facts."

He had spelled it out in a little more detail in the report he sent to Secretary Henry of the Smithsonian Institution on April 25.

> **One-third of the entire area of the United States is so arid that agriculture is dependent on irrigation, and within that same area it is not possible to redeem for agricultural purposes more than three percent. of all this territory, probably much less. The deposits of precious metals, ores, and other minerals are the chief incentives to the settlement of this country. With a proportion of area fit for agricultural purposes so small that the probable demand for the products of the soil by those who follow other pursuits will be greater than can be supplied by agriculturists, it is a matter of primary importance to determine the amount of water which can be used for irrigation, and the extent of the several districts to which these waters can be applied. Impressed with the importance of this, we have carefully examined the facts to determine the several districts of country which can be used for agricultural purposes within the territory embraced in the survey. In the mountainous regions where is found the maximum precipitation of moisture in this country, there are small elevated valleys, but they are too cold for successful cultivation, and are only valuable for summer pasturage and hay-fields. On the more elevated plateaus we find extensive grass-lands; they are also too cold for general agricultural purposes. On the lower plateaus and hilly countries the lands are desert wastes, often covered with drifting sands or surfaces of naked rock. A few valleys nestling along the rivers can be made available to the farmer.**

Among those he listed were Henry's Fork, Brown's Park, a broad rich valley on the south side of the Uinta Mountains, the valley of the Uinta and its branches, and Gunnison Valley.

The Committee considered all the testimony, and the many memorials submitted in response to Professor Hayden's request, from college faculties and leading scientists, all favoring civilian control of the scientific surveys, and concluded that "each of the surveying parties has been doing very excellent work for the benefit of the people and appropriate for the particular end it had in view." For the time being, they decided against consolidation, saying "There is an abundance of work for the best talent of both the War and Interior Departments in these scientific examinations of the Western Territories for many years to come, and the committee believe that at present it would not be of public benefit to place the whole of the surveys under one Department." But they gave warning that "The time is approaching, however, when it may be proper so to consolidate them, with a view to the making of a grand geographical, geological, and topographical map of the Territories worthy of the nation because of its accuracy and minuteness of detail; and the committee believe that they would be conducted most to the public interest by being placed under the control and guidance of the Interior Department." Thus, they concluded "that the surveys under the War Department, so far as the same are necessary for military purposes, should be continued; that all other surveys for geographical, geological, topographic, and scientific purposes should be continued under the direction of the Department of the Interior, and that suitable appropriations should be made by Congress to accomplish these results."

Hayden wrote jubilantly to Sir Archibald Geikie, the Scottish geologist: "I have had a hard struggle to gain a foothold in our Government and finally had to fight the entire War Department with President Grant at the head, but I conquered."

Professor Hayden's jubilation was premature. True, he received an appropriation of $95,000 in the Sundry Civil bill of June 23 and was instructed to continue his investigations westward toward the Green and Colorado Rivers. True, the Secretary of War ascertained from the Secretary of the Interior that the most southern limit of Dr. Hayden's survey had been the highest of the Spanish Peaks in southern Colorado and had then instructed Lieutenant Wheeler to confine his surveys to the area south of an east-west line through that peak except when necessary to connect his triangulation points. On May 1, however, Secretary Henry of the Smithsonian Institution had submitted to Congress a report on the Survey of the Colorado River of the West with an accompanying letter that said: "Professor Powell in his last year's survey completed the work for which the appropriations by Congress have been made. He now suggests the propriety of a further appropriation for one year, to enable him to connect his surveys with those of Clarence King on the north, and those of Dr. Hayden on the east. I have no hesitation in saying that this additional work is of importance, and that an appropriation for the purpose would be well applied. But whatever may be the determination of Congress on this point, in view of the valuable results already obtained at a comparatively small expense, I would respectfully and earnestly recommend that a sufficient appropriation be made to prepare a detailed report of the whole work." Congress in the Sundry Civil bill approriated $20,000 for completion of the Powell Survey under the Department of the Interior.

Before transferring to the Department of the Interior, Powell completed and delivered to the Secretary of the Smithsonian Institution the manuscript of *Exploration of the Colorado River of the West and its Tributaries Explored in 1869, 1870, 1871, and 1872 Under the Direction of the Secretary of the Smithsonian Institution.* The contents included what was purported to be a journal of the exploration of the Green and the Colorado in 1869, an account of Powell's land exploration of 1870, and a report by A. H. Thompson on his trip to the mouth of the Dirty Devil in 1872. A second part contained Powell's geologic descriptions and discussion. The journal of the exploration is actually a composite of the two river trips, and the account of the land exploration of 1870 includes part of his exploration in the winter of 1871–1872 in what is now Zion National Park. Neither account can be read as history, but they do make a good adventure story. There have been attempts to explain the discrepancies—that he made these composites deliberately to heighten the romanticism, to make it appear that he had been in the area, before Wheeler, or to help obtain appropriations. There is also the possibility that he was hurried and careless. Under the Department of the Interior he would have new scope for his interests.

Chapter 12.
No Mere Intellectual Play, 1874–1877

> **Geology has ceased to be mere intellectual play, a transcendental excursion into the charming world of planetary genesis, and become, instead of that, the slave of the economy; a guide to the treasures of force; a fosterer of the comfort of the mass of mankind; the fee'd expert of the Iron Manufacture; and a respected friend of money-makers on 'Change.**
>
> **—J. Peter Lesley**

Josiah Dwight Whitney, Sturgis-Hooper Professor of Geology at Harvard, complained in the *North American Review* after only one field season, that no good had been accomplished by the congressional investigations; the work was going on exactly as before. The influence of the most eminent scientific men throughout the country had been exerted in favor of the continuance of the geographic work begun by Gardner for the Hayden survey because the maps issued by the Engineers were so defective and so far inferior to the work of the Fortieth Parallel Survey that it seemed inconceivable, when public attention was called to the fact, that the poorer work would not be stopped. It was something to be thankful for that the opposition of the Engineers had not succeeded in wiping out the appropriation made for the extension of the Coast Survey triangulation through the interior. Whitney was equally critical of the surveys by the General Land Office, which were "marked by the most serious defects, both of plan and execution." He did not allude, he said, to "the defective and even fradulent character of portions of the less important details" but to "the principal meridians, by which the rest of the work is co-ordinated," parts of which were miles away from where they ought to be. Whitney attributed to King the improvement in topographic mapping and also an advance in the methods and aims of the geologic work of the other surveys, especially Hayden's work. Powell's work he dismissed as a duplication of Hayden's. With his customary acerbity, he remarked that "It was probably admiration of Mr. Powell's pluck and endurance, as manifested in his at first almost unaided exploration of the canyons of the Colorado, which led Congress to encourage and adopt the work, rather than a knowledge of his having had any scientific training or peculiar fitness to be at the head of a topographical or geological survey."

Moreover, Whitney observed, it was chiefly through its connection with mining and the development of mineral resources that geology had acquired importance, especially in relation to the government. "But little has ever been done by any government to encourage scientific research where there was not some pretty direct practical result to be attained." The work of a geological survey should never be brought to a close. New facts found and new discoveries made, changes in commercial and financial conditions, new uses for old materials, accumulated experience and knowledge that shed new light on what was once obscure—all these circumstances indicated that the time would never come when everything would be known in regard to the geology of an area.

The Department of the Interior had decided that the "one great object" of the Interior surveys was "the construction of suitable maps of the country surveyed for the use of the Government and of the nation, which would afford full information concerning the agricultural and mineral resources and other characteristics of the unexplored regions of our territorial domain," and that, to that end, a uniform plan for mapping should be followed. On July 1, 1874, Secretary Columbus Delano issued instructions for construction of an atlas of the territory of the United States west of meridian 99° 30′. The area to be covered was thus essentially the same as that being mapped by the Geographical Surveys West of the 100th Meridian. The scale of the mapping, however, was to be 4 miles to the inch, the same as that used by the Fortieth Parallel Survey rather than the 8 miles to the inch chosen by Wheeler.

The instructions read:

> **As the area mentioned embraces the greater part of the arid region of the United States, and has within its limits the greater number of mining districts therein, it is necessary that the maps composing the atlas contemplated shall be on a scale of sufficient magnitude to exhibit all the important geographical and geological features of the country; and in order that the several parties working under the direction of this department may properly connect their work, that the progress made in their surveys may at all times be understood, and that the several surveys may be conducted on a uniform system, this plan has been adopted.**
>
> **1st. There shall be two classes of maps, one known as 'General', the other as 'Special' maps, and the 'General' maps shall be subdivided into two classes, viz., 'Topographical' and 'Geological.'**
>
> **2nd. The 'General' maps shall be on a scale of four miles to an inch or 1/253,440. The sheets thereof shall be 26 inches long by 37 inches wide, including the border, and to be folded once. The area to be represented on each sheet shall be two and one-half degrees in longitude and one and one-fourth degrees in latitude.**
>
> **The one hundredth and twelfth meridian shall be taken as the standard from which the maps are to be projected in an easterly and westerly direction, and the thirty-eighth parallel as the standard from which they shall be projected in a northerly and southerly direction; these lines forming the division lines between the atlas sheets adjacent thereto.**
>
> **3d. Maps or charts of the second of 'Special' class may be constructed on other scales and embracing other areas, whenever it shall be found necessary for the purpose of properly representing mining districts, mineral, agricultural, pasture, or timber lands, or for other special purposes.**

The instructions were, Hayden said, confirmation of what had been agreed on in his survey during 1873.

Hayden and Powell were also instructed to obtain the "necessary information for preparation of charts upon which would be indicated the areas of grass, timber, and mineral lands, and such other portions of the country as might be susceptible of cultivation by means of irrigation" and to "collect specimens of mineralogy, Indian art, &c. in order to enlarge, as far as possible, the collections of such articles now in the Smithsonian Institution, and which are designed for exhibition at the Centennial Exposition of 1876." Powell later claimed that the classification of the public lands originated in his survey, but this has not been demonstrated. He had at least stated that he had classified lands, although he had produced no maps. Marvine's report for Hayden in 1873 also had the elements of classification, however. The idea of collecting Indian objects for the Smithsonian Institution may well have come from Powell.

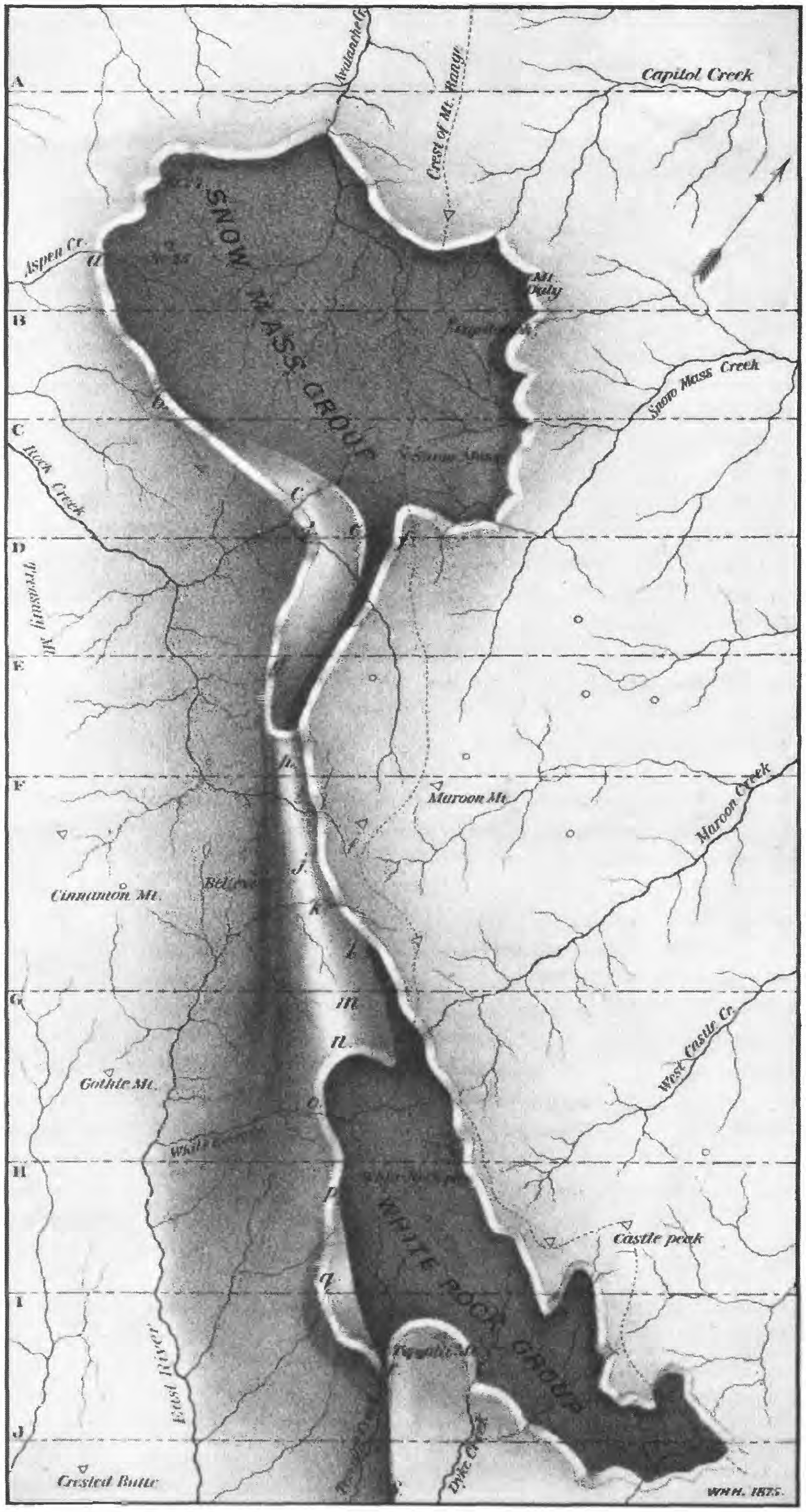
Hayden went back to Colorado to continue his survey, as specified by the appropriation law, "westward toward the Green and Colorado Rivers." In addition to the six parties of the previous year, there was a seventh, led by Hayden himself, to undertake special geologic and topographic investigations in the upper Arkansas Valley, where Wheeler's party had been encountered the year before, in the Elk Mountains, and along the mountain front. The party under Marvine worked in North Park and the area immediately to the west. Gannett's party was assigned to northwestern Colorado, south of the Eagle and Grand Rivers and west to the territorial boundary. Allen Wilson was in charge of the party mapping in the San Juan Mountains.

The photographic party under Jackson went first to Middle Park, then worked its way southward, eventually to the San Juan Mountains. Jackson was persuaded by Captain John Moss, an itinerant miner, to take the route through the Mancos River valley to the La Plata region to see the Indian ruins and cliff dwellings. In October, the ancient ruins of Mesa Verde were sighted, and Jackson hauled his equipment up the cliff with the long ropes used for animals and succeeded in obtaining 40 negatives.

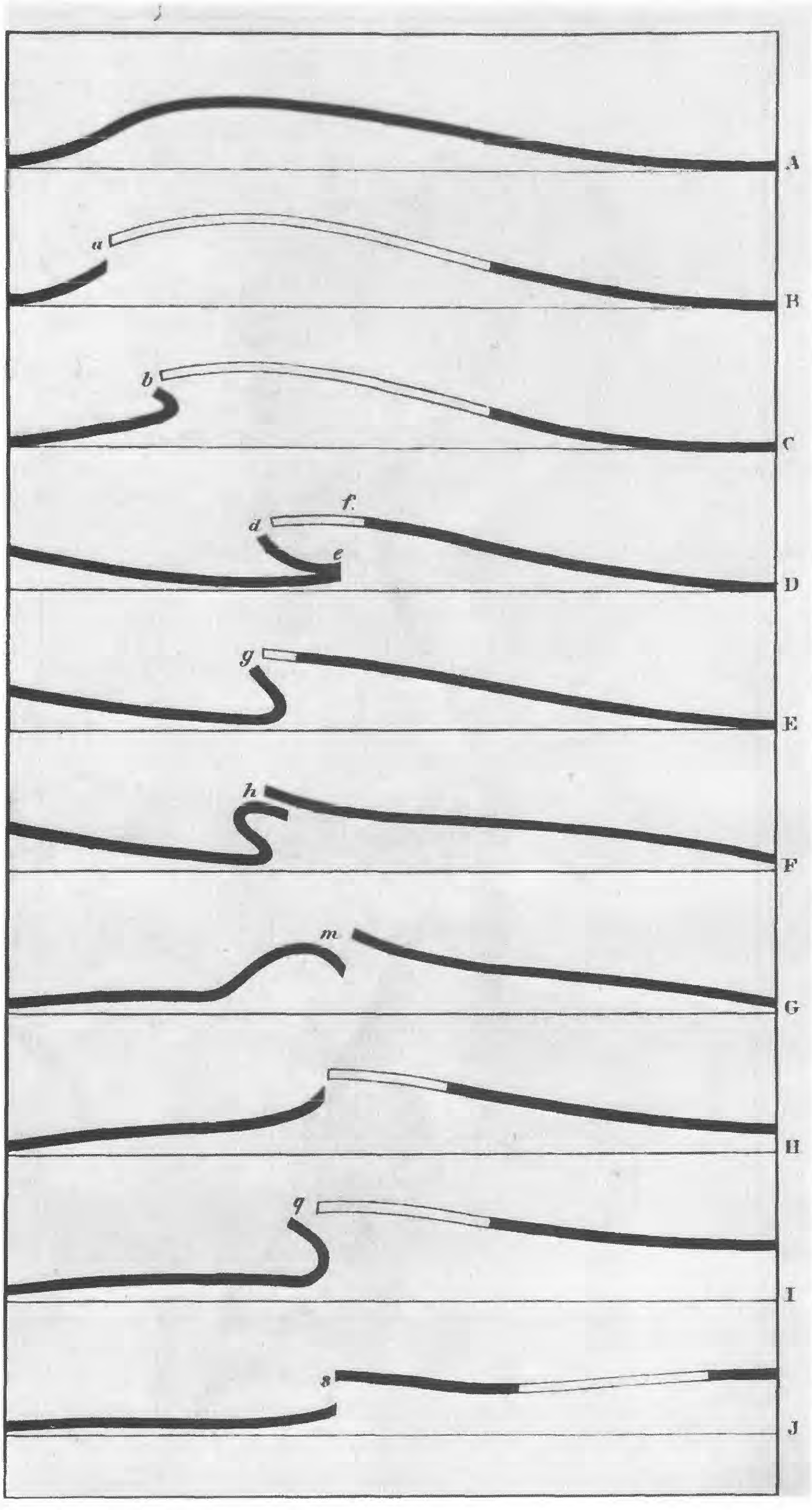
Cyrus Thomas was now in charge of the office, superintending the printing of reports. Hayden's publication plan had now "matured." Publications were to be divided into three principal classes: annual reports or reports of progress; miscellaneous publications on different subjects connected with the West; and more technical and matured results, in quarto form, for libraries and men of science. Publication of a series of bulletins was begun "for the purpose of giving the world, more rapidly than through the Annual Reports, the vast amount of new material which was constantly accumulating under the auspices of the Survey, and, in most, instances, demanding prompt publication."

The first bulletin was primarily a paper by Professor E. D. Cope *On the Stratigraphical Relations and Vertebrate Paleontology of the Formations Which Represent the Pliocene Epoch, as at Present Understood, in Northeastern Colorado.* It was based on material collected in the summer of 1873, and Professor Cope disagreed, politely enough, with Professor Marsh on several identifications. The second bulletin made history. That contained Cope's *Review of the Vertebrata of the Cretaceous Period Found West of the Mississippi River.* Hayden prefaced it with a note: "The article *** is one of no ordinary value. While I dissent from some of his views, I regard his researches as having a direct bearing on the solution of the problem to which I have repeatedly called the attention of geologists in my annual reports as the most important one in the geology of the western portion of our continent, viz: the relations of the Cretaceous and Tertiary periods to each other. I have always expressed my belief in the continuity of all the great formations from the Silurian to the present time, and that the highest privilege of the geologist is to discover the evidence that bridges over all chasms and obliterates all the lines of demarkation." He had asked both Lesquereux and Cope to make special studies. Cope had described a saurian which he identified as Cretaceous; nearby Lesquereux had identified the flora as Tertiary. Cope had concluded: "There is, then, no alternative but to accept the result that a Tertiary flora was contemporaneous with a Cretaceous fauna, establishing an uninterrupted succession of life across what is generally regarded as one of the greatest breaks in geologic time." That conclusion provided a problem that occupied the attention of many geologists for many years.

In the summer of 1874, Major Powell went back to the Uinta Mountains to continue the geologic investigations he had begun several years before. The Fortieth Parallel survey had already mapped the area, but he felt there were still other aspects to be covered. He was accompanied by C. A. White who made a systematic collection of fossils from localities where Powell had previously observed them. A. H. Thompson began mapping atlas sheets in southern Utah and adjacent parts of Arizona, using Kanab as a base of operations. E. E. Howell joined the Powell survey and continued his study of central Utah which he had begun the year before for the Wheeler survey.



The Hayden survey found the structure of the Elk Mountains of Colorado extraordinarily complex. W. H. Holmes attempted to explain it by showing the fold in relief on an outline map (left) and a series of sections (right) on the base of the Cretaceous. A combination of movements, principally lateral, he suggested, had produced a fold so abrupt that the beds were crushed and shattered and the severed edges shoved past each other. (From F. V. Hayden, 1876.)



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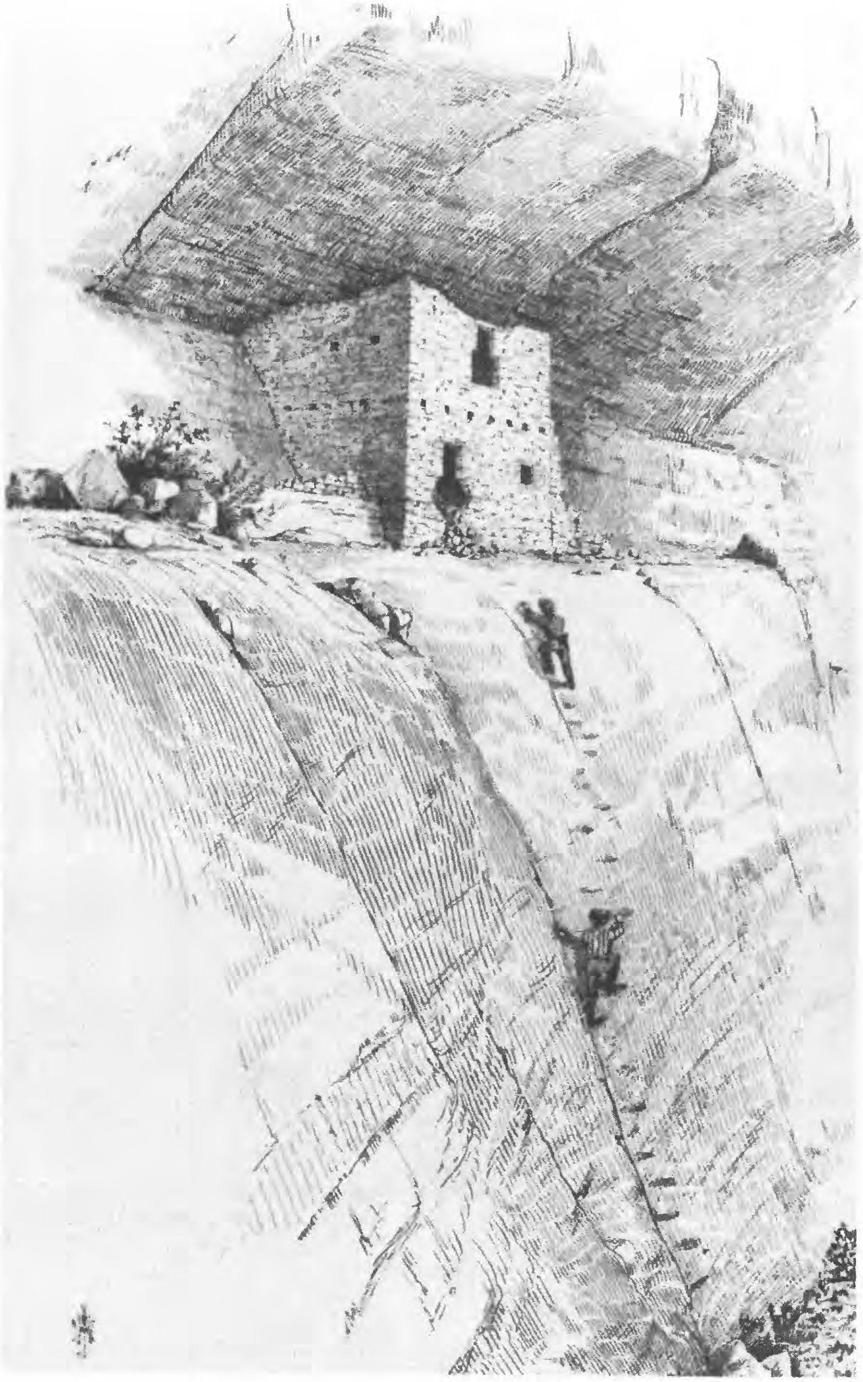


In 1874, the Hayden survey discovered the Indian ruins at Mesa Verde in southwestern Colorado. W. H. Jackson, accomplished with pen as with camera, sketched the difficult climb. (From F. V. Hayden, 1876.)

The main parties of the Wheeler survey were organized and operated out of Pueblo, Colorado, in 1874, but most of the mapping was in New Mexico. The work became a completely connected survey on a geodetic base, and 23,281 square miles were mapped. No systematic geologic work was done. Gilbert completed his report on the geologic work of previous seasons early in the year, and his employment ended on September 30. E. D. Cope and Oscar Loew did a little geologic work in connection with their paleontologic and mineralogic investigations. Wheeler also began a more systematic classification of the lands being mapped, sent a special photographic party to the Pueblo ruins, and collected a few Indian vocabularies.

The Army sent out another expedition in 1874, accompanied by a geologist. By 1874, prospectors searching for gold began arriving in the Black Hills even though this area was part of the Sioux Indian Reservation and the Sioux were among the most warlike of the Plains Indians. Colonel George Custer was sent on a reconnaissance of the region, a reconnaissance which the Army stoutly maintained was not for the purpose of looking for gold. However, both Custer and the Engineer officer attached to his command asked permission to hire a geologist, and N. H. Winchell, professor at the University of Minnesota who also served as the State Geologist of Minnesota, accompanied the party. In midsummer, Colonel Custer sent back a despatch that "gold has been found at several places, and it is the belief of those who are giving their attention to this subject that it will be found in paying quantities."

The principal concerns of the Department of the Interior in 1874 were not the western surveys but the public lands and the Indian affairs. In the summer of 1874, the grain-growing areas of the Great Plains from Texas northward into Canada were devastated by a plague of locusts, or Rocky Mountain grasshoppers, the worst in many years. Homesteaders on the plains were also beginning to use wire to fence their fields; cattle rangers, who had been accustomed to open land and free access to water, and homesteaders began their long battle over use of the rangeland.

Quite apart from these problems, the destruction of American forests was then becoming a matter of concern. On the public lands, timber operators looking for a quick cutover and early departure had been among the chief offenders in preemption violations, but there was no way for them to acquire the land legally except at auction sales, and these were increasingly infrequent after passage of the Preemption and Homestead acts. At the annual meeting of the American Association for the Advancement of Science in 1873, Franklin B. Hough read a paper *On the Duty of Governments in the Preservation of Forests,* and a resolution was adopted that a committee be appointed to memorialize Congress and several State legislatures on the importance of promoting the cultivation of timber and the preservation of forests.

In 1874, the Commissioner of the General Land Office, S. S. Burdett, said: "I fail to find, from the beginning of the Government to the present time, a single enactment of Congress providing any distinctive method for the disposal of that vastly extensive and proverbially valuable class of lands known as 'pine lands.' These lands are notoriously unsuited for general agricultural purposes, but have been held subject only to preemption and homestead entry." The Commissioner personally favored sale of the timber without the land but feared that administration of such a law would be expensive and open to corruption, so instead he recommended appraisal and sale of the lands at not less than the appraised value.

Treatment of the Indians who had been placed on reservations had become somewhat of a national scandal. Accusations of frauds in the Indian service had been investigated in both the 42d and 43d Congresses. The 42d Congress expressed surprise and regret; the 43d Congress reported that it had been unable to discover any evidence of fraud. In the fall of 1874, Prof. O. C. Marsh visited a promising fossil region south of the Black Hills. When he reached the Red Cloud Indian Agency, a short day's ride southeast of the Black Hills, he found the Indians there in an ugly temper. Red Cloud had been complaining to the soldiers about the poor quality of the rations and blankets that were issued to them, and he also poured his troubles into Marsh's sympathetic ear. Marsh promised help, and when he went to Washington in April 1875, for the National Academy of Sciences meeting, he took with him representative samples of the rations that Red Cloud had given him and called on both the Commissioner of Indian Affairs and President Grant. Marsh found willing allies in the press of the country, and after a long and stormy summer of hearings, charges, and denials, both Secretary of the Interior Delano and the Commissioner of Indian Affairs resigned.

Congress had appropriated $95,000 for the continuation of the Geological and Geographical Survey of the Territories in 1875: for "the first division, under F. V. Hayden, in Colorado and such adjacent portions of Utah and New Mexico as were not explored in the preceding year, $75,000"; and for "the second division, under J. W. Powell, in Utah, $25,000." An additional $45,000 was appropriated for preparation of illustrations, $20,000 for Hayden and $25,000 for Powell.

Hayden continued his work in Colorado, completing the mapping of the southern and southwestern parts of the Territory and a 15-mile-wide belt of northern New Mexico and eastern Utah in order to complete quadrangles. There were seven parties as in 1874: Gardner was again in charge of triangulation; A. D. Wilson, in charge of the work in southeastern Colorado; W. H. Holmes, that in southwestern Colorado; and Henry Gannett that in the western or "Grand" region. For the topographic mapping that year, Hayden observed, experience had shown that a combination of the plane-table system, meander surveys, and triangulation was necessary to obtain the best results. Considerable attention was given to ethnology. Both Jackson and Holmes returned to Mesa Verde and made extensive surveys of the Mancos Valley. Hayden reported that "The prehistoric remains in the canons and lowlands of the Southwest are of great interest, and the study of them by Mr. Holmes was as complete as possible under the circumstances." In addition, a good collection of pottery and stone implements was made, and models of the major ruins were prepared for exhibition at the Centennial Exposition.

Powell had stated in his budget estimate that two-thirds of his funds, would be spent on topographic mapping, and A. H. Thompson continued mapping the Colorado Plateau from the base at Kanab. Howell had left to rejoin Ward's establishment at Rochester, but G. K. Gilbert accepted Powell's offer to join the Powell survey. Captain Clarence Dutton of the Ordnance Corps was also detailed from the Army at no expense to the Powell survey. Major Powell had proposed to Dutton the year before that he undertake the study of the High Plateaus, but Dutton had declined, "distrusting his own fitness for the work." In 1875, however, Powell renewed the proposal in such a way that Dutton felt refusal would seem ungenerous. Major Powell took the matter up with the Secretary of War, the General of the Army, and the Chief of Ordnance, all of whom approved, probably somewhat to Captain Dutton's surprise. Dutton was interested in science but not trained as a geologist. He had graduated from Yale, at 19, in 1860, where he was a classmate of O. C. Marsh. He had joined the army as a volunteer in 1862, and in 1864, he was transferred to the regular army with the rank of captain and assigned to the Ordnance Corps. After tours of duty at the Watervliet Arsenal near Albany, New York, where he came to know James Hall, and the Frankford Arsenal, near Philadelphia, where he became acquainted with the scientific community, Dutton had been assigned to Washington, D.C. There he promptly became active in the Philosophical Society and met Major Powell. Both Gilbert and Dutton spent the field season on the High Plateaus of Utah, where Gilbert had already done some work in the summer of 1872 as a member of the Wheeler survey. Powell himself returned for another season in the Uinta Mountains.

There were so many prospectors in the Black Hills in the summer of 1875 that the Interior Department also sent out an expedition to examine the

FIG. 154.

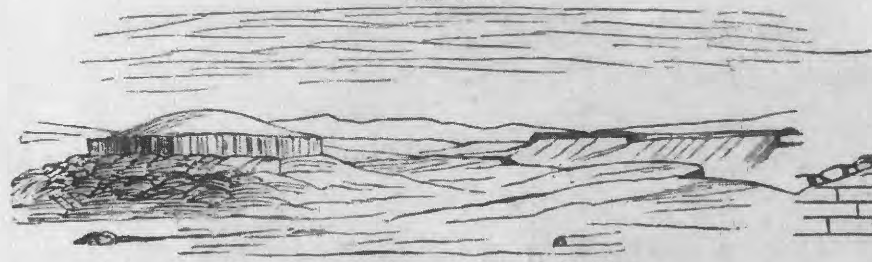


FIG. 155.

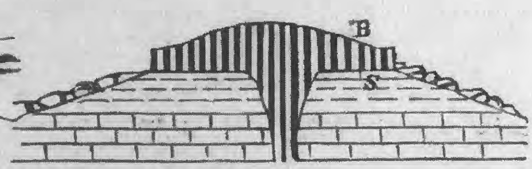


FIG. 154.—Lava butte near Covero, N. Mex.
FIG. 155.—Ideal cross-section of the same. B, Basalt; S, Cretaceous sandstone and shale.

FIG. 156.

FIG. 157.

