PIONEER GEOLOGIC INVESTIGATION
IN PENNSYLVANIA

BY BRADFORD WILLARD*

BEGINNINGS

A MINERAL producing state, Pennsylvania has a long, important history. Coal (hard and soft) abounds; the anthracite is without equal. Petroleum and natural gas exploitation reach back to the drilling of the first well at Titusville in 1859. Iron has been mined since colonial times, and limestone is important as a source of cement and as a blast furnace flux. Zinc production has been intermittent. Siliceous sandstone, crushed for silica sand, is used in glass manufacturing and making silica brick. Gravel, sand, and clay are less important products. Except for iron and zinc, metal production has never been extensive, although years ago a little copper, chromite, nickel, and lead were mined, and copper and gold are today by-products of the Cornwall iron mines. Water, our most important natural resource, is something with which Pennsylvania is generally amply blessed, although recent wasteful exploitation and contamination cause apprehension. Pollution is beginning to be controlled, but uneconomical use of water, for example in air cooling systems, may seriously lower the water table locally.

When the first Europeans came to settle in Penn's Woods, they knew nothing about its mineral resources. The Indians passed on no information. Stone for building was early used, both "field stone" and quarried blocks. Construction with limestone in south-

*Dr. Willard is Professor Emeritus of Geology at Lehigh University. Until his retirement in 1959, he was Department Head. He is the author of over 100 articles on the geology of Pennsylvania.

central and southeastern counties is illustrated by many colonial farmhouses. The massive walls of eighteenth-century buildings of the Moravian settlement in Bethlehem are an illustration. The lasting qualities may be attributed in part to the substantial walls. Some years ago the purchaser of what was said to be the John Harris house in Harrisburg modernized it and remarked that the installation of pipes and wires was a veritable quarrying operation.

Wood was the universal fuel. Precious iron was at first imported, but by the early 1700's native ore was worked. It seems almost incredible that the forefathers penetrating the wilderness recognized small, workable deposits of iron ("bog") ore. Doubtless, some men had had experience in the Old World and were on the lookout for ore. William Penn himself knew iron furnaces in Sussex, England, and mentions iron and copper in the new country. Today, those scattered pockets of ore are long abandoned—worked to bed rock and the pits tree-grown. So assiduously were they exploited that it is not easy today to find a hand specimen.

Visitors to Bethlehem sometimes express astonishment that the great steel works is here, far from ore or fuel. Go back to earlier days and conditions for the answer. In slack times, the local farmers dug ore from pockets in the limestone of the Lehigh Valley, or from quartzite along the flank of South Mountain, and carted the product to small, charcoal-fired furnaces in town. The operation had at its door limestone for flux. As local ore was depleted, the newly developed railroads brought ore and coal to enlarged and converted furnaces. From small beginnings grew a mighty steel industry.

A different transportation problem is exemplified by the now long-abandoned Lehigh Furnace on the south flank of Kittatinny Mountain west of the Lehigh Water Gap. This furnace was opened in 1826. The ore and flux were trekked to the furnace from mines and limestone quarries in the valley. Why? The third ingredient, charcoal, was made locally from the forest, but to have carted this fragile fuel south to the furnaces over the rough roads of those...
days would have reduced it to powder. The charcoal remained where it was made, the ore and limestone were brought to it. Mohammed came to the mountain.

Eventually, some of the charcoal-burning furnaces in eastern Pennsylvania besides Bethlehem were converted to coal-fired ones. Durham in northeast Bucks County is an instance. Ore was discovered here in 1698; smelting commenced in 1726. Locally, limestone was quarried and charcoal produced. The ore at Durham was not dug from pits, but mined underground in Rattlesnake and Mine Hills in the form of hematite and magnetite associated with ancient metamorphic rocks. With the completion of the Lehigh Canal from Mauch Chunk (Jim Thorpe), anthracite was hauled to Durham. In earlier days the finished product, pig iron, was shipped to Philadelphia in Durham boats on the Delaware River. The coming of the railroads made coking coal from the west available, leading to discontinuance of the use of “hard coal.” Operations at Durham ended in 1908. Other early iron works were at Pool Forge (1717), Colebrookdale (1820), “Redding” on French Creek (about 1728), and Martic (1750-1872) and Windsor (1742 through the War of 1812) in Lancaster County (cf. Klein, footnote 1). Cornwall, a charcoal-fired furnace, started in 1742, and was later converted to coal. Here, Peter Grubb in 1735 leased from the Indians rights to “use the red dirt as long as grass grows and water flows.” Grubb and the Indians are gone, but mining continues at Cornwall (cf. footnote 3).

