

Geophysical Laboratory  
Carnegie Institution of Washington  
Washington, DC 20008

## Abstract

Historians have often analyzed the development of geology in eighteenth-century North America in terms of contributions made by European visitors. However, more than 400 eighteenth-century American publications also document the formative aspects of the earth sciences. The great majority of these works chronicle isolated events such as earthquakes, volcanic eruptions, and the discovery of new mines or unusual fossils. Of particular note are the more than 50 New England earthquake sermons from 1727 and 1755, as well as John Winthrop's 1755 *Lecture* on the physical causes of the events. In the last third of the century several new scientific periodicals, including the *Transactions of the American Philosophical Society* (1771), the *Memoirs of the American Academy of Arts and Sciences* (1785), and the *Medical Repository* (1798), provided specialized forums for the analysis of geological phenomena. During this period, as a result of an increasing awareness of geological theories developed in Europe, American workers were able to place their observations in a more comprehensive framework. By the end of the eighteenth century several American naturalists (most notably Samuel Latham Mitchill) had begun to collect geological data systematically in order to produce more comprehensive regional studies.

Key words: History of geology.

## Introduction

Geology is a science of objects and events as well as ideas. Unlike physics or chemistry, which normally advance within the confines of a laboratory, the earth sciences also depend upon the description of chance natural events and the classification of countless specimens. Eighteenth-century America had no institutions to compete with European centers of learning, but the North American continent did provide a vast, unexplored field area of dramatic topography and remarkable natural productions.

From the beginning European explorers took great interest in the North American land, its features and natural wealth. As travel accounts of the sixteenth and seventeenth centuries demonstrate, the search for precious metals, especially gold, was a major occupation of the early adventurers. Like the Spanish in South America, the English, French, and Dutch explorers prospected for ores, noted potential mine sites, and interrogated local Indians about mineral deposits. In addition, their chronicles of exploration touched, at least in passing, on basic geological features of the newly discovered lands. Thomas Hariot (1588) in a sixteenth-century report on Virginia, for example, described the Piedmont and coastal plain, and made the important observation that Virginia possessed marketable quantities of iron ore (Mulholland, 1981). In 1612 John Smith published notes about rock types and soil characteristics in *A Map of Virginia, with a description of the country*. These rather crude discussions were only a hint of what was to come. During the eighteenth century the practice of observing and recording data about earth-related features in America was to continue and diversify.

As in the earlier centuries, much work continued to be done by visiting Europeans for whom the vastness of the American landscape and its often unfamiliar features proved irresistible. Peter Kalm, a Swedish scientist sponsored by the Royal Academy of Sciences, Stockholm, was one notable naturalist visitor. Travelling extensively in the American colonies between 1749 and 1751, Kalm recorded information about land features along with his better known remarks about other aspects of natural history. His description of Niagara Falls is one of the earliest available in English (White, 1969). Kalm also made original suggestions about the nature and origin of local rock types; this information sparked the interest of Americans after Kalm's *Travels in North America* became accessible to them in the 1771 English edition. Johann David Schöpf, another foreigner visiting America, wrote the first treatise devoted exclusively to the geology of North America. Schöpf had come to America as a physician with the Hessian troops during the American Revolution, but when peace was established he undertook a journey in the eastern United States. He published his *Beyträge zur Mineralogischen Kenntniss des Östlichen Theils von Nord Amerika und Seiner Gebürge* in Erlangen, Germany (Schöpf, 1787). Mention should also be made of Count C.F. Volney, who traveled in America from 1795 to 1798. He hiked throughout the United States collecting rock and mineral specimens, noting the geographical divisions of the country, and producing a map with geological notations. His research was published in France in 1803 and was translated a year later into English for British and American readers.