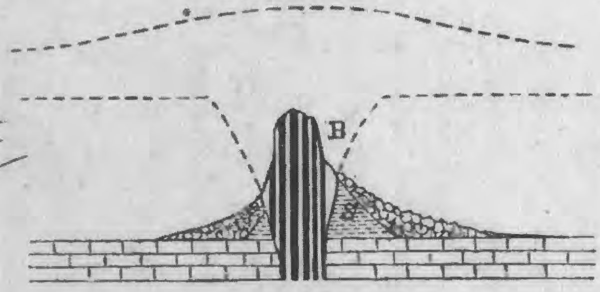


FIG. 156.—Black butte north of Covero, N. Mex.
FIG. 157.—Ideal cross-section of the same. B, Basalt; S, Cretaceous shale and sandstone. The dotted lines give a restored section of the basalt.

G. K. Gilbert, geologist for the Wheeler survey, recognized in two lava buttes near Covero, New Mexico, a similarity in origin and difference in erosion. (From G. M. Wheeler, 1875.)

region so a proper basis might be secured for negotiation of new treaties with the Indians. W. P. Jenney was appointed to undertake the work, with Henry Newton as assistant. Both Jenney and Newton were products of the Columbia School of Mines. Jenney had been employed as a mining engineer and geologist for private industry since graduation. Newton, who was a protege of Newberry's, had been with the Ohio survey. The party entered the region on June 3, 1875, with a large military guard, and returned to Fort Laramie on October 14. Jenney's preliminary report on the mineral resources of the Black Hills, accompanied by a map by V. T. McGillycuddy, the topographer, was published in the report of the Commissioner of Indian Affairs for 1875, and the complete report on mineral wealth, climate and rainfall, and natural resources was published as a congressional document in 1876.

The prospectors did not wait for formal opening of Indian land. Despite the efforts of the military to keep them out, some penetrated the Black Hills and found gold in Deadwood Gulch. By the fall of 1875, more than 15,000 prospectors were in the area, and two main camps had been set up at Custer City and Deadwood before the Indian Bureau began the task of negotiating new treaties with the Indians.

In the summer of 1875, there were two divisions of the Geographical Surveys West of the 100th Meridian, one again operating out of Pueblo, Colorado, and mapping in Colorado and New Mexico, the other operating out of Los Angeles and mapping mostly in California. Jules Marcou, long at odds with most American geologists, had replaced Gilbert as geological observer and made some studies of the geology of southern California. A. R. Conkling, a graduate of Sheffield Scientific School and a nephew of Senator Conkling of New York, also joined the Wheeler survey. Oscar Loew, in addition to geologic work, made some archeological studies and continued collecting Indian vocabularies. The Wheeler party further systematized its classification studies; some of the assistants, the Lieutenant reported, began "laying down upon the preliminary maps and *** tabulating the areas whose natural resources permit of use for agricultural, mining, grazing, and timber purposes as in contradistinction to those absolutely worthless, being arid and barren." Tabulated data for 13 atlas sheets were included in his annual report. A special party under Lieutenant Eric Bergland was also sent to determine the feasibility of diversion of the Colorado River of the West for purposes of irrigation. Bergland concluded that it could not be diverted at any point along its channel in the United States.

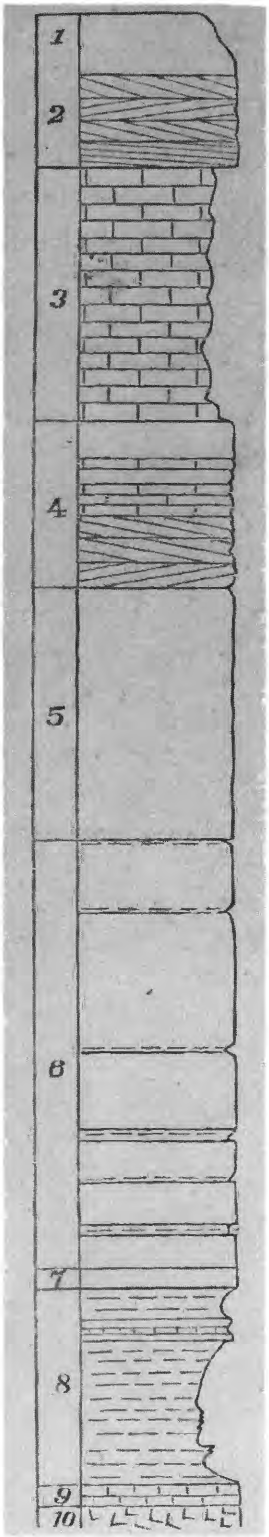
Former Senator Zachariah Chandler, one of the richest men in the State of Michigan and the undisputed boss of its Republican machine for many years, became Secretary of the Interior in the fall of 1875. Chandler had been one of the most radical of Radical Republicans. He had supported the Reconstruction Acts although he considered them too lax in some aspects, and his aggressive Republicanism was matched by his clamorous jingoism in regard to Great Britain. He was elected to the Senate in 1857 and for many years was chairman of the Commerce Committee, which handled the Rivers and Harbors bill. He had lost his Senate seat, however, in the wake of the great Democratic landslide of 1874.

In the annual report prepared shortly after he became Secretary, Chandler made passing reference to the report of the Indian Commissioners, only some of which he agreed with. However, he said that an early solution of the problem of the Black Hills was necessary.

> **The failure of the negotiations for the relinquishment of the Black Hills necessitates the adoption of some measures to relieve the Department of the great embarrassment resulting from the evident determination of a large number of citizens to enter upon that portion of the Sioux reservation to obtain the precious metals which the official report of the geologist sent out by the Department shows to exist therein. The very measures now taken to prevent the influx of miners into the Black Hills, by means of a military force in that neighborhood, operate as the surest safeguard of the miners against the attack of Indians. The Army expels the miners, and, while doing so, protects them from Indians. The miners return as soon as the military surveillance is withdrawn and the same steps are taken again and again.**

With regard to the problems of the public lands, the Secretary invited attention to the report of the Commissioner of the General Land Office. Commissioner Burdett reported that the quantity of land disposed of under the homestead and timber culture laws had been much less than in the preceding year. He attributed the decline to the grasshopper plague, the drought, the falling off of emigration, and the general business depression. However, he predicted a steady diminution in the future because "in the localities most desirable for homestead settlement, on account of the general fertility of the soil and the presence of conditions necessary to the honest observance of the requirements of the law, the lands, to a large extent, have passed to private ownership." Burdett pointed out that

> **Legislation and executive practice have heretofore been suggested and controlled by the physical and climatic conditions prevailing between the eastern boundary of the State of Ohio and the central portions of the State of Kansas and Nebraska, covering the valleys of the Ohio, the Mississippi, and the Missouri Rivers, and extending from the eighty-first degree to the ninety-fifth degree of west longitude. This is well classified as the 'fertile belt' of the continent. To this region, agricultural in its every feature, both the exactions of the homestead and pre-emption laws in the matter of residence and cultivation upon the tract entered, and the limitation of quantity allowed to be taken by any one person, are of undoubted applicability. Beyond and westward of this belt, or in all that section lying between the one hundredth meridian on the east. and the Cascade Range and Sierra Nevada Mountains on the west, and, within these limits, from the Mexican line on the south to the international boundary on the north, a totally different set of conditions, geographical, physical, and climatic, are found to exist. Within this vast area agriculture, as understood and pursued in the valley of the Mississippi and to the eastward, has no existence. Irrigation**



Gilbert was the first to apply formal names to Grand Canyon rock units, saying "it was found convenient * * * to attach local names to the more important subdivisions." Units 1, 2, and 3, constituting an upper terrace, were called the Aubrey Group; units 4, 5, and 6, the Redwall Group; and 7, 8, and 9, the Tonto Group. (From G. K. Gilbert, 1875.)

is indispensable to production. That there are limited areas within which by its aid crops are and may be secured is true, but the proportion of land within the area now treated of, which, under the present system of disposal, can by this means be made productive is insignificant.

The Commissioner said that throughout most of the area, title could not be obtained honestly under the homestead laws. Vast areas were suitable for grazing, but such use was impracticable when only a quarter section could be obtained and cultivation was required. The Land Office recommended that the land be sold.

President Grant visited the West in the autumn of 1875, and in his message to Congress on the State of the Union in December, he recommended the appointment of a Joint Commission to visit the West and make recommendations concerning disposition of the public lands. The 44th Congress, elected in November 1874, met in December 1875 for its first session, with little prospect of accomplishing any significant lawmaking. The Democrats had won firm control of the House, but the Senate, elected by legislatures, remained Republican, and it was a presidential election year. The House Democrats decided upon an investigation of the Grant administration as its contribution. A. S. Hewitt, one of the new Congressmen, was, because of the unusual circumstances of his election, one of the House leaders. He had been urged to enter politics in New Jersey and took the unusual step of transferring his legal residence from Ringwood, New Jersey, to New York City, where he lived half the year to avoid entering New Jersey politics. In New York, however, Samuel J. Tilden, whom he had aided in the overthrow of the Tweed Ring in 1872, was running for Governor, and Hewitt found himself nominated for Congress so he could be Tilden's principal lieutenant in Washington, while Tilden himself, with his eye already on the Presidency, was in Albany.

The Democrats had counted on exposing a certain amount of laxity and extravagance in the Grant administration. Instead they brought to light scandal after scandal of a magnitude that shocked the Nation. The Whisky Ring which involved Grant's private secretary had already been exposed, but the House investigation implicated the Secretary of War, and a resolution of impeachment was passed. Hewitt himself was involved in the investigation of the Emma mine scandal in which former Senator Stewart of Nevada and the American minister to Great Britain were exposed as profiting from favors rendered while British investors were fleeced of about £ 2million.

The year 1876 was the centennial of American independence, and a year of celebration. The Centennial Exposition in Philadelphia, the greatest celebration of the United States of America, opened on May 10. President Grant spoke at the opening:

One hundred years ago our country was new and but partially settled. Our necessities have compelled us to chiefly expend our means and time in felling forests, subduing prairies, building dwellings, factories, ships, docks, warehouses, roads, canals, machinery. Most of our schools, churches, libraries, and asylums have been established within a hundred years. Burdened by these great primal works of necessity, which could not be delayed, we have yet done what this Exhibition will show in the direction of rivaling older and more advanced nations in law, medicine, and theology; in science, literature, philosophy, and the fine arts. Whilst proud of what we have done, we regret that we have not done more.

Then he pushed the lever that started the great Corliss engine in Machinery Hall, and soon all 13 acres were clattering and humming with the noise of revolving machines.

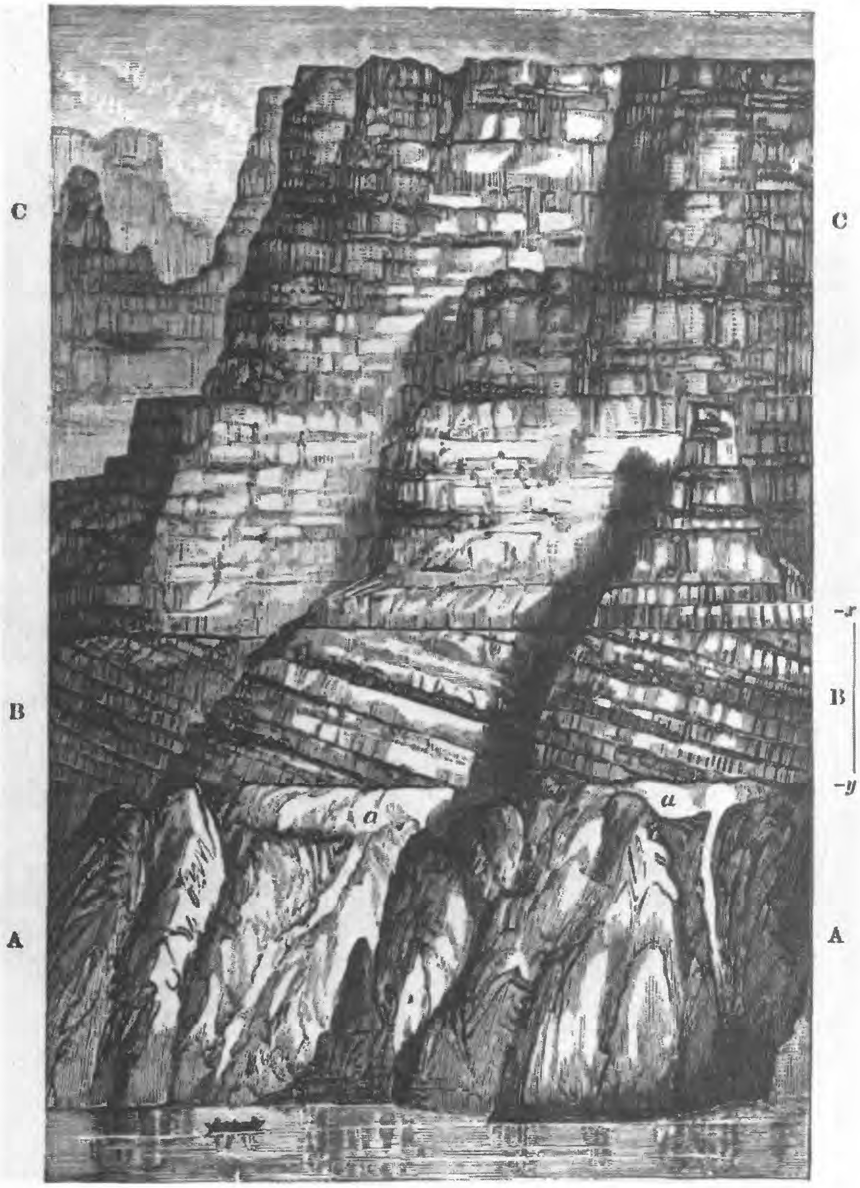
The Corliss engine was the star attraction of the Exhibition, but there were other marvels: a lamp that burned electricity, a typewriting machine, Alexander Graham Bell's telephone. Professor Francis Walker of Yale, who


R. H. Nichols

was on the jury of awards, found it a liberal education. The Smithsonian Institution had a colorful display of Indian objects, including some collected by the Interior Department surveys.

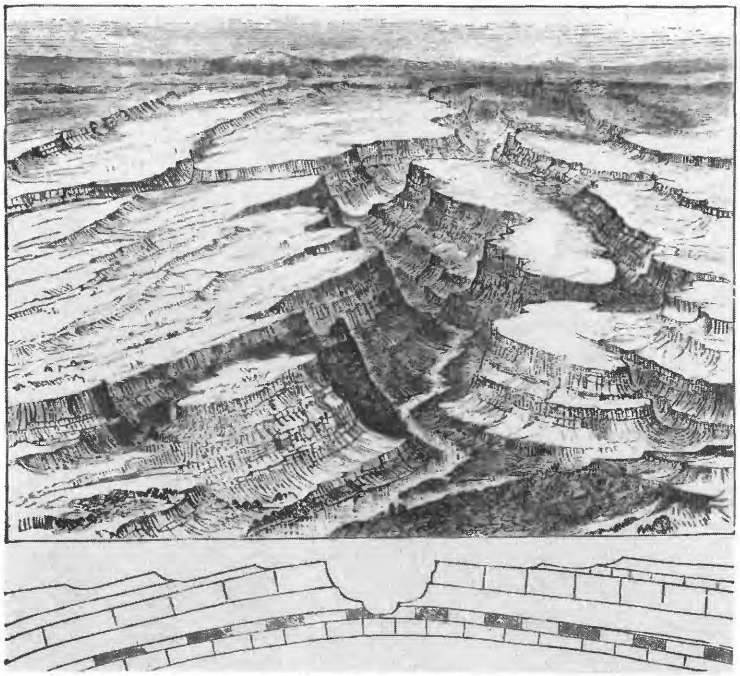
For the Centennial Year, when many foreign visitors were expected to attend its meetings, the AIME had chosen Congressman Hewitt as President. At a special meeting in Philadelphia during the week of June 19, he reviewed. "A century of mining and metallurgy in the United States." He had repeatedly predicted that the United States would soon wrest the leadership in production of iron and steel from Great Britain, and in his 1876 address, he predicted that annual world production would double in the next 17 years, and that this would come about largely through development in the United States. By the turn of the century, the United States would be producing 40 million tons of iron ore and 100 million tons of coal annually, which would require an investment of not less than half a billion dollars.

These statements were greeted with a certain amount of incredulity. Other statements received a mixed reaction. The United States had reached its present state of development of mineral resources, "a point at which for coal,



The section of the wall in the Grand Canyon in Powell's report is more graphic, and thus more intelligible to the layman, than J. S. Newberry's or G. K. Gilbert's. Powell shows only three groups, AA being the lowermost granite, BB a series of nonconformable beds which he later named the Grand Canyon Group, and CC, which he identified merely as the overlying horizontal beds. (From J. W. Powell, 1875.)

Powell's report on his exploration of the Colorado River was published in 1875. Aside from being the purported journal of the trip it was to a large extent a treatise on denudation of the land. The *American Journal of Science* said that never was the subject more appropriately and grandly illustrated. H. H. Nichols of the Smithsonian Institution prepared many of the illustrations, including this bird's-eye view of the Grand Canyon looking east from Grand Wash with its somewhat whimsical identifications: one bird, Echo Cliffs; two birds, Kaibab Plateau; three birds, To-ro-weap Cliffs; four birds, Hurricane Ledge; five birds, Shi-vwits Plateau. (From J. W. Powell, 1875.)



An Anticlinal Valley, with section

A Diaclinal Valley

A Cataclinal Valley

A Synclinal Valley

H. H. Nichols' drawings of valleys adds a third dimension to the diagrams of Henry Darwin Rogers (p.99–101). (From J. W. Powell, 1875.)

iron, gold, silver, copper, lead, and zinc, we are independent of the world, with abundant capacity to supply as well our growing wants, as to export these blessings of civilization to other and less favored lands" without Government control of the mining industry. This was in contrast to other nations with their elaborate mining codes and administrative bureaus, where one of the miner's commandments was "Thou shalt not waste wantonly or ignorantly the resources which, once exhausted, will never grow again." Americans had wasted as much as they liked, and no one had interfered, but there was a growing consciousness of the need for conservation of natural resources. Conservation of mineral wealth was so great an end that governmental action might even be proper, though Hewitt personally believed in restricting the functions of Government as much as possible. Before that became necessary, he hoped that forces already at work might combine to bring about the desired end. One was the spread of knowledge on the subject, especially through the western surveys and the reports on mining statistics. "The government," he conceded, "has not done too much in this direction; it seems to me that it should continue this most *necessary and proper work in a more systematic and uniform way.*" (Hewitt's other great force was the development of corporations, of which he had a rather idealistic view derived from his own management experience. He envisioned it as a combination of capital derived from an unlimited number of small investors, including the workers themselves, managed by a few for the benefit of all. "In its perfect and ultimate development," he said, "it embodies the Christian idea of 'having all things in common,' yet rendering unto Caesar the things that are 'Caesar's.' " The conditions that made the existence of great companies a necessity as well as a possibility imposed on them certain duties and responsibilities. To begin with, he proposed that the coal companies set aside a fixed sum for each ton of coal mined to pay for improving the social, moral, and intellectual conditions of the miners and their families. Hewitt himself, it must be noted, kept the Trenton mills open all during the depression so that the workers were employed although the company lost money.)

In the summer of 1876, a crisis in the money market was brought on by the changing market values of gold and silver. The United States had demonetized silver in 1873 when the price of silver was high, but a month after that law was passed, a new body of paying ore was discovered in one of the Comstock mines in Nevada, so rich that it became known as the Big Bonanza, and the price of silver began to decline. The change to the gold standard in Europe put pressure on the gold market, and by 1875, the change in the previous ratio of market values of gold and silver became marked.

On the last day of the session, Congress passed a joint resolution establishing a special commission of three Senators, three members of the House of Representatives, and experts, not exceeding three in number, to be selected by and associated with them, to inquire into the change which had taken place in the relative value of gold and silver and the consequences thereof, the policy of the restoration of the double standard in the United States and, if restored, what the legal relation between silver and gold coins should be, and the policy of continuing legal-tender notes concurrently with the metallic standards. The commission was also to look into the best means of providing for facilitating the resumption of specie payments and to submit a report to Congress no later than January 15, 1877.

In the Uinta Mountains, which Powell described as "a down-turned wrinkle, or, in the language of the geologist, a synclinal fold," the fold has been cut off, and the upturned edges of the formations exposed. The softer formations have been eroded, leaving irregular valleys between intervening ridges of harder rocks which were called hogbacks. (From J. W. Powell, 1875.)

Powell's report on his exploration of the Colorado River was published in 1875. Part of it purported to be the journal of the trip, and for this part Thomas Moran prepared many illustrations, some of them fanciful of events he had not witnessed, some of them of scenery, such as this one of the Gate of Lodore, which may be compared with the engraving made from Timothy O'Sullivan's photograph on page 170. (From J. W. Powell, 1875.)

The Comstock was regarded as the chief culprit, and even the British silver commission in 1876 devoted considerable attention to its probable output. The Congressional commission, after an extensive investigation, however, concluded that reports of the Comstock wealth had been exaggerated.

> **Similar bodies of nearly equal extent had been previously discovered and exhausted in the Spanish-American silver lodes and in the Comstock lode, without attracting universal attention or arousing universal fear that the commerce of the world was about to be deluged by a flood of silver, but in the present instance, through persistent and infectious exaggeration in respect to the extent and richness of the new ore body, the most visionary expectations and unwarranted fears became universally epidemic. The estimates of the value of the ore in sight ranged from $300,000,000 to five times that amount, all of which was generally believed to be in silver.**

The Commission's own investigation had shown that the total product of the Big Bonanza in the 4 years it had been worked was not more than $52.5 million and that 45 percent of it was gold.

A crisis of a different kind was caused by the eager miners who arrived in numbers at the Black Hills too large to be held back. For 10 years, the Sioux and Northern Cheyenne had been fighting desperately to preserve their hunting grounds on the Great Plains. The Black Hills were holy ground, which the Government had promised to retain for them inviolate, so the Indians, under Sitting Bull and Crazy Horse, prepared to strike back. Early in June 1876, Colonel Custer was sent from Bismarck to disperse the Indians, and on June 25, he and his entire command were killed in a battle on the Little Big Horn River. At the end of October, U.S. troops finally defeated Sitting Bull and Crazy Horse, and the Indians were forced to give up their claims to the Black Hills area. The mining had proceeded irregardless of the Indians, and both placer and lode claims were established.

The work of the Fortieth Parallel Exploration was now almost completed. Zirkel's memoir on microscopic petrography was published as Volume VI and was followed by Volume IV on paleontology. Volume II on descriptive geology, by Emmons and Hague, was completed, and King's own report on systematic geology was well along.

King was invited by Daniel Gilman, president of the new Johns Hopkins University, to lecture there as a nonresident professor. This was a signal honor for one of his youth, for Gilman had set about gathering a faculty who were not only able lecturers but also researchers. King discussed the matter with Gilman in March but felt that he was not free to accept until other commitments were filled. In April, King was elected to the National Academy of Sciences, becoming its youngest member.

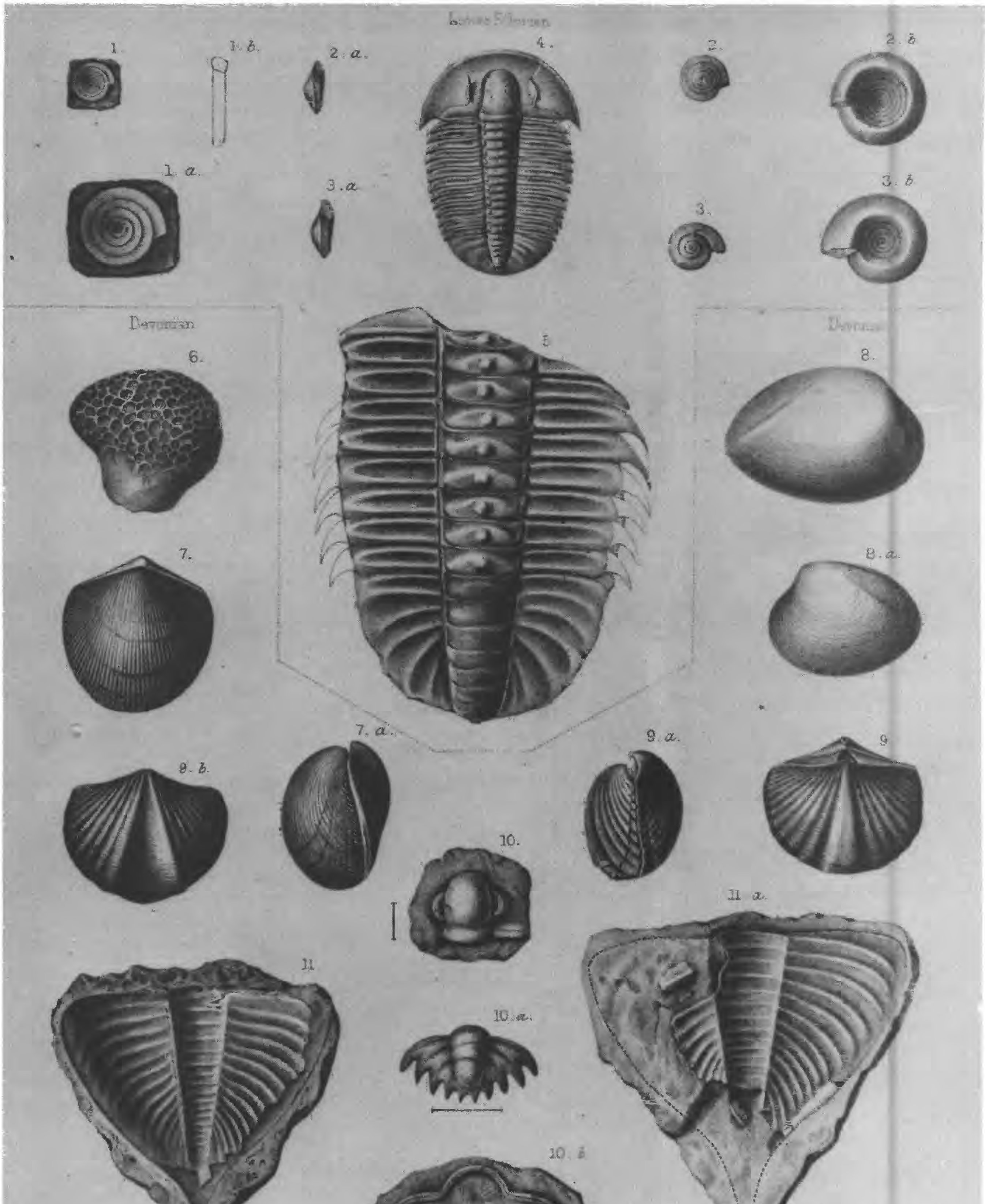
In May, King had a fling at politics, joining the Republican Reform Club of New York, along with Carl Schurz, Charles Francis Adams, and others who hoped to bring about an improvement in the Federal service. His enthusiasm soon flagged, however, for he was not really interested in practical politics.

In August, Thomas Henry Huxley, the English biologist, arrived in the United States to give a series of lectures on evolution and the major address at the formal opening of Johns Hopkins University in September. Huxley spent a week with Professor Marsh at Yale, engrossed "in birds with teeth, and reptiles without 'em, to say nothing of other palaeontological wonders." The collection, he wrote his wife, was "the most wonderful thing I ever saw." One of his lectures was to be on the genealogy of the horse, which he had already written about on the basis of European specimens. After seeing Marsh's specimens, he abandoned his own conclusions in favor of Marsh's.

Huxley also met with King, and in accordance with King's request wrote to him with regard to the toothed birds: "It is of the highest importance to the progress of biological sciences that the publication of this evidence, accompanied by illustrations of such fulness as to enable palaeontologists to form their own judgment as to its value, should take place without delay." King wrote to General A. A. Humphreys, the General agreed, and a seventh volume was added to the reports of the Exploration of the Fortieth Parallel, a monograph on Odontornithes, the extinct toothed birds of North America. It was a triumph for all involved. General Humphreys demonstrated the Engineers' interest in pure science, King secured publication of important documentation, and Marsh, who had published innumerable short papers, had an opportunity for an extensive work with ample illustrations.

With all the investigations and other matters, Congress was delayed in passing appropriations bills in 1876, and consequently the field season was short. Lieutenant Wheeler again had two divisions in the field, one operating out of Fort Lyon in Colorado and mapping in Colorado and New Mexico, the other operating out of Carson, Nevada, and mapping in California and Nevada. A. R. Conkling with the western party mapped the geology of an area around Lake Tahoe and another near Carson City, but no geologic work was done by the eastern party.

On July 31, $65,000 was appropriated for continuation of the Hayden survey and $30,000, including $10,000 for preparation of illustrations, for


Lower Silurian
Devonian
Devonian

Completion of the final reports of the King survey became possible when reports were received from the paleontologists. "It is the misfortune of geology," King had complained, "to be more or less dependent on this branch of specialists. Without their specific determinations, the geological maps, even, cannot receive their ultimate color-designations, nor can reports, which, like ours, involve a wide range of stratigraphy, be safely written." Meek identified *Conocoryphe kingii* (now *Elrathia kingii*) as Lower Silurian, probably from the Primordial zone. King, who preferred to follow the English nomenclature rather than American usage at that time, called the Pogonip limestone, in which it was found, Cambrian. (From F. B. Meek, 1877.)

completion of the Powell survey. Hayden went back to Colorado, which became a State on August 1, to complete the work there. The area of investigation in 1876 was in the extreme northwestern part of the State, far remote from settlements and among hostile bands of Ute Indians who had attacked three of the parties the previous year. J. T. Gardner had left in the fall of 1875 to become Director of the New York State Museum; Allen Wilson became chief topographer and took over the work of primary triangulation. Henry Gannett directed the Grand River division, with A. C. Peale as geologist; G. B. Chittenden directed the White River division, with F. M. Endlich as geologist. The Yampah division worked in the district between the Yampa and White Rivers and between the Green River and the subordinate range west of and parallel to the Park Range. That party was directed by G. R. Bechler, and Dr. C. A. White accompanied it as geologist. All three parties extended their work beyond Colorado into Utah.

W. H. Holmes accompanied the triangulation party in a quick trip through Colorado, touching also parts of New Mexico and Utah, which gave him a splendid view of the Cretaceous and Tertiary formations. He also visited the Sierra Abajo, a small group of mountains in eastern Utah, where he found that the structure was identical with that of four other isolated groups in the same region. A wedgelike mass of trachyte had been forced up through fissures in the sedimentary rocks and caused a considerable amount of arching of the sedimentary rocks. Both Holmes and W. H. Jackson revisited the Indian ruins to continue their investigations.

Hayden reported that

> **excellent progress has been made in the report on the general geology of the country west of the 94th meridian. It is the intention of the survey to discuss the geology of the portions of the West which have been reported on either by the parties under my charge or by others. It is believed that there is a remarkable unity in the geological structure of the entire area; that although formations of the same age have received a great variety of local names, they will be so correlated that a single system of classification will include all.**

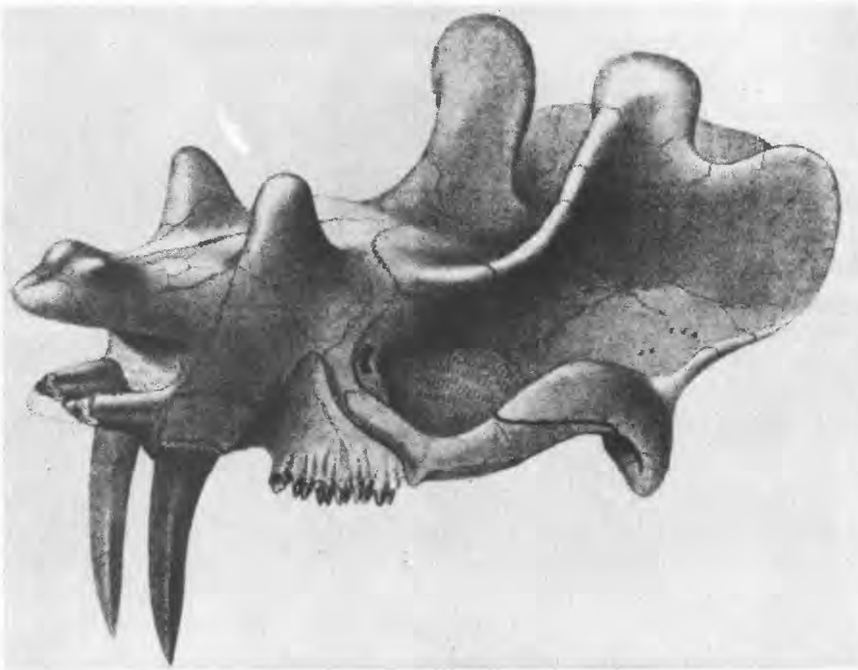
In order to show that unity, he planned a map of the country west of the 94th meridian on a scale of 12 miles to the inch.

