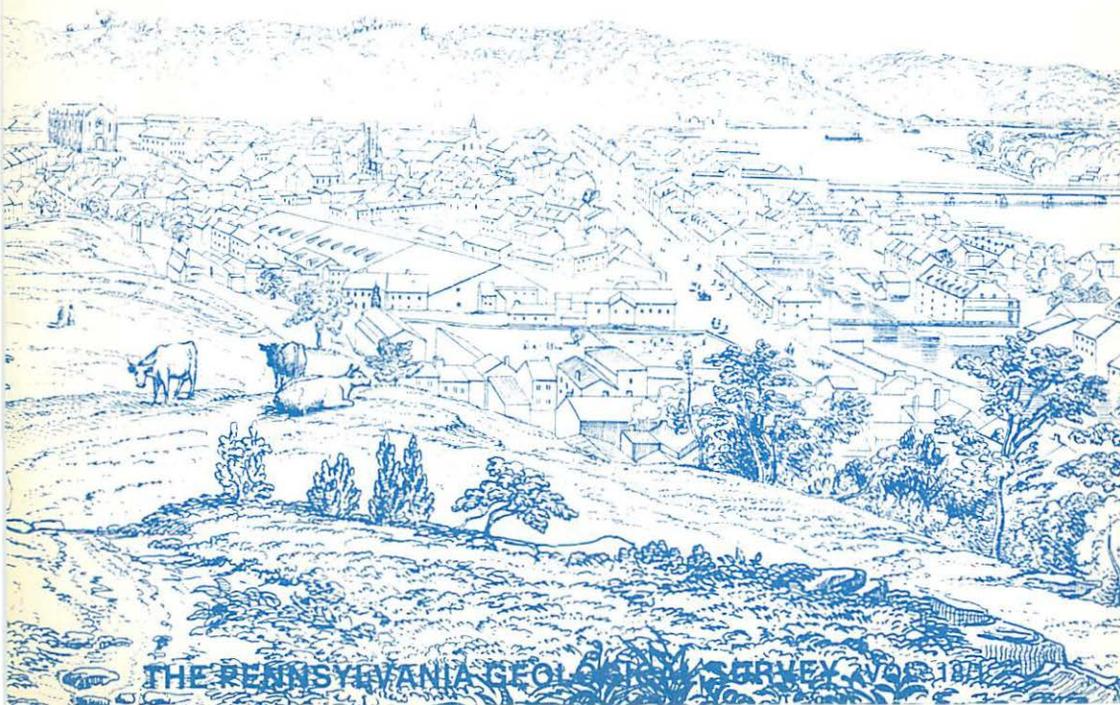
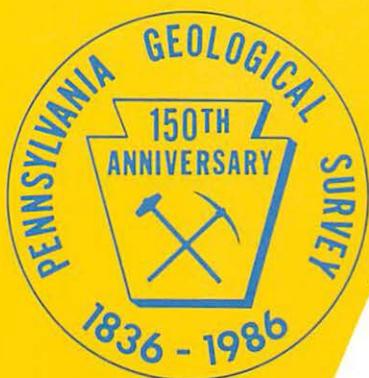


G PENNSYLVANIA

O L O G Y



THE PENNSYLVANIA GEOLOGICAL SURVEY VOL. 184

COMMONWEALTH OF PENNSYLVANIA

Robert P. Casey, Governor

DEPARTMENT OF ENVIRONMENTAL RESOURCES

Arthur A. Davis, Acting Secretary

OFFICE OF RESOURCES MANAGEMENT

Patrick J. Solano, Deputy Secretary

TOPOGRAPHIC AND GEOLOGIC SURVEY

Donald M. Hoskins, Director

CONTENTS

This issue is devoted to the history of the Pennsylvania Geological Survey and is the culmination of our sesquicentennial year's activities.

The First Geological Survey of Pennsylvania: <i>The discovery years</i>	1
The Second Geological Survey of Pennsylvania: <i>The golden years</i>	9
The Third Geological Survey of Pennsylvania: <i>The topographic years</i>	19
The Fourth Geological Survey of Pennsylvania: <i>The resource years</i>	23

ON THE COVER: Reproduction of a portion of a copper-plate lithograph entitled "Pittsburgh in 1840, from Grant's Hill," sketched by George Lehman, an artist employed by Henry D. Rogers in the 1840's to illustrate *The Geology of Pennsylvania, a Government Survey*, published in Philadelphia, Pa. in 1858.

PENNSYLVANIA GEOLOGY is published bimonthly by the Topographic and Geologic Survey, Pennsylvania Dept. of Environmental Resources, Harrisburg, Pennsylvania 17120.

Editor, Donald M. Hoskins

Associate Editor for Vol. 18, No. 1, Jon D. Inners

Articles may be reprinted from this magazine if credit is given to the Topographic and Geologic Survey.

VOL. 18, NO. 1

FEBRUARY, 1987

The First Geological Survey of Pennsylvania:

THE DISCOVERY YEARS¹

by Donald M. Hoskins

The Pennsylvania Geological Survey, known today as the Bureau of Topographic and Geologic Survey, in the Department of Environmental Resources, is one of only a very few Executive Branch agencies whose history can be traced to the first half of the 19th century. Created in 1836, the First Geological Survey was the first of four geologic and topographic surveys active over the past 150 years.

Pennsylvania in the 1830's was a ferment of activity. Population was rapidly increasing, industry was expanding, and anthracite coal was proving useful in the manufacture of iron. Internal developments—the building of turnpikes, canals and railroads—and the creation of a system of Common Schools were the concern of the Governors and Legislators of Pennsylvania. They believed that internal developments and public education were necessary if the resources of the Commonwealth were to be developed.

On March 30, 1836, the General Assembly of Pennsylvania received notice from Governor Ritner that he had signed their bill establishing “a geological and mineralogical survey of the state with a view to determine the order, succession, arrangement, relative position, ... of the several strata or geological formations within the state, and to discover and examine all beds and deposits or ores, coals, clays, marls ...as may be necessary to make a full and complete geological and mineralogical survey of the state.” This bill became Act 73 of 1836.

Pennsylvania was the ninth state to enact legislation for a geologic survey and in 1836 joined Georgia, Maine and New York, whose legislative bodies also created geologic surveys in that year.

¹This article is condensed and revised from “Celebrating a century and a half: The Geologic Survey” by D. M. Hoskins which appeared in “Pennsylvania Heritage, Quarterly of the Pennsylvania Historical and Museum Commission,” Summer 1986, Vol. XII, No. 3, p. 26-31.

Created in 1836, the First Geological Survey was the first of four geologic and topographic surveys active over the past 150 years.

Maryland and New Jersey had previously established geologic surveys in 1833 and 1835, and Pennsylvania's legislative action was not unusual for 1836. The emphasis on internal improvements in Pennsylvania and other States, and the desire to discover usable mineral resources, were all related to the then current concept of mercantilism which held that each state should be broadly involved in the field of economics.