In the past, historians have analyzed the development of eighteenth-century American geology almost

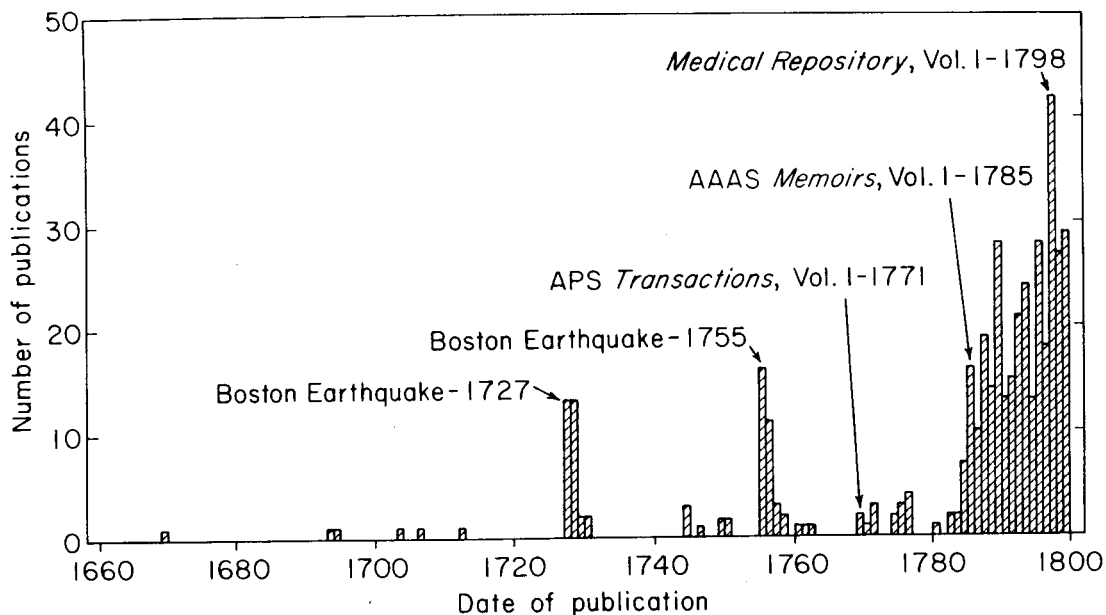


Figure 1. The number of earth-science publications in America from 1660 to 1800. Number of publications is plotted versus year of publication. (From Hazen and Hazen, 1980, by permission of Hutchinson-Ross Publishing Company, Stroudsburg, Pennsylvania.)

exclusively in terms of the contributions made by these and other European visitors (see, e.g., Merrill, 1924). That their work was sophisticated and noteworthy is indisputable. That their work was central to, or even related to, work on the earth sciences carried out by Americans is in question. Any assessment of the emergence of American geology must also look at the nature of the ongoing geological inquiries in America. Such inquiries are the focus of this article.

#### Eighteenth-Century Geological Publications

It is not surprising that Americans viewed their land with great curiosity. They lived in a kind of geological laboratory where earthquakes, giant bones, and dramatic terrains were not uncommon. In addition, for those in the process of operating farms, establishing mines, or digging wells, an understanding of earth-related phenomena could be a practical advantage. Publishers, who anticipated a favorable response to information about the earth, produced books and journals that contained many references to geological subjects. One useful method of learning about geology in eighteenth-century America is to examine these American earth-science publications.

An investigation of early American earth-science publications was undertaken by the authors and resulted in a bibliography and index, *American Geological Literature, 1669 to 1850* (Hazen and Hazen, 1980). Included in this compilation were more than 14,000 books, pamphlets, periodical notes and articles, geological maps, mining company reports, and other American-published works relating to what we know as the earth sciences. Analysis of the more than 400 eighteenth-century works listed in this bibliography reveals some interesting patterns.

Most striking is the pattern of growth. During the eighteenth century the number of geological publications per year increased dramatically, as illustrated in Figure 1. The first half of the century saw only

occasional geological writings, most of which dealt with the earthquake of 1727 in New England. By mid-century the publication rate increased, especially after the earthquakes of 1755 in Portugal and New England. During the last two decades of the century the publication rate averaged almost 20 contributions per year. Of the approximately 430 geological books, articles, pamphlets, and broadsides of the eighteenth century listed by Hazen and Hazen, 80 percent appeared in the last 20 years.