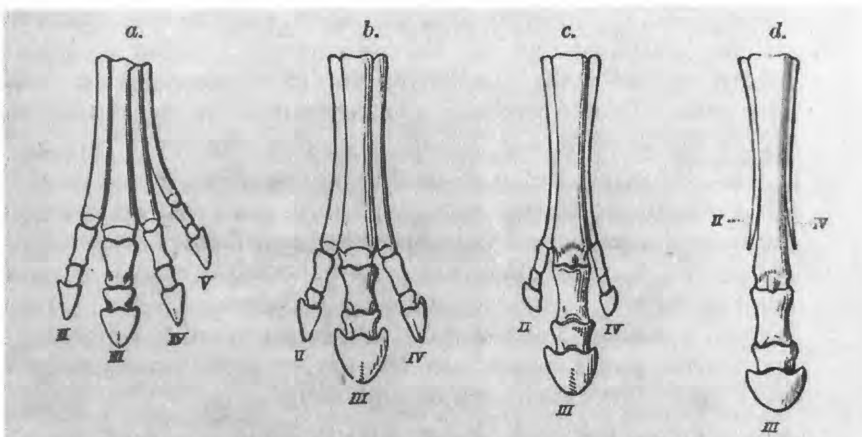
> **The work of the season of 1876, shows very clearly the harmonious relations of the various groups of strata over vast areas, that although there may be a thickening or a thinning out of beds at different points, they can all be correlated from the Missouri River to the Sierra Nevada basin. The fact, also, that there is no physical or paleontological break in these groups over large areas from the Cretaceous to the Middle Tertiary is fully established. The transition from marine to brackish water forms of life commences at the close of the Cretaceous epoch, and, without any line of separation that can yet be detected, continues on upward until only pure fresh-water forms to be found. Dr. White, an eminent paleontologist and geologist, says that the line must be drawn somewhere the Cretaceous and Tertiary epochs, but that it will be strictly arbitrary, as there is no well-marked physical break to the summit of the Bridger group.**

That statement posed a problem that geologists argued about for the next 25 years.

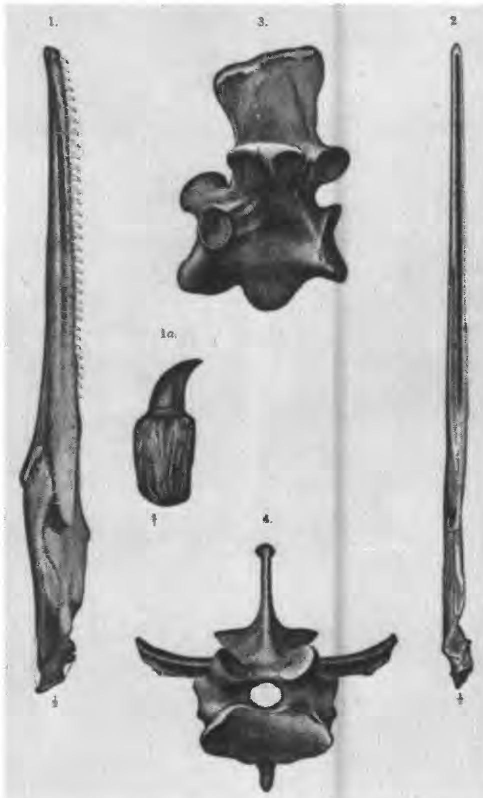
There was little evidence in the activities of the Powell survey of any effort to complete the work as called for by Congress in making the appropriation. A. H. Thompson continued his triangulation, and the two topographic parties under J. H. Renshawe and Walter H. Graves continued their mapping. Clarence Dutton continued his study of the igneous rocks of southern Utah, and G. K. Gilbert began a detailed study of the Henry Mountains, which he had briefly examined the year before and which he thought contained some new kind of intrusion.

Gilbert had assumed the role, if not the title, of chief geologist of the Powell survey. For the *American Journal of Science,* he explained that "As a





a. Orohippus (Eocene); *b. Miohippus* (Miocene); *c. Hipparion* (Pliocene); *d. Equus* (Quaternary).



Invertebrate paleontology had been an essential part of stratigraphic geology, but vertebrate paleontology at this time was still a biologic science, a branch of morphology or comparative anatomy. *Dinoceras mirabilis,* the giant dinosaur, and *Hesperornis regalis,* the bird with teeth, were curious creatures from the past, and "birds with teeth!" became a Congressional battle cry in later years as the symbol of useless scientific studies. Marsh was one of the first to appreciate the value of vertebrate paleontology for stratigraphic purposes, and his study of the modification of the limbs of a horse is related to the passage of geologic time. (*Dinoceras,* O. C. Marsh, 1873; foot of horse, O. C. Marsh, 1874; *Hesperornis regalis,* O. C. Marsh, 1875.)

field for the studies of the geologist, the Plateau province offers valuable *matter* in an advantageous *manner.*" Because of the climate and the drainage, rocks were exposed with exceptional thoroughness; there was little vegetation or glacial debris to obscure them. Thus stratigraphy, erosion, mountain building by displacement, and mountain building by eruption could all be investigated. When Powell's Uinta Mountains report was published later in the year, the *American Journal of Science* reprinted a few pages from it on "types of orographic structure" because, as Dana put it, "the views were only partly those adopted by Mr. Gilbert."

Powell himself had turned his attention wholly to ethnography. "In pursuing these ethnographic investigations," he wrote, "it has been the endeavor as far as possible to produce results that would be of practical value in the administration of Indian affairs, and for this purpose especial attention has been paid to vital statistics, to the discovery of linguistic affinities, the progress made by the Indians toward civilization, and the causes and remedies for the inevitable conflict that arises from the spread of civilization over a region previously inhabited by savages." He himself was making a classification of Indian tribes. In October 1876, he suggested to Secretary Joseph Henry that the Smithsonian Institution turn over to him for publication its material on Indian languages, and Secretary Henry agreed promptly "in accordance with the general policy of the Smithsonian Institution of doing nothing with its income which can be equally well done by other means."

The presidential election may have been the most exciting event of 1876. Both major nominating conventions were held in June. The Republicans met first and nominated Governor Rutherford B. Hayes of Ohio for President. Up to the final balloting, the leading candidate had been the Speaker of the House, James G. Blaine, but he had been accused before a House Committee of using his position for personal gain only a short time before the convention. The Democrats met later in the month and nominated Governor Samuel J. Tilden of New York, who had gained a national reputation for his role in reforming New York City government.

In July, A. S. Hewitt was elected Chairman of the Democratic National Committee, which meant that he would be Tilden's campaign manager. He was also the favorite candidate for nomination to succeed Tilden as Governor of New York but was ineligible because his New York residence dated only from 1874. He was therefore nominated for a second term in Congress. Secretary of the Interior Chandler was the Chairman of the Republican National Committee.

In the November voting, Tilden received a majority of the popular vote and apparently of the electoral vote also. The *New York Times* refused to concede the election, although other newspapers had done so. If Hayes won Florida, South Carolina, and Louisiana, he would win. Secretary Chandler was aroused from sleep, hasty telegrams were despatched to Republican chairmen in those three States, and on the following day the *New York Times* and Secretary Chandler announced that Hayes had been elected by one electoral vote. In December, two sets of returns were reported from these three States and also from Oregon, which had already been counted as a Republican victory. To resolve the problem Congress on January 26, 1877, established an Electoral Commission to consist of 15 members: 3 Republicans and 2 Democrats from the Republican Senate, 2 Republicans and 3 Democrats from the Democratic House, and 5 justices of the Supreme Court (2 Republicans, 2 Democrats, and 1 Independent). On the very day that the Electoral Commission became law, however, the Independent judge was elected to the Senate by his State legislature and promptly resigned from the Supreme Court. His place was taken by a Republican.

With the intense interest and effort going into the decision on the presidential election, congressional attention on other matters was somewhat desultory. Commissioner James A. Williamson of the General Land Office stressed the problems of the arid lands in his first report in the fall of 1876. Williamson, who had succeeded Burdett in June 1876, was personally familiar with these problems. Formerly an Illinois lawyer, he had acquired an active interest in western lands after the Civil War and had preempted a quarter section in Utah. Williamson repeated Burdett's recommendation that the arid lands be offered for cash purchase, adding that all or nearly all the water that could be diverted for irrigating purposes by individual enterprise or by small corporate captal had already been so diverted and used. Large streams could be used for irrigation but only by companies with a large amount of capital, and neither companies nor individuals would engage in such enterprises when they could not acquire title to the land. A bill was introduced in Congress in December 1876 and passed in the closing days of the session, being approved on March 3, 1877. The Desert Land Act authorized individuals to acquire 640 acres at 25 cents an acre, provided the land was irrigated within 3 years. Commissioner Williamson said the law could not be put into effect.

As the depression was well into its fourth year, Congress was in a mood for economy. Early in January 1877, Powell wrote several letters asking help in getting another appropriation. Professor Newberry wrote promptly to Congressmen Garfield and Hewitt, suggesting that if retrenchment must come, it should fall on Hayden rather than Powell. The Appropriations Committee in reporting out the Sundry Civil Expenses bill reduced the appropriation for continuation of the Hayden survey to $50,000 and recommended only $20,000 for completion of the Powell survey, including preparation and publication of reports. When the matter first came up on the floor on February 21, only a few members were present. (The presidential election had not yet been decided. The Electoral Commission had voted on two sets of returns from the States; two more remained.) After a gentleman from California delivered his opinion that the surveys had taken some stereoscopic views that were useful for young gentlemen to amuse young ladies with but had accomplished nothing else for the public good, action on the appropriation was hastily deferred. The argument had been chiefly on the merits of the Hayden survey in relation to public-land surveys, and the Powell survey was not mentioned.

A few days later, the appropriation for the General Land Office came up for consideration, and Congressman Peter Wigginton of California proposed several amendments: to abolish the office of surveyor-general of the several States and Territories, to transfer the records and management to the Commissioner of the General Land Office, and to make changes in the surveys of the various classes of public lands. All went out on points of order.

When the appropriation for the scientific surveys came up, Congressman Ames Townsend of Ohio, who had been absent from the floor on February 21, proposed an increase to $75,000 in Hayden's appropriation, and the House accepted his amendment. Then Congressman Adlai Stevenson of Illinois proposed that Powell be given $50,000, and that amendment was also passed. The Senate accepted the House version of these appropriations.

The final vote by the Electoral Commission was taken on February 28, and on March 2, Hayes was declared elected. Southern Democrats had been induced to support the Commission's decision by Republican promises that Federal troops would be withdrawn from the South, that at least one Southerner would be appointed to the Cabinet, and that substantial appropriations would be made for internal improvements in the South. To make sure that Hayes honored the agreement, the House refused to pass the Army Appropriations bill. The Sundry Civil Expenses bill was passed, however, and signed by President Grant on March 3, 1877.

Washington was tense on the weekend of March 3 and 4, fearful of an armed rebellion against the decision of the Electoral Commission. Hayes took the oath of office privately on Saturday, March 3, and again publicly on March 5, and nothing untoward occurred. On March 5, he appointed David M. Key of Tennessee as Postmaster General, and in April he withdrew the last Federal troops from the South. The end of the reconstruction period had finally come.

Chapter 13. The Importance Which Geology Now Has, 1877–1878

It is chiefly through its intimate connection with the art of mining and the development of the mineral resources of the country that geology has acquired the importance which it now has and especially in its relation to the state.
—Josiah Dwight Whitney

In accepting the nomination, Hayes had stated that, after the withdrawal of the troops from the South, the main object of his administration would be the restoration of the civil service, and at the first meeting of the Cabinet he asked Secretaries Evarts and Schurz to draw up rules to govern appointments in the executive departments. The appointments of William Evarts as Secretary of State and Carl Schurz as Secretary of the Interior had been particularly bitter pills for some of the Republican hierarchy. Senators Conkling and Blaine had been rival candidates for the presidential nomination in 1876, and Blaine might have won if Senator Conkling and Secretary Chandler had not thrown support to Hayes in order to thwart his chances. Conkling was particularly outraged, therefore, by the selection of Evarts, a New Yorker whom he especially disliked, as Secretary of State. Chandler, among the most radical of Radical Republicans, was more than upset by the appointment of Carl Schurz, one of the original Liberal Republicans, to his own post as Secretary of the Interior. The withdrawal of troops from the South had not set well with some of the Senators; the active espousal of civil service reform was the last straw.

The new Secretary of the Interior, Carl Schurz, had been born in Germany in 1829 but had been forced to flee the country because of his involvement in the revolution of 1848. He had eventually migrated to the United States. In 1856, he settled in Wisconsin, where he became active in politics and helped organize the Republican party. During the Civil War he had served in the Union Army, with the rank of brigadier and then major general, and was accounted one of the better of the political generals. In 1869, he was elected to the Senate from Missouri and served a single term during which he was an outspoken critic of the Grant administration and sought the establishment of a merit-based civil service system. Although Schurz was one of the chief organizers of the Liberal Republicans, he had supported Hayes in the 1876 election, and he became the strongest voice for reform in the Hayes Cabinet.

The major public-lands problems facing Secretary Schurz were the protection of the timberlands, where timber trespassing was still flagrant, and the protection and distribution of the arid lands of the West. Congress had made a token response to the memorial from the American Association for the Advancement of Science on promoting the cultivation of timber and preservation of forests by appropriating $2,000 in July 1876 so the Commissioner of Agriculture could pay the salary of a "man of proven attainments" to undertake forestry investigations. F. B. Hough had been appointed on August 30, 1876, but he could not be expected to accomplish much without additional funds. Congress had made no response to the recommendations of

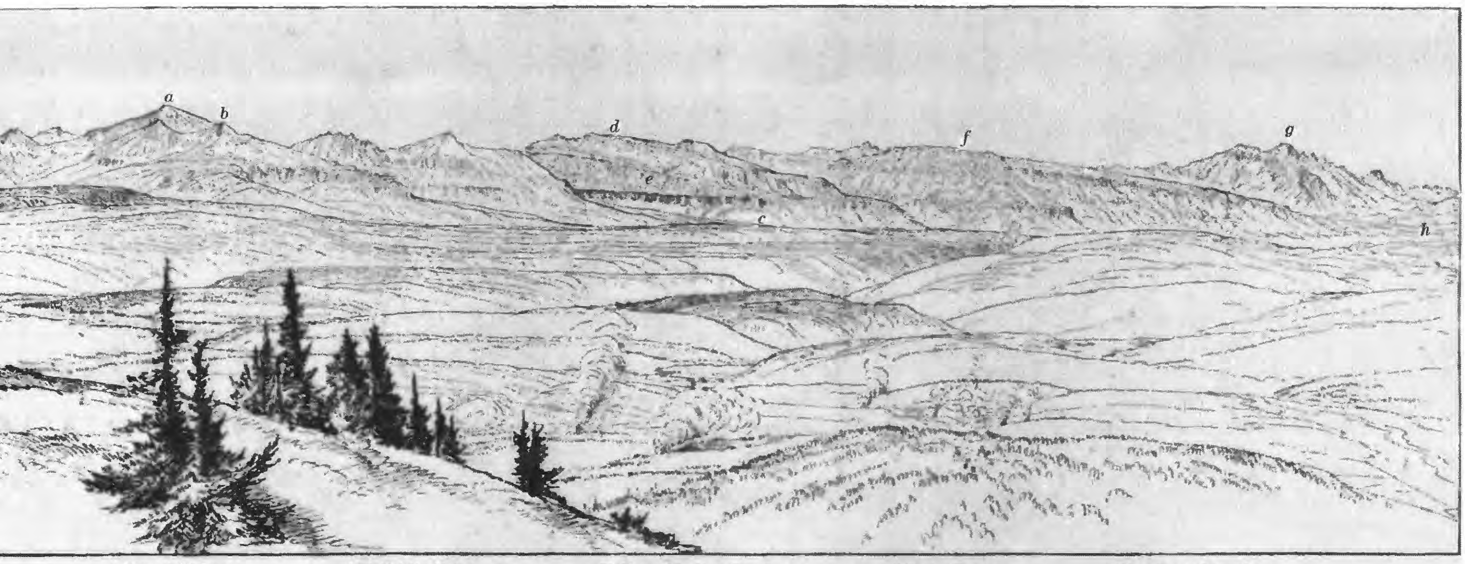
Commissioner Burdett of the General Land Office or his successor Commissioner Williamson that the public timberlands be appraised and sold. Secretary Schurz was personally interested in forest conservation, and on May 2, 1877, all duties connected with the timber on public lands were transferred from the local land officers to employees directly under the Commissioner of the General Land Office. They were told to ferret out when, where, and by whom forest depredations had been committed and to determine whether legal proceedings were warranted.

At the April meeting of the National Academy of Sciences, Major Powell, who though not a member had been invited to present a paper, delivered an address on the public domain, pointing out that the existing land system, whether land was acquired by purchase, preemption, or the homestead plan, was not suitable for the arid region. Land was not valuable as land in the arid region; what was really of value was the water privilege, and all the streams had been appropriated, and the owners were charging others for the use of water. Areas were suitable for pasturage, but the homestead plan could be applied only by modifying it so that more land was provided as well as abutment on a stream where animals could be watered.

The paper was not a new or an original contribution. Commissioner Burdett had said as much in 1874, and Commissioner Williamson had repeated it in 1876 in the annual reports of the General Land Office. Powell's paper, however, provoked a lively discussion and attracted the attention of the newspapers. The *New York Tribune,* commented that "if it be true that there is scarcely any good land left fit for a poor man's homestead farm, the sooner the fact is announced the better."

Professor Newberry wrote to Secretary Schurz on March 17, asking that the report on the Black Hills survey of 1875 by Henry Newton, which Newberry was convinced Hayden had blocked, be authorized as a publication of the Powell survey. Newberry also wrote to Powell directly on March 18, asking for financial assistance in a fossil-hunting trip to Colorado. Powell, without waiting for authorization from Schurz, guaranteed publication of the Newton report and arranged to pay half of Newton's expenses to the Black Hills to clear up doubtful points, but he regretfully turned down Newberry's own request. On May 28, Secretary Schurz formally placed the completion of Newton's work under Powell's direction.

In May, Secretary Schurz became deeply involved in Indian affairs which led to the appointment of yet another board of investigation in June and ultimately to the dismissal of the Commissioner of Indian Affairs. On May 22, Major Powell wrote to the Secretary, formally proposing that the ancillary work of the Hayden and Powell surveys be divided, one survey to be responsible for natural history (paleontology, zoology, and botany) and the other, for ethnography, and that each survey transmit to the other appropriate collections for working up. The choice was no choice; Powell had done very little in the way of natural history, and with the help of Secretary Henry, he had made himself a leader in ethnographic work. Secretary Schurz did not reply to the letter immediately, but on June 13, 1877, at his request, the Secretary of War formally detailed Captain Garrick Mallery, who had become interested in Indian languages while serving in Dakota Territory, to work with Powell, and during the summer of 1877, Powell was almost wholly occupied with ethnographic work. He continued preparation of his manual of Indian languages, and two volumes of *Contributions to American Ethnology* were made ready for publication, the first comprising a report by W. H. Dall for the Smithsonian Institution on Indian tribes of Alaska and a report by George Gibbs for the Office of Indian Affairs on the Indian tribes of western Washington



In 1877, the Hayden survey resumed mapping in Wyoming, Idaho, and Montana, including a more intensive study of Yellowstone National Park. W. H. Holmes prepared this panoramic view of the East Gallatin Range, one of the striking topographic features of the park. The view is from the southeast, looking across 20 miles of igneous plateau and the newly discovered Gibbon Geyser Basin in the foreground. (From F. V. Hayden, 1883.)

and northwestern Oregon; the second was a report by Stephen Powers on the tribes of California.

At the start of the field season, Hayden began mapping nine atlas sheets in Wyoming, Idaho, and Montana north of the area mapped by the Fortieth Parallel survey, extending from 107° to 112° W. and north to Yellowstone. Allen D. Wilson continued as his chief topographer, and Gannett, Chittenden, and Bechler were in charge of the three mapping parties. Holmes and Jackson were detached from the main survey to make a tour through northern New Mexico and northeastern Arizona to secure material on the methods of building by the Pueblo Indians. In August, Secretary Schurz wrote to Hayden, suggesting that Powell's proposal to divide the ancillary work was fair and directing him to make a choice. Hayden chose natural history, leaving ethnography to Powell, and in November, Acting Secretary A. Bell confirmed the choice and directed Hayden to turn over his collections in ethnography to Powell.

From the Powell survey, at the start of the field season, Gilbert went to northern Utah, to the area that had been mapped by the Fortieth Parallel survey, to classify the lands. Actually he undertook a special study of irrigation in the drainage basin of the Great Salt Lake and extended his research from water supply to a consideration of climatic changes. Dutton continued his work on the High Plateaus and incidentally examined the irrigable lands in the Sevier River valley and measured the flow of the Sevier River. Thompson, Renshawe, and Graves continued the triangulation and topographic mapping in Utah.

The Geographical Surveys West of the 100th Meridian had a long field season in 1877, beginning in May, and 32,744 square miles were mapped. The two main divisions were based in Fort Lyon, Colorado, and Carson, Nevada, and mapping was continued in Colorado, New Mexico, California, and Nevada. Lieutenant Wheeler organized and spent some time with a special party completing the survey of the Lake Tahoe region. He then led another special party from Ogden, Utah, northward to the east of Cache Valley in the vicinity of Bear Lake, along Twin Creeks, and then eastward in the Green River drainage area, among other matters, tracing the Bonneville beach, the outline of the ancient freshwater lake of the Great Basin, about which both Gilbert and King had written. John Adams Church, a graduate of the Columbia School of Mines in 1867 and later an acting professor there and editor of the *Engineering and Mining Journal,* made a special study of the Comstock, where the workings were at much greater depths than they had been when King and Hague had studied it nearly a decade earlier.

Volume II of the King survey reports, *Descriptive Geology,* by S. F. Emmons and Arnold Hague, was received favorably. The volume was 890 pages long, divided into five chapters corresponding to the five geological maps of the Atlas. Emmons and Hague stressed that it

> does not claim to be a systematic survey like those of Europe, based on accurate maps, but is rather a geological reconnaissance in an unknown and often unexplored region, where geology and topography had to go hand in hand, and that therefore, while details were often, from the necessities of the case, somewhat neglected, it was the general bearing of the leading geological facts that was most constantly in our minds.

The *American Journal of Science* did not comment critically on the volume. Publication of the volume was noted immediately, but the reviewer assigned to prepare a report on it was too slow to produce a manuscript on so important a volume, so a lengthy abstract of its contents was offered instead.

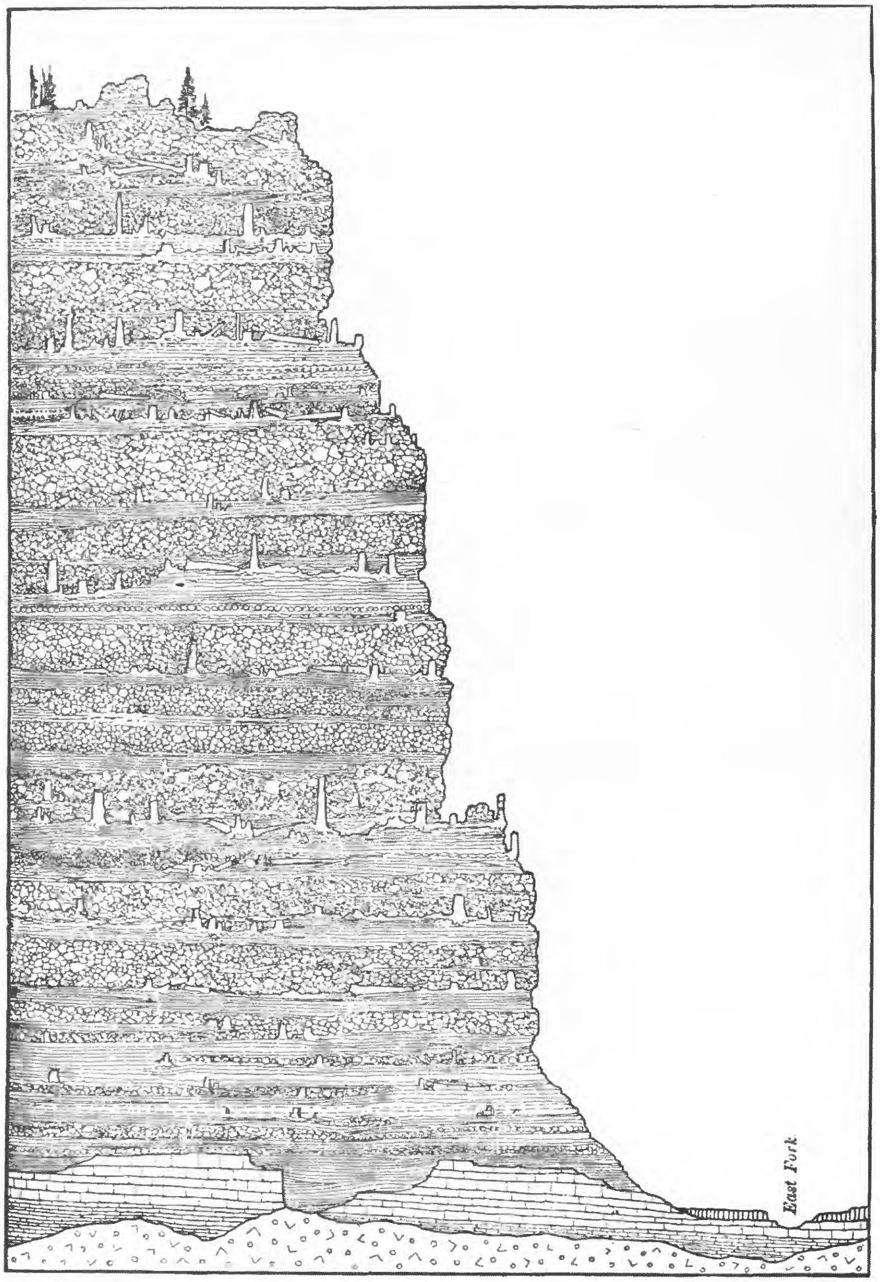
King himself upset the geological world in June 1877 with his commencement address at the Sheffield Scientific School on *Catastrophism and the Evolution of Environment.* Darwinian evolution, by natural selection, was then widely accepted by scientists and its principles were being extended to social thought. Darwinian evolution depended on uniformitarianism. In 1868, Kelvin, having had almost no success in diverting geologists from that principle, had declared that a great reform in geological speculation was necessary if geology were to be returned to the path of true science. Thomas Henry Huxley had felt obliged to answer him the following year with an attempt to divorce biological evolution from the uniformitarian concept of time.

King thought that he had evidence from his studies of western geology that catastrophes had had an effect on the development of life. He did not propose a return to the discredited notion of catastrophism and its destructions and new creations, but thought that

> the evolution of environment has been the major cause of the evolution of life; that a mere Malthusian struggle was not the author and finisher of evolution; but that He who brought to bear that mysterious energy we call life upon primeval matter bestowed at the same time a power of development by change, arranging that the interaction of energy and matter which make up environment should, from time to time, burst in upon the current of life and sweep it onward and upward to ever higher and better manifestations. Moments of great catastrophe, thus translated into the language of life, become moments of creation.

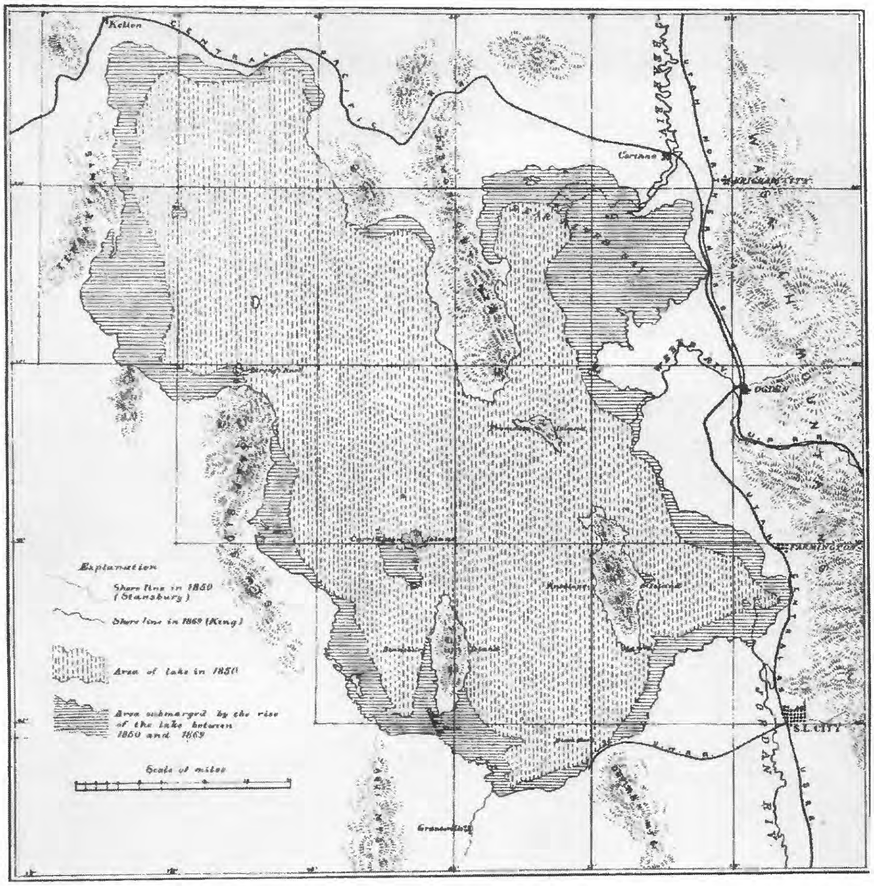
King's friends were embarrassed and others were outraged. The paper was not published in the *American Journal of Science,* which would have been the normal outlet, but in the *American Naturalist.* Gilbert, for one, thought King had gone too far and considered writing a paper in controversion but apparently never did so. Marsh, however, took a strong stand in favor of Darwinian evolution at the August 1877 meeting of the AAAS in Nashville. In his vice-presidential address, he made a long summation of what was then known of American fossil vertebrates, opening with the statement that "to doubt evolution to-day is to doubt science, and science is only another name for truth." Marsh's address was published in the *American Journal of Science* and also in *Nature, Popular Science Monthly,* and the *Revue Scientifique.* C. S. Peirce, the founder of pragmatism and now considered the most original thinker and greatest logician of his time, thought that King's theory should be considered a third method of evolution, as significant as Darwin's natural selection and Lamarck's inheritance of acquired characteristics.

W. H. Holmes also drew this section of the walls of Amethyst Mountain on the south side of the valley of the East Fork of the Yellowstone River. Petrified tree trunks of ancient forests are abundant, and in the steeper middle portion of the mountain face, Holmes said that the rows of upright trunks stood out on the ledges like columns of a ruined temple. (From F. V. Hayden, 1883.)



This mode of evolution, by external forces and the breaking up of habits, seems to be called for by some of the broadest and most important facts of biology and paleontology; while it certainly has been the chief factor in the historical evolution of institutions as in that of ideas; and cannot possible be refused a very prominent place in the process of evolution of the universe in general.

In his annual report in the fall of 1877, Secretary Schurz recommended that the timberlands be withdrawn from operation of the preemption and homestead laws and that timberlands fit for agriculture be sold only for cash and at prices to make the purchaser pay for the value of the timber thereon. He noted that in the mining States and Territories, timber necessary for mining operations and smelting works had to be obtained from the public lands. The Department had refrained from prosecution of such cases except where the quantity taken had been unduly large. Legislation should be provided, however, so that the timber could be obtained legally and so that it would be paid for by those who took it. Schurz also recommended that the



G. K. Gilbert, who made a special study of the drainage basin of Great Salt Lake for the Powell survey, found that although popular impressions of fluctuations in climate are often erroneous, there was no doubt that the steam flow in Utah had increased since settlement of the area. The accumulation of water in Great Salt Lake, he pointed out, was an effective measure of the increase, for the lake had no outlet and its level was determined by the relation of evaporation to inflow. Comparison of the shoreline as mapped by the Howard Stansbury survey of 1850 and the King survey in 1869 indicated that the lake was 7 or 8 feet higher than it had been and its area 17 percent greater. The hypothesis that the rise of the lake was due to a change in climate he regarded as tenable but not proven. (From J. W. Powell, 1878.)