Long before petroleum was produced from wells, it was known in western Pennsylvania. Indians wove legends about it, and Braddock’s men in the expedition against Fort Duquesne in 1755 are said to have anointed their weary feet with “rock oil.” An early mineralogist, Parker Cleaveland, comments on its presence in northwestern Pennsylvania. “Oil springs” were recognized by

\textsuperscript{6} Much information on early iron mines is to be found in the writings of Professor Billinger of Lehigh University: Robert D. Billinger, “Early Iron Works in Pennsylvania, the Durham Furnace,” Industrial and Engineering Chemistry, XXX (1938), 428-436, and “The Cornwall Furnace, in Early Iron Works in Pennsylvania,” Iron and Steel Engineers, XV (1938), 68-72.


early settlers. Some oil was recovered by soaking it up in blankets which were rung out, the bottled product marketed as "Seneca Oil." One enterprising wight sold it under the following quatrain, encountered by the writer of this article when he was an undergraduate:

The useful balm from nature's hidden spring
The bloom of health and youth to man does bring.
As from her depths the magic liquid flows,
To calm our sufferings and assuage our woes.

Credit is due the acumen of the first farmers who occupied the great limestone valleys with their excellent soil. Could they have known Lewis Evans's *Analysis* (cf. footnote 6)? Thomas Pownall (footnote 9), ostensibly quoting Evans, says: "Every Farmer has a Limekiln burnt for the dressing of his land..." These folks left the rocky hillside to others such as the "Scotch-Irish," who, 'tis said, imported three essentials: a flintlock, a jug of rum, and the family Bible. It is opined they understood the internal workings of all three.

Although the soil in the non-glaciated, limestone valleys is derived through age-long weathering of the basic carbonate bed rock, that soil is, paradoxically, acid. Weathering dissolves the carbonate compounds and leaves an insoluble residue of clay with silica and compounds of iron and aluminum which give an acid reaction. Parenthetically, occasional concentrations in pockets of the more iron-rich soil produced the "bog iron" deposits already mentioned.

It certainly was not through instinct that the settlers understood the acidity of the soil, and of course they had no chemical analyses, let alone soil testing kits! Yet understood it they did, perchance through experience in "the old country." These farmers knew that the land was "sour" and must be "sweetened." How was this to be done? On many farms in the limestone lowlands were opened small quarries from which limestone was "gotten out," dumped into kilns, calcined with charcoal or wood or fuel, and subsequently spread over the fields. Today, those long-abandoned quarries and tumbled-down kilns may still be spotted, but the modern farmer uses "boughten lime."

The foregoing anecdotes stem from the days when there were
no professional geologists worthy of the title. The science came into its own about the end of the eighteenth century under such European original thinkers as James Hutton, Abraham Werner, Nicolas Desmarest, J-E Guettard, the great Cuvier, and William ("Strata") Smith. The application to man's benefit was not long to follow. Even before that time, there was at least one man who applied earth lore in evaluating the country.6

Lewis Evans, a Welshman, came to Pennsylvania early in the eighteenth century and carried on as a "geographer," which in modern parlance might be best designated a cartographer. His first contribution was a map of the Walking Purchase, 1738. It shows the courses of the lower Delaware and Lehigh rivers and the distribution of some of the mountains. Evans followed this with his map of the Middle Colonies, 1749, which was corrected and improved in the 1755 edition, rushed through printing in time for Braddock to use it in his ill-fated expedition against Fort Duquesne.7