The First Geological Survey began field work in May 1836 and field campaigns were conducted each year until the summer of 1842. Work on the final report was temporarily suspended in 1842 due to lack of legislative appropriations, purportedly due to the State's "financial embarrassments." Field work was resumed in 1851 and eventually resulted in the beautifully illustrated, two volume, quarto-sized report and maps, which were published in 1858.

The beginnings of the First Pennsylvania Geological Survey can be traced to a meeting held September 30, 1826 in the hall of the Franklin Institute, Philadelphia. At this meeting Peter A. Browne, attorney and business promoter, disclosed a plan where he would "make a geological and mineralogical survey of Pennsylvania" and "make a set of geological maps of the state, twenty six in number, upon a comprehensive scale." Although a committee of Philadelphia citizens were formed at the 1826 meeting no further action took place until late February, 1832, when the Geological Society of Pennsylvania was formed. The Geological Society members were to use their influence to have the state geologically surveyed. Memorials prepared by the Society urging the support of

The Geologic Society members were to use their influence to have the state geologically surveyed.

a topographic, geologic and mineralogic survey of Pennsylvania were sent to the Legislature of Pennsylvania in December, 1832. A Legislative Committee report was read March 23, 1833 but no action was taken. Additional memorials were sent from the Geological Society of Pennsylvania in December, 1834.

In response to Governor Wolf's 1835 "Message to the Legislature," a Committee of the House of Representatives, chaired by Charles B. Trego, of Philadelphia, read a report of the need to conduct a geological and mineralogical survey and reported a bill for consideration. It is of interest to note that Mr. Trego was to become one of the Survey assistant geologists in 1837 and remained with the First Survey until 1842: he later returned to the House of Representatives. The bill was signed by Governor Ritner on March 29, 1836. Other substantive legislation of that date was an act that authorized calling of a state constitutional convention that convened in 1838.

Thus began the First Geological Survey of Pennsylvania whose investigations and discoveries, when finally published in 1858, after considerable difficulties, were destined to set the geologic framework for all subsequent geologic mapping in the states along the Appalachian Mountains. In addition, the discoveries of the First Geological Survey of Pennsylvania prompted a major new branch of the science of geology-structural geology. This branch of geology is concerned with the form and arrangement of rocks, and their internal structures, and in particular with the description and analysis of the structures.

Appointed State Geologist of the First Geological Survey was Henry Darwin Rogers, age 26, Professor at the University of Pennsylvania, and employed during 1835 as State Geologist of New Jersey. Joining him as assistants were James C. Booth, age 24, and John F. Frazer, also age 26, both of whom had studied at the University of Pennsylvania. Prof. Rogers' brother, Robert, was appointed Chemist for the Survey.

The young geologists proceeded to the field in May, 1836. Prof. Rogers and his assistants made a rapid trip across the state to Erie. This rapid traverse allowed Prof. Rogers to subdivide Pennsylvania into three geologically distinct sections. The Appalachian Section, the middle section, bounded by Blue Mt. on the southeast and Allegheny Mt. on the northwest, was then chosen for the first summer's campaign of field work.

Mr. Frazer went to Bedford County and, starting at Hopewell, where coal was being mined, examined the rocks exposed in the gap of Terrace Mountain and along the course of Yellow Creek through the gap in Tussey Mountain into the limestone valley of Morrison's Cove. Frazer's section began with the youngest rocks, and as he progressed, the section descended through geologic time to reveal that, along Yellow Creek, over 25,000 feet of rock

the discoveries of the First Geological Survey of Pennsylvania prompted a major new branch of the science of geology-structural geology.



Figure 1. Henry D. Rogers, State Geologist of the First Pennsylvania Geological Survey.

layers of varying character were tilted such that they were vertical, or nearly so, over the whole section. He was thus able to demonstrate that the resistant sandstone layers that underlie Tussey Mountain and Terrace Mountain were in fact, not the same, as had been thought by geologists who had examined the area in previous years. The sandstone and conglomerate layers supporting these mountains were, in reality, separated by many thousands of feet of intervening rock layers. Until this time geologists thought that all of the prominent ridges which make up the mountains of central Pennsylvania were underlain by rocks of the same age.

Professor Rogers, Mr. Frazer and Mr. Booth met in Huntingdon on a Sunday in the summer of 1836 and compared their field notes. Mr. Frazer's Yellow Creek section was disbelieved until confirmed by Rogers later that week in a visit to Yellow Creek. Mr. Booth verified the same sequence of rocks in a traverse along the Potomac River.

The examination of the Bedford County geology in the first year of the Survey, resulted in the conclusion that the coals of the Broad



Figure 2. A quarry in limestone, Consohocken. Sketched by G. Lehman, artist of the First Survey.

Top were of the same geologic position and geologic age as were the bituminous coals known to exist in Clearfield and Lycoming Counties. Previous to Mr. Frazer's section, rocks which underlie the Broad Top and the surrounding areas included in the Appalachian Mountains had been thought to consist of rocks which would include veins of quartz, volcanic rocks and their included metal ores, as well as coal. What they found allowed a profound new scientific understanding of Pennsylvania's geology because it meant that exploration for coal in the rocks of the Appalachian Mountains, except in the Broad Top, was useless inasmuch as no coal existed in these rocks. Where Rogers and his assistants had expected to find in Bedford County ores of metals such as zinc and tin they found instead a profusion of iron ores of the "brown" ore type.

What they found allowed a profound new scientific understanding of Pennsylvania's geology

Rogers and his assistants were also able to subdivide Bedford County's great thickness of rocks into twelve groups of rocks which were easily distinguishable from each other on clearly visible lithologic criteria. The nine oldest groups were given such names as the Cove Limestone, Cove Slate, White Fucoidal Sandstone, and Fossiliferous Sandstone. These nine were further grouped into his Appalachian System. The three youngest groups of rocks were included in the Carboniferous System. During the second year of the Survey Rogers renamed these groups of rocks as Formations and called each by a Roman numeral, from I to XII. This subdivision of formations and the denoting of each formation by Roman numerals, with but few modifications, was used by all geological assistants of the First Survey and by all subsequent Pennsylvania Geological Surveys, until the 1930's, as well as other Geological Surveys of the Appalachian States.

Booth and Frazer did not return in 1837 to do further field work. They were replaced by new assistants, one of whom was Charles Trego, the former legislator. Rogers wrote to his brother, William, State Geologist of Virginia, that "our great and pressing dilemma is for competent geological assistants. The country does not afford them: they are to be made by us..." From 1838 to 1840 a maximum of nine assistants were employed each year; most were trained by Rogers and were sent to various districts in Pennsylvania. The greatest attention was paid to the anthracite and

"our great and pressing dilemma is for competent geological assistants. The country does not afford them: they are to be made by us..."

bituminous coal areas as well as areas in southeastern Pennsylvania where metallic ores were being mined and in the valleys of the Appalachian Mountains where the brown iron ores were found.