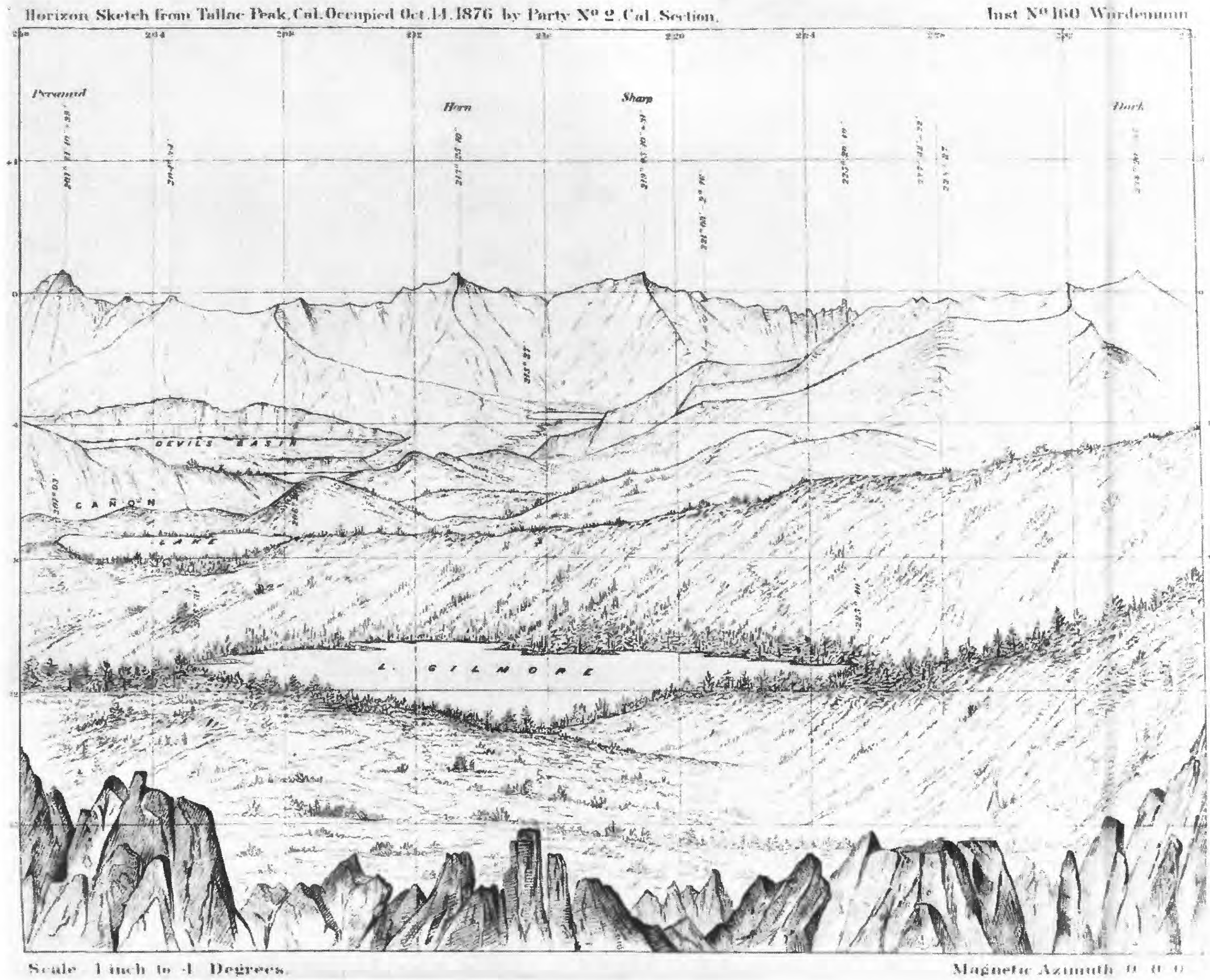
pasturage lands be leased and that the Desert Land Act be amended so that the desert character and quality of the land could be established before entry was permitted and the quantity or portion to be irrigated, cultivated, or improved could be specifically defined. He endorsed the recommendation of the Commissioner of the General Land Office that all offices of surveyors-general be consolidated into one Office of Surveyor-General at Washington with such assistants as were needed, and that the contract system of surveying the public lands be abolished. President Hayes in his annual message at the opening of Congress

> **earnestly recommend[ed] that the measures suggested by the Secretary of the Interior for the suppression of depredations on the timber lands of the United States, for the selling of the timber from the public lands, and for the preservation of the forests be embodied in law, and that, considering the urgent necessity of enabling people of certain States and Territories to purchase timber from the public lands in a legal manner, which at present they cannot do, such a law be passed without unavoidable delay.**

Accompanying the Secretary's report was one of Major Powell's rare reports, covering the field season of 1876, the office work of 1876–77, and the field season of 1877. He mentioned that much attention had been given to cartography and geological illustration and stated that "during the past six years one branch of our work has been considered of paramount importance, namely, the classification of lands and the subjects connected therewith. The object has been to determine the extent of irrigable lands, timber lands, pasturage lands, coal lands, and mineral lands." He pointed out that the lands that were cultivable only through irrigation were limited by the supply of water, but that the amount of land in the Territory of Utah that could be redeemed by the utilization of streams alone, without construction of reservoirs, was about 1,250,000 acres. The area where standing timber was actually found was very much smaller than the area where timber should have been found because so much timber had been destroyed by fire, far more than the amount taken for economic purposes. The important problem to be solved was the prevention of fire. Much attention had been given also to the utilization of the pasturage lands and to the best methods of surveying the mineral lands so that owners of mines might be relieved of the burden of litigation to which they were then subject because of the inaccurate and expensive methods then in vogue. He proposed "at an early day to submit a report on this subject to the honorable Secretary of the Interior, presenting the results of our work in the directions above indicated."

Two bills were filed to provide for a more economic and accurate survey of the public lands, one by Mr. Hendrich B. Wright of Pennsylvania on January 28, 1878, and the other by Mr. John D. C. Atkins of Tennessee on March 22. Then on March 25 and 26, Mr. Atkins and Mr. Lucien C. Gause of Arkansas filed bills to provide for a more economic survey and disposal of public lands. All bills were referred to the Committee on Public Lands. The committee held several days hearings on a bill "to provide a more economic and accurate survey of the public lands" in March. Major Powell, who was the first witness, was credited with authorship of the bill. He told the committee that the system for parceling the public lands into townships and sections and the methods of measuring these parcels and determining their position has been devised more than 80 years before for the great valley of

G. K. Gilbert, who completed the report on the Black Hills of South Dakota for the ill-fated Henry Newton, stressed the nature of erosion in the area. Near Harney Peak, the main peaks were of massive granite, fissured and cracked, weathered and worn in every direction. South and southwest of Harney, granite pinnacles or slabs were weathered out and stood 100 or 200 feet above the mass of the range, dividing some of the crests into "serried pinnacles, which near by resemble organ pipes and in the distance saw teeth." (From Henry Newton and W. P. Jenney, 1880.)



the Mississippi, for which region they were well suited. In the great mountain region of the west, however, some modifications were needed. There, the system of surveying should be adapted to the type of land and different methods used for irrigable lands, timberlands, pasturage lands, and mineral claims. Surveying was properly a question of scientific engineering, and a man so qualified should have charge of the work.

Professor Hayden and Captain Wheeler testified a week later. Hayden said he had no ambition beyond the care and protection of his own survey, but he agreed with Wheeler that the rectangular system of surveying was the best and cheapest. In fact, "one might as well introduce a dead language and force people to use it as to change the process and system."

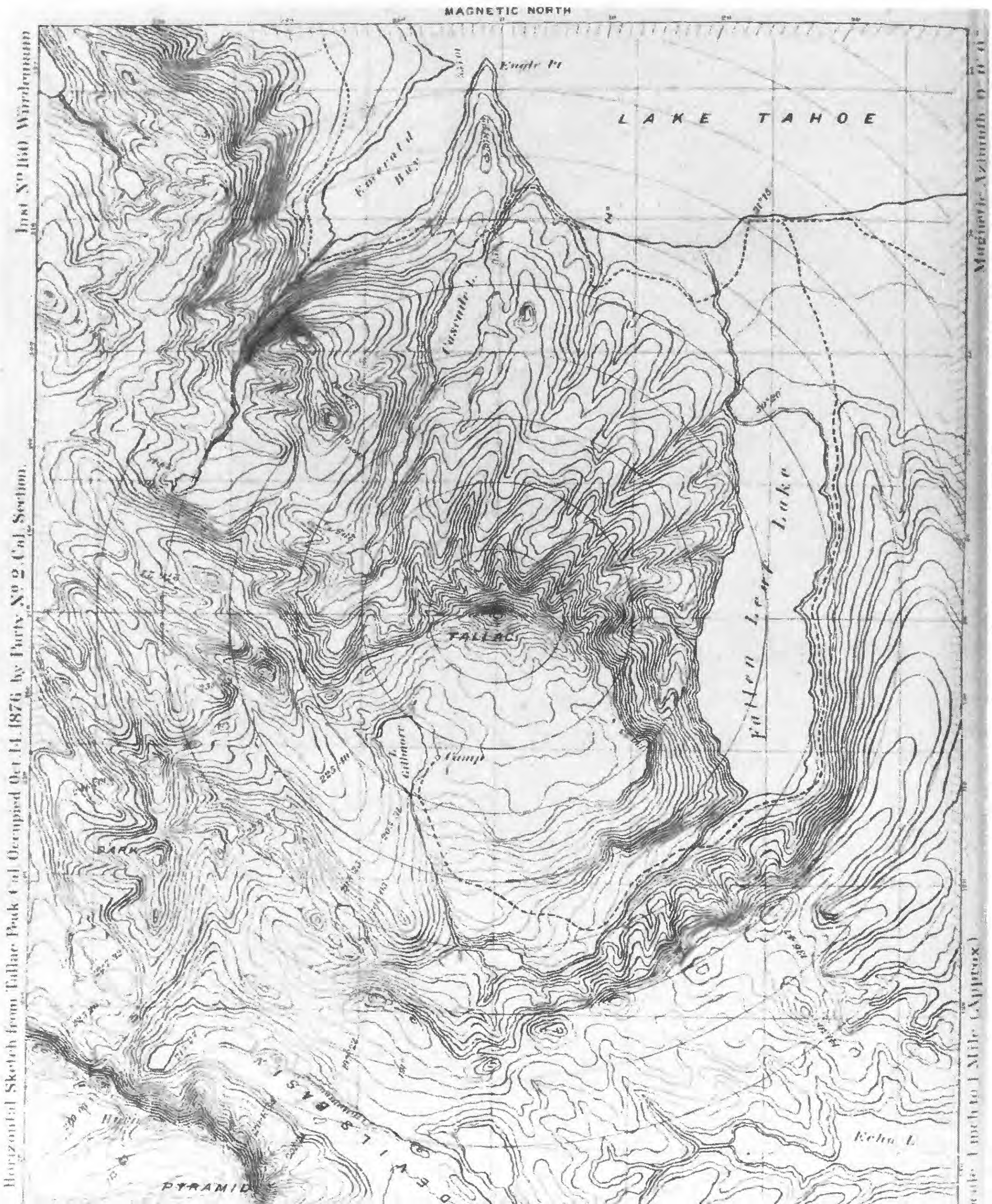
Congress was in no mood to change the land parceling system, and although Major Powell had spoken only of methods of surveying the public lands, one of the Atkins bills and the Gause bill, which were also before the committee, included changes in land parceling as well as surveying. None of the bills was reported out by the Committee.

On the evening of the day that he testified before the Public Lands Committee, Major Powell spoke before the Philosophical Society, giving them a preview of his *Report on the Lands of the Arid Regions of the United States.* The report itself was transmitted to the Commissioner of the General Land Office

Wheeler's parties continued to map vast areas west of the 100th meridian. His methods of mapmaking included preparation of a horizon sketch (a profile sketch of the entire horizon) (this page) at main and secondary triangulation stations, with marked points governed by measured angles, and horizontal sketches (opposite page) of the adjacent topography at particular stations and arbitrarily selected points to show the character and direction of drainage. (From G. M. Wheeler, 1889.)

on April 1. In the preface, Powell said that he had intended to write a work on the public domain, including the swamps of the southeast Atlantic and Gulf coasts, the Everglades, the flood plains of the great southern rivers, and the lake swamplands of the north-central region. All these lands required drainage or protection from overlow. The problem of the arid lands was more pressing, however, as thousands were migrating there every year; he had therefore decided to publish first that part of the whole report that dealt with the arid lands.

Powell defined the Arid Region as the region in which the mean annual rainfall was less than 20 inches. It began about midway in the Great Plains, approximately at the 100th meridian, and extended across the Rocky Mountains to the Pacific Ocean except for a small area in western Washington and Oregon and the northwest corner of California. In the Arid Region proper, the mean annual rainfall was insufficient for agriculture on the basis of the traditional patterns of the humid regions. Between the Arid Region of the West and the Humid Region of the East was a belt, covering approximately one-tenth the area of the United States exclusive of Alaska, in which droughts would occur, the frequency diminishing from west to east. This he called the Sub-humid Region.



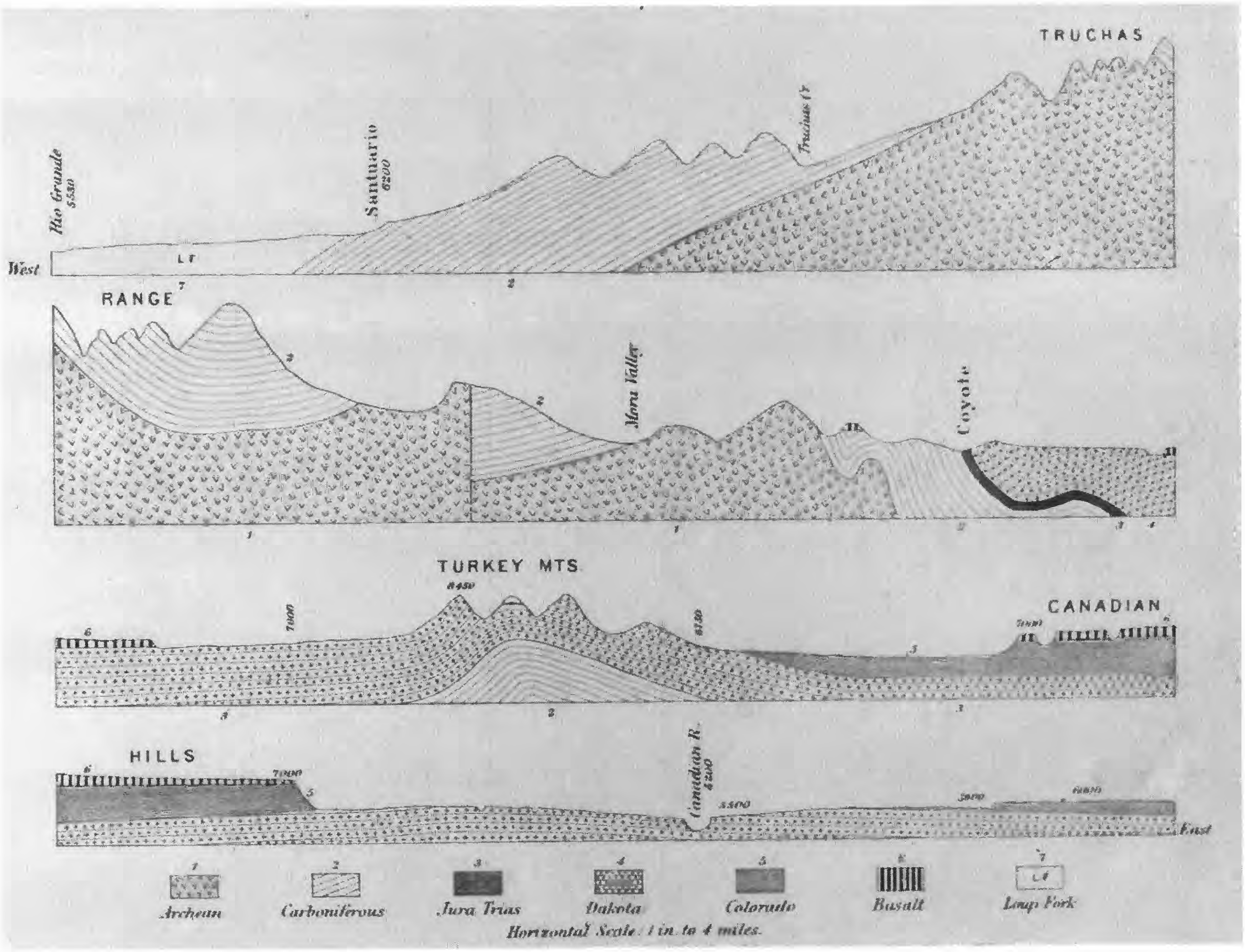
Only a small portion of the Arid Region was irrigable—the lowlands along the streams. In Utah Territory, with which Powell was familiar, only 2.8 percent of the lands could be cultivated by utilizing all the available streams during the irrigating season. In some of the other States and Territories of the Arid Region, the percentage of irrigable land would be less than that in Utah, in others greater; the percentage in the entire region was probably somewhat greater than that in Utah. To a great extent, the small streams were already used for irrigation, and the chief future development must come from use of the large streams. Cooperative labor or capital would be necessary for such development. The irrigable area could be increased by storage of water, and eventually this would be important. It would be wise to anticipate the time by reserving sites for reservoirs.

The mountains and high plateaus were timberlands, although only in part covered by standing timber. Fire had destroyed much timber where it would normally grow. The Timber Region in Utah was about 18,500 square miles, or 23 percent, but only 10,000 square miles, or 12.5 percent, was covered with standing timber, and the area of milling timber was even less. The figures for Utah were probably a fair average for the Arid Region. The amount of timber used for economic purposes, he said, would be more than replaced by natural growth, but the forests should be protected from fire. This could be largely accomplished by removing the Indians.

Between the timberlands and the irrigable lands were the grass-covered lands that could be used for pasturage farms. Pasturage farms to be of any practicable value must be of at least 2,560 acres and in many districts, much larger. They should not be fenced. Pasturage farms needed small areas of irrigable land for raising agricultural products for local consumption. Pasturage lands should be surveyed, not in regular tracts as square miles or townships, but in areas conforming to the topography so as to give the greatest number of water fronts. Farm residences should be grouped to secure the benefits of local social organization.

Included in the report were drafts of two bills for the organization of irrigation and pasturage districts by homestead settlements. To dispose of the public lands in such a way first required that the lands be classified. Major Powell said: "The largest amount of land that it is possible to redeem by irrigation *** should be classed as irrigable lands, to give the greatest possible development to this industry. The limit of the timber lands should be clearly defined, to prevent a fraudulent acquirement of these lands as pasturage lands.***All of the lands falling without these boundaries would be relegated to the greater class designated as pasturage lands." It would be difficult to draw a line between absolute desert and pasturage lands, and no purpose would be served thereby, as settlers would avoid the valueless lands.

The mineral lands were of small extent. Lode mines were in the mountains, and such lands were valueless for other purposes. Placer mines might be on agricultural lands, but their extent was limited. Withholding them from purchase and settlement as irrigable, timber, or pasturage lands would not materially affect the interests of the industries connected with them. The General Government, he said, could not reasonably engage in the research necessary to determine the mineral lands, but this was "practically done" by the miners themselves when they organized a mining district. The extensive coal fields in the Arid Region were a different problem. "These coal fields are inexhaustible by any population which the country can support for any length of time that human prevision can contemplate. To withhold from general settlement the entire area of the workable coal fields would be absurd. *** Only those lands should be classed as coal lands that contain beds



J. J. Stevenson's work for the Wheeler survey in 1878 led to preparation of a geologic section along the 36th parallel, the southern boundary of Colorado, from the Rio Grande to San Isidro Creek, a distance of approximately 90 miles. (From G. M. Wheeler, 1881.)

of coal easily accessible, and where there is a possibility of their being used as such within the next generation or two." To designate the coal lands would require a thorough geological survey, but the work of determining irrigable, timber, and pasturage lands would be comparatively inexpensive.

Commissioner Williamson sent the report on April 1 to the Secretary with a carefully worded disclaimer: "I have not been able, on account of more urgent official duties, to give Major Powell's report and proposed bills the careful investigation necessary, in view of their great importance, to enable me to express a decided opinion as to their merits. Some change is necessary in the survey and disposal of the lands, and I think his views are entitled to great weight, and would respectfully recommend that such action be taken as will bring his report and bills before Congress for consideration by that body." The Secretary acted with almost equal despatch and sent the report to Congress on April 3. He made no recommendation, but merely. "commend[ed] the views set forth by Major Powell and the bills *** to the consideration of Congress." The report was referred to the Committee on Appropriations and ordered to be printed, but the first printing was not received until August. Major Powell, however, had found an ally in Congressman Peter Wigginton of California, who filed bills on April 22 to organize pasturage and irrigation districts. These were referred to the Public Lands Committee and were not heard of again.

There was great economic interest in the iron and copper ranges of Ashland County, Wisconsin, which R. D. Irving of the Wisconsin survey was instructed to explore. As his map shows, the portion of Wisconsin that borders Lake Superior is traversed by two parallel belts of high and ridgy country, about 30 miles apart, the southern belt being a westward continuation of the high land that forms the backbone of Keeweenaw Point in Michigan. The region at the time of Irving's work was a wilderness, the streams nearly all made too rapid a descent for canoeing, and all investigations had to be made on foot, so he spent a total of 6 months in the field seasons to accomplish the work. (From R. D. Irving, 1880.)

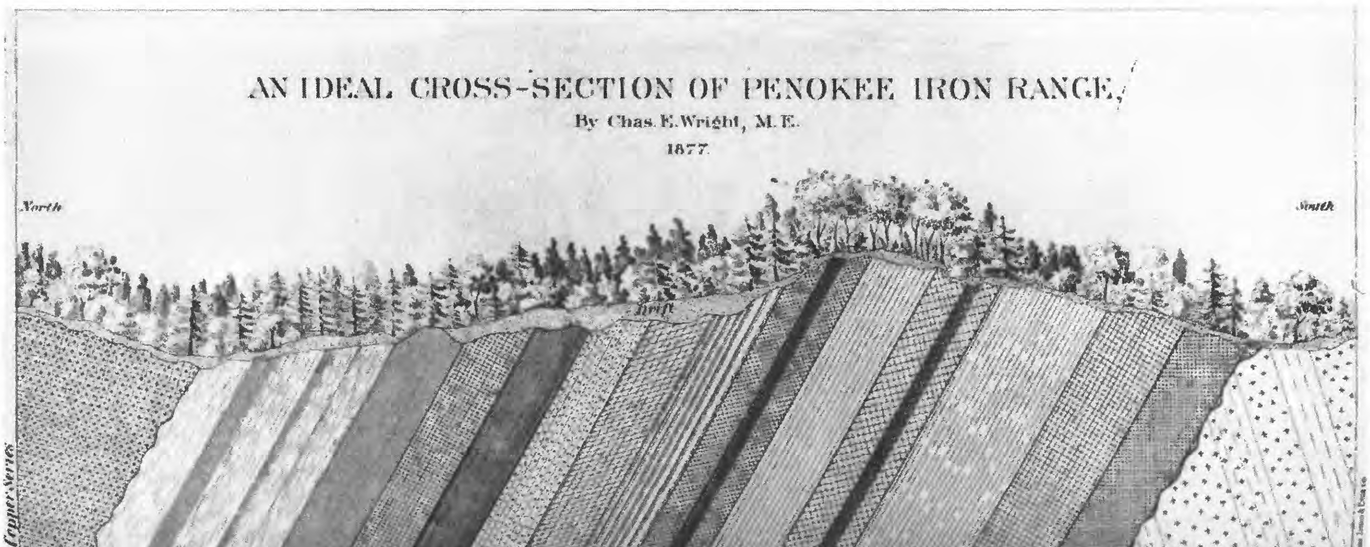
On February 4, 1878, Henry Gannett had forwarded a report on the arable and pasture lands of Colorado for inclusion in the Tenth Annual Report of the Hayden survey. The Powell and Gannett reports make an interesting comparison, for neither author gave any indication of being aware of the other's work. Gannett's report included not only his own observations and those of all other members of the Hayden survey but also data received from others, including E. S. Nettleton of Peublo and Captain E. L. Berthoud of Golden, both civil engineers engaged in irrigation. He seemed familiar with and quoted from George Perkins Marsh's works and the Engineers' 1874 report on irrigation in California. Powell's report was largely personal, although it included the work of Gilbert, Dutton, and Thompson in Utah. The one reference to Marsh said that his book had been frequently quoted but that the statements were misleading.

Gannett pointed out that for successful agriculture, four things were necessary: a fertile soil, a level surface, a sufficiently mild temperature, and the proper amount of moisture. These factors were implicit in the Powell report. The first two of these conditions, according to Gannett, were probably found in two-thirds of Colorado. The third condition reduced the amount of arable land very considerably, as many fine mountain valleys were from their great altitude too cold to be useful to agriculture. The fourth condition limited the arable land to a comparatively small amount. The arable lands were chiefly in the valleys of the consequent, or second-rate, streams. The rainfall in Colorado was "of so variable and explosive a character that it can be depended on for little except to do damage," so agriculture was almost universally dependent on irrigation. Powell's irrigable lands were also along the streams.

The quantity of water applied by irrigation to various crops, Gannett said, varied greatly in different parts of the earth. In Colorado "an inch of water" to the acre was a very common allowance. An inch of water, the amount that would flow through an aperture 1 square inch in section, said Gannett, varied with the pressure from head or velocity. Powell said that the inch was too indefinite to use and adopted instead the second-foot, or the flow of 1 cubic foot of water per second. In Utah, this amount would irrigate about 100 acres. Gannett said that the measurements of the discharge of streams to determine their irrigating capacity amounted to very little except as very general indications, because the volume of water carried could vary from day to day. Measurements, if made, should be made at the end of July or early in August, about the close of the irrigating season, and preferably during a dry season, as the minimum supply was what should be determined. Powell said that the practical capacity of a stream would be determined by its flow when that flow was least in comparison with the demands of growing crops, at different times in different parts of the Arid Region, but between the latter part of June and the early part of August.

Gannett estimated that in all Colorado tillable land totalled 7,323 square miles, or 4,686,720 acres, about 7 percent of the total land area, and that

In a study of both practical and scientific interest, C. E. Wright of the Wisconsin survey attempted to correlate the Penokee iron-bearing series of Wisconsin as nearly as possible with the iron-bearing series in Michigan, using magnetic measurements where necessary to trace the series. The numbers of the divisions shown in the illustration correspond to those of Michigan. (C. E. Wright, 1880.)



Glacial geology would seem to be exclusively pure science, but this map of New Jersey showing glacial drift was published in the *Transactions of the American Institute of Mining Engineers.* The State Geologist of New Jersey, George H. Cook, pointed out it had important practical and economic implications for the mining engineer. Some who did not understand the nature of glacial drift had undertaken expensive mining operations where they had found iron ore in boulders in the drift. (From G. H. Cook, 1877.)

there was water enough to irrigate all this area without the use of reservoirs. In addition to tillable land, 55,000 square miles (52.6 percent) was valuable as pasture land, 20,000 square miles (19.1 percent) was covered by spruce and pine timber, and 13,500 square miles (13.0 percent) was covered by quaking aspens, pinon pine, and scrubby cedar. Only 6,565 square miles, or 6.3 percent, could be classed as barren or worthless unless reclaimed by immense works. Such an undertaking, he thought, was too far in the future to worry about.

The Schurz-Williamson attack on timber trespass and the President's endorsement of legislation focused attention on the forest lands, and Congress responded by passing the Timber Cutting and the Timber and Stone Acts on June 3, 1878. The Timber Cutting Act permitted bona fide settlers and miners to cut timber on the public mineral lands for building, agricultural, mining, or other domestic purposes. The Timber and Stone Act provided for the sale of 160 acres of unoccupied, surveyed, nonmineral lands in Washington, Oregon, California, and Nevada valued chiefly for timber or stone and unfit for cultivation for not less than $2.50 an acre. Neither law really helped the situation. On June 20, Congress also appropriated $25,000 to meet the expenses of suppressing depredations on timber on the public lands. The disposition of the arid lands remained unchanged.

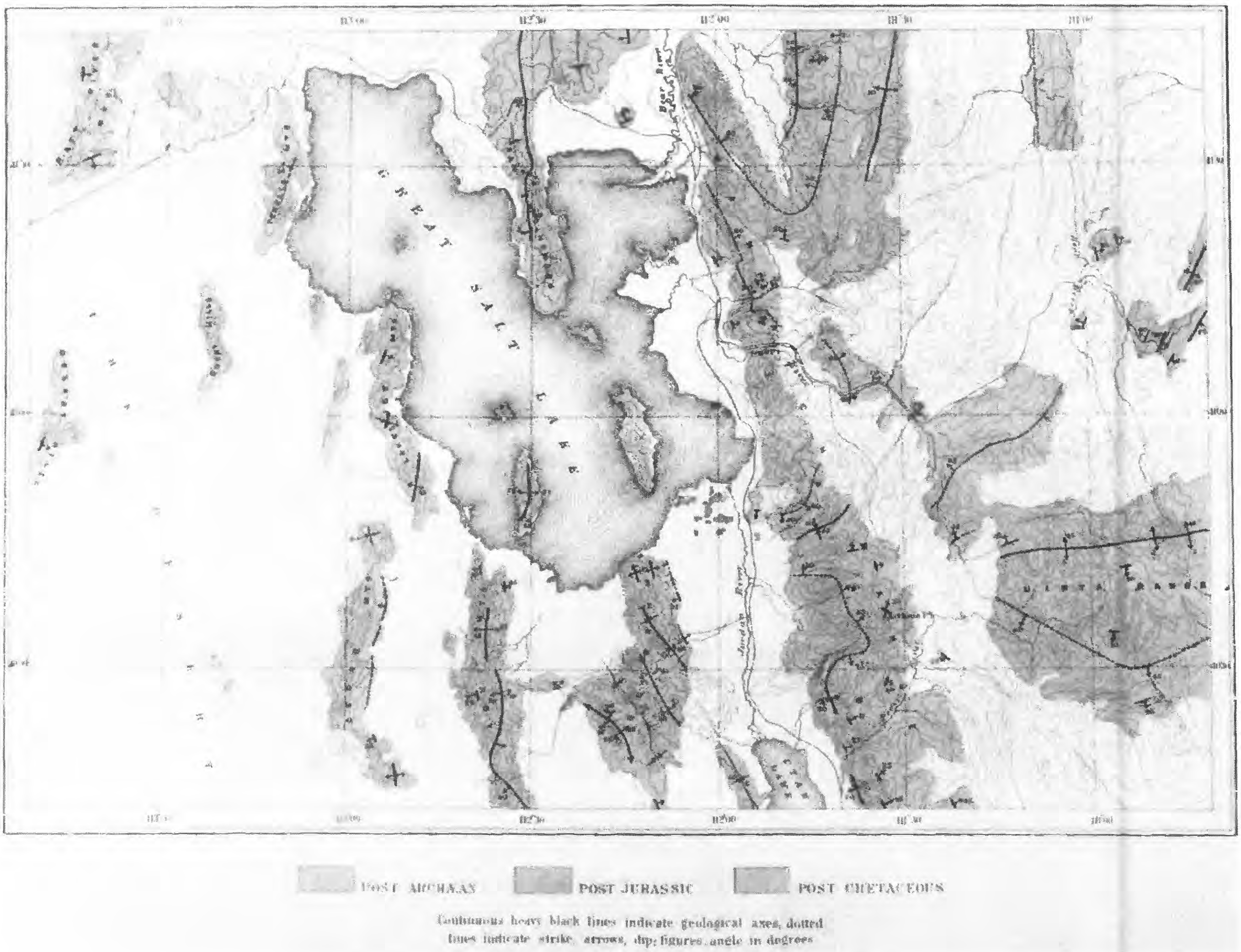
Money and monetary policy were the major issues in that session of Congress. The 45th Congress was called into session early, on October 15, 1877, because the Army Appropriations Act had not been passed. By the time Congress convened, there were other financial matters to consider. Part of the Interior Department building had been completely destroyed by fire, and funds were needed to replace it. The United States had been invited to participate in the Paris Exposition in the summer of 1878. And Congress itself had some matters to take up that the President did not mention in his special message.

There seemed to be no end to the depression that had been going on since 1873. The resumption of specie payments, opposed by inflationist elements, was scheduled to begin on January 1, 1879, and Congress was deluged with a barrage of cheap money proposals. The agrarian and labor groups who were urging cheap money had found allies in the western silver interests, who were urging a return to bimetallism, and in one week, between October 29 and November 5, 1877, twenty bills were filed in the House to remonetize silver.

In February 1878 the Bland-Allison Silver Purchase Act was passed, over President Hayes' veto, requiring the Secretary of the Treasury to make monthly purchases of not less than $2 million and not more than $4 million worth of silver at the market price, such purchases to be converted into standard dollars. In May, Congress passed a law to keep the $346.7 million outstanding in greenbacks as a permanent part of the currency.

The Bland-Allison Act had also provided for an international monetary conference. Professor Francis A. Walker of Yale was one of the delegates to the monetary conference held in Paris. Walker's book on *Money* had just been published, and in April 1878 he was elected to the National Academy of Sciences. Because of his experience as Director of the Ninth Census, he had also been called on by Secretary Schurz for aid in drafting legislation for the Tenth Census. Walker left no one uncertain about the difficulties he envisioned in taking the Tenth Census under the "clumsy, antiquated, and barbarous" law of 1850, which had been passed "when statistical science was in its infancy and the art of collecting statistical data was yet in a rude and imperfect state." To take the Tenth Census under the provisions of that act, he said, "would be to secure the minimum of statistical result at almost a maximum of annoyance, delay, and expense."

Walker was especially concerned about the collection of statistics on the mining of metals, which "in this period of universal monetary discussion" he believed "must be found of interest and value." To buttress his own opinion, he called on Professor Josiah Dwight Whitney of Harvard. Whitney, pointing out the importance of accurate knowledge of mineral resources and of progress in their development said: "The mineral treasures of the earth *** are there once for all; and if wasted in the removal or destroyed by reckless or unskilled management they are gone forever. And the temptation to sacrifice the future to the present is in new countries often very great."



King's volume on *Systematic Geology* (his treatise on pure geology and the summation of his work in the West was published in 1878. In his final chapter he included a series of analytical geological maps, the forerunner of our present-day tectonic maps, on which he attempted to relate structure, stratigraphy, and orogeny. However, because of "our provokingly defective knowledge of the very rudiments of terrestrial thermodynamics, from which alone we might hope to bridge the chasm still separating our phenomenal knowledge from the vague land of causes," a more complete discussion awaited the day when it could be done on a firmer physical foundation. (From Clarence King, 1878.)

He went on to say that "in civilized countries almost without exception, the mineral deposits, as well as the operations of the miner and metallurgist, have always been under the strict control of the government" and that the collection of mining statistics had long been recognized by the principal governments of Europe as an essential part of their watchful care over the public interest. It would be impossible to obtain statistics in the United States that were as accurate as the Prussian and French results, for American tradition would not countenance the constant inspection of mining localities that would be necessary. Nonetheless, something should and could be done. It must be done by experts, and the best way, he thought, would be to follow the system that he had used in collecting his statistics for *The Metallic Wealth of the United States:*

Let some man, whose character for integrity is beyond suspicion, be placed in charge of the Department of Mining Statistics, and let him visit such districts as his time may allow, sending assistants to other districts, to collect material to be elaborated into one work the object of which should be set forth as clearly and concisely as possible the actual condition of the development of our mining districts, giving such statistics as may be obtainable, with estimates where moderately accurate statistics are wanting, and with full particulars as to how these statistics have been obtained, so that their comparative value may be judged of by the person using the material thus collected.

