Werner's Influence on American Geology

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In 1826 Thomas Jefferson wrote in a letter that "to learn, as far as observation has informed us, the ordinary arrangement of the different strata of minerals in the earth, to know from their habitual collocations and proximities, where we find one mineral, whether another, for which we are seeking, may be expected to be in its neighborhood, is useful. But the dreams about the modes of creation, enquiries whether our globe has been formed by the agency of fire or water, how many millions of years it has cost Vulcan or Neptune to produce what the fiat of the Creator would effect by a single act of will, is too idle to be worth a single hour of any man's life" (Jefferson, 1905, XVI, 171). Early American geology followed along the utilitarian lines described by Jefferson, but its efforts were guided by the system of the foremost Neptunist of the era, Abraham Gottlob Werner.

One need only open a book or journal dealing with geological matters or a textbook of geology published in the United States during this period, or even the reports of various expeditions which the United States government sent out to explore the West, to find that Werner's terminology, Werner's theories, and Werner's teachings were familiar to American geologists.

Abraham Gottlob Werner was a graduate of the Bergakademie at Freiberg, Saxony. In 1774, at the age of twenty-five, he published a classification of the external characteristics of minerals entitled *Von den äusserlichen Kennzeichen der Fossilien*, a book which won him wide acclaim in the geological world as well as an offer to teach mining at his alma mater. Werner accepted the offer and taught at the Bergakademie from 1775 until his death in 1817. During these years he lectured on virtually all the phases of geology that are included today in a curriculum in geology, and in so doing "he was the first, " as Keferstein writes, "to bring this knowledge to the academic lecture, to treat it as a separate science, to try to define all related subjects and give a clear understanding of them, and thus he shaped a science of material which had long been at hand" (Keferstein, 1840, pp. 66-67). Students from all corners of the world came to Freiberg to study under Werner. They were particularly interested in a course which he called geognosy, in which he taught the structure, relative position, and mode of formation of the mineral masses of which the earth's crust is composed. As a syllabus for this course he used a classification of rocks, which he published in 1786 under the title *Kurze Klassifikation und Beschreibung der verschiedenen Gebirgsarten*. This classification was based on his theories of the formation of the earth's crust, in which theories the importance of the action of water and the doctrine of geological succession take a central and fundamental position. All rocks were put into four classes: primitive, flötz, alluvial, and volcanic. To these Werner later added a fifth class, which he called transitional. It was Werner's theory that the earth was once covered by a universal ocean and that the materials of which the earth's crust consists were at one time dissolved or suspended in that ocean. The primitive rocks were formed first. They are crystalline and contain no organic remains. Next came the transitional rocks, which are partly chemical depositions and partly clastic depositions. They contain some organic remains, and they are deposited in an unconformable position relative to the older rocks. After the formation of the transitional rocks, the flötz rocks were formed. (*Flötz* is a mining term for a horizontal stratum, and *flötz rocks* and *flötz formations* can best be translated as *stratified rocks* and *stratified formations*. They are sometimes referred to as secondary rocks.) Werner thought that the flötz rocks had probably been derived from primitive and transitional rocks. They contain many organic remains, they are more calcareous and argillaceous than the primitive rocks, and above all they are stratified. Volcanic rocks are those which owe their existence, or at least their alteration to fire, and Werner divided these into true volcanic and pseudo-volcanic rocks. The newest rocks he believed to be the alluvial rocks, which he described as lying one above the other in horizontal beds of extremely different thicknesses, consisting almost entirely of parts of destroyed primitive and flötz, and sometimes even volcanic, formations (Ospovat, 1958, pp. 18-23).

One famous American geologist who adopted Werner's classification as well as Werner's nomenclature was William Maclure, who published the first geological map of the United States, thereby earning the title of "father of American geology" (Merrill, 1906, p. 217). Maclure's map, together with an article entitled "Observations on the Geology of the United States, explanatory of a Geological Map," was published in 1809 in the *Transactions of the American Philosophical Society*.