Evans records with remarkable accuracy facts and observations on physiography, or, as he calls it, "the face of the country," in Pennsylvania and adjacent colonies. He recognizes distinct divisions from the Atlantic coast west through the Allegheny Plateau. The Coastal Plain is characterized as a band of ocean sand which overlies sea mud full of shells, among them some bivalves still articulated though thirty miles inland. He remarks on "drift trash," the outwash of debris from the western highlands. The present-day Triassic lowland with its red soil and many basaltic ridges is recognized across the colony as a "vein of red marl." Evans identifies our Piedmont with its small hills as "the Isenglass Mountains," and comments on the falls of several rivers which traverse this belt, a phenomenon more or less


7Recently, George W. White has published two summaries of Evans's contributions to the geology of the eastern states: George W. White, "Lewis Evans' Contributions to Early American Geology, 1743-1755," Illinois State Academy of Science, *Transactions*, XLIV (1951), 152-158; and "Lewis Evans (1700-1756): A Scientist in Colonial America," *Nature*, volume 177 (1956), 1055-1056. The present author is concerned only with those parts of Evans's work which apply to Pennsylvania.
identified with our Fall Line. The Older Appalachians are dubbed South Mountain, just as today, which he shows as a continuation of the Highlands of the Hudson. South Mountain (including Clay Hill) is set off from the next ridges, our Younger or Folded Appalachians, by a valley eight to twelve miles wide, largely underlain by limestone and possessing good soil. This is of course the Lehigh Valley and its continuation southwestward into other similar lowlands across the state. Beyond is “Kittatinny Mountain,” for which Evans also uses the synonyms Blue and North, terms still heard today, although Kittatinny is the accepted, official name. Evans’s “Kittatinny Mountain” merges eastward in New York with the “Shavingunk Mountain.” Evans maps the “Tuscarora Hill” beyond Kittatinny, and finally, stretching north and northwest, the “Endless Mountains” (a direct translation of Appalachian), embracing our Folded Appalachians, but also the Pocono Plateau (not “mountain”) and the Allegheny Plateau westward towards Ohio. “Allegheny Ridge” or “Mountain” is today’s Allegheny Front, the boundary between the Appalachians proper and the western plateau country.

Evans’s Analysis describes the rivers in considerable detail and shows a knowledge of their navigability. He mentions a number of economic “minerals” such as salt, limestone, grindstones, and the “red marl” which, in New Jersey, carries copper. The only metal which he records as being dug in Pennsylvania is iron. But he saw samples of lead and copper and mentions a “Chalybeat” (i.e., mineral) spring. Under “stones” are listed marble quarried near Philadelphia, and building stone near Chester. Clay for bricks is listed, and “Cimolia,” presumably serpentine, suitable for doorsteps. Finally, Lewis mentions flints, crystals, iron compounds, and gypsum, but no chalk cinnabar nor “sea coal.”

Thomas Pownall, colonial governor of Massachusetts, was a friend of Evans, and the latter dedicated his 1755 map to Pownall. Pownall was an enthusiastic geographer (cartographer). Late

[^8]: “Sea coal” was used for coal that was dug rather than manufactured charcoal. Even in Evans’s time this was an anachronism from Elizabethan English. It was used by Shakespeare for mined coal brought by boat to London. Cf. Bradford Willard, “The Geology of Shakespeare,” The Scientific Monthly, XLV (1947), pp. 399-404.

[^9]: Thomas Pownall, A Topographical Description of the Dominions of the United States of America (1784). This work was a revision of an earlier account and was republished in 1949, when it was edited by Lois Mulkearn, Librarian, Darlington Memorial Library, University of Pittsburgh (Pittsburgh: University of Pittsburgh Press, 1949).
in the century he re-edited Evans's map with changes and additions. The final edition of Pownall's material remained long in manuscript. Pownall added little to the geologic observations of Evans.