During the first 60 years of the century New England printers, especially those in Boston, produced more than 80 percent of the geological publications, most of which were earthquake descriptions and sermons. By the 1770s, however, Philadelphia asserted its dominance in geological publications, as well as in scientific research generally. The *Transactions of the American Philosophical Society* contained numerous geological references, as did the more general Philadelphia-based journals such as *The American Museum and Universal Magazine* and *The Columbian Magazine*. Prior to 1790 there were only nine New York City imprints, but in the last decade of the eighteenth century more than 70 New York publications on geological topics appeared, owing in large measure to Samuel Latham Mitchill and his *Medical Repository*. Occasional imprints from other American cities and towns, including Baltimore, Maryland, Charleston, South Carolina, and Washington, DC, were also issued. Of special note were two mining treatises published in German in Ephrata, Pennsylvania (Barba, 1763).

The authors of these works were diverse. Clergymen including Thomas Prince, Cotton Mather, Thomas Foxcroft, and Mather Byles produced speculations on earthquakes. Naturalists Benjamin Smith Barton and William Bartram gave descriptions of local rock types as they compiled more general natural histories. Statesmen Thomas Jefferson and James Madison turned their pens to the subjects of fossil bones and mineral springs, respectively, and of

course Benjamin Franklin, whose interests were almost limitless, considered various aspects of the physical nature of the earth. In addition to the contributions of American writers, numerous European articles, letters, and books were reprinted or excerpted in American periodicals.

Whether book, article, or pamphlet, the vast majority of these eighteenth-century publications were descriptions, some extremely detailed, of isolated geological events or phenomena. Earthquakes were the most popular subject, with approximately 75 accounts appearing in print before 1800. The approach to this subject varied. As might be expected, some of the publications simply used the terrifying occurrence of the shaking earth as a jumping-off point for religious exhortations. Other publications, also religious in tone, differentiated between "first" and "second" causes of earthquakes, and thus included speculations on the natural causes of these events, as well as affirmations of the power of God. For Harvard's Hollis Professor, John Winthrop, the earthquake of 1755 provided an opportunity to observe and consider the characteristics of quakes. His *Lecture on Earthquakes* (Winthrop, 1755) contains data about the speed and manner in which the quake spread through New England and concludes with a perceptive interpretation of the wave-like motion of earthquakes. Even poets considered earth tremors suitable subjects, as in *Lines made after the great earthquake in 1755* (Anon., 1756):

In seventeen hundred fifty-five  
When vice its empire did revive  
Consuming fire, a jealous God  
Call'd on New England with his rod.  
Hark New England — Loud the thunder  
Awake ye sinners from your slumber  
By deeds no longer do defy  
That power descending from the sky.

One detailed treatise on New England earthquakes (Williams, 1785) lists more than 10 separate shocks (including the 1727 and 1755 quakes) as having occurred in the eighteenth century, so it is little wonder that there was much published about them. Other dramatic geological subjects, however, also elicited interest. Almost 30 separate accounts of volcanoes, especially Vesuvius and Etna, were published in America before 1800. There were no known active volcanoes in eastern North America, but readers were nevertheless interested in the destructive phenomena. Accounts ranged from short anecdotal pieces to longer discussions with reference to theories of volcano formation.

The discovery of mineral springs at Berkeley in western Virginia, Saratoga in New York, and other eastern localities led to the publication of more than 25 articles and pamphlets on the medicinal value, chemical composition, and origins of such waters. Articles on English springs appeared as well. Many eighteenth-century naturalists were trained as physicians, so this was a particularly appropriate union of disciplines.

Fossils, among the most intriguing geological objects, were noted throughout the eighteenth century. As early as 1706 such American "organic relics" were described, and by 1800 about 30 separate articles and notes had appeared documenting finds of fossils, especially giant bones, in Kentucky, New York, Virginia, Pennsylvania, and other eastern states. With some satisfaction, Thomas Jefferson

cited the discovery of the huge bones of the *Megatherium* to refute Buffon's assertion that American animals were degenerate (Jefferson, 1799). Occasionally the less spectacular, but equally important, fossilized remains of marine invertebrates were described in print.

During the last decade of the eighteenth century the number of publications on mining increased dramatically. Before the Revolution there were only four or five publications devoted to ores and mining, whereas more than 20 such contributions appeared in the period following 1785. Many articles deal with foreign mining in Poland (Willeska salt mine), Spain (mercury mines of Idria), and England (Cornish tin deposits). There are also short notes on the development of new American mines as well as the more general 1797 publication entitled "Observations on erecting and working mines in this country" (Rhode, 1797).