Major geologic discoveries made in the subsequent years of the First Survey, were that the anthracite coals were of the same age and origin as the bituminous coals, even though of markedly different chemical and physical characteristics. The use of topography in determining the underlying geology was discovered in 1838, as was the origin of brown iron ores. Dr. Robert Jackson, a physician and later Chief Surgeon of the Army of the Cumberland, was a geological assistant from 1838 to 1841. He studied the brown iron ores of the many limestone valleys in central Pennsylvania and determined that they originated from accumulation of the undissolvable iron resulting from solution of limestone in which the iron naturally occurred. From his and the other assistant's observations in 1838 came the first understanding of the effect of erosion on the earth's surface. Their conclusions were later to be acknowledged and accepted by European geologists.

In 1840 and 1851 Prof. Rogers employed George Lehman and Augustus Dalson, respectively, as artist-draftsmen, who traveled throughout Pennsylvania sketching scenes of the topography and geology. The illustrations accompanying this article are from Lehman's pen and brush.

Field work ended with the 1841 season but the corps of assistants continued work until April 1, 1842. When the Pennsylvania General Assembly did not appropriate funds in 1842, Prof. Rogers was left with no resources to bring the field notes, sketches, section descriptions and maps into order for publication. "Financial embarrassment" of the Commonwealth was the stated reason but perhaps some of the answer for the lack of support could be found in a legislator's comment in 1840. Rogers, in a letter to his



Figure 3. Indian Chief Rock, near Williamsburg, Juniata River. Sketched by G. Lehman, artist of the First Survey.

brother in Virginia, reported that a Legislator uttered: "Mr. Speaker, I shall vote against this appropriation, on the ground of its unfairness to other sciences of like nature with this geology. The bill, sir, makes no provision for phrenology, physiognomy, animal magnetism, and the highly important science of *water-smelling*..."

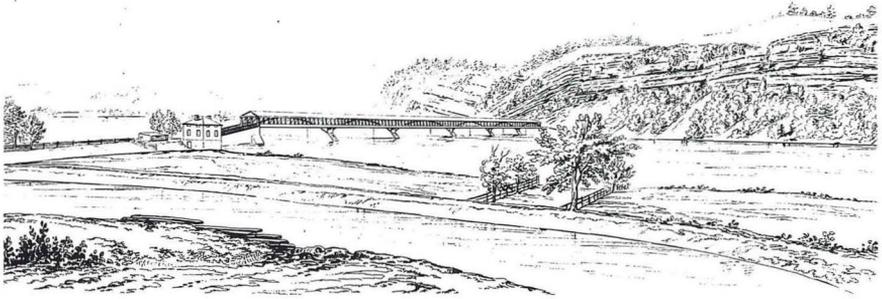


Figure 4. Canal and bridge across the Susquehanna River, with folded rocks, near Northumberland. Sketched by G. Lehman, artist of the First Survey.

A small appropriation in 1843 was apparently used by Prof. Rogers to employ one of the former geological assistants, J. Peter Lesley, (later to be the Chief Geologist of the Second Geological Survey), in the preparation of a set of final maps and reports. They were delivered to the Secretary of the Commonwealth in 1847 for publication. Nothing transpired until 1851 when citizens, particularly in the anthracite regions, clamored for the publication of Rogers' report and maps. Upon their urgings the Legislature appropriated \$32,000 of which \$16,000 was to be used for publication by "an eminent publishing firm" of Philadelphia and \$16,000 for the further work of Prof. Rogers, geological assistants, and miners, in bringing the work up to date.

Additional field work was conducted in 1851 and 1852, largely in the anthracite fields. Prof. Rogers continued work on iron ores, notably the "fossil" iron ores near Danville. He was also engaged in arranging the voluminous individual area descriptions and illustrations, prepared by each geological assistant, into a form suitable for publication, and in writing the summarizations and scientific interpretations for which the final report would become famous throughout the geologic world, in the United States and in Europe.

Rogers proposed in 1855, when all of the materials were ready for engraving and the text for typesetting, that he be given the copyright to the report and maps and the contract for publication. He volunteered to forego his salary in the supervision of the publication process.

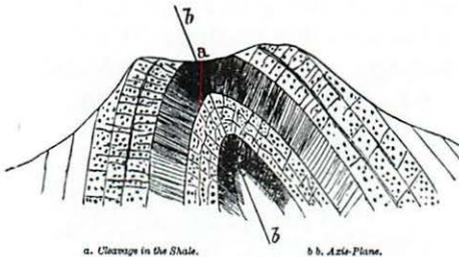


FIG. 715.—Fan-like arrangement of Cleavage at an Anticlinal Axis.

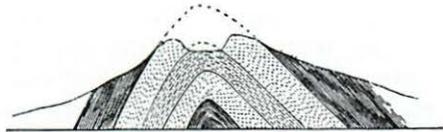


FIG. 740.—Double-crested Anticlinal Ridge, or simple Valley of Elevation.

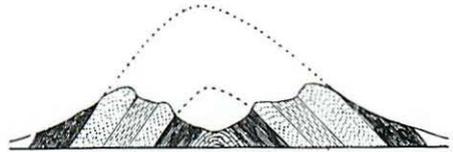


FIG. 741.—Complex Valley of Elevation.

Figure 5. Woodcut illustrating cleavage fanning a fold. Rogers' analysis of such structures as this led to the development of the science of structural geology.

Figure 6. Woodcuts illustrating development of ridges and valleys by erosion. Rogers' synthesis was the first to classify landforms produced by erosion.

Rogers then left for Scotland where he arranged with W. & A. K. Johnston of Edinburgh to engrave the illustrations and maps. William Blackwood & Sons of Edinburgh printed the quarto volumes. They were sold in the United States by Lippincott.

The final report is a magnificent example of the publication processes of the 1850's. It was printed in two quarto volumes of 1631 pages. Included are 778 engraved woodcuts inserted in the text pages. Twenty three engraved plates are devoted to illustrations of fossil plants. Other plates include engravings of geological sections throughout the state and sketches of the scenery and geology along the rivers of Pennsylvania.

Notable for their beauty are the three full-color lithographs bound in the volumes.

With the publication of this beautiful report came the end of the First Geological Survey of Pennsylvania. Soon, however, the demands of the mineral industries, particularly to fulfill the needs of the War Between the States, the discovery of petroleum in northwest Pennsylvania, and the need for accurate geologic maps resulted in the creation of the Second Geological Survey in 1874.

ADDITIONAL READING AND SOURCES OF INFORMATION

- Lesley, J. Peter. Historical sketch of geological explorations in Pennsylvania and other states: Pennsylvania Geological Survey, 2nd ser., Report A, 200 p.
- Rogers, Henry D., 1858, *The geology of Pennsylvania, a government survey*: Philadelphia, J. B. Lippincott and Company, v. 1, 586 p.; v. 2, 815 p.
- _____, 1836 to 1842, Annual Reports of the State Geologist for 1836, 1838, 1839, 1840, 1841, and 1842: Harrisburg, Pa.
- Rogers, E. S., 1896, *Life and letters of William Barton Rogers*: Boston and New York, Houghton, Mifflin and Company, v. 1, 427; v. 2, 451 p.