**EARLY APPLICATIONS OF MODERN GEOLOGY**

When did modern geology invade the United States and Pennsylvania? In the closing years of the eighteenth and the beginning of the nineteenth century, there were printed a few desultory papers of little significance, and doubtless unintelligible to most of the contemporary citizenry. Many of these articles seem quite naive today. Most of the early writers were handicapped by being still immersed in the Noachian deluge, despite the influence (or their ignorance) of James Hutton. A selection of some of the more significant papers follows.

Probably the first publication devoted solely to a geological phenomenon or observation in Pennsylvania is by the Reverend Mr. T. Hutchins on the falls of the Youghiogheny River at Ohiopile. In 1817 Henry Steinhauer published a paper adorned with copper plates illustrating coal plants, and about the same time, trap rocks were discussed by J. B. Gibson. J. Finch (1824) left an interesting description of the region about Easton. He mentions the minerals found between the Delaware and Lehigh Water Gaps. H. H. Hayden (1833) mapped mineral localities in the "iron belt" from Maryland to near Philadelphia, and in 1830 described the Bedford Springs and coal near "Pittsburg" (no final "h" in those days). According to J. P. Lesley (1874, cf. footnote 23), Richard Harlan found a trilobite near Reading about

1835. This reference has not been verified. However, in 1838 Jacob Green described a trilobite from Huntingdon. Green published several papers on trilobites, some of which apply more or less directly to Pennsylvania. Gerard Troost in 1826 printed a map and description of the geology around Philadelphia.

Albeit Amos Eaton is best remembered for his comments on New York geology, he did cross the border into Pennsylvania. In 1833 Eaton commented on coal plants, which he compared with descriptions by the French paleobotanist, Brogniart. In 1830, Eaton published his Text-book. This pathetic little volume is poorly organized and lacks cohesion. There are a colored map and sections of New York and northeastern Pennsylvania. Eaton lists five “Carboniferous” formations and apparently used the word to designate any thick, black shale. He describes a section from Jefferson County, New York, to Northampton County, Pennsylvania, and mentions coal at the bases of the Allegany and Catskill “mountains” as at Carbondale, Pennsylvania. He has the bituminous coal of Tioga extending all the way north to Cayuga Lake! Like some contemporaries, Eaton was sure New York had coal and he was bound to prove it.

Richard C. Taylor, an Englishman, spent much time in Pennsylvania and published several creditable papers. Some of the more significant are listed below. Probably his best contribution

---

17 Amos Eaton, “The Coal Beds of Pennsylvania Equivalent to the Great Secondary Coal Measures of Europe,” American Journal of Science (Silliman’s Journal), XXIII (1833), 399-400.
is a map of the southwestern part of the Anthracite Region (1840). It is well drawn and shows not only the hard coal areas but adjacent (westward) bituminous basins. Taylor had analyses of the coals run at Columbia College. He believed some of the southern anthracite was actually bituminous and printed analyses to prove it, two examples being here quoted:

<table>
<thead>
<tr>
<th></th>
<th>Carbon</th>
<th>Volatiles</th>
<th>Ashes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example</td>
<td>78.8</td>
<td>13.2</td>
<td>8.0</td>
</tr>
<tr>
<td></td>
<td>77.5</td>
<td>11.0</td>
<td>11.5</td>
</tr>
</tbody>
</table>

Other tests indicated several varieties of coal, some of which were suitable for coking and use in potential iron smelting. Some coal was tried out in a "locomotive engine," some at the Brooklyn Navy Yard, and more in an iron manufactory in Boston. Taylor's observations of Pennsylvania's geology were wider than his publications indicate, for James Hall (cf. footnote 27) gives Taylor credit for most of the information on Pennsylvania geology incorporated in Hall's 1843 map of the eastern United States.