Maclure has been said to have studied under Werner, but this is not known with certainty. There are indications, however, that he did: during his travels in Europe he visited Saxony, and among the books that he gave to the Academy of the Natural Sciences of Philadelphia was Oppel's revised edition of Kern's *Bericht vom Bergbau*, which Werner used as a text in his course on mining and for the introductory part of his course on geognosy (Werner, 1778).

Be that as it may, it is quite clear that Maclure understood Werner's theories well. Although he wrote that in adopting Werner's nomenclature he did not mean to enter into the origin of the different materials which compose the earth's crust, he also wrote that in the geology of the United States might "perhaps be found . . . the most correct elucidation of the general exactitude of that [Werner's] theory, as respects the relative position of the different series of rocks" (Maclure, 1809, pp. 427, 412). Maclure had little use for anything that was not useful, but he could not very readily separate the classification of rocks from the theory on which it was based.

Maclure thought Werner's system "the most perfect and extensive in its general outline" (Maclure, 1809, p. 411), and his map is clearly based upon it, showing four classes of rocks: primitive, transition, secondary (Werner's flötz), and alluvial. The alluvial class occupied the area beginning with Long Island, extending southward and westward, roughly following the fall line, to the eastern border of Texas and from there northward along the Mississippi River somewhat beyond the point where the Illinois River flows into it. The primitive class occupied most of the New England states, extending southward to Long Island, where the fall line became its eastern border, and then south to the Alabama River. Its western limit was the Appalachian Mountains. To the west of the primitive class ran a narrow belt of transitional rocks, which extended from Albany, New York, to the Tombigbee River in Alabama. Between the alluvial rocks which followed the Mississippi River and the transitional rocks lay the flötz, or secondary, rocks. When a second edition of Maclure's work was published in 1817, the map was somewhat revised, but the classification and nomenclature were still Werner's.

A very significant landmark in the history of American geology is the appointment in 1802 of Benjamin Silliman to the professorship of chemistry and natural science at Yale University. Silliman had been educated in law and did not have even the most rudimentary knowledge of the sciences he was to teach. To prepare himself for the task, therefore, he went to Philadelphia to attend lectures on chemistry and, in 1805, to Edinburgh, then the geological center of the English speaking world, where such proponents of the aqueous and igneous theories of the origin of the earth's crust as the Wernerians Jameson and Murray and the Huttonians Hall and Playfair were arguing their case. Silliman listened to both sides and emerged a Wernerian. He wrote, "I was a diligent and delighted listener to the discussion of both schools. Still the igneous philosophers appeared to me to assume more than had been proved regarding internal heat. In imagination we were plunged into a fiery phlegethon, and I was glad to find relief in the cold bath of the Wernerian ocean, where my predilections inclined me to linger" (Silliman, 1842, pp. 229-230). The fact that Silliman had become a Wernerian was important to early American geology because he was to teach the subject to many Americans, not only at Yale but also in popular lectures throughout the eastern states. In 1829 he published an *Outline of the Course of Geological Lectures given in Yale College,* in which he wrote, "The arrangement implied in the following sketch is . . . founded upon the great outlines of the Wernerian plan. Whatever may be the errors and imperfections of that system, (for it undoubtedly has both,) its great outlines still appear to be founded in truth, and to the present the best clew to conduct the young pupil through the labyrinths of geology. It has become fashionable to decry Werner; but, without being his blind admirer, I may be permitted to ask, who has done more for geology, and who has done it better?" (Silliman, 1829, p. 4).