The Second Geological Survey of Pennsylvania

THE GOLDEN YEARS

by Clifford H. Dodge

The discovery and exploitation of mineral wealth in Pennsylvania accelerated during the decade that followed publication of H. D. Rogers' "Final Report" of 1858. Pennsylvania's industrial growth and the discovery of oil prompted public demand for more complete and detailed geologic information about the State's coal, petroleum, iron ore, and other mineral resources. With this in mind, the Pennsylvania Legislature approved a bill on May 14, 1874 to establish the Second Geological Survey of Pennsylvania (1874-1889).¹

The legislative act creating the Second Geological Survey provided for a ten-man oversight committee (with the Governor, initially, as its *ex-officio* president), or Board of Commissioners, which was authorized to select a State Geologist and to approve all of his plans and major recommendations in operating the Survey. At the first meeting of the Board in Harrisburg on June 5, 1874, it wisely selected J. Peter Lesley (1819-1903) to the post of State Geologist and Director of the Second Geological Survey. Governor Hartranft approved and promptly appointed Lesley, who, at the age of fifty-four, was well prepared for his greatest challenge.



Figure 1. J. Peter Lesley, State Geologist (from a portrait by his daughter, Margaret; in Ames, 1909, v. 1, frontispiece).

¹Several different dates—particularly 1887, 1889, and 1895—are commonly given to mark the end of the Second Geological Survey. Although the bulk of the field work was completed by 1887, some continued intermittently, primarily using geologists on a contractual basis, through 1890 and beyond. The last reports of the Second Survey were published in 1895, but the major reduction in activities occurred in 1889 when an act of the State Legislature ordered the work of the Survey in the anthracite fields to cease and the geological assistants to disband by June 1 of that year.



Figure 2. J. Peter Lesley and his wife, Susan, in their parlor at 1008 Clinton Street, Philadelphia, in 1890. Lesley maintained his office here while he was State Geologist. Photograph from Ames (1909, v. 2, facing p. 369).

J. Peter Lesley, a native of Philadelphia, was eminently well qualified and widely respected among his peers. He was professor of geology and mining at the University of Pennsylvania and in 1875 the Dean of the Towne Scientific School. He had been an assistant to H. D. Rogers on the First Geological Survey of Pennsylvania (1836-1842) and was, at the time of his appointment, an acknowledged expert in several fields of geology, particularly coal and petroleum. His broad knowledge of Pennsylvania geology developed during his years with the First Survey and

thereafter as a geologic consultant. He was a pioneer, if not the pioneer, in the use of topographic and structure contouring and aneroid altimeters in geologic mapping (Owen, 1975, p. 80-81). Lesley was a respected author of many articles, reports, and publications prior to the organization of the Second Survey. Perhaps most notable were his *Manual of Coal and Its Topography* and *Iron Manufacturers' Guide*, published in 1856 and 1859, respectively. Moreover, he was actively involved with many scientific organizations including the American Association for the Advancement of Science, the American Philosophical Society, and the National Academy of Sciences (of which he was a founding member). Lesley's remarkable life has been discussed at length by Ames (1909), Lyman (1909), and Davis (1915), and his interrelationship with the Second Geological Survey has been examined in detail by Jordan and Pierce (1981) and Chance (1909).

Though subject to its approval, the Board of Commissioners nevertheless gave Lesley wide latitude in planning and executing the work of the Second Survey:

...the board of commissioners extended to him [Lesley] the utmost freedom, conferring upon him power to use his own methods, to select his assistants, to determine what work should and what should not be done, relying upon his judgement and ability to produce the best results at least cost, and standing loyally by him as staunch friends and supporters...(Chance, 1909, p. 492).

...the Board of Commissioners gave Lesley wide latitude in planning and executing the work of the Second Survey.

Lesley was firm but fair with his staff, and almost universally respected and admired by them.

In comparing the work of the First Geological Survey with that envisioned for the Second, Lesley (1876, p. viii-ix) wrote that

the first survey was essentially a reconnaissance. Those engaged in it thirty years ago worked chiefly without instruments of precision and under the greatest inconveniences. Their views were broad, their isolated observations numerous and exact, but their districts never were *accurately surveyed* by them, nor could be. The second survey is intended to supply this lack; to take up their work where they left off; to reduce their general statements to precision; to measure, where they could only estimate; to define, what they could only indicate; to demonstrate what they could see to be true, but which they could not prove and show in all its truth.

There were relatively few trained geologists in the United States when the Second Survey began. Yet, Lesley was able to attract many talented individuals. At the outset, each assistant geologist was

assigned to a certain district or to special duties, and given one or two [or more] younger men as aids. With these as a nucleus, he [Lesley] gradually built up, chiefly by promotion from among the younger men, a large and efficient corps of trained workers, to whom he accorded the greatest latitude,...holding them responsible only that their work be well and accurately done (Chance, 1909, p. 492).

Many of the inexperienced aides came to the Second Survey almost immediately after graduation from college, but in a year or two were themselves made assistants capable of independent research. Lesley was firm but fair with his staff, and almost universally respected and admired by them. He demanded the highest standards of scientific accuracy and attention to details, which he assured in his added role as editor and proofreader of all Survey publications. His assistants worked hard to please him and, in turn, became better geologists. One cannot help but feel a twinge of envy regarding the mode of operation of the Survey:

Probably no public organization was ever less bound by the red-tape of officialism than this survey corps, whose members he [Lesley] left untrammelled, unhampered, trusting each other to do his duty, thus placing each in a position where he was driven to do his best, where he would be ashamed to do less (Chance, 1909, p. 492).

Assistants of the Second Survey read like a "Who's Who" in late nineteenth century American geology and included C. A. Ashburner, J. F. Carll, H. M. Chance, E. W. Claypole, J. H. Dewees, E. V. d'Inwilliers, Persifer Frazer, Jr., F. A. Genth, T. S. Hunt, Leo Lesquereux, B. S. Lyman, A. S. McCreath, Franklin and W. G. Platt, Frederick Prime, Jr., J. J. Stevenson, I. C. White, Arthur Winslow, and others.

Lesley's style and philosophy pervaded every aspect of the Survey and developed largely as a result of his break with H. D.

Lesley's style and philosophy pervaded every aspect of the Survey...



Figure 3. *Callipteridium* leaflets of probable Pennsylvanian age (from Lesquereux, 1879, plate XXXIII, figure 3).

Merrill (1924, p. 495) once described the publications of the Second Geological Survey as “the most remarkable series of reports ever issued by any survey.” During the two decades that it operated, the Second Survey published nearly 120 atlases and volumes, comprising numerous maps, drawings, columnar sections, and cross sections and more than 25,000 pages of printed matter. In addition, it produced a “Grand Atlas” (in six parts) and a geologic map of Pennsylvania (scale, 1 inch = 6 miles). The publications of the Survey are practical and not theoretical, a condition imposed by Lesley. The reports generally contain detailed descriptive information on the geology of the various counties or districts. The atlases provide much supplemental material.