Most accounts of early geologic mapping in the United States commence with William Maclure, 1809, but recently John W. Wells has carried the matter back a step to a French count, F-C. Volney. Volney is listed in the United States Geological Survey bibliography, but his work seems to have been neglected. Volney observed geology in the States, then returned to France and published his findings. His text and colored geologic map, 1803, includes Pennsylvania. The work was translated by C. B. Brown a year later (cf. footnote 21). The map, "Face of the Country," reaches from Canada to Florida and from the Atlantic to the Mississippi. Volney cites Evans, and it is obvious that he made free use of the latter's work in compiling his map, although

---

Footnotes:
21 F-C Chasseboeuf Volney, Tableau du climat et du sol des Etats Unis d'Amérique, suivi d'éclaircissements sur la Floride, sur la colonie française en Scieia sur quelque Colonies canadiennes et sur les sauvages (2 vols., Paris: Courcier et Danton, 1803) [with colored geologic map of the eastern part of the United States]. Volney's original was apparently well received, for an English translation by C. B. Brown was published in Philadelphia the following year, 1804.
with several errors. Nevertheless, Volney's was, so far as is now known, the first colored geologic map to embrace Pennsylvania.

By 1830, interest in geology was becoming widespread in the United States, and much of this interest may be attributed to the publications of William Maclure. Maclure, a Scot and no amateur geologist, came to the United States and spent months gathering geologic information on the eastern part of the country. He had experience in Europe where he knew some of the leading geologists, and he was later acquainted with Benjamin Silliman at Yale. In 1809 Maclure published a hand-colored geologic map of the eastern states and a short accompanying text.²² J. P. Lesley in his "Historical Sketch" refers to Maclure as "the father of American Geology," an encomium which may have been exaggerated (cf. Wells, footnote 21), although Maclure's influence was considerable.²² Besides his map and text, he contributed to the endowment of the Philadelphia Academy of Natural Sciences and presented it with his library and "cabinet."

Maclure's brochure came at a period when men were moving west, and when many of these migrants were on the qui vive for mineral deposits. As public interest in geology waxed, funds were appropriated in several Eastern states to establish official geologic surveys.

When the journal of the Philadelphia Academy of Natural Sciences commenced in 1817, several geologists were interested. By 1832 certain public spirited geologists, among them R. C. Taylor, Richard Harlan, Jacob Green, Gerard Troost, T. A. Conrad, William Maclure, and G. W. Featherstonbaugh, formed the Geological Society of Pennsylvania. The society was organized "for the scientific and practical study of the mineral resources of the Commonwealth" and with the express purpose of memorializing the legislature to authorize an official survey. This society, by the way, was ancestral through its successor, the Association of American Geologists (1840), to the American Association for the Advancement of Science, which was born in Philadelphia in 1848. The original Geological Society of Pennsylvania opened with


seven members and grew to over 200. Backed by other organizations in nearby parts of the state, it petitioned the legislature for the creation of a survey. After some haggling, an act was passed, May 29, 1836. The society thereupon disbanded. Henry Darwin Rogers, Professor of Geology and Mineralogy at the University of Pennsylvania and brother of William Barton Rogers, State Geologist of Virginia, was appointed Pennsylvania’s first state geologist.

THE FIRST PENNSYLVANIA SURVEY

The establishment of the First Geological Survey of Pennsylvania initiated a long series of exploration and exploitation of the rocks of the state and led to more systematic investigation of its mineral resources. With little to go by from the past and operating under primitive conditions, the Survey was in the words of G. P. Merrill “a brilliant success.” To the present-day geologist with his automobile and airplane reconnaissance, the difficulties of old can hardly be appreciated unless, indeed, the modern field man is assigned to some wilderness. The present author comments on the Rogers Survey thus:

It is remarkable that, hampered by inadequate funds, a dearth of trained helpers, operating almost before transportation began to shift from stage coach and Conestoga wagon to canal and railroad, and working in a nearly unmapped region, much of which was still a wilderness so wild that even the pack train proved impracticable, such results were obtained.