The assistants thus appointed must themselves be experts, and such should be preferred as have already some acquaintance with the regions they are to

report upon. It need hardly be added that they must in all cases be men of scientific education, who have absolutely no pecuniary interest in the region they have under their charge.

The task even so would be difficult, and in order that it be successfully accomplished, the one in charge would have to be "a man of energy, possessing both practical and scientific knowledge of economic geology." Above all, he would have to be a man "who could not be bought at any price."

The combination of depression and an election year made it inevitable that Congress would be in a mood to economize on appropriations. All the surveys would face difficulties in obtaining funds. On March 8, 1878, the House had passed a resolution proposed by Chairman John D. C. Atkins asking the Secretaries of Interior and War for a statement on the cost and accomplishments of the various western surveys, whether there had been any duplication, and if so, the cost and the reasons therefor. Secretary Schurz replied in April, forwarding a letter from Hayden on the 18th and one from Powell on the 29th. Powell attached a map showing the plan for Interior's atlas of the territory west of 99°30′. Hayden supplied a series of documents pertaining to the history of his work. The Hayden survey had received appropriations amounting to $615,000 in 10 years of existence; Powell had received only $209,000 but had had, in addition, Army rations for 25 men and two Army officers, Captains Clarence Dutton and Garrick Mallery, who had been detailed to his survey. Of the two Army surveys, the Exploration of the Fortieth Parallel under Clarence King, now completed, had cost $383,711.85 and the Wheeler survey had cost to date $368,770.55.

Both Hayden and Wheeler disclaimed any duplication. Each was mapping the West but for different purposes. Their achievements they measured by their publications. Hayden listed 9 annual reports, 9 miscellaneous publications, 4 volumes of bulletins, 8 monographs, 31 maps, and the atlas of Colorado, which included 16 maps, sections, and panoramic views. Wheeler had 8 preliminary or annual reports, 4 monographs or quarto reports, 13 special publications, 22 maps for the topographic atlas, 7 geologic maps, and 7 land classification maps.

Powell had fewer publications: four preliminary reports, his *Report on the Exploration of the Colorado River* and the *Report on the Uinta Mountains, Contributions to American Ethnology,* and the *Introduction to the Study of Indian Languages.* Gilbert's Henry Mountains report was in press, as was Powell's report on the Arid Region. Most of his reply was a dispassionate recital of the duplications among the various surveys and a reasonable explanation of how the Powell survey, because of its different viewpoint, could work in the same area as the others without duplication of work.

The Sundry Civil Expenses bill came up for consideration in mid-June. The Committee on Appropriations had been more specific than it had ever been before with regard to the two Interior surveys. For Hayden, the Committee recommended $50,000 to be used "for salaries of scientific corps; for employees in the field; transportation of party to and from field; office rent, stationery, and postage; expressage and freight, outfitting and provisions during field season; purchase of arms and ranching animals; purchase of and repairing instruments; miscellaneous expenses in the field, such as provisions, toll, and blacksmithing; and preparation of reports." Hayden was also limited to the area north of the 42d parallel and west of the 100th meridian. For Powell, the Appropriations Committee recommended $30,000 and restricted him to the area south of the 42d parallel and west of the 100th meridian.

Immediately following these appropriations was a requirement that the National Academy of Sciences at its next meeting

> **take into consideration the methods and expenses of conducting the above surveys and the surveys of the Land Office, and report to Congress, as soon thereafter as may be practicable, a plan for surveying and mapping the Territories of the United States on such general system as will, in their judgment, secure the best possible results at the least possible cost; and also to recommend to Congress a suitable plan for the publication and distribution of reports, maps, and documents, and other results of said surveys.**

The wording of the appropriations language and the charge to the National Academy of Sciences make it clear that more than economy was involved. The rivalries between the two Interior surveys, a growing dissatisfaction with the General Land Office surveys, and uneasiness over the large publication program of the Hayden survey were also at issue. It is clear from the later discussion on the floor of the House that A. S. Hewitt was the author of the request to the Academy. Hewitt had been managing the Army appropriations bill to which the Democratic leaders, bent on correcting abuses in the use of the military in civil affairs in the South, had attached a provision forbidding the use of the Army as a posse comitatus and had given the Republicans the choice of passing the bill with this provision or having the Army's funds cut off. The House had passed the bill on May 28, the Republican Senate had finally yielded on June 15, and so the Army appropriations had been passed and funds provided for the Wheeler survey.

The appropriations came up first; that for Hayden was raised to $75,000 and that for Powell to $50,000, the same as they had received for the current year. When the provision for the Academy study was brought up, several members suggested that it should include the Wheeler survey as well. The amendment proposed by Representative Thomas M. Patterson of Colorado was adopted, by which "the above surveys" became "all surveys of a scientific character under the War or Interior Departments." There were only a few days before adjournment, the Senate made no objections, and the bill was passed and approved by the President on June 19, one day before Congress adjourned.

Chapter 14.
Upon a Firm and Enduring Basis: The Establishment of the U.S. Geological Survey, 1879

If we can but rise to the height of this great argument, we shall place the work of national development and the elements of future prosperity upon the firm and enduring basis, of truth and knowledge, from which they cannot be moved so long as the Republic shall endure.

—A. S. Hewitt

Both Hayden and Wheeler had full field seasons in 1878. Hayden organized four parties. A. D. Wilson was in charge of primary triangulation. That party was robbed of all its animals and half its outfit by Indians so did not accomplish as much as had been hoped. A party under Henry Gannett made an especially detailed geological and geographical survey of Yellowstone National Park. Holmes was the geologist with this party, and A. C. Peale made a detailed study of thermal springs and geysers. A third party under F. A. Clark surveyed the Wind River Mountains, part of the Wyoming Range, the Gros Ventre Range, and a large area in the Snake River valley. Orestes St. John was the geologist in this party. Hayden himself traveled with the photographic party which had been reactivated after a lapse of 2 years.

The Wheeler parties mapped 25,550 square miles in New Mexico, Utah, California, Nevada, and Oregon. J. J. Stevenson made a special geological investigation in Colorado south of Spanish Peaks and in north-central New Mexico. I. C. Russell was attached to one of the other parties as assistant geologic observer surveying the Great Salt Lake area.

Powell did not go into the field in the summer of 1878. He was busy for a while with his Arid Lands report and with *Contributions to American Ethnology*. In August, he attended the AAAS meeting in St. Louis, where he was elected vice-president of the Section of Anthropology; afterwards, he led an excursion to Colorado. Thompson and the other topographers, however, mapped 10,000 square miles in Utah and northern Arizona while Gilbert continued his studies of the Great Salt Lake area.

At home, President Hayes continued his efforts at civil service reform and widened the breach between himself and the Senate oligarchy. One of the most flagrant examples of corrupt patronage had been the New York customhouse, where Senator Roscoe Conkling had controlled appointments. When Hayes became President, he asked for the resignations of Chester A. Arthur, port collector of customs, and Alonzo B. Cornell, port naval officer, but his request was ignored, and under the Tenture of Office Act he could not remove these officials. He nominated new officers in December, and the Senate blocked them. As soon as Congress adjourned for the summer, Hayes suspended Arthur and Cornell.

Many Americans went to Europe in the summer of 1878 to enjoy the great International Exposition at Paris and to inspect the new Eiffel Tower. The International Congress of Geologists met in conjunction with the exposition for six daily sessions beginning August 29, and about 250 people were present. James Hall, George H. Cook, J. Peter Lesley, W. P. Blake, E. D. Cope, and T. C. Chamberlin attended from the United States. Plans were made for a second congress, to be held in Bologna, Italy, in October 1881, and two committees were set up, one charged with unification of colors and signs on geologic maps and plans, and the second, with unification of geological nomenclature, including not only classification but questions related to the value and significance of mineralogical, lithological, and paleontological characters. Lesley was appointed to represent the United States on the map committee, and James Hall, the committee on nomenclature and classification.

James Hague was sent to represent the United States as Mining Commissioner to the Exposition. Hague found the exhibit so comprehensive that he restricted his official investigation to one class only, ores, minerals, and crude products of the mining industry, and with the help of a friend, Prof. George F. Becker of the University of California, produced a 190-page report discussing the mining industry of France and the French colonies, Great Britain, Australia, Russia, Sweden, Norway, Belgium, Austria-Hungary, Italy, Spain, Portugal, Greece, and the Dutch East Indies. The United States exhibit included little that was new, so Hague and Becker concluded their report with an essay on the bullion product of the United States, a matter of considerable interest to monetary commissions throughout the world.

The committee of the National Academy of Sciences to consider a plan for surveying and mapping the Territories was appointed in late summer, when the Acting President, Prof. O. C. Marsh, returned from Europe in early August. Joseph Henry, the grand old man of American science who had been Secretary of the Smithsonian since 1846 and President of the National Academy of Sciences since 1867, had died on May 13, 1878. Professor Marsh, who had been elected Vice President in April, then became the Acting President. Marsh ruled out as members "any of those who had taken part in the controversy between the then existing government surveys" and appointed Prof. James D. Dana of Yale, William B. Rogers, president of the Massachusetts Institute of Technology, Prof. J. S. Newberry and Prof. W. P. Trowbridge of the Columbia School of Mines, Prof. Simon Newcomb of the Nautical Almanac, and Prof. Alexander Agassiz of Harvard to serve on the committee. He himself served as chairman, ex officio.

Clarence King was evidently a key, though unnamed, figure in these activities. The original proposal by Congressman Hewitt that the National Academy consider the Interior surveys very likely had been suggested to him by King, who was his close friend and business associate and a member of the Academy. King was also a friend of Secretary Schurz and Professor Marsh. The committee was drawn exclusively from the eastern-most urbanized and industrialized part of the country, and almost exclusively from the academic world. Although both pure and practical science were represented, Professors Rogers, Newberry, Trowbridge, and Agassiz all had strong interests in the use of science in the development of mineral resources. There was no one, with the possible exception of Professor Trowbridge, to present the military point of view, but Professor Trowbridge's experience qualified him equally well to present the point of view of the Coast Survey. The committee seemed almost to have been chosen to consider Congressman Hewitt's original proposal before Representative Thomas M. Patterson's amendment broadened the scope of its investigation to include the War Department mapping.

Marsh said that Dana's "long experience as geologist and naturalist of the Wilkes exploring expedition, and subsequent residence in Washington, while preparing his report, had especially fitted him to advise on government

The following eight illustrations are portraits of the members of the National Academy of Sciences Committee on the Scientific Surveys of the Territories.

Othniel C. Marsh

Professor of paleontology at Yale, Acting President of the National Academy of Sciences, Chairman. (Courtesy of the Prints and Photographs Division of the Library of Congress.)

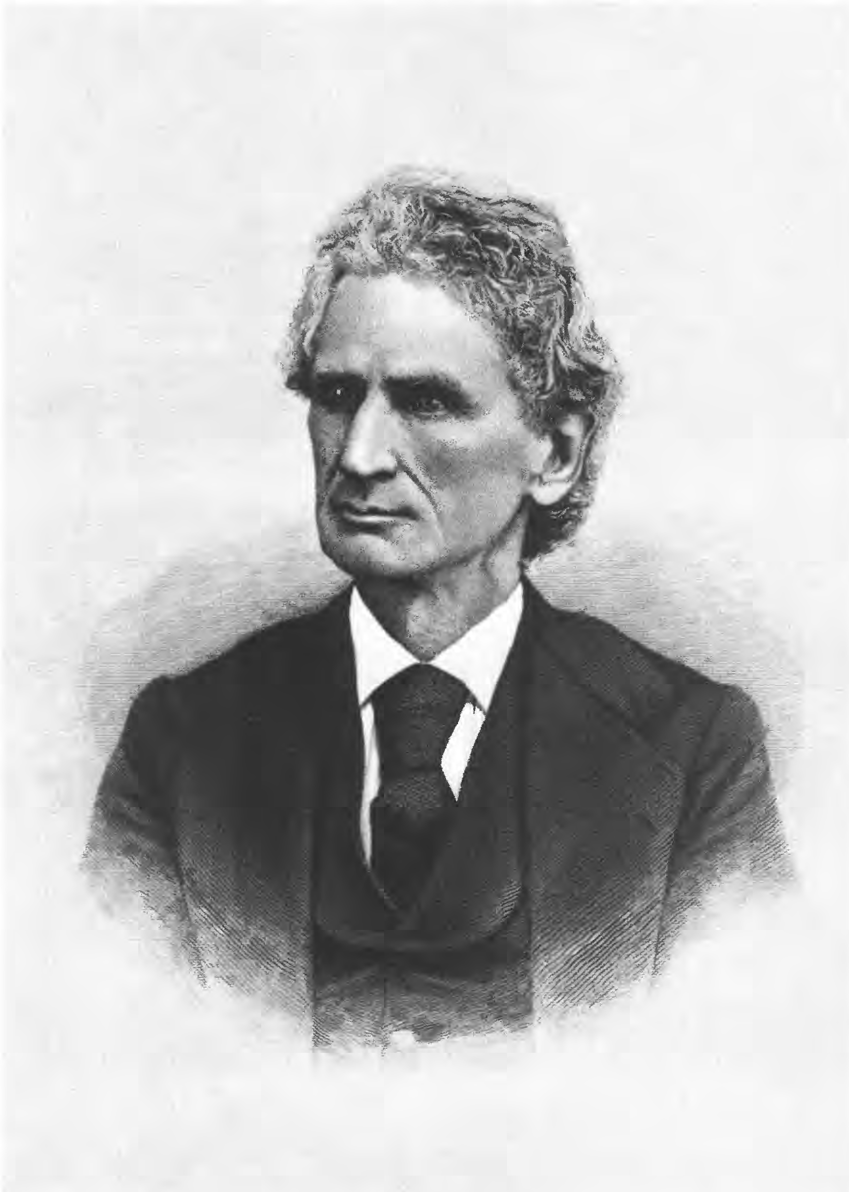
work"; he failed to say that in the 30 years since that time, Dana had been a Yale professor and had numbered among his students O. C. Marsh and Clarence King. Professor Rogers was the "Nestor of American geology" and "had had long and varied experience with geological surveys"; he was also the founder and first president of the Massachusetts Institute of Technology, which James Hague had left to become a member of the Fortieth Parallel Survey, and which already had laboratories for study of mineral resources. J. S. Newberry "was the State geologist of Ohio, who had spent several years in the West on government exploring expeditions under the War Department"; he was also the first professor of geology at the Columbia School of Mines, and had characterized the work of the Fortieth Parallel as "an important contribution to science," and "a high honor to those by whom the work has been performed, and to the government, by which it was organized." W. P. Trowbridge was "a graduate of West Point, who, while a member of the Corps of Engineers, served for several years on the Coast Survey"; he had also been the president of an ironworks and had been a member of the Yale faculty for several years, a post which he had left only recently to join the faculty of the Columbia School of Mines. Simon Newcomb's "knowledge of mathematics and astronomy rendered his advice most valuable"; Simon Newcomb was also one of America's most distinguished scientists, a graduate of Harvard, who at 43 had already received honorary degrees from Columbia, Yale, and the University of Leyden, and the gold medal of the Royal Astronomical Society; he was currently serving as the president of the American Association for the Advancement of Science. Prof. Alexander Agassiz's "experience both in mining and engineering and biology made him a fit representative of those departments"; Professor Agassiz, who was the same age as Simon Newcomb, had also made enough money as superintendent of the fabulous Calumet and Hecla copper mines in Michigan to be able to devote himself to science, to establish the Museum of Comparative Zoology at Harvard, and to invest in mining and cattle enterprises with Clarence King as partner.

The broadening of the investigation proposed by Congressman Patterson may have changed Clarence King's future. When his final report, *Systematic Geology,* had been transmitted to the Corps of Engineers in March 1878, he had included a graceful tribute to General A. A. Humphreys: "That which a student of geology most earnestly longs for, I have freely received at your hands, and whatever value this report may possess, either as a permanent contribution to knowledge or as a stepping-stone worthy to be built into the great stairway of science, I feel that the honor belongs first to you. For those who are to continue the arduous labor of American field-study, I can wish no happier fortune than to serve within the department which you command." In March 1878, he evidently was not thinking of an independent agency.

King, however, was only 36; he had achieved an extraordinary position for so young a man, and he had no immediate commitments. His 1870 report on the mining industry had been called "the most valuable contribution yet made" to the literature on mining when it was published, and he was being urged to bring out a new edition in the light of developments in the decade since. At the same time, his *Mountaineering in the Sierra Nevada,* a series of sketches which has been characterized by one critic as "probably the most exciting book ever written about mountain-climbing," was so well written that the editor of the *Atlantic Monthly,* William Dean Howells, thought it a pity that a man of such literary talent should waste his time on science. Moreover, King had a wide circle of friends in positions of influence outside scientific circles, among them F. A. P. Barnard, president of Columbia, Andrew White, president of Cornell, and Daniel Coit Gilman, president of Johns Hopkins; Peter Cooper, iron manufacturer, inventor, and philanthropist, as well as his son-in-law, Congressman Hewitt; John Hay, Assistant Secretary of State as well as Secretary Schurz; Henry Holt of the publishing family and E. L. Godkin, editor of the weekly *Nation.* as well as William Dean Howells; George Bancroft, the historian, John LaFarge, the artist, and Bret Harte, who may have suggested the mountaineering sketches; the Adams brothers, Henry and Charles Francis, Jr.; Alexander Agassiz, of Harvard University and the Calumet and Hecla Mining Company. He was a member of the Century Club of New York and also of a small group of bons vivants, the Round Table Club, that included Yale professors Francis Walker and William Graham Sumner, as well as Marsh, Hay, and Godkin.

In September, King went to Cambridge to see Whitney to inquire first whether he (Whitney) would be a candidate for directorship of a new bureau, if Congress established one, and secondly, if not, whether he would back King for the position. Whitney answered that King was the "only person to be thought of," and King thereafter frankly sought the position. He told a visiting German scientist of his hopes, and the word filtered back to Hayden.

On September 28, Professor Marsh wrote to the Secretaries of War and Interior for information on the plans and wishes of the departments so that these could be laid before the Academy at its next meeting on November 5. For the War Department, the Acting Chief of Engineers replied, on October 29: "No other department of the government is so much interested in, or has so many uses for, a complete survey of the entire area as the War Department." The survey recommended for adoption by Congress should be a "trigonometrical and topographical survey of the Territories, which shall be founded on accurate astronomical and geodetic methods; *** which exhibits with sufficient accuracy, and with variable degrees of detail according to circumstances, the forms and elevation of the mountain ranges and passes, the roads, the trails, the lakes and ponds, the water-courses, the forests, and all the prominent natural features of the country, including its capacity for agriculture, for grazing, and for mining; which included the gauging of streams with reference to the irrigation of those portions of the country which are susceptible of occupation by a grain-growing population and



James Dwight Dana

Professor of geology and mineralogy at Yale. (Courtesy of the Prints and Photographs Division of the Library of Congress.)

which shows at a glance everything necessary to be known in connection with the movements of troops and supplies." If the framework of the map was accurate, limited areas could then be surveyed with any degree of exactitude required for special purposes connected with the geography, geology, or natural history.

The survey of more than 300,000 square miles already made by the Engineers was believed "to fulfill all the foregoing requirements of the War Department, and of the nation at the present time, and until the Territories are not less thickly settled than the more recent States of the Union." The Engineers believed also that because Army officers had been the first to use refined methods of topographical surveying and among the first to apply refined methods of geodetic surveying, because they had made most of the explorations since the Government had territories to explore and had borne the hardships and exposure of the preliminary examinations and surveys when the region was an unknown wilderness, and because the supervision of methods and the checks on expenses exercised by the Chief of Engineers were watchful and constant, the best interests of the Government would be served by continuing the surveys of the Territories under the Engineer Department. The Engineers also thought it would be a waste of public money to make surveys of any parts of the public land in order to pass title unless there was a probability of their sale; therefore, the War Department surveys should precede the selection by the Interior Department of lands for subdivision surveys.

The Commissioner of the General Land Office, however, said:

> **In arriving at results sought for by this office under the present system of surveys, the employment of methods called into service in projecting extensive and connected geographical and topographical surveys is regarded unnecessary. Regarding any proposed change in the method of surveying the public lands, I desire to say that any departure from the rectangular system or any change in the measurement of subdivision of the lands would, in my opinion, create confusion, which no advantage gained by the change could compensate for. I am, however, of the opinion that combining a geological and geographical survey with the survey of the public lands might be most beneficial and economical.**

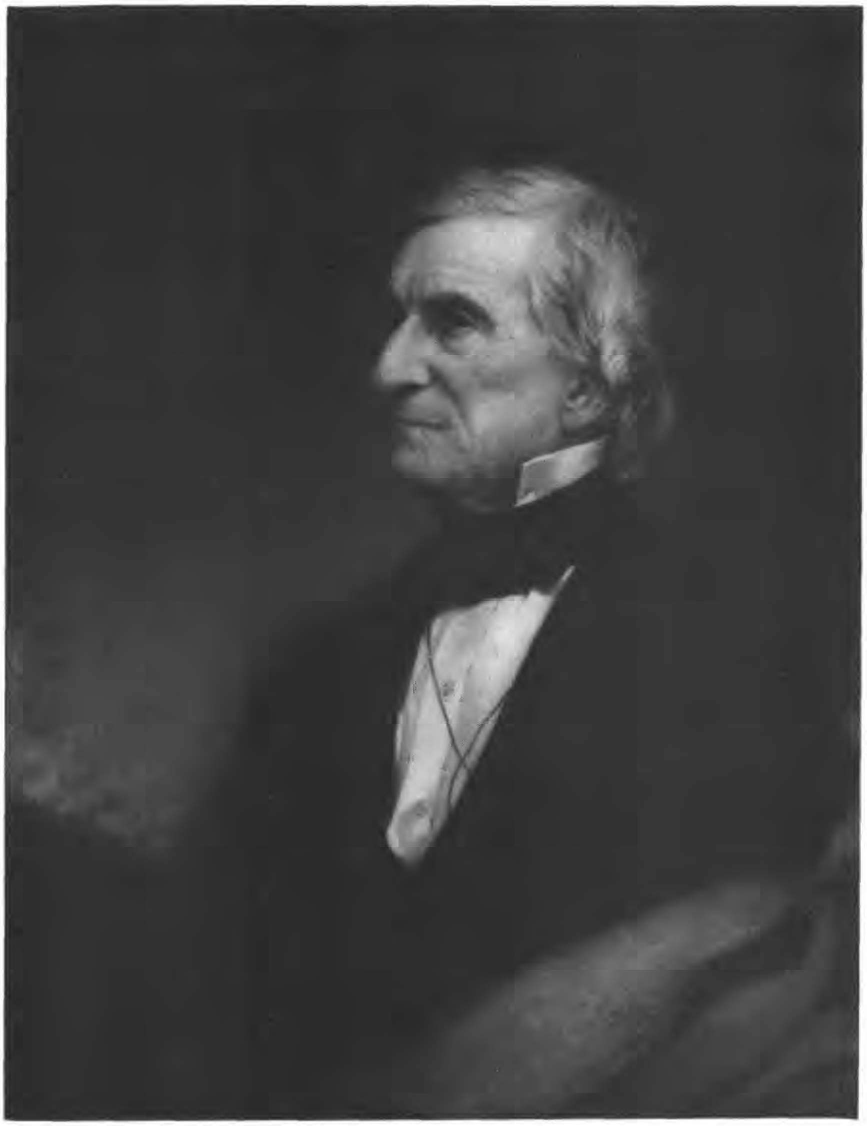
As the Engineers had spoken with a sense of pride in their own organization, so did Professor Hayden speak of the Geological and Geographical Survey of the Territories. "The organization under my direction consists of men with peculiar fitness for and a large practical experience in the special departments of the work assigned to them.*** The organization is complete in all its parts, and ready to perform any work which can be required of a geological and geographical survey in its most comprehensive senses. *** No material changes in the organization could be productive of good, but, on the contrary, would cause much evil and expense, and greatly retard the progress of our western survey." He believed that to combine the geological and geographical surveys and the public-land surveys under one bureau would prove fatal to the former and that to divorce topography from geology, placing the former under the War Department and the latter under the Interior Department, would be "impracticable as well as unwise." Moreover, the geological surveys should be directly under the Secretary of the Interior, and not under any other bureau officer, for if directly under the Secretary, "the chief of the survey receives his general instructions, and he is untrammeled by specific orders or the intermeddling of one who has little else to do."

Major Powell alone favored unification of all the surveys.

> **The prosecution of the work by a number of autonomous organizations is illogical, unscientific, and in violation of the fundamental law of political economy, namely, the law of the division of labor. The work should be unified or integrated**

William Barton Rogers

President of the Massachusetts Institute of Technology. (Photograph of an oil portrait by Jacob H. Lazarus courtesy of the Massachusetts Institute of Technology Historical Collections.)



by placing it under one general management, and the division of labor should have a scientific basis; that is, it should be differentiated so that there shall be a division for the geographical work embracing all methods of mensuration in latitudes, longitudes, and altitudes, absolute and relative; and the representation of the results in appropriate charts. There should be a department of geology embracing all purely scientific subjects relating to geological structure and distribution, and practical subjects relating to mining and agricultural industries. If ethnology, botany, and zoology are to be embraced in the general scientific survey, such subject should have but a single organization, with a single head subordinated to the general plan. In such a way only can a proper integrated and differentiated organization be made.

The geographical work, he said, should be based on a transcontinental triangulation on a comprehensive plan, and transcontinental lines of levels should be established for the hypsometric work; if funds were divided among several surveys it would be impossible for either type of work to be done. A transcontinental triangulation was already in progress under the Coast Survey, and that triangulation should be made the basis of all future geographical work. Observations at barometric stations already established by the Signal Service could be used in the hypsometric work. The hypsometric work was of very great economic importance, because in areas where agriculture was dependent on irrigation, the levels of the land relative to adjacent streams by which these levels were to be fertilized had to be determined.

Unification would also lead to a more suitable system of cartography. Cartography was an important part of the total expense of the work, and each survey, desirous of showing the greatest results for the appropriations received, had tried to curtail the expense and to reproduce the maps by cheap methods to serve temporary purposes.

> **A system of cartography should be used that will best represent the characteristics of the topography and convey the greatest amount of practical information, limited only by considerations of cost. The maps thus constructed should be placed upon materials that are enduring, so that thereafter the plates could be used by the government to meet all wants that may arise from time to time.**

For the proper administration of the land laws, the public lands should be classified. Eight classes of land were then recognized under the laws: agricultural, swamp, irrigable, timber, live-oak and cedar, mineral vein, placer, and coal. However, no adequate provision had been made for securing an accurate classification. The deputy surveyors failed to provide the facts needed, and, in practice, the facts were obtained, not from experts competent to perform the task, but on affidavits from the interested parties or those selected by them. A thorough survey was necessary, one embracing the geological and physical characteristics of the entire public domain.

John Strong Newberry

Professor of geology and paleontology at the Columbia School of Mines. (Courtesy of the Smithsonian Archives, Merrill Collection.)

William P. Trowbridge

Professor of engineering at the Columbia School of Mines. (Courtesy of the Smithsonian Archives, Merrill Collection.)

Such a thorough survey would also be of importance to the industrial interests of the country. The greater part of the lands still in possession of the Federal Government required drainage or protection from overflow or irrigation, and the utilization of these lands depended on the solution of great engineering problems. Only a small part of the land in the Arid Region could be redeemed by irrigation. However, some land was bountifully supplied with timber, and broad stretches were valuable to some extent for grazing purposes. The Far West was a region of vast and inexhaustible mineral wealth, and in Arkansas and the Gulf States east of the Mississippi River, the mountains were great repositories of such wealth. For these regions, a geological survey was necessary, not only for proper administration of the land laws but also for determining the character and extent of the Nation's mineral resources.

To summarize, Powell said:

> a proper scientific survey embracing the geography of the public domain with the parceling of the lands, and the geology with all the physical characteristics connected therewith, is necessary for the following reasons: First, to secure an accurate parceling of the public lands and enduring boundary lines; Second, for a proper administration of the laws relating to the public lands; Third, for a correct and full knowledge of the agricultural and mineral resources of the lands; and Fourth, for all purposes of abstract science.

He advised that in submitting a plan to Congress for the organization of a geographical and geological survey, the survey be "allied to the great industrial interests of the country, those relating to agriculture and mining being of greatest magnitude, and affecting the largest number of people." Such a survey would always receive ample support because the results of its work would increase the national wealth and beneficially affect the largest proportion of the people. A geographical and geological survey divorced from economic considerations and devoted to research chiefly for abstract science would have an uncertain tenure because its funds would be the first to be cut off in any effort to reduce expenses. "A geographical and geological survey, to be permanent, vigorous, and efficient, should include the survey of the public lands and be subsidiary thereto."

How much, if at all, the committee was influenced by the written documents is questionable for the Special Committee on Scientific Surveys of the Territories of the United States submitted a unanimous report to a special session of the Academy only a few days later, on November 6, 1878.

The committee had concluded that the field of inquiry proposed to it covered only surveys that pertained to the public domain and did not include in their recommended plan "surveys and investigations, however scientific in method and character," that applied only to engineering works such as the improvements of rivers and harbors, irrigation and drainage of public lands, reclamation of tidal lands, and protection of alluvial regions from floods. Such surveys were inseparably connected with engineering problems and should be conducted by the Engineer Corps of the Army. The surveys with which they concerned themselves were the Geographical Surveys West of the One Hundredth Meridian under the War Department, the Geological and Geographical Survey of the Territories and of the Geographical and Geological Survey of the Rocky Mountain Region under the Interior Department, and the system of land surveys under the supervision of the General Land Office; to these four, the committee added a fifth, although it was not mentioned in the law, the geodetic work of the newly renamed Coast and Geodetic Survey. The committee then pointed out that all the work could be included under two heads: surveys of mensuration, and surveys of geology and economic resources of the soil. It proposed two surveys to encompass the work, the United States Coast and Interior Survey and the United States Geological Survey.

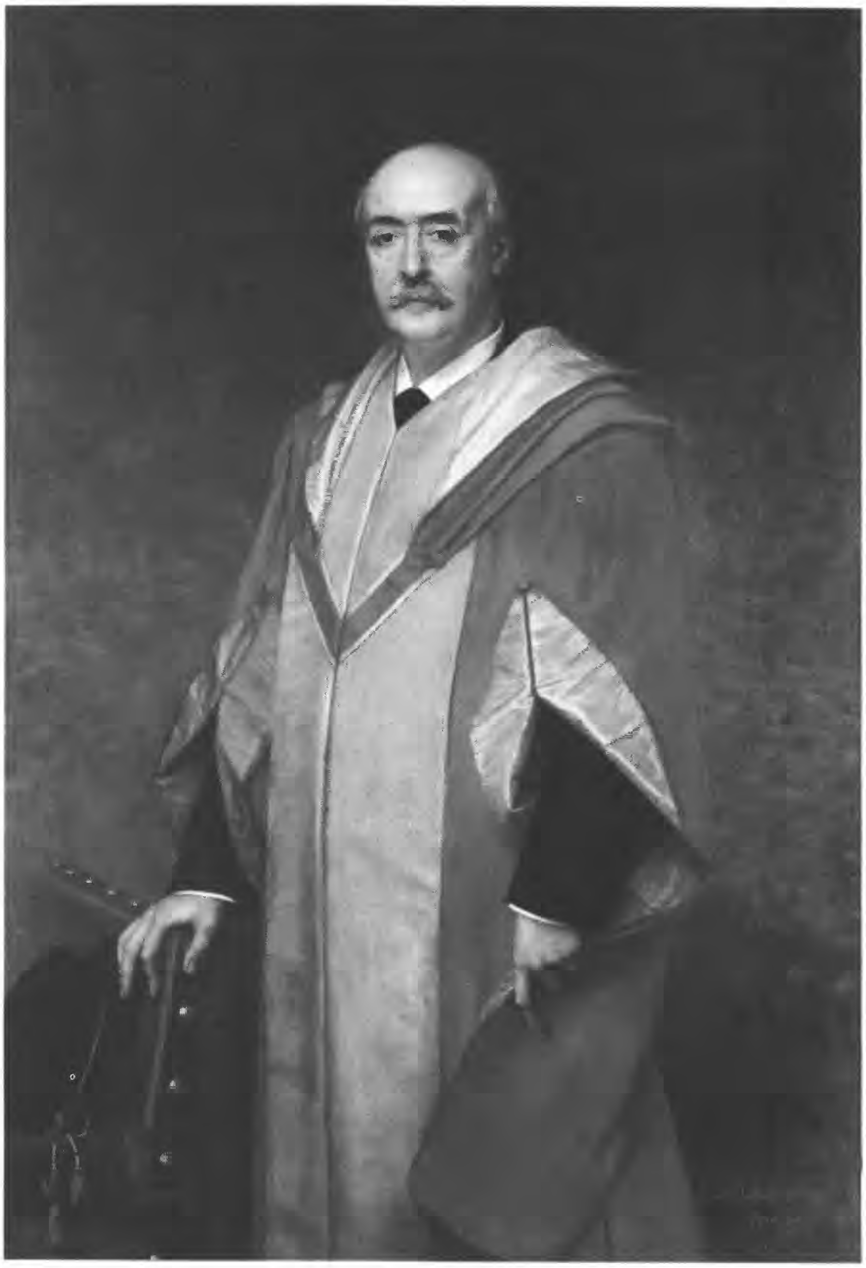
"To attain the desirable accuracy and economy [in the surveys of mensuration]," the committee said, "it is absolutely essential that there should be only one geodetic system, one topographical system, and one land-parceling system, all conducted under the same head.*** After a careful consideration of the facilities at the disposal of the several existing organizations engaged in this work, the committee believe that the coast and geodetic survey is practically best prepared to execute the entire mensuration system required." The Coast and Geodetic Survey should be transferred from the Treasury Department to the Department of the Interior, where, in addition to its original field of operation, it would assume the entire mensuration of the public domain and be known as the United States Coast and Interior Survey. In addition to its former work, the new survey would undertake a geodetic survey of the whole public domain; a topographical survey comprising both detailed topographic work and reconnaissance; and land-parceling surveys. The committee recommended that the Superintendent of the Coast and Interior Survey be appointed by the President and report directly to the Secretary of the Interior.