Although the maps and illustrations were intended to be utilitarian, many are truly works of art. One need only glance at the lithographs of the fossil coal flora (Lesquereux, 1879) or the Olean Conglomerate

Rogers, who, Lesley believed, failed to acknowledge the specific contributions and ideas of the First Geological Survey assistants. Consequently, “Lesley pointedly used methods at variance with those of Rogers. Where Rogers had amassed draft reports, sketch maps and cross-sections from his assistants for the purpose of publishing a definitive final report, Lesley published reports from each district or project as soon as the material could be assembled and edited” (Jordan and Pierce, 1981, p. 75). In this way, the results of the Second Survey were more useful and timely, and their value to the public was continually made apparent. In addition, Lesley made certain that his assistants always received proper credit for their authorship and ideas.

Merrill once described the publications of the Second Geological Survey as “the most remarkable series of reports ever issued by any survey.”

(Ashburner, 1880) to appreciate the beauty of the workmanship. Some of the most striking yet accurate geologic maps of the Second Survey were prepared for the anthracite coal fields, where more detailed information was available (see Dodge, 1981, p. 90-91). The use of multiple colors on these maps to distinguish surface and subsurface features was unsurpassed at that time by any other State surveys or the newly formed U.S. Geological Survey. Examples such as these can be repeated many times.

The Second Geological Survey contributed much to our understanding of the geology of Pennsylvania. It established the rock stratigraphy of the State



Figure 4. Type locality of the Olean Conglomerate, Rock City, Cattaraugus County, New York (from Ashburner, 1880, plate I, facing p. 50).

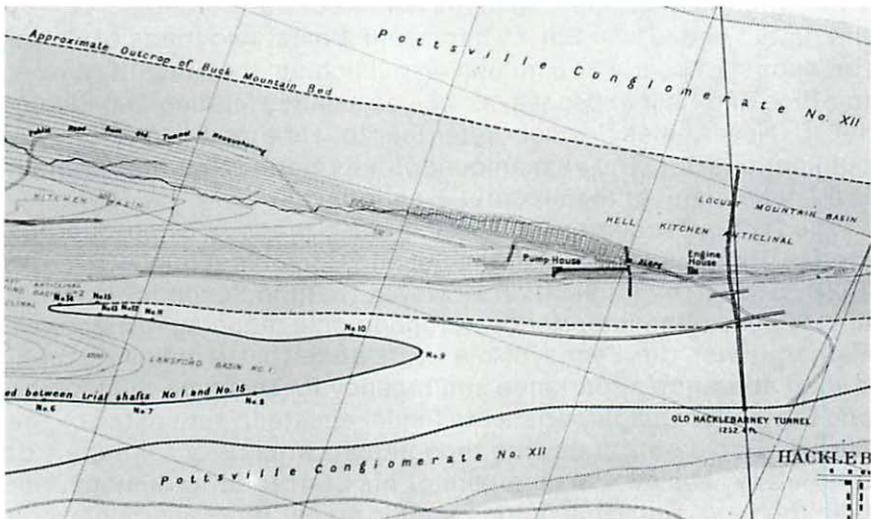


Figure 5. Example of the early use of structure contours, portion of mine sheet 1, Panther Creek basin, Southern Anthracite field (from Ashburner, 1882).

and much of the stratigraphic nomenclature still in use today. It published geologic maps for all 67 counties. The Geological Survey was particularly successful in its correlation studies in the coal and oil regions of western Pennsylvania. It achieved international acclaim for its unprecedented detail and precision in mapping the geology of the anthracite mining districts. During its anthracite studies, conducted between 1880 and 1889, it began the first large-scale, systematic use of structure contours (Dodge, 1981, p. 90), and it constructed a number of topographic base maps on which to compile the extent of deep mining. Even though its paleontological studies were subordinate to its main objectives (i.e., mineral-resources investigations), the Survey received considerable praise for its reports on the fossil coal flora.

Despite all of its success, the Second Survey was not free of difficulties or criticism. One constant source of frustration was the uncertainty of renewal of its biennial appropriation. This created problems when trying to plan future activities and led to resignations of staff who wanted stable employment at a good salary. By the mid-1880's, criticism from the Pennsylvania Legislature grew concerning publication costs, the number of volumes produced, and "the amount of relatively undigested and repetitious material presented in the many volumes" (Jordan and Pierce, 1981, p. 83). These factors ultimately led to the demise of the Second Survey. By the time it ended, the Survey had spent almost two-thirds of its entire budget of nearly \$1.6 million on publishing; the other third went to office and field expenses, as well as salaries (Jordan and Pierce, 1981). Nevertheless, when referring to various Second Survey publications, it is the vast amount of information that they contain that make many of them useful even today!

The lack of accurate topographic base maps is often cited as "the fundamental defect" of the Second Geological Survey (Merrill, 1924, p. 496). The implication, however, that the Second Survey did not recognize the importance of topographic mapping is incorrect. Rather, it was the Pennsylvania Legislature that remained unconvinced about the importance and urgency for this type of mapping and that failed to appropriate the funds repeatedly requested by the Second Survey for statewide topographic work. From the start of the Survey, Lesley and members of his staff tried to demonstrate both the need and value of topographic maps. Time and money per-

mitting, the Survey undertook its own topographic mapping, initially for topical studies and later in conjunction with geologic mapping in the anthracite fields. As early as 1884, the

**By the time it ended,
the Survey had spent
almost two-thirds of its
entire budget of nearly
\$1.6 million on
publishing...**

U. S. Geological Survey and U. S. Coast and Geodetic Survey offered to participate in a cooperative program with Pennsylvania for the purpose of conducting comprehensive topographic and triangulation surveys of the State (Lesley, 1886, p. xxxviii-xxxix). The Board of Commissioners endorsed the proposal, but the Legislature did not. Thus, the proposal failed, even though the State would have had to contribute only about 20 percent of the money needed for the program. In 1888, as part of its cooperative program with New Jersey, the U. S. Geological Survey began to map the topography of the Pennsylvania portions of the 15-minute quadrangles that also extended into New Jersey. Thereafter, at the urging of Lesley, the U.S. Geological Survey undertook some topographic quadrangle mapping in the anthracite fields and adjacent areas in southeastern Pennsylvania (Powell, 1890). However, systematic, statewide topographic surveys did not begin until the cooperative agreement between Pennsylvania and the U. S. Geological Survey was finally signed in 1899 (see Sevon, this volume).