In the span from 1836 to 1842, when most of the field work was done, Rogers and his staff gathered a remarkable store of facts. In the first year he ran a traverse from near Chester to Erie and recognized essentially all of the major divisions of the Paleozoic rocks of Pennsylvania. Six annual reports were issued. Although


not exactly entertaining reading, they tell of areas explored and observations recorded. Among items stressed are coal, the Clinton iron ores of central Pennsylvania, and the mighty structures or “lay of the rocks.” With Rogers, structural geology in the United States began and previously existing fictions vanished. A unique feature of these reports is that they were issued bilingually, in English and what purported to be German. An example of the latter language is a comment on “anthracite kohlen Basins.”

Because of its bearing upon Rogers’s studies, mention seems in order of contemporaneous work by James Hall in New York and Charles Lyell from England. The New York Survey was founded contemporaneously with that of Pennsylvania, but followed a different approach with emphasis on paleontology under the leadership of James Hall, the greatest paleontologist the United States has produced. Hall’s 1843 report is graced with a hand-colored geologic map on a scale of thirty miles to the inch. It covers the area from the Province of Quebec to Virginia and from the Atlantic Coast to the Mississippi River. The map shows clearly and accurately the distribution of formations. There is also a remarkably good cross-section. Hall acknowledges the help of R. C. Taylor (cf. footnote 19), who supplied data for eastern Pennsylvania.

Sir Charles Lyell, the eminent if not the foremost of British geologists of all time, visited the United States and traveled widely in the early 1840’s. On his rounds he visited and conferred with many of our leaders in geology and from them gleaned much information. Returning to England, Lyell published Travels in America, and with the text a hand-colored geological map, on the scale of seventy-five miles to the inch, of the Eastern states. Lyell was, according to John M. Clarke, a plagiarist. The work was printed with few credits to the men whom he interviewed.

27 James Hall, Geology of New York, part 4, comprising the survey of the Fourth Geological District (Albany, 1843) [with hand colored geologic map].

28 Charles Lyell, Travels in North America in the years 1841-1842 (2 vols., New York, 1845) [includes a hand colored geologic map]. Also subsequent editions.

29 John M. Clarke, James Hall of Albany, Geologist and Paleontologist (Albany: John M. Clarke, 1921). Clarke refers to Lyell as “the pump” because of his appropriation of data from local geologists. Among Lyell’s acquaintances was Henry D. Rogers, whom Lyell later was to see more of when Rogers became professor at Glasgow.
Lyell’s map includes Pennsylvania, but adds little or nothing to Hall’s. However, both Hall’s and Lyell’s maps were available to Rogers while he was compiling his final report and accompanying map.

In 1857 Rogers was appointed Regius Professor of Natural History at the University of Glasgow, Scotland, where he remained until his death in 1866. For a United States citizen to have been offered such a post at that time is a remarkable tribute to Rogers’s fame and ability.

While in Scotland, Rogers finished his comprehensive *Geology of Pennsylvania*. The text was printed in Philadelphia, the plates and map were engraved in Edinburgh. A truly magnificent work in two quarto volumes, it contains handsome illustrations reproduced from sketches made in the field by George Lehman before the days when outdoor photography was common. Accompanying the text is a 75 by 38-inch, colored geologic map of the Keystone State. It is one of the earliest of its kind printed in colors, in contrast to its hand-colored predecessors. According to J. B. Marcou, “Chromatolithography” was introduced into geologic maps in 1854.

Rogers coined his own terminology for the several time-rock divisions of the Paleozoic of Pennsylvania because he did not accept terms currently in use, particularly in New York, although he lists their equivalents to his nomenclature. His names are based on Latin-derived words for the parts of the day, descending from Seral (nightfall) at the top or youngest, to the oldest at the base, Primal (dawn). The late J. B. Woodworth in his Harvard lectures on the history of geology remarked that Rogers “published a bizarre, Byzantine Latin nomenclature whose terminology was wholly unrelated to lithology, fossils, localities or any other distinguishing geologic feature or phenomenon.” The nomenclature is forgotten, but Rogers’s contributions to Pennsylvania’s geology stand time’s erosion.