Two reasons were given for establishing a United States Geological Survey: "The best interests of the public domain require, for the purposes of intelligent administration, a thorough knowledge of its geological structure, natural resources, and products" and "to meet the requirements of existing laws in the disposition of the agricultural, mineral, pastoral, timber, desert, and swamp lands, a thorough investigation and classification of the acreage of the public domain is imperatively demanded." The Geological Survey should be charged with the study of the geological structure and economical resources of the public domain and should be placed under a director, to be appointed by the President, who would report directly to the Secretary of the Interior. Although the committee stressed that investigation and classification of the public domain was necessary, the Geological Survey was to be charged only with the study of the geologic structure and resources.

There were other specific recommendations. The director and members of the Geological Survey, "charged as they are with the investigation of the natural resources of the public domain, shall have no personal or private interests in the lands or mineral wealth of the region under survey, and shall execute no surveys or examinations for private parties of corporations." The Surveys West of the 100th Meridian, except those necessary for military purposes and local improvements, and all surveys by the Department of the Interior should be discontinued. The Geological Survey should be authorized

Simon Newcomb

Director of the Nautical Almanac Office, President of the American Association for the Advancement of Science. (Engraving by J. J. Cade courtesy of the Library of Congress.)



Alexander Agassiz

Curator of the Museum of Comparative Zoology, Harvard. (Photograph of oil portrait by Jules J. LeFebvre courtesy of the Harvard University Portrait Collection.)

to make local topographic surveys for special purposes. The publications of the Geological Survey should consist of an annual report of operations; geologic and economic maps, illustrating the resources and classification of the land; reports upon general and economic geology in all its branches; and the necessarily connected paleontology. All collections made by the Coast and Interior Survey and the Geological Survey, when no longer needed for investigations in progress, should be transferred to the National Museum.

As its final recommendation, the committee urged

> that upon the organization of the United States Coast and Interior Survey and the United States Geological Survey, a commission be formed, to consist of the Commissioner of the Land Office, Superintendent of the Coast and Interior Survey, Director of the United States Geological Survey, the Chief of Engineers of the Army, and three other persons to be appointed by the President, who shall take into consideration the codification of the present laws relating to the sur-

vey and disposition of the public domain, and who shall report to Congress within one year a standard of classification and valuation of the public land, together with a system of land-parceling survey. The necessity of this commission is evident from the fact that by far the larger part of the public domain lies in the region where, from geological and climatic causes, the lands are for the most part not valuable for field-culture, and where the system of homestead pre-emption and sale in accordance with existing laws is both impracticable and undesirable.

Thirty-five members of the Academy attended the special session to consider the report, and all but one voted for it. The lone dissenter was Professor Cope, who probably found himself unable to vote for anything advocated by Professor Marsh. His attitude has sometimes been considered a reflection of Hayden's, with whose survey he had been associated, but Hayden himself was apparently pleased with the report, because it spoke for civilian science. Hayden wrote to Sir Archibald Geikie on November 24:

The report recommends the cutting off all this Interior Geodetic and geologic work from the Engineer Corps and the entire abolition of Wheeler & the formation of three Bureaus under the Interior Dept. 1. The Coast and Interior Survey to do all the Geodetic work. 2. and a bureau for Geology to be called the U.S. Geological Survey. 3. a Land Office for the sale of public lands and granting titles. The Engineers are to be confined to Rivers & Harbors, fortification & their legitimate work. This report was unanimous representing 80 or 90 of the best scientific men in America. Hence Wheeler and Humphreys have been snubbed again most unmercifully. He (the latter) is terribly indignant and has resigned is [sic] seat in the Academy. We look forward to a great struggle. The Coast Survey & the Engineer Corps will now be pitted against each other and how the Geological Surveys will come out I know not.

Edward D. Cope

Paleontologist, who had been a member of both the Hayden and Wheeler surveys, the lone dissenter to the report of the Academy Committee. (Photograph of oil portrait courtesy of the American Philosophical Society.)

Marsh left for Washington after the Academy meeting, and by the end of that week secured the endorsement of Secretary of the Interior Schurz, Secretary of the Treasury John Sherman and his older brother, Chief of Staff of the Army William T. Sherman, Superintendent Patterson of the Coast Survey, and the President himself.

The Academy report was submitted to Congress on December 2, the opening day of the last session of the 45th Congress, and was referred to the Committee on Appropriations. A new Congress had been elected in November, on the very day that the Academy approved the report, but it would not take office until the 45th Congress expired on March 4, 1879. Among those who would not be returning to the new Congress was A. S. Hewitt, who had sponsored the resolution calling for the Academy report. Tammany had blocked his nomination for another term because of his friendship with Tilden. Although Southern policy, labor reform, temperance, and women's suffrage were all issues in the 1878 elections, also public-land policy in some States, the basic issue was the economic situation. There were renewed demands for free coinage of silver and a greenback currency system. Both major parties lost in the House, and, although the Democrats retained a majority, the balance of power would be with the Greenbackers and other minority-party members.

Proponents and opponents of the measure had already begun their campaigns, and in the background, those who favored the new order began to build up the as-yet-unannounced candidacy of Clarence King for director. When General A. A. Humphreys resigned from the Academy, Superintendent Carlile P. Patterson of the Coast Survey sympathized, and both J. E. Hilgard, the Assistant Superintendent, who admitted he was rooting for King, and Major Powell immediately sent out a call for King to get in touch with Patterson, who did not know him.

Early in the session, Simon Newcomb thought the measure would go through the House without much difficulty but suggested that King come to Washington as his help was needed with the Senate. However, opposition soon developed in the House. Although the Academy report was officially in the hands of the Appropriations Committee, the Committee on Public Lands had also taken it up. On December 19, Congressman Peter Wigginton wrote to Major Powell for a report, stating that he, Congressman Thomas M. Patterson of Colorado, and Congressman Goldsmith Hewitt of Alabama had been appointed a subcommittee to study the matter. Wigginton assumed that Patterson and Hewitt, who were opposed to the measure, would be aided by Professor Hayden and wanted Major Powell to supply him with help. Hayden, however, at that time approved the report as it would end the mapping by the Engineers.

The Engineers opened their formal attack on the proposal with a communication to the Appropriations Committees of Senate and House and the House Committee on Commerce on January 10, 1879. The Secretary of War stated that the National Academy's plan would "prevent the prompt supplying of the War Department with the maps which are requisite for its economic administration and for the use of its officers in the field." The Coast Survey maps were not sufficiently detailed for the Engineers who would have to do the work over. He recommended that appropriations for military and geographic surveys be made as heretofore. General Humphreys, in an accompanying document, complained that the recommendation to turn over the surveying and mapping to the Coast Survey was a matter on which the Academy had not been consulted by Congress and which was entirely outside their sphere of action. General Humphreys estimated that maps of the West on the scale recommended by the Academy and done by the Coast Survey would cost $876 million, whereas the Engineers could map the country for only $61.5to $78 million. Coast Survey-style mapping was not warranted at that time and would not be for many years to come. Surveys on the scale of 1:25,000 might be proper for the East, but maps on a scale of 1:250,000, which the War Department could make for $2.50 a square mile, would be sufficient for the thinly settled and unexplored areas of the country west of the Mississippi. Superintendent Patterson replied mildly a week later that the cost of all surveying varied with the character and scale of the work. He thought that the estimates by the War Department were exaggerated and suggested that "Respecting comparisons as to the several classes of surveying, it is, I think, safe to assume that the cost must be about the same by whatever body of skilled men of integrity the work may be performed."

Major Powell joined the argument with a letter forwarded to Congress by Secretary Schurz on February 7. Powell stated that in order to defeat the proposition, the Chief of Engineers assumed in his letter that the proposal was to extend the same system of surveys over the interior as that used along the coast, whereas the surveys necessary to properly administer the laws relating to the public domain differed radically in purposes, methods, and results from coast surveys. Hence, the discussion of the cost of coast surveys was not germane to the discussion of the cost of interior surveys. Powell stated flatly that the physical characteristics of more than 19/20 of the country to be surveyed were such that the geographic work, including triangulation and topography, could be executed at very small expense. He estimated that the triangulation could be done for 35 cents a square mile and the topography at 4 miles to the inch for $2 a square mile, giving, therefore, approximately the same figure as that General Humphreys had given.

King arrived in the Capital early in January, armed with letters of introduction to President Hayes, to work for passage of the plan by Congress and to promote his own candidacy for director. Before leaving for Washington, he had asked Marsh to obtain supporting letters from the Yale faculty and from members of the Academy Committee. Hayden had been told that King was interested but apparently did not take his candidacy too seriously until King arrived in Washington. In mid-January, King noted that "Hayden is outwardly for the bill but his soul is distracted." Hayden on January 24 wrote an urgent appeal to Sir Archibald Geikie: "Clarence King is here and is my competitor.*** I think I ought to have letters from some eminent men abroad on the subject, stating that from long service as a pioneer and the builder up of the important survey under my charge, its long services and the struggles it has passed through, I should be the Director. As matters stand now, I can say confidentially that there is no doubt of my appointment, but the time for pressure has now come." And on February 4, he wrote again: "I write to ask you to address a letter to the President of the United States as a foreign scientific worker requesting my appoint[ment] to the Directorship of the new Survey.*** Please write the letter and send to me by return mail for the whole matter will be decided by the 4th of March. All looks well now. My most formidable competitor is Clarence King, who is now rallying his forces and making headway. He has most of the New England and New York influence."

King was indeed a formidable competitor. His *Systematic Geology* had been published in the latter part of 1878. In its January 1879 issue, the *American Journal of Science*, in noting its publication, said: "In thus bringing together in a single volume the grand results of his survey, Mr. King has given much greater and more permanent value to the labors of himself and his associates. The clear and systematic manner in which both the facts observed and the theories advanced are presented, is worthy of high praise; Mr. King's graceful pen never showed itself to better advantage. It is perhaps unnecessary to add that the appearance of the volume is all that could be desired." In the February issue, a complete resume of the stratigraphic geology was offered, and Raphael Pumpelly was designated to prepared a review of the results and generalizations in other departments.

The *Engineering and Mining Journal* also published a long and highly favorable review, which editor Rossiter Raymond concluded by the observation:

> **There is no doubt that Mr. King adorns what he touches, and it is much to his credit that the adornment is kept so generally subordinate to the underlying fact. If weak spots shall be hereafter found in his logic, however, we think they will be traceable to his happy but perilous faculty of seeing things in picturesque and striking lights. But we will not prematurely commit the error of the lady who said of another, 'Oh! she can't be good, because she is so pretty,' by fancying that because Mr. King's volume is brilliant, it can not therefore be also sound. The gods do sometimes (most unfairly) grant both gifts at once.**

John D. C. Atkins

Chairman of the House Appropriations Committee. In his speech introducing the legislation, he was especially concerned about the land-parceling surveys. (Courtesy of the Library of Congress.)

The recommendations in the Academy report, with minor exceptions, were embodied in the Legislative, Executive, and Judicial Expenses bill introduced in the final session of the 45th Congress, and an appropriation for the expenses of the Geological Survey was included in the Sundry Civil Expenses bill. The Legislative bill was taken up first, and on February 10, the Chairman of the Appropriations Committee, John D. C. Atkins of Tennessee, opened the discussion with a plea for economy. "The condition at present and the estimated surplus in the Treasury at the end of the present fiscal year admonishes continued and renewed efforts for economy upon the part of the Representatives of the people in withholding appropriations that all useless and extravagant expenditures may be prevented. The most sanguine expectations of the Secretary of the Treasury compels the admission that, with the sinking fund satisfied, there will be a deficiency of ten or twelve millions of dollars." The Committee was also concerned about the number of employees in the Executive Departments. The Departments had asked for 4,545 employees for fiscal year 1880, but the Committee had reduced that number to 4,329. They had raised a few salaries, among them the salaries of the Commissioner of Indian Affairs and the Commissioner of Pensions in the Interior Department. Those officers would now receive $4,000, the same as the Commissioner of the General Land Office, the three offices being in the Committee's estimation about equal in importance and duties.

Mr. Atkins said that there were only two propositions over which there was likely to be a serious contest: (1) the equalization of the number and salaries of the clerical staff and other employees of the House and Senate (and that had been a sore point for some years), and (2) the change proposed by the National Academy of Sciences in the mode of conducting the geological and geographical surveys and land-parceling surveys. He described the latter as "the placing of the scientific surveys and the surveys of the General Land Office under the control of the Coast Survey, and the transfer of that bureau to the Interior Department; also the abolition of the office of Surveyor-General and the creation of the office of geological director, who shall be attached to the Coast Survey, but who shall be especially charged with the geological, geographical, and other scientific surveys. It is designed to substitute the surveys of the geological director for the surveys now carried on by Wheeler, Hayden, and Powell, which it is proposed to abolish." The Academy had recommended two surveys, but Mr. Atkins was chiefly concerned about the land-parceling surveys. "The Academy," he said, "is to be commended for looking to the solution of the practical idea and leaving the scientific feature as a secondary one."

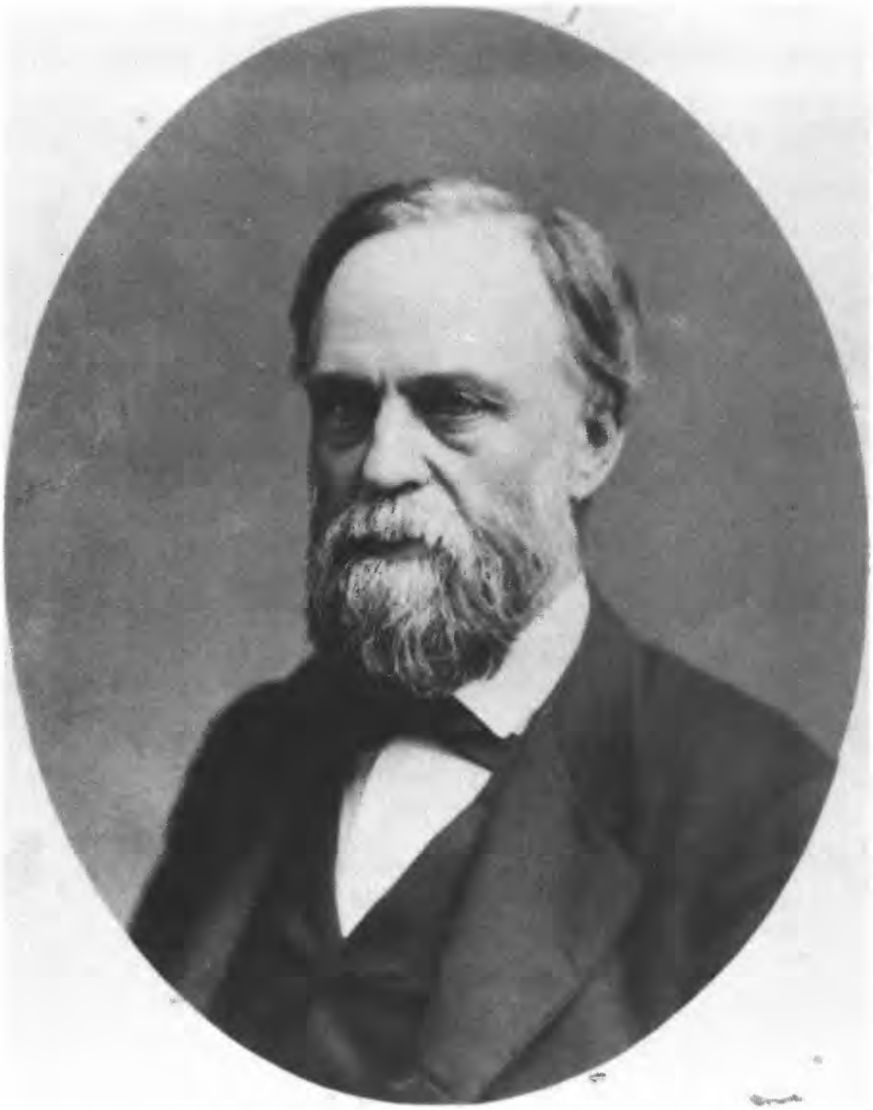
He then launched into a discussion of the land-parceling surveys. The practical question was whether the new plan promised the best results at the least cost, or whether the plan that had been in use for a century still had most claims to the approval of Congress. "It may be urged that in effecting this change in our system of land surveys we are giving up a tried and known for an untried and unknown system. Well, it is conceded even by the Land Office that the present system is a costly, clumsy, and an unsatisfactory one; hence there is a demand for reform and improvement." Atkins cautioned the House "to keep in mind that this bill does not repeal the rectangular method of surveys. It only provides that the commission composed of the Superintendent of the Coast Survey, the geological director, and the Commissioner of the Land Office, and three persons appointed from civil life by the President shall be empowered and required to submit in one year to Congress such methods of surveying the public lands as it may deem wise and practicable. Until that report is made changing the method, and Congress shall adopt it, the present system of rectangular surveying will remain undisturbed." (Again there was a slight variation from the Academy report which had proposed that the Chief of Engineers be a member of the public lands commission.) He also pointed out that very few agricultural lands were still unsurveyed and that much of the remaining unsurveyed lands, mineral, placer, coal, and cedar lands, could not be accurately surveyed and marked by the usual methods of running lines from established corners or from standard meridians and parallels. By a system of triangulation from a base line, parcels of land could be accurately surveyed; moreover, part of an area might be surveyed and the remainder left unsurveyed until necessary. The bill would not deprive the new States of the sections for common-school purposes, as had been alleged, but it did change the present law that authorized one or more persons to have land surveyed by depositing the cost of surveying by requiring that five or more persons make the deposit before the surveyor general make the survey. If there were not enough persons living in a township to combine and have it surveyed, it seemed that the States were not likely to have immediate need of the proceeds of the school sections.

The representatives, however, were as suspicious of the proposed change as they had been the spring before. The attack on the changes in the public land surveys began promptly, led by Congressmen Horace Page of California and Thomas M. Patterson of Colorado. Congressman Wigginton did much of the rebuttal. "Gentlemen," he said, "are unnecessarily alarmed when they fear this measure proposes to overturn our whole land system. It does not. It does not interfere with the law relating to mineral land or private land claims or the securing of homesteads or pre-emption. It is simply to unify, systematize, consolidate and make efficient that which is now unsystematic, crude, unsatisfactory, chaotic in the matter of the surveys of the public lands. And one further thing which I deem of great importance and from which I confidently expect important benefits to my people and those of all new States and the Territories if adopted: it proposes a commission of able, intelligent men who are to view the whole field and report to this body." Mr. Martin Maginnis, the Territorial Delegate from Montana, said, however, that Wigginton was the only one from the Territories or the Pacific coast that favored the proposal, and no one contradicted him.

Mr. A. S. Hewitt then made a formal speech favoring the proposal. He recommended that all read the "admirable exposition" by Major Powell in order to learn of the advantages of the proposed changes in the land surveys. He too emphasized that the legislation did not propose to do away with the rectangular system of land-parceling or even to modify the present method of parceling surveys for arable land. It simply infused elasticity into the system. It would "sooner or later abolish sixteen needless offices held by men lacking the technical knowledge to adopt engineering knowledge to varying geographical conditions, and place the work under the control of the most competent, scientific, and economical surveying organization in the world, directing it to do this work in accordance with the existing land laws and such modifications thereof as may from time to time be adopted." Hewitt attached no significance to the controversies between military and civilian and the questions of relative economy. "It is obvious to every reflecting mind that the cost of the surveys will be in proportion to the amount of detail which they involve, and with equal skill and diligence, it is quite certain that no great difference could exist whether the surveys are executed under civil or military supervision." He had at first thought that surveys should be under the War Department but had concluded that it was "not to be expected that the large body of scientific men required to make these surveys a success" would "consent, willingly, to place themselves under the control of the younger officers of the Engineer Corps. Whatever may be their devotion to science, they are men of such eminence in their respective walks that they cannot and ought not to be reduced to the ranks."

Hewitt's greatest eloquence was reserved for the geological survey, and he did not restrict it to the territories but spoke of it as national in scope. "Nations become great and independent as they develop a genius for grasping the forces and materials of nature within their reach and converting them into a steady flowing stream of wealth and comfort," he said.

> **Without a sound knowledge of the facts of nature it is not possible to develop a healthy material growth. It was this conviction which gave birth to the national surveys, and disjoined as they have been no man can estimate the value, scientific and material, of the results already achieved.**
>
> **What is there in this richly endowed land of ours which may be dug, or gathered, or harvested, and made a part of the wealth of America and of the world, and how and where does it lie? These are the questions which the enterprise, the capital, and the labor of the United States are engaged in working out with such signal energy, and it is to the solution of these questions, the greatest of all national problems, that the scientific surveys of the public domain should be**



Abram S. Hewitt

Congressman from New York, who initiated the Academy study and favored adoption of its plan, but was most eloquent about the value of a geological survey. (Courtesy of Culver Pictures.)

directed. For the manifold wants, for the daily and hourly need of the Government and the people, a comprehensive and accurate survey is now deemed to be a necessity. The need of a thorough survey for the wise organization and distribution of American industry is in the future as imperative as a constitution on which to found our laws.

Mr. Hewitt used vivid phrases to describe the "all but exhaustless beds of anthracite" lying "like the leaves of a crumpled book" in Pennsylvania, iron which was "the inseparable and indispensable ally of coal in the triumphs of man over nature," mountains "riven and threaded with veins of silver and gold," and "riverbeds of vanished streams filled with golden sands." Mr. Hewitt wanted the new survey directed toward a profound study of "these immeasurable elements of national wealth." Petty disputes should be cast aside. The scheme came from the highest scientific authority in the land. It commended itself to the judgment of the men who had been the most energetic and successful in the development of our resources, the "captains of industry." "If we can but rise 'to the height of this great argument'," he concluded, "we shall place the work of national development and the elements of future prosperity upon the firm and enduring basis, of truth and knowledge, from which they cannot be moved so long as the Republic shall endure. Esto perpetua!" and sat down to great applause.

Mr. Hewitt was followed by Mr. Garfield of Ohio who thought it "a misfortune" that so important a measure had been placed in one of the appropriation bills. The sections pertaining to the public lands surveys should have been embodied in a separate bill and "subjected to the most careful scrutiny." The scientific surveys, however, had been supported for 10 or 12 years without any other place in the laws except the appropriation bills, and it was on the relation of the National Government to science that Mr. Garfield wished to speak:

> **We are accustomed to hear it said that the great powers of government in this country are divided into two classes: national powers and State powers. That is an incomplete classification. Our fathers carefully divided all governmental powers into three classes; one they gave to the States; another to the nation; but the third great class, comprising the most precious of all powers, they refused to confer upon the States or the nation, but reserved for themselves.***
>
> **Our fathers, though recognizing in common with Germany and other Christian nations of the earth the supreme importance of religion among men, deliberately turned to the great nation they were to establish and said: You shall never make any law about religion;' and to the States they virtually said "You shall never make any law establishing any form of religion.'***
>
> **What I have said in reference to religion, applied with almost equal force to science. In the main, the framers of our Government trusted science to the same jurisdiction to which they intrusted religion.*** This leads me to inquire what ought to be the relation of the National Government to science? What, if anything, ought we to do in the way of promoting science? *** Generally, the desire of our scientific men is to be let alone to work in free competition with all the scientific men of the world; to develop their own results, and get the credit of them each for himself; not to have the Government enter the lists as the rival of private enterprise.**
>
> **As a general principle, therefore, the United States ought not to interfere in matters of science, but should leave its development to the free, voluntary action of our great third estate, the people themselves. *** To the general principle I have stated, there are a few obvious exceptions which should be clearly understood when we legislate on the subject. In the first place the Government should aid all sorts of scientific inquiry that are necessary to the intelligent exercise of its own functions. *** There is another exception to the general rule of leaving science to the voluntary action of the people. Wherever any great popular interest, affecting whole classes, possibly all classes of the community, imperatively need scientific investigation, and private enterprise cannot accomplish it, we may wisely intervene and help where the Constitution gives us authority. *** I might perhaps include in a third exception those inquiries which, in consequence of their great magnitude and cost, cannot be successfully made by private individuals. Outside these three classes of inquiries, the Government ought to keep its hands off ***.**

James A. Garfield

Congressman from Ohio, who thought, for the most part, that the Government should not interfere in matters of science but supported the idea of a geological survey of the public lands. (Courtesy of the Library of Congress.)

Garfield was not, he said, attacking the geological surveys. It was "absolutely vital" that the character and quality of the public lands be determined. They should be consolidated under one head, however, and not scattered to "waste money and duplicate work and make the name of science ridiculous in the United States." He concluded by suggesting that

> **besides going too far in scientific explorations, we have greatly wronged the scientific publication societies of this country. *** We are printing thousands of volumes in competition with the private associations of the country, and thereby injuring and crippling them. I believe we ought simply to confine ourselves to our own business and not needlessly travel into their field.**

Only a few objections to the geological survey were raised. Mr. John H. Baker of Indiana said that the idea of a geological survey was never contemplated by the 1878 resolution and only came about because five of the seven members of the Academy Committee were geologists. "It is marvelous that a Congress, given over to a system of cheese-paring economy on petty things, should be ready to swallow a scheme which will require a score or more of years and a hundred or two millions of dollars to complete it. This geological survey will cost more in my judgment than the whole of the lands to be surveyed are worth." Mr. D. C. Haskell of Illinois perhaps reflected a more common view when he said:

> **Now I do not object to geological surveys or to any kind of scientific surveys. I will continue to vote for them; they ought to be had. I do not quite agree with the gentleman from Ohio that we ought to leave science and religion out of this Hall. I think if we had a little more science and religion in this House and a little less of politics we would get along a great deal better. But is it necessary, in order to take care of these scientific gentlemen, that you should come in here with a proposition to burden every settler on the frontier with the cost of surveying his own land? What an idea!**

The bill was amended to exclude the public land surveys from the work of the Coast and Interior Survey, and the entire bill was passed and sent to the Senate on February 25. Under a suspension of the rules, the Sundry Civil Expenses bill had already been read and passed without debate, including an item: "For the expenses of the geological survey and the classification of the public lands and examination of the geological structure, mineral resources, and products of the national domain, provided for under ______ section of the act 'making appropriations for the legislative, executive, and judicial expenses of the Government for the fiscal year ending June 30, 1880, and for other purposes,' approved March ______, 1879, to be expended by the Director of the Geological Survey under the direction of the Secretary of the Interior, $100,000."

The Senate took up the Sundry Civil bill first, and there the Committee on Appropriations proposed to add "of the Territories" after geological survey so that the clause began "For the expenses of the geological survey of the Territories and the classification of the public lands ***" There was some question of the intention, so Senator Aaron A. Sargent, whom Hayden once described as his "best friend," explained that "Congress at its last session improvidently authorized a body called the Academy of Sciences to report a plan for the consolidation of the surveys; and they with a singular incongruity, showing little reflection, recommended that a body whose duties are confined entirely to the coasts and which adopts very expensive methods, necessarily on account of the nature of its work shall be changed into an amphibious animal living upon land and water as well, that this Coast Survey shall be extended all through the interior, that it shall deal with geological and botanical questions, with paleontology and ethnology, and that the surveys, which heretofore have been made under the authority of the United States and which have made the name of American scientific exploration illustrious, shall be dispensed with and thrown over." The Senator then proceeded to read from a private document composed of letters from scientists endorsing the Hayden survey, including letters from Sir Joseph Hooker and Professor Archibald Geikie.

The Senate without further debate agreed to amend the bill, so that it read. "For the expenses of the Geological and Geographical Survey of the Territories, and the classification of the public lands, and examination of the geological structure, mineral resources, and products of the national domain, to be expended under the direction of the Secretary of the Interior, one hundred thousand dollars." The Senate then added three amendments, appropriating $20,000 each "for the preparation of reports, maps, and such other illustrations as may be necessary for completing the office-work" of the Geological and Geographical Survey of the Territories and the Geographical Surveys West of the One Hundredth Meridian, and $20,000 "for the completion of the reports of the Geographical and Geological Survey of the Rocky Mountain Region with the necessary maps and illustrations." When the Legislative, Executive, and Judicial bill came up for consideration on

Aaron Sargent

Senator from California and good friend of F. V. Hayden, who derided the Academy plan at first but voted for the conference report. (Courtesy of the Library of Congress.)

March 1, the Senate accepted the recommendation of its Committee on Appropriations that the entire section on the reorganization of the surveys be deleted. The Senate action seemed clearly to be a triumph for Hayden.

On Sunday, March 2, both bills moved to conference. There were items restricting jurors' oaths and the supervision of elections, holdovers from reconstruction days, in the Legislative, Executive, and Judicial bill on which the Democratic House and Republican Senate simply could not agree. After several reports of inability to come to an agreement, and the appointment of new conferees who continued to disagree, it became apparent that the Legislative bill would not be passed before the mandatory end of the session. The conferees on the Sundry Civil bill, Messrs. Atkins, A. S. Hewitt, and Eugene Hale for the House and William Windom, Stephen W. Dorsey, and Henry G. Davis for the Senate, then agreed that the sections of the House version of the Legislative bill that established the Geological Survey and a commission on the codification of public-land laws would be placed in the Sundry Civil bill. References to the Coast and Interior Survey in these sections, except for one reference to samples which may have been overlooked, were deleted. In legislative parlance, the House receded from its disagreement to the amendment of the Senate and agreed to the same with amendment: that in lieu of the entire paragraph (the Senate's appropriation for the Geological and Geographical Survey of the Territories), there be substituted the sections establishing and appropriating funds for the Survey and the public-land commission, and the Senate agreed to the same. The three Senate amendments providing funds for completion of office work and reports of the Hayden, Wheeler, and Powell surveys were accepted by the House but took on new meaning with the termination of those surveys on June 30, 1879.

The conference report was accepted by the House in the afternoon and the Senate in the evening of March 3. In both houses, the yea and nay votes were tallied, and the vote was decisive, 148 to 107 in the House and 33 to 24 in the Senate. The House debate on the report was principally on a provision for funding the debt of the District of Columbia, and the House was assured by Mr. Atkins that the provision for the Survey conformed to the legislation it had passed. The Senate, however, debated the Survey legislation, was told that the Senate Appropriations Committee had recommended the change in the Sundry Civil bill because it opposed the appropriation of funds for an unestablished agency whose purpose it knew nothing about because the Legislative bill had not been received from the House. The Senate vote was therefore a positive vote for the establishment of the Geological Survey, and Senator Sargent was among those voting "Yea." The bill became law when President Hayes signed it in the very late evening of March 3.

The entire legislation is brief:

> **For the salary of the Director of the Geological Survey, which office is hereby established under the Interior Department, who shall be appointed by the President, by and with the advice and consent of the Senate, six thousand dollars; *Provided,* That this officer shall have the direction of the Geological Survey, and the classification of the public lands, and examination of the geological structure, mineral resources, and products of the national domain. And that the Director and members of the Geological Survey shall have no personal or private interests in the lands or mineral wealth of the region under survey, and shall execute no surveys or examinations for private parties or corporations; and the Geological and Geographical Survey of the Territories, and the Geographical and Geological Survey of the Rocky Mountain Region, under the Department of the Interior, and the Geographical Surveys West of the One-Hundredth Meridian, under the War Department, are hereby discontinued, to take effect on the thirtieth day of June, eighteen hundred and seventy-nine. And all collections of rocks, minerals, soils, fossils, and objects of natural history, archaeology, and ethnology, made by the Coast and Interior Survey, the Geological Survey or by**

any other parties for the Government of the United States, when no longer needed for investigations in progress, shall be deposited in the National Museum.

For the expense of a commission on the codification of existing laws relating to the survey and disposition of the public domain, and for other purposes, twenty thousand dollars:

Provided, that the Commission shall consist of the Commissioner of the General Land Office, the Director of the United States Geological Survey, and three civilians, to be appointed by the President, who shall receive a per diem compensation of ten dollars for each day while actually engaged, and their travelling expenses; and neither the Commissioner of the General Land Office nor the Director of the United States Geological Survey shall receive other compensation for their services upon said commission than their salaries, respectively, except their traveling expenses while engaged on said duties; and it shall be the duty of this commission to report to Congress within one year from the time of its organization; first, a codification of the present laws relating to the survey and disposition of the public domain; second, a system and standard of classification of public lands; as arable, irrigable, timber, pasturage, swamp, coal, mineral lands and such other classes as may be deemed proper, having due regard to humidity of climate, supply of water for irrigation, and other physical characteristics; third, a system of land parcelling surveys adopted to the economic uses of the several classes of lands; and, fourth, such recommendations as they may deem wise in relation to the best method of disposing of the public lands of the western portion of the United States to actual settlers.