REFERENCES CITED

- Ames, M. L. (1909), *Life and letters of Peter and Susan Lesley*: New York, G. P. Putman's Sons, v. 1, 526 p., v. 2, 562 p.
- Ashburner, C. A. (1880), *The geology of McKean County, and its connection with that of Cameron, Elk and Forest*: Pennsylvania Geological Survey, 2nd ser., Report R, 371 p.
- _____, (1882), *Southern Anthracite field, Part I*: Pennsylvania Geological Survey, 2nd ser., Report AA [Atlas], 13 sheets.
- Chance, H. M. (1909), *A biographical notice of J. Peter Lesley*, in Ames, M. L., *Life and letters of Peter and Susan Lesley*: New York, G. P. Putman's Sons, v. 2, p. 484-495 [reprinted from *American Philosophical Society Proceedings* (1906), v. 45, p. i-xiv].
- Davis, W. M. (1915), *Biographical memoir of Peter Lesley, 1819-1903*: *Biographical Memoirs of the National Academy of Sciences*, v. 8, p. 152-240.
- Dodge, C. H. (1981), *The geologic genius of Charles Albert Ashburner*: *Northeastern Geology*, v. 3, p. 86-93.
- Jordan, W. M., and Pierce, N. A. (1981), *J. Peter Lesley and the Second Geological Survey of Pennsylvania*: *Northeastern Geology*, v. 3, p. 75-85.
- Lesley, J. P. (1876), *Historical sketch of geological explorations in Pennsylvania and other states*: Pennsylvania Geological Survey, 2nd ser., Report A, 200 p.
- Lesley, J. P., *State Geologist* (1886), *Annual report of the Geological Survey of Pennsylvania for 1885*: Pennsylvania Geological Survey, 2nd ser., 769 p.
- Lesquereux, Leo (1879), *Atlas to the coal flora of Pennsylvania, and of the Carboniferous formation throughout the United States*: Pennsylvania Geological Survey, 2nd ser., Report P [Atlas], 18 p., 87 plates.
- Lyman, B. S. (1909), *Biographical notice of J. Peter Lesley*, in Ames, M. L., *Life and letters of Peter and Susan Lesley*: New York, G. P. Putnam's Sons, v. 2, p. 452-483 [reprinted from *American Institute of Mining Engineers Transactions* (1903), pamphlet, 35 p.]
- Merrill, G. P. (1924), *The first one hundred years of American geology*: New Haven, Yale University Press, 773 p.
- Owen, E. W. (1975), *Trek of the oil finders: A history of exploration for petroleum*: *American Association of Petroleum Geologists Memoir* 6, 1647 p.
- Powell, J. W., *Director* (1890), *Tenth annual report of the United States Geological Survey to the Secretary of the Interior 1888-'89, Part 1 - Geology*: U.S. Geological Survey, 774 p.

The Third Geological Survey of Pennsylvania:

THE TOPOGRAPHIC YEARS

by W. D. Sevon

J. P. Lesley, director of the Second Pennsylvania Geological Survey, commented in 1876 (p. 112-113), "In its very nature a geological survey is continuous ad libitum, and should be perpetual. Its first stages are rapid and of the nature of a reconnaissance, or general survey of the country to be afterwards better surveyed. As it advances it discovers its own future work and prepares to do it. The longer it lasts the more local, special, exact and important it becomes." This sentiment was reiterated by the Commissioners of the Second Survey in 1892 when they said: "The work of a geological survey is never done in one sense...new discoveries are continually being made. Such discoveries should...be subjected to investigation by competent experts...the geological survey should be made a permanent bureau." The commissioners went on to emphasize the need for topographic mapping as well as geological studies (McNees and others, 1906, p. 44). However, the admonitions were not heeded. Field work of the Second Survey ended in 1887 and the final volume was published in 1895. Continuity in Pennsylvania geologic investigations was once again broken.

"The work of a geological survey is never done in one sense...new discoveries are continually being made."

THE THIRD SURVEY

The Third Pennsylvania Geological Survey was established as the Topographic and Geologic Survey of Pennsylvania by Legislative Act approved by Governor William A. Stone on the 28th day of April, 1899. The act established a commission of three unpaid citizens to confer and accept cooperation with the United States Geological Survey for the purpose of preparation and completion of contour topographic and geologic maps of the state. The

sum of \$20,000 was appropriated for each of the first two years of the survey; G. W. McNees, Simon Harrold, and Fred D. Barker were appointed commissioners; and contractual agreement with the U.S. Geological Survey was signed on July 12, 1899.

A legislative enactment of May 13, 1909 signed by Governor Edwin S. Stuart authorized the establishment and maintenance of a topographic and geologic survey of the State and the appointment of a State Geologist with an annual salary not to exceed \$3000. Provisions were made for publication of reports, deposition of specimens in the State Museum, and the lawfulness for survey employes to enter upon and cross all lands. The act called for an appropriation of \$20,000 per year, but only \$10,000 per year was allowed because of "insufficient State revenue." Richard R. Hice was appointed State Geologist.

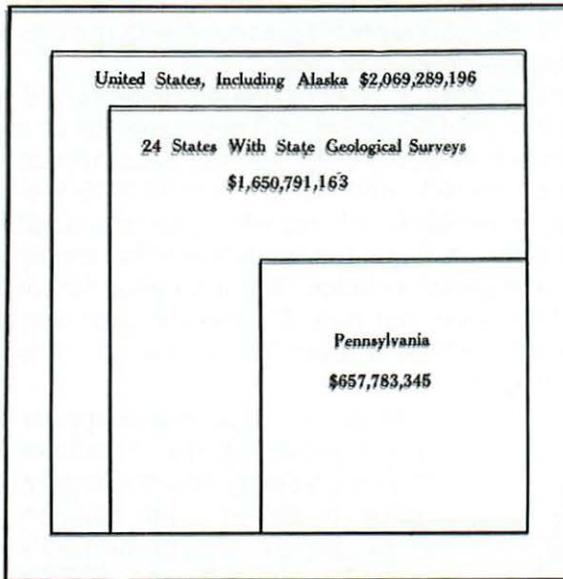


Figure 1. Richard Hice, State Geologist of the Third Pennsylvania Geological Survey.

Hice, a brick manufacturer and founder of the American Ceramic Society, maintained his office in Beaver and directed Third Survey efforts primarily towards coal, gas, and oil. His philosophy was (Hice, 1912, p. 156): "The primary purpose of a Geological Survey is the encouragement of the mineral production of the State." In 1911 he entered into agreement to cooperate with the U.S. Geological Survey in collection of the mineral statistics of the State, a cooperative effort which still exists.

Money for geologic and topographic work never flowed like water from the Pennsylvania legislature. McNees and others pointed out in 1910 (p. 22-26) that the relative value of mineral products in the United States, including Alaska, was \$2,069,289,196 of which \$657,783,345 was produced by Pennsylvania. But while Pennsylvania had nearly a third of the mineral products wealth of the United States, it was spending for geologic and topographic work only one dollar for each \$65,700 of the annual mineral products. This contrasted to the one dollar being spent for each \$2,440 in New York and for each

"The primary purpose of a Geological Survey is the encouragement of the mineral production of the State."



Relative Value of Mineral Products of the United States, Including Alaska; of 24 States with State Geological Surveys and of Pennsylvania.

Figure 2. Value of Pennsylvania's Mineral Production compared to other States and the U.S. during the Third Survey.

\$1,989 in New Jersey. In 1914 (p. 20-21) Hice showed that Pennsylvania had a mineral production value of \$9,981 per square mile, almost twice that of the second richest state, West Virginia, but spent only \$0.33 per square mile on geologic work. It appears that these statistics had little or no effect on the Legislature. During the existence of the Third Survey less than \$250,000 was spent by the State for topographic and geologic work.

There are no administrative or legislative records about the Third Survey after 1914. No publications ensued and there is no indication that the Legislature appropriated any money for the Survey. Limited correspondence on file at the present Survey indicates that Hice still maintained an office in Beaver when Ashley was named State Geologist of the Fourth Survey in 1919. Hice apparently shipped some Survey materials to Ashley in Harrisburg. The Commissioners also had an office in Harrisburg in 1919, but there is no record of the disposition of the Commissioners or any Survey items which may have been in their possession.