The final report presents many data on the occurrences of

---


30 Henry D. Rogers, *The Geology of Pennsylvania* (2 volumes, Philadelphia, 1858) [with colored geologic map].

mineral deposits, particularly iron ores. There are over 400 pages devoted to anthracite, only about half as many to bituminous coal. Once Rogers mentions petroleum, stating that a little had been noticed in quarries (presumably a seep). The *Geology of Pennsylvania* rang down the curtain on the First Survey. Doubtless many then believed that its publication left nothing more to be done but apply its wisdom. It so remained for a generation. In another three years after its printing, the country was fighting the Civil War, which interrupted geologic progress. Possibly there was application of Rogers's map in the Gettysburg campaign in Pennsylvania, as mentioned recently by the present author.\(^{53}\)

**INTERSURVEY YEARS**

With the return of peace, the combination of unsettled conditions, the postbellum upsurge of industry, the opening of scores of new mines, railroad cuts, and other rock exposures, the further migration westward of Easterners, and the rehabilitation of the South, the mineral industry expanded rapidly. Blast furnaces demanded ore, coking coal, and limestone. The general introduction of the Bessemer process followed close after the war. Railway tracks edged farther and farther across the landscape as woodburners gave place to coal-fired locomotives. Anthracite was in ever growing demand in the northeastern states as the chief fuel for heating private and public buildings. Railways operating out of the anthracite fields of Pennsylvania were known as "the hard coal roads," not only because of their freight from mines to cities, but also because of their use of anthracite as a fuel for the locomotives. The smokeless motive power made summer travel beside open car windows a luxury on "The Road of Anthracite" (the Delaware, Lackawanna and Western), the Lehigh Valley, the Jersey Central, the Delaware and Hudson, and the Philadelphia and Reading.

Slate, today largely supplanted by "artificial" roofing materials, was widely used. It was quarried in northern Lehigh and Northampton counties. Petroleum production was booming in our northwestern counties since the completion of the Drake well in 1859. In the Lehigh Valley the manufacture of portland cement began

\(^{53}\) Bradford Willard, "Geology and Wars," *Pennsylvania History*, XXX (1963), 393-419.
GEOLOGIC INVESTIGATION

at Coplay in 1873, although there had been feeble efforts to produce natural cement in the 1830’s. The valley was destined to become one of the great cement producing areas in the nation.24

Zinc mines were opened in the Saucon Valley south of Bethlehem. In 1830 an unknown mineral discovered at Friedensville had been tested for iron with negative results. However, in 1845 the presence of zinc was proved,25 and the manufacturing of zinc oxide for paint began. Water flooding problems developed and beset open cuts and subsurface workings. To control the floodings, there was installed about 1872 a huge pumping engine, “The President.” It dewatered the mines, sure enough, but also the regional wells, so that the local people were up in arms. With threatened suits, the engine was abandoned, and production ceased pro tem. Since World War II the New Jersey Zinc Company has resumed operation with modern methods of handling the water problem.

The interest in geology spurred the teaching of the subject in our colleges. In the early 1830’s it was offered at University of Pennsylvania and probably at Dickinson,26 and geology and mineralogy were available at Lafayette College from 1837 to 1848.27 Today about a dozen colleges and universities within the state’s borders offer a major in geology, and several of them have graduate programs. Pennsylvania’s latest development in geologic education is the offering of “Earth Science” in our public schools.

THE SECOND PENNSYLVANIA SURVEY

Pressure from the mineral industry in post-Civil War years incited the creation of the Second Pennsylvania Geological Survey. The public clamor is described by R. W. Stone.28 J. P. Lesley,