The publications of the Geological Survey shall consist of the annual report of operations, geological and economic maps illustrating the resources and classification of the lands, and reports upon general and economic geology and paleontology. The annual report of the Geological Survey shall accompany the annual report of the Secretary of the Interior. All special memoirs and reports of said survey shall be issued in uniform quarto series if deemed necessary by the Director, but otherwise in ordinary octavos. Three thousand copies of each shall be published for scientific exchanges and for sale at the price of publication; and all literary and cartographic materials, received in exchange shall be the property of the United States and form a part of the library of the organization; and the money resulting from the sale of such publications shall be covered into the Treasury of the United States.

The Sundry Civil bill also included as additional provision regarding the Powell survey—an appropriation of $20,000 for completing and preparing for publication its Contributions to American Ethnology with the proviso "that all the archives, records and materials relating to the Indians of North America, collected by the Geographical and Geological Survey of the Rocky Mountain Region, shall be turned over to the Smithsonian Institution, that the work may be completed and prepared for publication under its direction" and the added proviso that such action meet the approval of the Secretary of the Interior and the Secretary of the Smithsonian Institution. Thus, Major Powell, after 5 years in the Interior Department, would be able to return to the Smithsonian Institution, where Spencer Baird had succeeded Joseph Henry as Secretary.

Exactly what was intended by the legislation was not immediately clear. The *Washington Post* reported vaguely that some surveys in the Interior Department had been reorganized. Rossiter Raymond, who, as editor of the *Engineering and Mining Journal* and aid to Hewitt in his private enterprise, had followed developments rather closely, missed the full significance. In the March 8 issue of the *Journal*, he commented:

From the somewhat fragmentary reports of the daily press concerning the disgracefully confused and hasty work of the closing hours of the session of Congress, we gather that the suggestion made by us, concerning the National Surveys, has turned out to be a prophecy. The geodetic and land-parceling surveys are left for the present as they are; but the geological surveys of the Territories are, by a clause appended at the eleventh hour to one of the Appropriations bills, consolidated under a Director, to be appointed by the President, and to be responsible to the Secretary of the Interior.

Rutherford B. Hayes

President of the United States. In the late evening of March 3, 1879, he approved HR 6471, which included the Organic Act of the United States Geological Survey. (Courtesy of the Library of Congress.)

The legislation, although hastily passed, indicated that Congress had reached several important conclusions. It acknowledged that in the 95 years since the first public-land law was proposed, public-land policy had changed, and, moreover, that the public lands of 1879 were vastly different from those of 1784. In the intervening years, as policy was modified and new lands were added to the public domain, Congress had passed more than 3,000 land laws, some of them in conflict with earlier laws that had not been repealed, some intended only as local in application or temporary in nature that had been extended to the entire public domain. It was time for a new look at public-land law, and the inclusion of the Director of the Geological Survey as one of the commission of experts conceded the usefulness of science in the formulation of public-land policy.

A decision on national mapping policy was postponed. Western opposition to any change in the public-land surveys that might hinder development precluded any immediate change in the General Land Office surveys, despite

Carl Schurz

Secretary of the Interior, whom Clarence King numbered among his friends and in whose Department the new bureau was placed. (Courtesy of the Library of Congress.)

the evidence of their unsuitability to western terrain. The hope of the Eastern States for Federal assistance in topographic mapping to aid in the development of mineral resources and industrial development was left unfulfilled. The Coast and Geodetic Survey continued to survey the coasts and to extend triangulation from the Atlantic to the Pacific coasts; for the time being it was left to the States to do the mapping within their own boundaries.

Most important of all, however, Federal geologic work was given new status. There is no better description of what happened than that given by Clarence King: "During the years when the Federal geologists were following the hurried and often painful marches of the western explorers, many States inaugurated and brought to successful issue State surveys whose results are of dignity and value. Since 1867 the Government work has been equal to the best State work, and in some important branches has taken the lead. The wisdom of the legislation which placed in the field those well-organized, well-equipped, and ably-manned corps is apparent in the improved and enlarged results obtained. But there remained one more step necessary to give the highest efficiency and the most harmonious balance to the National geological work. It was the discontinuance of the several Geological Surveys under personal leadership, and the foundation of a permanent Bureau charged with the investigation and elucidation of the geological structure and mineral resources and productions of the United States." With the establishment of the Department of Agriculture in 1862, Congress had acknowledged that its power to provide for the common defence and general welfare warranted sponsorship of scientific research in the older of the two basic industries. The Act of March 3, 1879, acknowledged the importance of the second basic industry in the national economy. It thus marked the culmination of one era and the inauguration of a new one.

As important as the legislation in the future course of the new Survey was the selection of its first director. Rossiter Raymond said in his editorial of March 8,

> **Much depends upon the action of the President in choosing the right man for this great enterprise. If the geological survey were an established institution, with its rules, methods, and traditions, there would be less danger in placing at its head a man of mediocre ability. But the Director now to be appointed must create his institution as well as administer it. The impulse now given to it will determine its future. The manner in which it is conducted for the next two years will either fix it as a recognized and esteemed branch of the public service, or expose it to utter overthrow, and doom the country to recurring chaos in this department. *** If the new Director is wise, he will understand that his primary object must be to ascertain and make known the resources of the public lands. Let him boldly put the economical problems first, and win public respect for scientific work by showing, even to the unscientific, what benefits it can confer upon the community. Let him imitate the sagacity of Clarence King, who published first of all his volume on the Mining Industry, and last of all his theoretical deductions in continental geology.**

Dr. Hayden, as the director of the older of the Interior surveys discontinued by the legislation, was the obvious candidate, and Simon Newcomb, who observed events first hand, wrote in his *Reminiscences of an Astronomer* that: "At first there seemed to be but one voice on the subject. Professor Hayden had taken the greatest pains to make known the work of his survey, not only to Congress, but to every scientific society, small and great, the world over. Many of these had bestowed their approbation upon it by electing its director to honorary membership. Two-thirds of the members of Congress were said to have sent a recommendation to the President for the appointment of so able and successful man to the new position. However," Newcomb said, "the leaders in the movement considered that Mr. Clarence King was the better qualified for the duties of the new position," and that "hopeless though the contest might have seemed, an effort was made by three or four of the men most interested to secure Mr. King's appointment".

Major Powell took it upon himself to forestall Hayden's appointment. As soon as the bill was passed, he wrote to Mr. Atkins, who had stressed the reform of the land surveys in his speech, that "if Dr. Hayden is appointed all hope of further reform in the system of land surveys is at an end or indefinitely postponed." Three days later, in a memorandum to Mr. Garfield, he attacked Hayden on the very points that Garfield had brought out in his speech. Hayden had published scientific work with which he had had nothing to do, he had carried on work "for noise and show" and work that was "utterly irrelevant." Powell praised King as the "pioneer and founder of a whole system of survey work which was novel and original, exactly suited to the region and which though it may be susceptible of improvement will on the whole be the only practicable system for the far west." King, he said, had "an orderly, sagacious, logical mind which places him among the truly great men of science in the estimation of those who know how to appreciate his work."

Recommendations came from Yale, Columbia, Johns Hopkins, New York University, the State Museum at Albany, and the American Museum of Natural History, and from every member of the Academy Committee except Dana. Marsh and W. H. Brewer traveled to Washington to press the case with the President, as did Professor Newberry, who had been State Geologist of Ohio when Hayes was Governor. President Hayes consulted Charles William Eliot, the President of Harvard, for a confidential opinion and was told that Dr. Hayden did not command the confidence of American men of science, and his appointment would seem to them "discreditable, discouraging, and unpromising."

King's appointment was announced, prematurely as it happened, on March 11, and in the March 15 issue of the *Engineering and Mining Journal,* Raymond confessed that "our opinion, entertained from the beginning [was], that Mr. King is the very best man who could have been selected. The general and impersonal picture which we have given in former articles of the ideal Director, will appear, on examination, to be little else than a portrait of Clarence King."

King's nomination was sent to the Senate on March 20, and he was confirmed on April 3. An unhappy Hayden wrote to Sir Archibald Geikie that Professor Marsh

> came here in person from New Haven and centered the entire committee of the Academy on King's nomination except Prof. Dana. Yale & Harvard College were brought to bear to a great extent. There are so many graduates of these universities in power here that their influence was all powerful. The Secretary of Interior, Carl Schurz, a German, had great power in the matter. So when the time came for the appointment, Mr. King got it. *** I do not know what my fate will be in connection with the organization. I only know it will not be important. The operations, Mr. King says, will be confined to mining geology for several years to come.

Clarence King

First Director of the U.S. Geological Survey.

Notes and Bibliography

The chapter notes identify the sources of directly quoted material and a few indirect statements, some incidental biographical data, and give the reference to the U.S. Statutes at Large for all laws mentioned in the text. These have been related to the relevant page and either to the first few words of the quotation or to a significant phrase. Complete citations for all material used as background, including the more extensive biographical works, and for quotation or illustration are given in the bibliography. Citations are arranged alphabetically by author, and include for Congressional documents (in parentheses at the end of the citation), the serial number of the volume in which the document appears.

To aid the reader in finding pertinent references in such a bibliography or in seeking additional material on a particular topic, a simple index has been prepared, with references identified by author and date. Primary or contemporary documents are listed first, with but a few exceptions in chronological order, followed by more recent secondary sources, alphabetically by author. Biographical data not otherwise identified were obtained from the Dictionary of American Biography, National Cyclopedia of American Biography, Who Was Who in America, or Who Was Who in American Politics by Dan and Inez Morris.

Notes

Chapter 1. The Sum of the Past

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1. "Whether we consider the rocky layers * * * ": Pierre Teilhard de Chardin, The future of man, 1964, p. 12.
   "Representatives * * * ": The remarks by Speaker Randall are reported in the House Journal for the 45th Congress, 3d session, p. 696.
   "increasing the knowledge * * * ": Annual Report of the U.S. Geological Survey for Fiscal Year 1976, p. 59.
5. "Generations come * * * ": Ecclesiastes 1:5–9.
6. "The more a man knows * * * ": Ecclesiastes 1:18.

Chapter 2. Western Pilgrims

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7. "Americans are the western pilgrims * * * ": M. G. J. de Crèvecoeur, Letters from an American Farmer, 1782.
8. "no talke, no hope, nor worke * * * ": Captain John Smith's Description of Virginia and Proceedings of the Colonie, 1612, *in* L. G. Tyler, ed., 1907, Narratives of early Virginia 1606–1625: New York, Charles Scribner's Sons, p. 136.
10. The statements by William Penn and Gabriel Thomas are reported in J. M. Swank, 1884, p. 122.
11. Philippe Renault and La Compagnie de la Louisiane ou d'Occident have been discussed by several authors, including T. A. Rickard, 1932, p. 153–154, and W. R. Ingalls, 1908, p. 95. See also H. R. Schoolcraft, 1819.
12. Benjamin Winslow's map is in the Enoch Pratt Library of Baltimore. It has been reproduced in H. N. Eavenson, 1942.
17. "a copious supply * * * ": Alexander Hamilton, 1791, p. 139.
18. The Land Act of 1796 is in U.S. Statutes at Large, v. 1, p. 464 (1 Stat. L, 464).
    The Land Act of 1800 is 2 Stat. L, 73.
    An act to establish an Executive department to be denoted the Department of the Navy, 1 Stat. L, 553, approved April 30, 1798.
    Congress appropriated $200,000 for "purchase of growing or other timber, or of lands on which timber is growing, suitable for the Navy and to cause proper measures to be taken to have the same preserved for the future uses of the Navy" on February 25, 1799, 1 Stat. L, 622.
    The authorization to employ an agent to collect information on Lake Superior copper was approved April 16, 1800. The statements quoted were made by William Cooper of New York, Annals of the 6th Congress, p. 583.

Chapter 3. Cherished for Its Own Sake, 1801–1829

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19. "While Science will be cherished * * * ": Benjamin Silliman, American Journal of Science, 1818, v. 1, p. v.
20. "if moderate encouragement is given by the government * * * ": Moses Austin, 1804, p. 208.
    The lead lands were reserved March 3, 1807, in "An act to prevent settlements being made on lands ceded to the United States, until authorized by law," 2 Stat. L, 445. Section 2 provides "that in all cases where the tract of land applied for, includes either a lead mine or salt spring, no permission to work the same shall be granted without the approbation of the President of the United States, who is hereby authorized to cause such mines or springs to be leased for a term not exceeding three years, and on such conditions as he shall think proper."
    The law of February 10, 1807, (2 Stat. L, 413) did not establish the Survey of the Coast as a Government agency. It provided "that the President of the United States shall be, and he is hereby authorized and requested, to cause a survey to be taken of the coasts of the United States * * *," and authorized the President "to cause proper and intelligent persons to be employed."
22. "to superintend * * * ": Unlike the Survey of the Coasts, the General Land Office (2 Stat. L, 716) was established by law as an office in the Department of the Treasury and provided with a commissioner who was authorized to employ a staff.
23. Live oak and red cedar lands were reserved in "An act making

reservation of certain public lands to supply timber for naval purposes," 3 Stat. L, 347, March 1, 1817.

The Calhoun bill was debated on February 4, 1817. Calhoun's speech is in the Annals of the 14th Congress, 2d session, p. 851–858.

24. "irregular and unconstitutional": Henry Clay in the Annals of the 15th Congress, 1st session, p. 1374, March 13, 1818.

25. "Let the end be legitimate * * * ": M'Culloch *v.* Maryland is reported in Henry Wheaton, Reports of Cases Argued and Adjudged in the Supreme Court of the United States 1816–1827, v. 5, p. 323.

26. Edmund Ruffin's work was published in the *American Farmer* for December 28, 1821, v. 3, p. 313–324.

27. "the investigation of the mineral and fossil bodies * * * ": G. P. Merrill, 1924, p. 19.

30. "first attempt yet made in this country * * * ": Amos Eaton and T. R. Beck, 1820, p. 5.

"have the sanction * * * ": Letter (undated) from Stephen van Rensselaer to Amos Eaton, quoted in Ethel M. McAllister, 1941, p. 301.

"for the purpose of instructing persons * * * ": Stephen van Rensselaer to Dr. Blatchford, November 5, 1824, quoted in Ethel M. McAllister, 1941, p. 368.

"some person of competent skill and science * * * ": G. P. Merill, 1920, p. 366.

"accompanied by some Geological speculations * * * ": Denison Olmsted, 1824, note on p. 33.

"a thin stratum of gravel * * * ": Denison Olmsted, 1824, p. 33, and 1825, p. 5.

31. "This auriferous stratum * * * ": Denison Olmsted, 1824, p. 40.

"with peculiar care": Annals of the 17th Congress, 2d session, p. 18.

33. "American system": As Clay himself used this term, the American system was the opposite of a colonial or foreign system. It meant use of the protective tariff to build up American industry which would serve as a source of national wealth and support an urban population that would in turn be a market for domestic agricultural products.

34. "partly from principle * * * ": Theodore Roosevelt, 1886, p. 63.

35. "without any pretension * * * ": Benjamin Silliman, 1830, p. 309.

"the weary eyes * * * ": J. P. Lesley, 1876, p. 11.

36. An Act to authorize the President of the United States to cause the reserved lead mines, in the State of Missouri, to be exposed to public sale, and for other purposes, 4 Stat. L, 364, approved March 3, 1829.

Chapter 4. Accession to Resources and Knowledge, 1829–1841

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37. "What an accession * * * ": Edward Hitchcock, 1828, p. 231.

"so far as they can be promoted * * * ": Andrew Jackson's First Inaugural Address, *in* J. D. Richardson, Messages and Papers of Presidents, v. 2, p. 437.

38. "Liberty and Union * * * ": Register of Debates of the 21st Congress, 1st session, p. 80, January 29, 1830.

"gentleman of the name of Wilhero * * * " and "the indications for gold were not strong * * * ": Jacob Peck, 1833, p. 3.

40. An act concerning the gold coins of the United States and for other purposes, 4 Stat. L, 699.

"the intelligent * * * ": Edward Hitchcock, 1828, p. 250.

"presence of valuable ores * * * ": Edward Hitchcock, 1833, introductory note, and G. P. Merrill, 1920, p. 149.

41. "doubtful whether the discovery * * * ": Edward Hitchcock, 1832, p. 65.

42. "when our Cumberland mountains * * * ": Gerard Troost, 1831, p. 498.

43. "On letting down a stone * * * ": Edward Hitchcock, 1841, p. 294.

"nowhere could a foundry for a national arsenal * * * ": Gerard Troost, 1840, p. 28

"my opinion is that gold is not so abundant * * * ": Gerard Troost, 1837, p. 26.

"nothing in this act * * * ": The act of July 10, 1832, reviving the Coast Survey (4 Stat. L, 570) is entitled "An Act to carry into effect the act to provide for a survey of the coast." It appropriated funds not to exceed $20,000 and authorized the President to employ "all persons in the land or naval service of the United States, and such astronomers and other persons as he shall deem proper." Dupree's suggestion is in A. H. Dupree, 1957, p. 53.

44. "praying for the patronage * * * ": Senator Marcy's memorial in behalf of G. W. Featherstonhaugh was presented to the Senate July 12, 1832, as recorded in the Journal of the Senate for the 22d Congress, 1st session, p. 454.

"one suitable person": Secretary Cass's reply of January 17, 1833, is in U.S. Congress, 22d, 2d session, Senate Executive Document 35, v. 1, p. 5–7 (230).

"ascertaining the geology * * * ": The instructions to the Committee on Ways and Means were given on December 23, 1833, Journal of the House, 23d Congress, 1st session, p. 14 (253).

45. "great wealth * * * ": Governor John Floyd of Virginia, quoted in G. P. Merrill, 1920, p. 507.

46. Biographical data on J. T. Ducatel are from the American Journal of Science, 2d series, v. 8, p. 146, 1849.

"Among the endless variety * * * ": Edward Hitchcock, 1833, p. 294.

"not only an inquiry * * * ": J. T. Ducatel and J. H. Alexander, 1834, p. 2.

"provide for making a new and complete map * * * ": G. P. Merrill, 1920, p. 128.

47. "few subjects * * * ": John J. Abert, 1833, Report of the Chief of the Topographical Bureau, *in* Report of the Secretary of War: U.S. Congress, 23d, 1st session, House Executive Document 1, p. 121 (254).

"It is not merely * * * ": John J. Abert, 1834, Report of the Chief of the Topographical Bureau, *in* Report of the Secretary of War: U.S. Congress, 23d, 2d session, House Executive Document 2, p. 182 (271).

"from the seat of government": Abert's instructions to Featherstonhaugh in 1835 are in John J. Abert, 1835, Report of the Chief of the Topographical Bureau, *in* Report of the Secretary of War: U.S. Congress, 24th, 1st session, House Executive Document 2, p. 218 (286).

49. "the science which investigates * * * ": Charles Lyell, 1830, p. 1.

"has done much to recall geologists * * * ": American Journal of Science, 1836, v. 29, p. 358.

The various laws inaugurating the State surveys are usually contained in the reports of the individual surveys but are most conveniently collected in C. W. Hayes, 1911, and G. P. Merrill, 1920.

54. An Act to reorganize the General Land Office, 5 Stat. L, 107, provided that "from and after the passage of this act, the executive duties now prescribed, or which may hereafter be prescribed by law, appertaining to the surveying and sale of the public lands of the United States * * * shall be subject to the supervision and control of the Commissioner of the General Land Office under the direction of the President of the United States."

55. For a history of the Patent Office, see G. A. Weber, 1924.

The United States Exploring Expedition is discussed in A. H. Dupree, 1957, p. 56–81.

56. "necessary to a prudent and profitable location of canals * * * ": C. W. Hayes, 1911, p. 36–37.

"duty while surveying a country * * * ": D. D. Owen, 1838, p. 6.

"with a view to imparting * * * ": J. C. Booth, 1841, p. iii.

57. "the localities of all minerals * * * ": W. W. Mather, 1838, p. 21.

58. "any law of Congress * * * ": Section 4 of the Act of June 26, 1834, setting up new land districts in the western half of Wisconsin Territory, 4 Stat. L, 686.

"having reference as well * * * ": The resolution of February 6, 1839, was presented by Arphaxed Loomis of New York for the Committee on Public Lands: Congressional Globe, 25th Congress, 3d session, p. 175.

60. "The district surveyed * * * ": D. D. Owen, 1850, p. 8.
"an officer skilled in the sciences * * * ": Letter of transmittal from the Commissioner of the General Land Office, Ibid., p. 7.
"no one could have ventured * * * ": Ibid., p. 8.
"in a pecuniary point of view * * * ": Ibid., p. 8.
"It has been the policy * * * ": U.S. *v.* Gratiot et al, *in* Richard Peters, Reports of cases argued and adjudged in the Supreme Court, v. 14, p. 526, 1840.
"lands on which are situated * * * ": The Preemption Act of September 4, 1841, is 5 Stat. L, 453. The exclusion from entry of lands on which are situated any known salines or mines is in Section 5.

Chapter 5. Man's True Interests, 1841–1849

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61. "Mind, no longer tasked * * * ": James K. Polk's Inaugural Address, *in* J. D. Richardson, Messages and Papers of the Presidents, v. 4, p. 376.
63. "not worked in America * * * ": J. H. Alexander, 1840, p. 109.
Coal production figures are taken from H. N. Eavenson, 1942, tables; R. C. Taylor, 1848, p. xix; and from Mineral Resources of the United States 1906, p. 24–26.
Johnson's work on coal is reported most fully in W. R. Johnson, 1844. For Rogers on the origin of coal, the most complete source is H. D. Rogers, 1858.
64. "embodying as well the fruits * * * ": American Journal of Science, v. 41, p. 160.
"The annual reports have been confined * * * ": Edward Hitchcock, 1841a, p. 238.
"Permanent inequality of conditions * * * ": Alexis de Tocqueville, 1840, Democracy in America, "Why the Americans are more concerned with the applications than with the theory of science," v. 2, ch. 10.
"that the rocks which in England are called Silurian * * * ": Report of the meeting of the American Association of Geologists, *in* American Journal of Science, 1843, v. 45, p. 157.
65. "Nowhere is there known * * * ": James Hall, 1843, p. 20.
66. "in harmony with the natural relationships * * * " and "pliancy as to admit * * * ": H. D. Rogers and W. B. Rogers, 1844, p. 111.
67. "mere collections of hard names * * * " and "the greatest of all sciences": Issachar Cozzens, 1843, Preface.
"has nine, and probably ten * * * ": Ibid., p. 50.
The Army Reorganization Act of 1838, more properly "An Act to increase the present military establishment of the United States" (5 Stat. L, 256), provided for the organization of the corps of topographical engineers to consist of 1 colonel, 1 lieutenant colonel, 4 majors, 10 captains, 10 first lieutenants, and 10 second lieutenants.
71. The investigation of the Coast Survey in 1841–1842 is reported in Florian Cajori, 1929. The conclusions of the select committee were reported in the House on February 25, 1843, during consideration of the appropriations. See the Congressional Globe, 27th Congress, 3d session, p. 351–352.
72. "sufficient materials to form some probable conclusions * * * ": J. C. Frémont, 1845, p. 295.
73. The literature on the Smithson bequest and the establishment of the Smithsonian Institution is voluminous. See, for example, A. H. Dupree, 1957, ch. IV; G. B. Goode, 1897; and P. H. Oehser, 1949.
74. "very remarkable rock * * * " and "presented a pretty exact outline * * * ": J. C. Frémont, 1845, p. 151.
"for the examination of our soil * * * ": G. P. Merrill, 1920, p. 460.
75. "the waters of the Inland Sea * * * ": J. C. Frémont, 1845, p. 151.
The definitions of descriptive and practical geology are in Michael Tuomey, 1848, p. 1.
76. "The Geologist who would close * * * ": Michael Tuomey, 1844, p. 40–43.
77. "the true resources * * * ": Douglass Houghton, 1841, p. 76.
78. "native copper and native silver * * * ": C. T. Jackson, 1849, p. 387.
79. "the shores of Keeneenaw Point * * * ": J. D. Whitney, 1854, p. 249.
82. "Whilst the President will make no effort * * * ": Secretary of State James Buchanan's instructions to Consul Thomas O. Larkin, October 17, 1845, have been discussed in all works relating to the Mexican War. See also Allan Nevins, 1939, for Frémont's reaction.
"foams around piles of rock * * * ": D. D. Owen, 1852, p. 56.
83. The Supreme Court decision in 1845 in U.S. *v.* Gear is reported in B. C. Howard, Reports of cases argued and adjudged in the Supreme Court, 1843–1861, v. 3, p. 120.
"radically defective" and "reserving to the Government * * * ": James K. Polk's annual message to Congress, December 1845, Congressional Globe, 29th Congress, 1st session, p. 10.
The law of July 11, 1846, authorizing sale of reserved mineral lands is 9 Stat. L, 37.
84. An Act to establish a Land Office in the northern part of Michigan and to provide for the sale of mineral lands in Michigan, approved March 1, 1847, 9 Stat. L, 146.
An act of March 3, 1847, (9 Stat. L, 178) provided for the admission of Wisconsin as a State. The act providing for an additional land district, geological survey, and sale of the mineral lands followed (9 Stat. L, 179).
"It may be useful to the public * * * ": C. T. Jackson, 1849, p. 473.
"what regions are most likely * * * ": D. D. Owen, 1848, p. 6.
"Coal and iron, in abundance * * * ": D. D. Owen, 1852, p. xx.
85. "scientific researches, which to some men * * * ": D. D. Owen, 1848, p. 7.
86. "This arrangement, besides interlocking * * * ": A. H. Dupree, 1957, p. 108.
87. "promote intercourse * * * ": Constitution of the American Association for the Advancement of Science, *in* the Proceedings, v. 1, p. 8–12. See S. G. Kohlstedt, 1976, p. 80–87.
88. "comprehensive as the title * * * ": London, Edinburgh and Dublin Philosophical Magazine and Journal of Science, 1849, 2d series, v. 34, p. 380.
"one of the most extraodinary * * * ": D. D. Owen, 1852, p. 196.
"unmitigated by a breath of air * * * " and "drooping spirits of the scorched geologist * * * ": Ibid., p. 197.
90. "The wide distribution of property * * * ": R. C. Taylor, 1848, p. xi.
"in connection with the corresponding advance * * * ": Ibid., p. 119.
"upwards of 4,000 men * * * " and "from $30,000 to $50,000 * * * ": R. B. Mason, 1849, p. 532.
"The entire gold district * * * ": Ibid., p. 532.

Chapter 6. Gold is the Touchstone, 1849–1855

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91. "Gold is the touchstone * * * ": Thomas Fuller, The Holy State and The Profane State, 1642.
"to preserve the mineral lands * * * ": James K. Polk's annual message to Congress, December 1848, *in* Congressional Globe, 30th Congress, 2d session, p. 6.
An Act to establish the Home Department and to provide for the Treasury, an Assistant Secretary and a Commissioner of the Customs, 9 Stat. L., 395. Although the title says "Home Department," Section 1 provides for establishment of a Department of the Interior, and the latter name was adopted.
92. "We are already planning * * * ": J. D. Whitney to W. D. Whitney, December 11, 1848, *in* E. T. Brewster, 1909, p. 107.
"abstain from the introduction * * * ": Zachary Taylor's annual message to Congress, December 1849, *in* Congressional Globe, 31st Congress, 1st session, p. 71.

"afford important facilities * * * ": Ibid., p. 71.
"the deposits of gold * * * ": Report of the Secretary of the Interior, U.S. Congress, 31st session, House Executive Document 5, v. 3, pt. 2, p. 10 (570).
93. An act to enable the State of Arkansas and other States to reclaim the "swamp lands" within their limits, 9 Stat. L., 519.
An act to reduce the minimum price of the mineral lands in the Lake Superior District of Michigan and in the Chippewa District of Wisconsin (9 Stat. L., 472) ended the distinction between agricultural and mineral lands in those two land districts.
"lands that contained 'iron ore' merely * * * ": Opinions of Attorneys General, v. 5, p. 247, August 28, 1850.
"having only a temporary connexion with the soil * * * ": Commissioner of the General Land Office J. Butterfield, *in* Report of the General Land Office for 1850, 31st Congress, 2d session, Senate Executived Document 2, p. 19.
"In deference to opinions * * * ": Millard Fillmore's annual message to Congress, December 1851, *in* Congressional Globe, 32d Congress, 1st session, p. 18.
94. "the Atlantic States were searched * * * ": J. D. Whitney, 1854, p. xxvi.
George Martin Lane, who shared bachelor's quarters with Whitney, deserves mention in a history of the Geological Survey as the author of "The Lay of the Lone Fish Ball," for the plaintive rendition of which several members of the Pick and Hammer Club of World War II vintage attained a certain fame.
"the mere blowing up * * * ": J. D. Whitney, 1854, p. xxvii.
96. "could never again attain * * * ": Ibid., p. 424.
"no one acquainted with the manufacture * * * ": Ibid., p. 352.
97. "nature, character, and value * * * ": G. P. Merrill, 1920, p. 369.
98. H. D. Rogers' report of the first Geological Survey of Pennsylvania was reviewed in the American Journal of Science, 1859, 2d series, v. 28, p. 149–151.
100. "to employ such portion * * * ": An Act making appropriations for the support of the Army * * *, approved March 3, 1853, 10 Stat. L, 219.
101. "an institution of science * * * ": A. D. Bache, 1851, p. xlviii.
"eat an outrageously good dinner * * * ": For an account of the Lazzaroni, see L. B. Miller and others, 1972.
103. "by whirling motion * * * ": H. D. Rogers, 1858, p. 489.
"to develop the mineral resources * * * ": G. C. Swallow, 1855, p. 37.
104. "Our mineral wealth * * * ": Ibid., p. 39.
106. "presented the characters of true veins * * * ": Edward Daniels, 1854, p. 19.
"Mining like manufacturing * * * ": Ibid., p. 43.
"with no purpose * * * ": E. G. Beckwith, 1855, p. 126.
107. "It is reported * * * ": G. P. Merrill, 1920, p. 309.
109. "were formed, doubtless * * * ": E. G. Beckwith, 1855, p. 51.
"complete and thorough geological survey * * * ": G. P. Merrill, 1920, p. 2.
"thorough geological, mineralogical, and chemical * * * ": Ibid., p. 106.
"It is just the sort of map * * * ": D. D. Owen to J. G. Norwood, *in* Norwood, 1853, note on p. 8.
110. The report on the resolution of the American Geographical and Statistical Society on topographic surveys is in the American Geographical Society Bulletin, 1856, v. 2, p. 40–42.

Chapter 7. Necessary for Welfare and Progress, 1855–1861

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115. "Is it not incumbent * * * ": D. D. Owen, 1858, p. 10.
117. "acquired an importance * * * ": Constitution of the American Iron Association, *in* J. P. Lesley, 1859, p. 49.
119. "It has often been said * * * ": S. T. Dana, 1956, p. 306.
120. "I must here protest * * * ": James Hall, 1882, p. 31.
"may assume to know something * * * ": Ibid., p. 34.
"elevation is due to deposition * * * ": Ibid., p. 55.
121. "uplifting has not produced elevation * * * ": Ibid., p. 56.
"The progress of the earth * * * ": Ibid., p. 62.
"The idea was so entirely new": Joseph LeConte, *in* "Honors to James Hall at Buffalo," Science, 1896, new series, v. 4, p. 699.
"could never attain the importance they once had * * * ": J. D. Whitney, 1854, p. 424.
122. "unable to answer in the affirmative." James Hall and J. D. Whitney, 1858, p. 471.
"no one acquainted * * * ": J. D. Whitney, 1854, p. 352.
"ore in sufficient quantity * * * ": James Hall and J. D. Whitney, 1858, p. 471.
123. "to make reconnaissance of the State * * * ": G. P. Merrill, 1920, p. 13.
124. "the vine-clad hills of the beautiful Niangua * * * ": G. C. Swallow on "Grape culture in Missouri," *in* Proceedings of the American Association for the Advancement of Science, 1858, p. 282.
125. "not only the largest * * * ": H. L. Abbot, 1855, p. 36.
126. "with its snowy crest * * * ": Ibid., p. 60.
127. "an uninteresting monotony": J. S. Newberry, 1856, p. 31.
128. "beds of concrete": Ibid., p. 46.
"milepost in American cartography.": C. I. Wheat, 1954, p. 165.
"may properly be deemed * * * ": Ibid., p. 165.
130. "the region explored * * * ": J. C. Ives, 1861, letter of transmittal.
"slowly crawling along up the muddy Colorado * * * ": J. S. Newberryto F. V. Hayden, *in* G. P. Merrill, 1924, p. 684.
"from the western rim * * * ": Henry Englemann, 1858a, p. 45.
Macomb expedition: A. A. Baker, *in* U.S. Geological Survey Bulletin 841, questions whether the members of the Macomb expedition actually reached the junction of the Green and Colorado Rivers. From the text and illustrations in the Newberry report, Baker believes that the stream referred to as "Canyon Colorado" is now called "Indian Creek" and that the supposed junction of the Green and Colorado Rivers was actually the group of bends of the Colorado now known as "The Loop."
132. "is exceedingly tortuous * * * ": J. S. Newberry, 1861, p. 25.
134. "to make an accurate and complete geological survey * * * ": G. P. Merrill, 1920, p. 30.
135. "at intervals the sedimentary rock is covered * * * ": J. S. Newberry, 1861, p. 66.