THE SURVEY WORK

The U. S. Geological Survey was already involved in various topographic and geologic projects in Pennsylvania when the Third Pennsylvania Survey was created. However, an increased amount of field work was possible with the additional money provided by Pennsylvania and the equal dollars matched by the U. S. Geological Survey. The cost of publication and the responsibility for scientific control of those projects was borne by the Federal Survey. The order in which the work was done was determined by mutual agreement. M. R. Campbell was the supervisor in charge of Pennsylvania geologic work from 1900 to 1904 when George H. Ashley, then a U. S. Geological Survey employee, took charge until 1910.

Geologic work during the first cooperative year included mapping the Uniontown and Masontown quadrangles as well as the Gaines and Elkland quadrangles. These were published as part of the geologic folio series by the U. S. Geological Survey. Of particular note is the field season of 1902 during which time A. C. Roberts went to the Houtzdale quadrangle and "made numerous notes on the geologic features, including the location of several faults, and prepared a preliminary areal geologic map." (McNees and others, 1908, p. 100). Work continued intermittently in this area for more than half a century before reports were finally published in 1968 (Edmunds) and 1977 (Glass and others) by the Fourth Survey.

Work continued intermittently in this area for more than half a century.

Most of the geologic work was done in the western part of the State and was oriented almost exclusively toward economic resources. Numerous reports were published by the U. S. Geological Survey during the existence of the Third Survey and 17 volumes totalling 3200 pages were published by the Third Survey itself. One of the most important works published was a report on the Broad Top coal field (Gardner, 1913) which still remains the primary source of information about this area. Among the geologists who worked in Pennsylvania during the Third Survey cooperative era were several whose work was prominent during the Fourth Survey era: G. H. Ashley, C. Butts, M. R. Campbell, B. L. Miller, R. W. Stone, and G. W. Stose. However important the geologic work was, equally important work was accomplished by the less heralded topographic mappers.

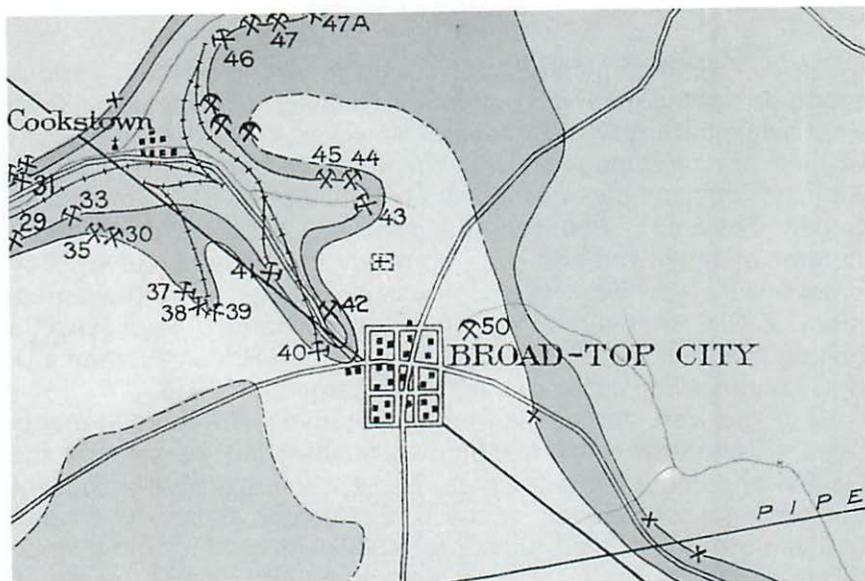


Figure 3. A portion of the Geologic Map of the Broadtop Coal field.

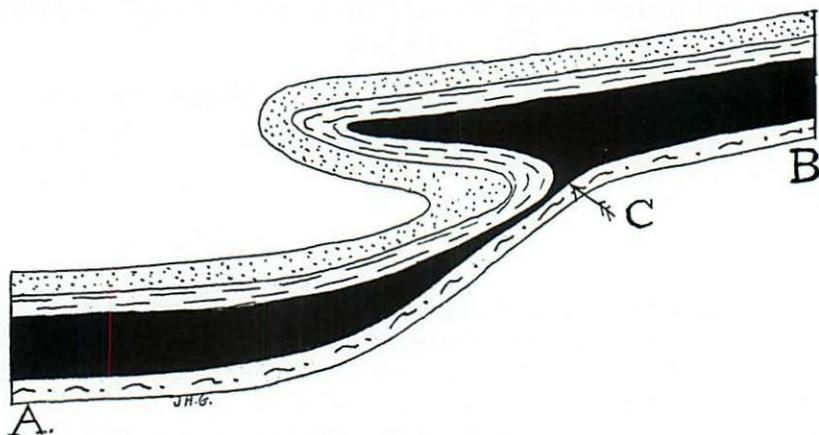


PLATE XXV.

Figure 2.—Sketch, showing manner in which a "split" is produced by an overthrust roll. Illustrated by local conditions in Judith and Rock-bar Mines.

Figure 4. Cross sections of the coals in the Broadtop Coal basin showing the complexities encountered by mappers of the Third Survey.

The value of the topographic mapping cannot be overemphasized. Lesley (1876, p. 115-116) pointed out that one of the great problems of the First Survey was the lack of a base map: "The best county maps extant at that time were very imperfect, and as for the State map published by Melish, it was a wilderness of blunders

more or less absurd...As a topographical or geographical statement all the northern and western half of Melish's map was simply a monstrous misnomer." The Melish map had been authorized by the Legislature by an act approved in 1816 and was issued in several editions in the 1820's and 1830's. Lesley reiterated his complaint about the lack of a Legislature supported map in 1886 (p. xxxvii-xxxix) because the Melish map was still the only map available, and decried the fact that a cooperative agreement with the U. S. Geological Survey for topographical mapping had not been arranged as recommended by the Board of Commissioners in 1885. The Third Survey resulted from pressure on the Legislature when enough people of the State appreciated the desirability of having an accurate topographic map of the State and the economic value of a cooperative arrangement with the U.S. Geological Survey.

Procedures for topographic mapping were well established by the U. S. Geological Survey prior to 1899. Triangulation stations within Pennsylvania already astronomically located by the U. S. Coast and Geodetic Survey or the U. S. Lake Survey made such work unnecessary by the U. S. Geological Survey. The topographic mappers created baselines through triangulation, set primary traverses with theodolite measurements, did secondary traverses along roads by buggy or buckboard using the revolution of the wheel to measure distance, determined many elevations by leveling or aneroid barometer, and used the plane table to fix the position of large numbers of points. The most important part of the map making, sketching in the details, was generally the work of the chief of the party. "Sketching is artistic work, some men seem to have the native ability for it, to others it only comes as the result of time and hard work, and still others may fail to acquire it." (McNees and others, 1906, p. 36).