America was an agrarian nation, and a dozen articles appeared in the 1790's on the analysis and improvement of soils. Gypsum, a sulfate of calcium, was advocated as a fertilizer in a series of essays, most notably by Richard Peters (1797).

Caverns were a source of fascination during the eighteenth century. Of the dozen eighteenth-century publications on caves, about half were descriptions of foreign sites. The remaining notices were on American caves in Virginia, Pennsylvania, and Vermont (Hazen et al., 1979). The existence of Mammoth Cave, the most publicized of all American caverns, may have been known to white men as early as the 1790s, but knowledge of this Kentucky wonder was not widespread until the 1820s.

The remaining geological publications covered a wide range of subjects. Many were simply excerpts from the natural history sections of studies about particular geographical regions. For example, the study of the earth was viewed as just one aspect of natural history in Thomas Jefferson's *Notes on the State of Virginia* (Jefferson, 1788) and Jeremy Belknap's *History of New Hampshire* (Belknap, 1784, 1792). Other topics that were discussed include magnetic studies, chemical analyses, descriptions of geysers, conjectures on the origin of the earth, and even treatises linking health with particular geological formations and types of building stone (i.e., medical topography).

### The Emergence of Geology

In the light of this extensive and diverse body of literature, it would be tempting to conclude that geology flourished in America in the eighteenth century. This conclusion, however, is unsupported.

In the first place, the notion of geology as a distinct scientific discipline did not develop until late in the eighteenth century. Even the word "geology" was not generally used until the last quarter of the century. Samuel Latham Mitchill was probably the first American to use the word in print (Mitchill, 1787), though it appeared at least 10 years earlier in Europe. Certainly there was great interest throughout the eighteenth century in things of a geological nature, as an overview of publications demonstrates. The fact that writings were published on subjects that we now consider to be pertinent to geology, however, does not mean that the authors themselves perceived their works as geological. As Kenneth Taylor (1979) pointed out, this distinction is

important. Only in the late eighteenth century can we discern the true beginnings of a cohesive discipline, with which scientists were able to place isolated geological phenomena in a larger context, and thus better understand earth processes.

Secondly, if one compares the development of geology in Europe with that in America, it is apparent that the United States lagged behind, often by decades. Eighteenth-century Europe produced the great geological thinkers. Abraham Werner proposed that the earth's crust was the result of gradual precipitation from a ubiquitous ocean. James Hutton emphasized the importance of igneous action in the formation of rocks and clearly stated the concept of an incomprehensibly old earth. The theories these men held about the formation of the earth were to dominate geological discussions for years. In the field of mineralogy, Rene Just Haüy, Richard Kirwan, and others developed elaborate classification systems. Georges Cuvier applied his work in comparative anatomy to the identification, reconstruction, and interpretation of vertebrate fossils, thus spurring the growth of paleontology. Not only did the United States fail to produce original scientific thinkers of such stature, but in general Americans of the late eighteenth century were conversant with only a small range of this geological thought developing in Europe. The articles and books reprinted in North America seem to be almost a random selection, resulting in a crazy quilt of imported information. Of course, American reprints were not the only source of information on European activities, but the pattern is striking.

If geology did not flourish in the eighteenth century, what can be said about its development in America? It is safe to say that in the early decades Americans functioned as field workers, observing and recording data on geological phenomena. A similar trend is evident in American contributions to botany, zoology, and astronomy (Hindle, 1956). Then, gradually, by the end of the century, there developed a series of events that signaled the beginnings of more comprehensive geological thinking. For example, supportive scientific organizations came into existence. The American Philosophical Society in Philadelphia, which had been fostering scientific inquiry since the 1740s, was joined in 1780 by the American Academy of Arts and Sciences in Boston. In 1788 John C. Lettsom called for the formation of a mineralogical society, and by the next decade this was accomplished with the formation within the Chemical Society of Philadelphia of a mineralogy section. One year later Samuel L. Mitchill founded the American Mineralogical Society, whose aim was to foster "the investigation of the mineral and fossil bodies" of the United States and the world. Although it did not last long (1798-1800), this society promoted interest in mineralogy to an extent previously unknown in North America.