The widespread interest in mineralogy and geology in the United States and the teaching of these subjects in schools of higher learning

created a demand for a textbook, and in 1816 the first one by an American was published in the United States. This was Parker Cleaveland's *An Elementary Treatise on Mineralogy and Geology*. By far the largest portion of the work is devoted to mineralogy, only fifty-five pages of a total of more than six hundred and fifty being devoted to geology. In his treatment of minerals Cleaveland adopted Werner's classification and definitions of the external and physical characteristics of minerals, combining these with the mineral system of the Frenchman Haüy, which was based largely on the crystal form of minerals. In the portion of the text reserved for geology Cleaveland followed Werner almost exclusively, remarking that the "classification of rocks has been effected by Werner with as much accuracy, perhaps, as the nature of the subject permits, in regard to all those rocks, which have fallen under his observation" (Cleaveland, 1816, p. 587).

Cleaveland's work was well received, and the demand for it was great enough that a second edition was published in 1822. Certainly it did much to spread Werner's teachings in America.

In 1818 J. Freeman Dana and his brother Samuel L. Dana published a brief description and map of the mineralogy and geology of Boston and its vicinity, employing not only Werner's classification of rocks but also his colors for the different minerals shown on the geological map. In the same year Samuel L. Mitchill, statesman, educator, and one of the outstanding scientists in America, published his "Observations on the Geology of North America," which was appended to Robert Jameson's edition of Cuvier's *Essay on the Theory of the Earth*. Mitchill believed that water was the most important agent in the formation and alteration of the earth's crust, and in his theories and terminology he followed Werner. His biographer writes that "examination of the Doctor's work in these two sciences [mineralogy and geology] fails to disclose any theories of the earth's formation out of harmony with Werner" (Hall, 1934, p. 72).

Amos Eaton's first important geological publication, *An Index to the Geology of the Northern States*, which he had prepared for the geological classes at Williams College, Northampton, Belchertown, Leicester and Worcester, Massachusetts, also appeared in 1818. Eaton had studied under Silliman and was a Wernerian. He classified all rocks as primitive, transition, secondary, superincumbent, and alluvial, and, like Werner, he attributed little importance to volcanoes. In his *Geological Nomenclature for the United States* (1828) he used Werner's system and terminology, and in his *Geological Text-book*, which he prepared in 1830 for popular lectures on North American geology, he wrote that Werner's "classification of facts must ever form the basis of all future geological enquiries" (Eaton, 1830, p. 13). It certainly formed the basis of all of Eaton's geological work.

While at Albany in 1818, Eaton was invited by Governor De Witt Clinton to deliver a course of lectures on chemistry and geology before the members of the legislature of New York (Schuchert, 1918, p. 56). He is probably the only American ever to have delivered such lectures before a state legislature. Because of this he became acquainted with important men and was able to arouse their interest in geology and also to influence their geological concepts.

The United States had learned very early in its history that it could not depend upon the whims of European statesmen such as Pitt the Younger and Napoleon Bonaparte if it wished to survive and remain independent. The War of 1812 made it clear that it must develop its own resources and dominate the country from ocean to ocean. The phrase "manifest destiny" had not yet been coined, but the spirit of it already existed during the Era

of Good Feelings. It was with this spirit in mind that Secretary of War John C. Calhoun gave his instructions to Major Long when, in 1819, he sent him to explore the Missouri and Arkansas rivers, the Mississippi River above the mouth of the Missouri, and the Red River. In his instructions to the geologist of the expedition, Long wrote that he was to report the "geology, so far as it relates to earths, minerals, and fossils, distinguishing the primitive, transition, secondary, and alluvial formations and deposits . . . without regard to the theories or hypotheses that have been advanced by men of science" (Thwaites, 1905, p. 42). And we find in the geological reports of the Long Expedition the name of Werner, as well as his classification and terminology.

George P. Merrill, in his book *Contributions to the History of American Geology,* names the early period in American geology after William Maclure and Amos Eaton, calling the period from 1785 to 1819 the Maclurean Era and the period from 1820 to 1829 the Eatonian Era (Merrill, 1906, p. 193). Considering Werner's influence on these men as well as many other American geologists, it would not be inappropriate to call this period the Wernerian Era of American geology.

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