24B. L. Miller et al., Lehigh County Geology and Geography (Pennsylvania Topographic and Geologic Survey, 4th series, Bulletin C39, 1941), and Northampton County, Geology and Geography (Pennsylvania Topographic and Geologic Survey, 4th series, Bulletin C48, 1939); and Limestones of Pennsylvania (Pennsylvania Topographic and Geologic Survey, 4th series, 1934).
25Cf. footnote 34, reference to Lehigh County.
26According to Gregory, Henry Darwin Rogers, Henry D. Rogers taught at Dickinson in 1830 but left under a cloud of censure by the governing body because he joined in a dance at an evening party.
27Letter from Professor James L. Dyson, Lafayette College, November 30, 1964.
who had served with the First Survey, became state geologist when an act of May 14, 1874, signed by Governor John Hartranft set the survey in motion. The need since 1858 of a more comprehensive and up-to-date knowledge was apparent. The new organization met the challenge, and lasted through the printing of the “Summary and Final Report,” 1892-1895.

Shortly after Lesley took command in Harrisburg, he issued his “Historical Sketch of Geological Exploration in Pennsylvania.” Lesley was inclined to be facetious. In mentioning the mysterious disappearance of a collection of fossils made by the First Survey and ostensibly deposited in the State Museum, he remarks that it turned up in the State Lunatic Asylum. Evidently, Lesley did not remove the collection, for the present writer some years ago mentioned this anecdote to an acquaintance who was then a physician at the asylum, and was informed that the fossils were still there, to the diversion of some of the inmates.

Lesley planned to publish a separate report for each of the sixty-seven counties with accompanying geologic maps. Not all were finished, but Volume X has a complete set of county geologic maps. Lesley emphasized Anthracite with a capital A through the medium of many maps and reports. Less is said about bituminous coal and iron. The Survey published a three-volume “Dictionary of Fossils.” It is merely a reproduction of cuts from older works of important or characteristic fossils, not necessarily from Pennsylvania. Leo Lesquereux wrote his treatise on coal plants.\(^2\) The Survey compiled a new geologic state map of about the same proportions as that by Rogers, but on a better base and with greater detail.

Among the men who worked under Lesley, several were or became well known professionally, such as Charles A. Ashburner for his reports on anthracite; J. J. Stevenson, regional geology; C. E. Beecher, paleontology; E. V. d’Invilliers, economic geology; Porsifer Frazer, general geology; T. S. Hunt in mineralogy and economic geology; Leo Lesquereux (already mentioned); J. F. Carll for the oil regions; E. W. Claypole, paleontology; and, of course, I. C. White, who is generally credited with establishing

the concept of potential occurrences of natural gas and petroleum under anticlines.

WE MODERNS, AN ADMONITION

With the demise of the Second Survey, official geology in Pennsylvania lapsed for a few years. It is not the purpose of this article to discuss the two twentieth-century surveys. The first of these, the third or “Commission” Survey, had a short life in 1908 and expired without accomplishing anything spectacular. The Fourth (present) Survey was organized under the able leadership of George H. Ashley in 1920 and is still functional long after his retirement.

The series of surveys illustrates progress in earth science in the state. The late S. H. Cathcart, who was state geologist after Dr. Ashley retired, once remarked that each generation of geologists does over the work of the preceding. This connotes progress, not needless repetition, yet some of the younger workers seem not fully cognizant of the labors and results of their forefathers. For the older men, notebook and pencil, pick and hammer, clinometer compass, aneroid, and hand-level were the chief field instruments. The out-of-doors was their first laboratory. Compare our up-to-the-minute topographic maps based upon aerial photographs with those old “hand-made” ones produced from slow, arduous ground surveys by civil engineers and topographers with their alidades, chains,compasses,transits,and levels. Paleontology has leaned heavily upon the biologists, and many an early vertebrate paleontologist was an M.D., since they alone were versed in osteology. There were applications of chemistry even before Rogers, when rocks, minerals and ores were analyzed. But, observe geochemistry, today almost a field in itself, and what contributions geophysics and seismology are making to sub-surface interpretations. Our concepts of stratigraphy and sedimentation and the origin of stratified rocks are constantly changing and expanding, amplified by the vast developments in oceanography and the origin of marine sediments. “The old order changeth, yielding place to new.” Yet without the foundations so painstakingly laid by the old order, the new could hardly have advanced to its present eminence.