Several publications were significant landmarks in the development of American earth science. In 1794 the *Compendious System of Mineralogy and Metallurgy* (Anon., 1794) was published in Philadelphia. This text was the first American book devoted exclusively to the description of earth materials. The *Medical Repository*, America's first annual scientific periodical, was founded by Samuel L. Mitchill in 1798. Among the subjects that regularly appeared in its pages were notices of mineral and fossil localities, descriptions of local topography, and applications of

the newly developed field of medical topography. In addition, society journals such as the *American Philosophical Society Transactions* and the *American Academy Memoirs* disseminated information on geology.

Although geological subjects had been discussed in American colleges earlier in the eighteenth century (for example, Winthrop delivered his lecture on earthquakes at Harvard in 1755), the last decade of the century saw the inclusion of geological theory as an integral part of some natural philosophy courses. Samuel Mitchill (1792) offered training in geology at Columbia College, and by the end of the century the medical school of the College of Philadelphia had accorded academic status to mineralogy (Greene and Burke, 1978); other schools were to follow within the decade. In a related institutional development, Charles Willson Peale founded his American Museum in Philadelphia in 1785. Here, where fossils, minerals, and other natural curios were displayed, was yet another kind of support for geology.

Eighteenth-century progress in the development of American geology culminated in the work of Samuel Latham Mitchill, who made significant, yet perhaps not adequately recognized, contributions to geological research, education, and publication. He was the first American to assemble geological data systematically in order to produce a comprehensive regional study. His *Geological Remarks on Maritime Parts of New York* (Mitchill, 1787) and his *Mineralogical History of the State of New York* (Mitchill, 1798-1800) incorporated observations from the field into an overall system and thus paved the way for his more famous successors, William Maclure, Benjamin Silliman, Amos Eaton, and Edward Hitchcock. As noted above, Mitchill further demonstrated his leadership as a pioneer in American scientific education at Columbia College, where he presented one of the first American courses to emphasize geology and mineralogy. In addition, as the founder and editor of *The Medical Repository*, he was responsible for the widespread dissemination of geological knowledge in America. These contributions coincide with the true beginnings of the science of geology in America.

In 1803 Samuel Miller published *A Brief Retrospect of the Eighteenth Century*, in which he claimed that although the United States had been slow in developing mineralogy, the hope for the future of American science was bright. He wrote,

The emulation of providing and sustaining a national character in science and learning begins to be generally felt . . . . A larger proportion of the growing wealth of our country will hereafter be devoted to the improvements of knowledge, and especially to the furtherance of all the means by which scientific discoveries are brought within popular reach, and rendered subservient to practical utility. American publications are every day growing more numerous, and rising in respectability and character . . . (Miller, 1803, p. 409).

Miller was right about the future of geology. Geological publications increased exponentially during the nineteenth century (Hazen, 1980), as Americans recognized that the earth is a physical system with a history that can be deduced from natural phenomena. Progress made during the eighteenth century marked only the beginning of the long and continued growth of geology in America.

## Acknowledgments

This paper was presented at the Winter 1980 meeting of the Society for Eighteenth-Century Studies in Washington, DC. Many helpful additions and corrections were suggested by Cecil Schneer and Hatten S. Yoder, Jr.