Chapter 8. Not From Our Permanent Part, 1861–1867

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139. "Our national strife * * * ": Abraham Lincoln's second annual message to Congress, December 1862, *in* J. D. Richardson, Messages and Papers of the Presidents, v. 6, p. 135.
140. "This country, until the present year * * * ": Report of the Secretary of War for 1863: U.S. Congress, 38th, 1st session, House Executive Document 5, p. 11 (1184).
141. "acquire and diffuse * * * ": An Act to establish a Department of Agriculture, 12 Stat. L, 387.
An Act to secure Homestead to actual Settlers on the Public Domain, 12 Stat. L, 387.
An Act to aid in the Construction of a Railroad and Telegraph Line from the Missouri River to the Pacific Ocean, and to secure to the Government the Use of same for Postal, Military and Other Purposes, 12 Stat. L, 489.
142. "provide colleges for the benefit * * * ": An Act donating Public Lands in the several States and Territories which may provide Colleges for the Benefit of Agriculture and the Mechanic Arts, 12 Stat. L, 503. Mineral lands were excluded from the donation.
"The valuable and extensive mineral lands * * * ": Report of the Secretary of the Interior for 1862: U.S. Congress, 37th, 2d session, Senate Executive Document 1, v. 2, p. 445 (1117).
"to the enlightened judgment * * * ": Report of the Commissioner

of the General Land Office for 1862, U.S. Congress, 37th, 2d session, Senate Executive Document 1, v. 1, p. 33 (1117).
"would relieve the necessities * * * ": Ibid., p. 30.

143. "permanent commission * * * ": F. W. True, 1913, p. 1–2.

144. "the Academy shall * * * ": An Act to Incorporate the National Academy of Sciences, 12 Stat. L, 806.

146. "At the time of the discovery * * * ": Report of the Secretary of the Interior for 1863: U.S. Congress, 38th, 1st session, House Executive Document 1, v. 3, p. iv (1182).
An Act for the Disposal of Coal Lands or Town Property in the Public Domain, 13 Stat. L, 343.

148. "a thorough and scientific examination * * * ": G. P. Merrill, 1920, p. 32.
"for public use, resort, and recreation * * * ": An Act authorizing a Grant to the State of California of the "Yo-semite Valley" and of the Land embracing the "Mariposa Big Tree Grove," 13 Stat. L, 325.

149. "the preservation and maintenance * * * ": Olmsted's report is quoted in F. P. Farquhar, 1965, p. 124, and discussed in L. W. Roper, 1973, p. 283–287.
"an immense extent of North American * * * ": G. P. Marsh, 1864, p. 49 in Belknap Press edition of 1965.
"with the present increased facilities * * * ": Ibid., p. 11.

150. "to reason upon all the relations * * * ": Ibid., p. 52.

151. "already more scientific * * * ": J. A. Church, 1871, p. 22.

153. "Neither party expected * * * ": Abraham Lincoln, Second Inaugural Address, *in* J. D. Richardson, Messages and Papers of the Presidents, v. 6, p. 277.

154. "Individual proprietorship it is conceded * * * ": Annual Report of the Secretary of the Interior for 1865: U.S. Congress, 39th, 1st session, House Executive Document 1, pt. 5, v. 2, p. iii, (1248).
"The existing financial condition * * * ": Ibid., p. iii.
The Mining Act of July 26, 1866, is 14 Stat. L, 251.

155. "all the topography * * * ": J. D. Whitney, 1865, p. xvii.

156. "reliable statistical information * * * ": In the act appropriating funds for sundry civil expenses, 14 Stat. L, 311.
"to give the people * * * ": G. P. Merrill, 1920, p. 91.

158. "gives a good general impression * * * " and "the number of basins": S. H. Daddow and Benjamin Bannan, 1866, p. 179.
"a large mass * * * ": G. J. Brush, *in* American Journal of Science, 1866, 2d series, v. 46, p. 430–431.
"of the most vast and magnificent description.": S. H. Daddow and Benjamin Bannan, 1866, p. 63.

159. "to direct a geological and topographical exploration * * * ": 14 Stat. L, 457.
"Eighteen sixty-seven, therefore * * * ": Clarence King, 1880, p. 4.
"the unexpended balance * * * ": 14 Stat. L, 470.

Chapter 9. The Matter of Highest Concern, 1867–1870

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161. "The proper development * * * ": J. S. Wilson, Report of the Commissioner of the General Land Office, *in* Report of the Secretary of the Interior for 1868: U.S. Congress, 40th, 3d session, House Executive Document 1, pt. 3, v. 2, p. 19 (1366).
"this element of power and progress * * * ": Report of the Commissioner of the General Land Office, *in* Report of the Secretary of the Interior for 1866: U.S. Congress, 39th, 2d session, House Executive Document 1, pt. 4, v. 2, p. 383. (1284).
"the most useful of all metals * * * ": Ibid., p. 384.
"the sandstone and shale * * * ": Ibid., p. 385.

162. "to examine and describe * * * ": General Humphreys to Clarence King, March 21, 1867, King Survey Letters Received.

164. "contained much that was novel * * * ": S. F. Emmons, 1897, p. 43.

166. "most directly applicable * * * ": J. D. Hague, 1870, note following title page.

167. "should be studied * * * ": American Journal of Science, 3d series, 1871, v. 1, p. 219.
"a superb piece of work * * * ": J. D. Whitney, 1875, p. 297.

169. "to ascertain the order of succession * * * ": F. V. Hayden, 1871, p. 3.

172. "Any report of the condition of mining affairs * * * ": F. V. Hayden, 1869, p. 201.

176. "a complete and thorough * * * ": G. P. Merrill, 1920, p. 303–304.
"entitled to be considered * * * ": J. S. Newberry, 1871, p. 33.
"at the head of a Geological and Scientific Department * * * ": E. T. Cox, 1869, p. 5.

177. "as complete a manual as possible * * * ": T. B. Brooks, 1873, p. iii.

178. "probably the most remarkable occurrence * * * ": J. D. Hague, 1870, p. 425.
"nothing very wonderful": Mining and Scientific Press, Oct. 31, 1868, p. 280.
"one of the most interesting * * * ": F. V. Hayden, 1872, p. 90.

179. "It looks as though Providence * * * ": U. S. Grant's First Inaugural Address, *in* J. D. Richardson, Messages and Papers of the Presidents, v. 7, p. 7.

180. "If he is in want * * * ": Report of the Secretary of the Interior for 1869: U.S. Congress, 41st, 2d session, House Executive Document 1, v. 3, p. viii (1414).
"inhabited * * * by powerful tribes of Indians * * * ": J. W. Powell to U. S. Grant, April 2, 1868, quoted in W. C. Darrah, 1951, p. 92.

181. "to make collections in geology * * * ": Letter from J. W. Powell to the Chicago Tribune, May 24, 1869, reprinted in Utah Historical Quarterly, 1947, v. 15, p. 73–74.

182. "thorough and careful reconnaissance * * * ": G. M. Wheeler, 1870, p. 7.

184. "full of faith * * * ": Henry Adams, 1918, p. 248.
"The fullest examination * * * ": F. A. Walker, 1878, p. 847.
"published in conformity * * * ": F. A. Walker, 9th Census Report.

185. "It is not a little discreditable * * * ": American Journal of Science, 1874, 3d series, v. 6, p. 65.
"estimates rather than statistics * * * ": R. W. Raymond, 1870, p. 16.
"whose legal knowledge * * * ": R. W. Raymond, 1870, p. 421.
"all forms of deposit * * * ": An Act to promote the Development of the mining Resources of the United States, 17 Stat. L, 91.

Chapter 10. Subservient to the Interests of a Civilized Community, 1870–1873

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187. "It gives me the greatest pleasure * * * ": Louis Agassiz to Benjamin Pierce, *in* Report of the United States Coast Survey for 1867: U.S. Congress, 40th, 2d session, House Executive Document 275, p. 183 (1344).
"Never has my faith * * * ": F. V. Hayden, 1871a, p. 6–7.

189. "hardly be considered authorized * * * ": General A. A. Humphreys to Clarence King, March 28, 1871, King Survey Letters Received.

190. "of inestimable importance * * * ": Report of the Superintendent of the United States Coast Survey, showing the progress of the survey during the year 1870: U.S. Congress, 41st, 3d session, House Executive Document 112, p. 4 (1459).
"that the triangulation shall determine * * * ": 16 Stat. L, 508.
"the great development of mines * * * ": Report of the Wilkes Barre meeting, Transactions of the American Institute of Mining Engineers, 1871–1873, v. 1, p. 3.
"The time has come * * * ": E. C. Pechin, 1872, p. 297.

191. "more economical systems of mining * * * ": Report of the Wilkes Barre meeting, Transactions of the American Institute of Mining Engineers, 1871–1873, v. 1, p. 3.
"in their proper places all streams * * * " and "and reliable, so far as section lines go": T. B. Brooks, 1893, p. 196.

"The omens are less favorable * * * ": B. A. Gould, 1869, p. 28.
"dependent upon subsidies * * * ": Ibid., p. 29.

192. "to earn his bread * * * ": Ibid., p. 30.
"the prime elements": R. W. Raymond, 1873, p. 39.

194. "capital is essential * * * ": A. S. Hewitt, 1872, p. 328.
"the common ground * * * ": Ibid., p. 328.

195. "calamity so serious * * * ": A. S. Hewitt, 1872, p. 328.
"From my own observation * * * ": W. A. Jones, 1872, p. 1117.

196. "those portions of the United States territory * * * ": G. M. Wheeler, 1872, p. 3.

197. "to make such instrumental observations * * * ": F. V. Hayden, 1878, p. 12.

198. "Professor Hayden and party * * * ": Congressional Globe, 42d Congress, 2d session, p. 484.
An Act to set apart a certain Tract of Land lying near the Head-waters of the Yellowstone River as a public Park, 17 Stat. L, 32.
"That our legislators * * * ": F. V. Hayden, 1872a, p. 295.

199. The Philosophical Society of Washington was established on March 13, 1871. J. W. Powell's appearance on March 9, 1872, is recorded in volume 1 of the Proceedings of the Society.

200. "the day of the path-finder has sensibly ended": G. M. Wheeler, 1872, p. 55.
The Geographical Surveys West of the One Hundredth Meridian were established by the appropriation of $75,000 "for the establishment of an astronomical base, and continuance of military and geographical surveys and explorations west of the one hundredth meridian of longitude, under the direction of the Secretary of War," 17 Stat. L, 367.
"The region mentioned * * * ": Joseph Henry, letter of transmittal, *in* J. W. Powell, 1872.
"the most magnificent sight * * * ": F. V. Hayden, 1872a, p. 123.

201. "paid some attention to elevations of water level * * * ": F. V. Hayden, 1873, p. 797.

202. "I may state * * * ": F. V. Hayden 1873, p. 276.

204. "I ought not to characterize * * * ": Clarence King 1873, p. 1206.
"Who's King of Diamonds now * * * ": J. D. Whitney to W. H. Brewer, December 5, 1872, Farquhar Collection, Bancroft Library, University of California.

Chapter 11. The Shifting Times, 1873–1874

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205. "Thus times do shift * * * ": Robert Herrick, Hesperides, 1648.
"on the one side * * * ": Allan Nevins, 1927, p. 290.
"There is probably no portion * * * ": F. V. Hayden to Secretary Columbus Delano, January 27, 1873.
"continuation of the geographical * * * ": 17 Stat. L, 513.
"for making maps * * * ": J. T. Gardner, 1873, p. 297.

207. "whatever may be the advantages * * * ": General A. A. Humphreys, letter of transmittal, *in* W. A. Jones, 1874.
"most remarkable * * * ": Joseph Henry, letter of transmittal, *in* J. W. Powell, 1873.
"The faulting and folding * * * ": J. W. Powell, 1873, p. 9.

208. "the sum of ten thousand dollars * * * ": 17 Stat. L, 513.
The report of the special commissioners on the Indians is in the Annual Report of the Commissioner of Indian Affairs for 1873, p. 409–434.

209. An Act to encourage the Growth of Timber of western Prairies, 17 Stat. L, 606.
An Act to provide for a Board of Commissioners to report a System of Irrigation for the San Joaquin, Sacramento, and Tulare in California, 17 Stat. L, 622.
"under regulations prescribed by law * * * ": An Act to promote the Development of the mining Resources of the United States,17 Stat. L, 91.
"all the marks * * * ": J. D. Whitney, 1875, p. 288.

210. An Act to provide for the Sale of the Lands of the United States containing Coal, 17 Stat. L, 607.
An Act revising and amending the Laws relative to the Mints, Assay-offices, and Coinages of the United States, 17 Stat. L, 424.
"The great Emma 'bonanza' * * * ": Clarence King's report to the Emma Silver Mine Company is in the Report of the Committee of Foreign Affairs on the Emma Mine investigation: U.S. Congress, 44th, 1st session, House Report 579, p. 632–634 (1711).
"The day has passed * * * ": Clarence King to General A. A. Humphreys, February 25, 1874, King Survey Letter Book.

213. "Irrigation is but little understood * * * ": B. S. Alexander and others, 1874, p. 34.
"that it is the duty of the government * * * ": Ibid., p. 78.
"as a matter of public policy * * * ": Ibid., p. 79.

214. "acquisition of the control * * * ": G. P. Marsh, 1874, p. 4.
"We must look to our rulers * * * ": Ibid., p. 15.
"as it is not to be presumed * * * ": U.S. Congress, 43d, 1st session, Senate Report 311.
The Shoemaker resolution of April 15, 1874, is in the Congressional Record of the 43d Congress, 1st session, p. 3095.
The replies of the President, Secretaries of War and Interior, and heads of the surveys, together with the transcript of the hearings, are in House Report 612 of the 43d Congress, 1st session (1626).

215. "By placing all these surveys * * * ": Ibid., p. 6.
"all surveys which are made * * * ": Ibid., p. 9.

216. "If a geologist is placed in charge * * * ": Ibid., p. 11.
"There is now left within the territory * * * ": Ibid., p. 14.
"It might be well * * * ": Ibid., p. 15.
"You can say that certain persons * * * ": Ibid., p. 25.
"as a matter of course * * * ": Ibid., p. 39.
"The geological survey is based * * * ": Ibid., p. 42.

217. "As is well understood * * * ": G. M. Wheeler, 1874, p.
"telegraphed Mr. Clarence King * * * ": U.S. Congress, 43d, 1st session, House Document 612, p. 43 (1626).

219. "and it seems to me * * * ": Ibid., p. 53.
"All of the country west of the 100th * * * ": Ibid., p. 53.
"One-third of the entire area * * * ": J. W. Powell, 1874, p. 10.

220. "each of the surveying parties * * * ": U.S. Congress, 43d, 1st session, House Document 612, p. 16 (1626).
"There is an abundance * * * ": Ibid., p. 16.
"The time is approaching * * * ": Ibid., p. 16.
"I have had a hard struggle * * * ": F. V. Hayden to Sir Archibald Geikie, September 20, 1874, Geikie Letters, University of Edinburgh Library.
"Professor Powell in his last year's survey * * * ": Joseph Henry, Letter of transmittal, *in* J. W. Powell, 1874.

Chapter 12. No Mere Intellectual Play, 1874–1877

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223. "Geology has ceased to be * * * ": J. P. Lesley, 1876, p. 27.
"marked by most serious defects * * * ": J. D. Whitney, 1875, p. 69.
"It was probably admiration * * * ": Ibid., p. 82.
"But little has ever been done * * * ": Ibid., p. 274.

224. "one great object * * * ": Report of the Secretary of the Interior for 1874: U.S. Congress, 43d, 2d session, House Executive Document 1, pt. 5, v. 6, p. xxvii (1639).
The instructions to the Interior Department surveys are summarized in the Secretary's report and are printed verbatim in J. W. Powell, 1878, p. 2.
"westward toward the Green and Colorado .": 18 Stat. L, 207.

225. "for the purpose of giving the world * * * ": F. V. Hayden, 1874, Prefatory note to Bulletin 1.
"The article * * * ": F. V. Hayden, Prefatory note to E. D. Cope, 1874.
"There is, then, no alternative * * * ": Ibid., p. 16.

229. "gold has been found * * * ": Custer's official dispatch of August 2, 1874, reported in Donald Jackson, 1966, p. 87.

"I fail to find * * * ": Report of the Commissioner of the General Land Office, *in* Report of the Secretary of the Interior for 1874: U.S. Congress, 43d, 2d session, House Executive Document 1, pt. 5, v. 6, p. 6 (1639).

230. "The prehistoric remains in the canons * * * ": F. V. Hayden, 1877, p. 7–8.

"distrusting his own fitness * * * ": Clarence Dutton, 1880, Report on the geology of the High Plateaus of Utah: Washington, preface.

231. "laying down upon the preliminary maps * * * ": G. M. Wheeler, 1876, p. 260.

232. "The failure of the negotiations * * * ": Report of Secretary of the Interior for 1875: 44th Congress, 1st session, House Executive Document 1, pt. 5, v. 4, p. vi (1680).

"in the localities most desirable": Report of the Commissioner of the General Land Office *in* Report of the Secretary of the Interior for 1875: Ibid., p. 6.

"Legislation and executive practice * * * ": Ibid, p. 6.

"it was found convenient * * * ": G. K. Gilbert, 1875, p. 158.

233. "One hundred years ago * * * ": Reports of the U.S. Centennial Commission, v. 2, p. 37–38, Washington, 1880.

235. "a point at which for coal * * * ": A. S. Hewitt, 1876, p. 176.

236. "The government * * * ": Ibid., p. 184.

237. "In its perfect and ultimate development * * * ": Ibid., p. 188.

"a down-turned wrinkle * * * ": J. W. Powell, 1875, p. 158.

The special monetary commission was established by a concurrent resolution adopted in the House on August 5, 1876, and concurred in by the Senate on August 15: Congressional Record, 44th Congress, 1st session, p. 5218 and 5240.

238. "Similar bodies of nearly equal extent * * * ": U.S. Congress, Joint Monetary Commission, 1877, p. 2.

239. "in birds with teeth * * * ": T. H. Huxley to his wife, quoted in Leonard Huxley, 1900, Life and Letters of Thomas H. Huxley, v. 1, p. 496.

"the most wonderful thing I ever saw.": Ibid.

"It is of the highest importance * * * ": T. H. Huxley to Clarence King, quoted in Charles Schuchert and Clara Levene, 1940, p. 238.

241. "It is the misfortune of geology * * * ": Clarence King, 1876, p. 919.

"excellent progress has been made * * * ": F. V. Hayden, 1878, p. xxiv.

"The work of the season of 1876 * * * ": Ibid., p. xxiii.

"As a field for the studies * * * ": G. K. Gilbert, 1876, p. 18.

242. "types of orographic structure * * * ": American Journal of Science, 1876, 3d series, v. 12, p. 306.

"In pursuing these ethnographic investigations * * * ": J. W. Powell, 1877, p. 297–298.

243. "in accordance with the general policy * * * ": Joseph Henry to J. W. Powell, October 10, 1876, reprinted in Contributions to North American Ethnology, v. 1, p. vii.

An act to provide for the sale of desert lands in certain States and Territories, 19 Stat. L, 377. Desert lands were defined as "all lands exclusive of timber lands and mineral lands which will not, without irrigation, produce some agricultural crop."

244. Professor Newberry's letter to Congressman Garfield has been reprinted in W. C. Darrah, 1951, p. 240–241. The letter to Congressman Hewitt is identical. In these letters Newberry said that Hayden had become so much of a fraud that he had lost the sympathy and respect of the scientific men of the country, and that he had become simply the political manager of his expeditions whereas Powell and Gilbert had done the work in the field themselves.

The discussion in the House on February 21, 1877, is in the Congressional Record, 44th Congress, 2d session, p. 1793. Congressman Peter Wigginton's amendments were proposed on February 26; see Congressional Record, p. 1949.

The motions by Congressman Townsend and Congressman Stevenson to increase the appropriations for Hayden and Powell are reported on page 1950 and 1952 of the Congressional Record.

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245. "It is chiefly through * * * ": J. D. Whitney, 1875, p. 274.

246. "if it be true * * * ": New York Tribune, April 28, 1877, quoted in W. C. Darrah, 1951, p. 226–227.

Professor John S. Newberry to Secretary Carl Schurz, March 17, 1877.

Professor John S. Newberry to J. W. Powell, March 18, 1877.

J. W. Powell to Secretary Carl Schurz, May 22, 1877, *in* J. W. Powell, 1878, p. 8–11.

247. Acting Secretary A. Bell's letter of November 9, 1877: Ibid., p. 11–12. The division of labor was to Powell's benefit in that his paleontological collections, which could be of importance in his geologic work, would be turned over to Hayden to be worked up, whereas the ethnologic collections, which were independent of geology, of both parties would be his to work up.

248. "does not claim to be * * * ": Arnold Hague and S. F. Emmons, 1877, letter of transmittal.

"the evolution of environment * * * ": Clarence King, 1877a, p. 470.

"to doubt evolution * * * ": O. C. Marsh, 1877, p. 338.

249. "This mode of evolution * * * ": C. S. Peirce, Collected Papers, v. 6, p. 17.

250. "earnestly recommend * * * ": Rutherford B. Hayes' annual message to Congress, December 1877: Congressional Record, 45th Congress, 2d session, p. 6.

"during the past six years * * * ": J. W. Powell, 1877, p. 805.

251. "serried pinnacles * * * ": Henry Newton and W. P. Jenney, 1880, p. 71.

"at an early date to submit a report * * * ": J. W. Powell, 1877, p. 805.

252. "one might as well introduce a dead language * * * ": Testimony before the Committee on Public Lands, U.S. Congress, 45th, 2d session, House Miscellaneous Document 55, p. 17 (1818).

254. "The largest amount of land * * * ": J. W. Powell, 1878, p. 43–44.

"These coal fields * * * ": Ibid., p. 45.

255. "I have not been able * * * ": J. A. Williamson to Carl Schurz, *in* J. W. Powell, 1878.

"commend the views * * * ": Carl Schurz, Letter of transmittal to Congress, *in* J. W. Powell, 1878.

257. "of so variable and explosive * * * ": Henry Gannett 1878, p. 315.

258. The Timber Cutting Act is actually "An Act authorizing the citizens of Colorado, Nevada and the Territories to fell and remove timber on the public domain for mining and domestic purposes," 20 Stat. L, 88. The Timber and Stone Act is "An act for the sale of timber lands in the States of California, Oregon, Nevada, and Washington Territory." Lands valuable for stone are not mentioned in the title but are included in Section 1.

259. "when statistical science was in its infancy * * * ": F. A. Walker, 1878, p. 839.

"The mineral treasures of the earth * * * ": J. D. Whitney, *in* F. A. Walker, 1878, p. 851.

260. "Let some man * * * ": J. D. Whitney *in* F. A. Walker, 1878, p. 856.

"Our provokingly defective knowledge * * * ": Clarence King, 1878, p. 727.

261. The House resolutions of March 8, 1878, one directed to the Secretary of the Interior and the other to the Secretary of War, are in the Congressional Record, 45th Congress, 2d session, p. 1593.

The replies to the House resolutions are in House Executive Documents 80 (Powell), 81 (Hayden), and 88 (War Department) of the 45th Congress, 2d session, Serial 1809.

The discussion of the appropriations for the Hayden and Powell surveys and the request to the National Academy are on p. 4559–4560, Congressional Record, 45th Congress, 2d session. The bill passed by both houses on June 19 was approved June 20, 1878. The proviso for the National Academy of Sciences study is 20 Stat. L, 230.

Chapter 14. Upon a Firm and Enduring Basis: The Establishment of the U.S. Geological Survey, 1879

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263. "if we can but rise * * * ": A. S. Hewitt, *in* Congressional Record, 45th Congress, 3d session, p. 1207.

264. "any of those * * * ": Report of the National Academy of Sciences, U.S. Congress, 46th, 1st session, House Miscellaneous Document 7, p. 7.

266. "That which a student * * * ": Clarence King, 1878, letter of transmittal.

"probably the most exciting book * * * ": Franklin Walker, 1932, San Francisco Literary Frontier, New York, Alfred A. Knopf, p. 287.

"only person to be thought of": Clarence King to W. H. Brewer, January 15, 1879, Farquhar Collection in the Bancroft Library, University of California.

267. "No other department * * * ": Acting Chief of Engineers, *in* U.S. Congress, 45th, 3d session, House Miscellaneous Document 5, p. 7.

"trigonometrical and topographical survey * * * ": Ibid., p. 7.

268. "to fulfill all the foregoing * * * ": Ibid., p. 7.

"In arriving at results * * * ": Acting Commissioner of General Land Office, *in* U.S. Congress, 45th, 3d session, House Miscellaneous Document 5, p. 10.

"The organization under my direction * * * ": F. V. Hayden, *in* U.S. Congress, 45th, 3d session, House Miscellaneous Document 5, p. 11.

"the chief of the survey * * * ": Ibid., p. 12.

"The prosecution of the work * * * ": J. W. Powell, *in* U.S. Congress, 45th, 3d session, House Miscellaneous Document 5, p. 16.

270. "A system of cartography * * * ": Ibid., p. 16.

271. "a proper scientific survey * * * ": Ibid., p. 21.

272. "allied to great industrial interests * * * ": Ibid., p. 23.

"surveys and investigations * * * ": Report of the National Academy of Sciences, *in* U.S. Congress, 45th, 3d session, House Miscellaneous Document 5, p. 2.

"To attain the desirable accuracy * * * ": Ibid., p. 3.

"The best interests of the public domain * * * ": Ibid., p. 3.

273. "charged as they are * * * ": Ibid., p. 4.

274. "that upon the organization * * * ": Ibid., p. 4.

275. "The report recommends * * * ": F. V. Hayden to Archibald Geikie, November 24, 1878.

Henry Nash Smith and Wallace Stegner writing on the establishment of the Survey confused Goldsmith Hewitt of Alabama with A. S. Hewitt of New York.

276. "prevent the prompt supplying * * * ": U.S. Congress, 45th, 3d session, Senate Executive Document 21, p. 2.

"Respecting comparisons * * * ": C. P. Patterson, *in* U.S. Congress, 45th, 3d session, House Executive Document 29, p. 4.

Powell's letter of February 7, 1879: U.S. Congress, 45th, 3d session, House Executive Document 72.

277. "Hayden is outwardly for the bill * * * ": Clarence King to O. C. Marsh, January 18 [1879].

"Clarence King is here * * * ": F. V. Hayden to Archibald Geikie, January 24, 1879.

"I write to ask you * * * ": F. V. Hayden to Archibald Geikie, February 4, 1879.

"In thus bringing together * * * ": American Journal of Science, 1879, 3d series, v. 17, p. 67.

"There is no doubt * * * ": Engineering and Mining Journal, January 11, 1879, v. 27, no. 2, p. 22.

"The condition at present * * * ": John D. C. Atkins, *in* Congressional Record, 45th Congress, 3d session, p. 1169.

278. "the placing of the scientific surveys * * * ": Ibid., p. 1169.

"The Academy is to be commended * * * ": Ibid., p. 1171.

"It may be urged * * * ": Ibid., p. 1171.

"keep in mind * * * ": Ibid., p. 1171.

279. "Gentlemen are unnecessarily alarmed * * * ": Peter Wigginton, *in* Congressional Record, 45th Congress, 3d session, p. 1200.

"admirable exposition": A. S. Hewitt, *in* Congressional Record, 45th Congress, 3d session, p. 1203.

"sooner or later abolish * * * ": Ibid, p. 1206.

"It is obvious to every reflecting mind * * * ": Ibid., p. 1204.

"not to be expected * * * ": Ibid., p. 1204.

280. "If we can but rise * * * ": Ibid., p. 1207.

281. "a misfortune * * * ": James A. Garfield, *in* Congressional Record, 45th Congress, 3d session, p. 1209.

"subjected to the most careful scrutiny * * * ": Ibid., p. 1209.

"We are accustomed * * * ": Ibid., p. 1209.

"absolutely vital * * * ": Ibid., p. 1210.

"waste money and duplicate work * * * ": Ibid., p. 1210.

"besides going too far * * * ": Ibid., p. 1210.

"It is marvelous * * * ": John H. Baker, Ibid., p. 1564.

282. "Now I do not object * * * ": Dudley C. Haskell, Ibid., p. 1211.

"Congress at its last session * * * ": Senator A. A. Sargent, *in* Congressional Record, 45th Congress, 3d session, p. 2084.

283. Conference report: Congressional Record, 45th Congress, 3d session, p. 2298, and House Journal, p. 635–636.

Debate in the House: Congressional Record, 45th Congress, 3d session, p. 2357.

Debate in the Senate: Ibid., p. 2301–2302.

"For the salary * * * ": 20 Stat. L, 394.

284. "that all the archives * * * ": 20 Stat. L, 397.

"From the somewhat fragmentary * * * ": Engineering and Mining Journal, 1879, v. 27, no. 10, p. 159.

286. "During the years * * * ": Clarence King, 1880, p. 4.

287. "Much depends * * * ": Engineering and Mining Journal, 1879, v. 27, no. 10, p. 159.

"At first there seemed to be * * * ": Simon Newcomb, 1903, p. 259.

"if Dr. Hayden * * * ": J. W. Powell to John D. C. Atkins, March 4, 1879, Geographical and Geological Survey of the Rocky Mountain Region Letters sent.

"for noise and show * * * ": J. W. Powell to James A. Garfield, March 7, 1879, Ibid.

288. "discreditable, discouraging, and unpromising": Charles W. Eliot to President Rutherford B. Hayes, February 28, 1879.

"our opinion * * * ": Engineering and Mining Journal, 1879, v. 27, no. 11, p. 179.

"came here in person * * * ": F. V. Hayden to Archibald Geikie, May 31, 1879.

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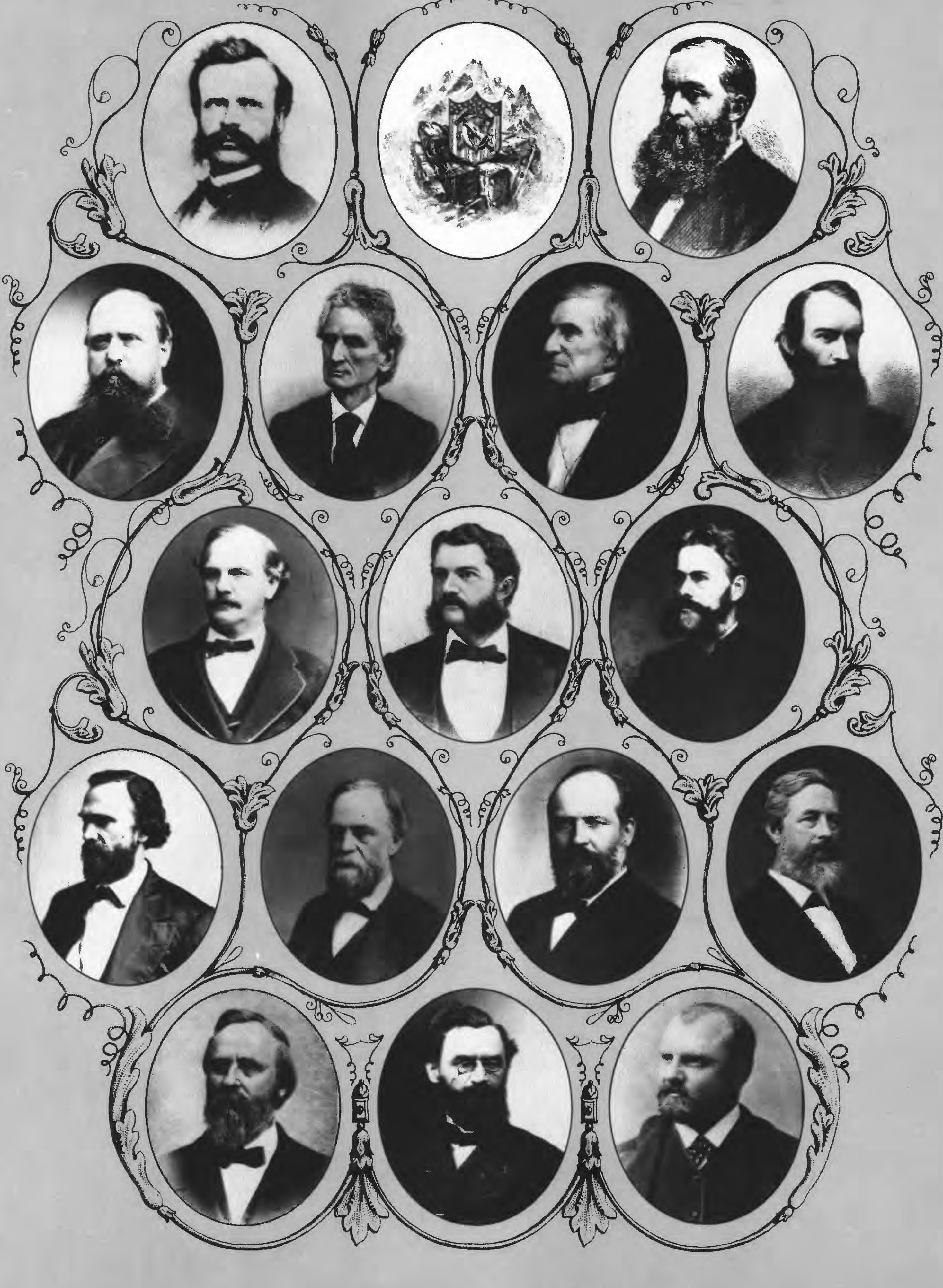

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interest of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U S. Administration.