## References Cited

- Anon., 1756, Lines made after the great earthquake, in 1755: Boston, broadside folio.
- Anon., 1794, A compendious system of mineralogy and metallurgy; extracted from the American edition of the Encyclopaedia, now publishing: Philadelphia, T. Dobson, 505 p.
- Barba, Alvaro Alonso, 1763, Grundlicher unterricht von den Mettalen, darinnen beschrieben wird, wie sie werden in der Erden generirt; und was man insgemein dabey findet. In zwey buchen: Ephrata, PA., J.G. Zeisinger, 2 v.
- Belknap, Jeremy, 1784-1792, The history of New Hampshire: Boston, I. Thomas and E.T. Andrews, 3 v.
- Greene, J.C., and Burke, J.G., 1978, The science of minerals in the age of Jefferson: American Philosophical Society Transactions, v. 68, p. 1-113.
- Hazen, R.M., 1980, Publication in American geology to 1850: Journal of Geological Education, v. 28, p. 249-255.
- Hazen, R.M., and Hazen, M.H., 1980, American geological literature; 1669 to 1850: Stroudsburg, PA, Dowden, Hutchinson and Ross, 431 p.
- Hazen, R.M., Hazen, M.H., and Finger, L.W., 1979, Speleological writings in early America: Journal of Spelean History, v. 13, p. 58-65.
- Hindle, H.B., 1956, The pursuit of science in revolutionary America: Chapel Hill, NC., University of North Carolina Press, 410 p.
- Jefferson, Thomas, 1788, Notes on the state of Virginia: Philadelphia, Prichard and Hall, 244 p.
- Jefferson, Thomas, 1799, A memoir on the discovery of certain bones of a quadruped of the clawed kind in the western parts of Virginia: American Philosophical Society Transactions, v. 4, p. 246-260.
- Merrill, G.P., 1924, The first one-hundred years of American geology: New Haven, CT, Yale University Press, 773 p.
- Miller, Samuel, 1803, A brief retrospect of the eighteenth century. Part first; in two volumes; containing a sketch of the revolutions in science, art, and literature, during that period: New York, T. and J. Swords, 3 v.
- Mitchill, Samuel Latham, 1787, Observations . . . To which are added geological remarks on the maritime parts of the state of New York: New York, J. M'Lean and Company, 16 p.
- Mitchill, Samuel Latham, 1792, Outline of the doctrines of natural history, chemistry, and economics . . . now delivering in the College of New York: New York Childs and Swaine, 31 p.
- Mitchill, Samuel Latham, 1798-1800, A sketch of the mineralogical history of the state of New York: Medical Repository, v. 1, p. 293-314, 445-452; v. 3, p. 325-335.
- Mulholland, J., 1981, A history of metals in colonial America: Birmingham, University of Alabama Press, 237 p.
- Peters, Richard, 1797, Agricultural enquiries of plaster of Paris: Philadelphia, C. Cist, 111 p.
- Rhode, Mr., 1797, Observations on erecting and working mines in this country: New York Magazine, v. 2, p. 449-453.
- Schöpf Johann David, 1787, Beyträge zur Mineralogischen Kenntniss des Östlichen Theils von Nord Amerika und Seiner Gebürge: Erlangen, Joh. Jakob Palm, 194 p.
- Taylor, K., 1979, in C.J. Schneer (ed.), Two-hundred years of American geology: Hanover, NH, University Press of New England, p. 75-90.
- Volney, C.F., 1803, Tableau du climat et du sol des États Unis d'Amerique: Paris, Courcier, Dentu, 2 v.
- White, G.W., 1969, In C.J. Schneer (ed.), Towards a history of geology: Cambridge, MA, Massachusetts Institute of Technology Press, p. 415-425.
- Williams, Samuel, 1785, Observations and conjectures on the earthquakes of New England: American Academy of Arts and Sciences Memoirs, v. 1, p. 260-311.
- Winthrop, John, 1755, A lecture on earthquakes: Boston, Edes and Gill, 38 p.

## About the Authors

Margaret Hindle Hazen received the B.A. at Wellesley College in 1970 and the M.A. in history at Boston University. She also holds an M.L.S. from Simmons College. Mrs. Hazen was a senior cataloger at the library of Boston University and subsequently became manuscript and rare book librarian of the New England Historic Genealogical Society. Her research interests include aspects of American social history and the scientific exploring expeditions of nineteenth-century America, as well as the history of American geology.

Robert M. Hazen, experimental mineralogist at the Carnegie Institution of Washington's Geophysical Laboratory, received the B.S. and S.M. in geology from the Massachusetts Institute of Technology in 1971 and the Ph.D. from Harvard University in 1975. His research interests include crystal chemistry of rock-forming minerals and high-temperature and high-pressure crystallography, as well as the history of North American geology.

## FOOD FOR THOUGHT

One of the principle objects of theoretical research in any department of knowledge is to find the point of view from which the subject appears in its greatest simplicity.

Josiah Willard Gibbs, 1881, Letter to the American Academy of Science (quoted in Science, v. 200, p. 1012).