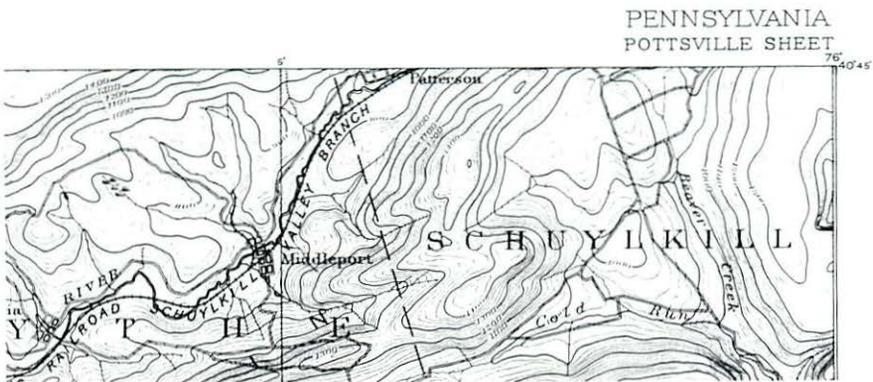


Figure 5. A portion of the Pottsville 15 minute topographic map, the first topographic quadrangle map of a part of Pennsylvania.

The Third Survey is best honored for the successful implementation of the cooperative Federal and State topographic mapping program which exists today for the benefits of the people of Pennsylvania.

The topographic maps produced were at a scale of 1:62,500 (15' quadrangles) and had a contour interval of 20 feet. These maps portrayed accurately for the first time the topography and position of natural and cultural features throughout the State. The first Pennsylvania 15' quadrangle was the Pottsville sheet surveyed in 1889 and published in 1891.

The production of these maps continued into the late 1950's. The slow and tedious field methods were replaced by photogrammetric methods after the Second World War. Mapping at the currently popular scale of 1:24,000 (7½' quadrangles) commenced in 1944, was completed in 1971, and is now periodically photo-revised. Compilation of the 1960 Geologic Map of Pennsylvania was done on the 15' topographic quadrangles; that of the 1980 map on the 7½' quadrangles. The immensely more obvious relationship of topography to rock lithology shown by the 7½' quadrangles greatly increased the precision of contact location during the latter compilation. The Third Survey is best honored for the successful implementation of the cooperative Federal and State topographic mapping program which exists today for the benefit of the people of Pennsylvania.

REFERENCES CITED

- Edmunds, W. E., 1968, Geology and mineral resources of the northern half of the Houtzdale 15-minute quadrangle, Pennsylvania: Pennsylvania Geological Survey, 4th ser., Atlas 85ab, 150 p., 15 plates.
- Gardner, J. H., 1913, The Broad-Top coal field: Pennsylvania Geological Survey, 3rd ser., Report No. 10, 81 p.
- Glass, G. B., Edmunds, W. E., Shepps, V. C., Inners, J. D., and Sholes, M. A., 1977, Geology and mineral resources of the Ramey and Houtzdale quadrangles, Clearfield and Centre counties, Pennsylvania: Pennsylvania Geological Survey, 4th ser., Atlas 85cd, 94 p., 10 plates.
- Hice, R. R., 1914, Biennial report of the Topographic and Geologic Survey of Pennsylvania: Harrisburg, Wm. Stanley Ray, State Printer, 232 p.
- Lesley, J. P., 1876, Historical sketch of geological explorations in Pennsylvania and other states: Pennsylvania Geological Survey, 2nd ser., Report of Progress A, 200 p.
- McNees, G. W., McCreath, A. S., and Hice, R. R., 1906, Report of the Topographic and Geologic Survey Commission of Pennsylvania, 1899-1906: Harrisburg, Harrisburg Publishing Co., State Printer, 308 p.
- _____, 1908, Report of the Topographic and Geologic Survey Commission of Pennsylvania, 1906-1908: Harrisburg; Harrisburg Publishing Co., State Printer, 375 p.
- McNees, G. W., McCreath, A. S., and d'Invilliers, E. V., 1910, Report of the Topographic and Geologic Survey Commission, 1908-1910: Harrisburg; C.E. Aughinbaugh, Printer to the State of Pennsylvania, 103 p.
- _____, 1912, Report of the Topographic and Geologic Survey Commission of Pennsylvania, 1910-1912: Harrisburg, C. E. Aughinbaugh, Printer to the State of Pennsylvania, 182 p.

The Fourth Geological Survey of Pennsylvania:

THE RESOURCE YEARS

by Rodger T. Faill

Geological knowledge of Pennsylvania had been greatly advanced by the Second Survey, but the need for additional information persisted. The Third (Commission) Survey's concentration on topographic mapping did little to satisfy this need and led in 1914 to the lapse of appropriations by the Pennsylvania Legislature. But the need was still there, and five years later the Legislature established a fourth survey with a broader mandate. On June 7, 1919, the present Topographic and Geologic Survey was created as a bureau within the Department of Internal Affairs, and on September 1 of that year, George H. Ashley assumed the office of State Geologist.

Perhaps the main reason the Fourth Survey has persisted and grown is because its objective has been one of continuing service to the Commonwealth in particular, and the geological community in general. The first two surveys had the limited objective of producing a single series of reports. When these objectives were accomplished, the Surveys were disbanded. The primary objective of the Third Survey was to produce topographic maps (in cooperation with the U.S. Geological Survey). Beyond this, it did not have well defined goals and was never able to mount and sustain a vigorous program in geological activity. In contrast, the Fourth Survey was em-



Figure 1. George H. Ashley, first director and State Geologist of the Fourth Pennsylvania Geological Survey (1919-1946).

powered to "undertake, conduct, and maintain...a thorough and extended survey of the State for the purpose of elucidating the geology and topography of the State." The enabling act spelled out a large number of activities, including locating and analyzing all types of minerals, resources, and useful rock formations, maintaining collections of samples, formation of a library, cooperation with state and federal organizations, and perhaps most importantly, publishing its results.

THE EARLY YEARS

It was natural that George Ashley was named State Geologist of the newly created Fourth Survey because he had worked in Pennsylvania, and with coal, for the first two decades of this century. He had been State Geologist of Tennessee for two years, but most of his prior experience had been with the U. S. Geological Survey, most recently as Chief of the Coal Section, where he supervised the coal projects in the eastern part of the United States. In a way it is ironic (or perhaps fitting) that one so involved in coal should start in 1919, for in the midst of the economic upheavals following World War I, a major nationwide coal strike had closed most of the industry.

But it was in natural gas, not coal, that the new survey made its first mark. The McKeesport gas field was discovered in August of 1919 and it promised to be a rich field. Ashley soon visited the area, and despite his warnings that excessive drilling would lead to large losses, drilling proceeded at a rapid pace. Within two years the overdeveloped McKeesport field was largely depleted. Ashley's interest in oil and gas may also be reflected in the fact that the first map produced by the Survey was one showing the locations of the oil and gas fields.

Coal, on the other hand, was not to be ignored. The uncertainties in supplies caused by the miners' strikes gave impetus to search for alternative sources. This underlay Ashley's instigation of culm bank and river coal studies. And the Highway Department's need for limestone as road building material in northwestern Pennsylvania was also an early focus for the new organization.

Responding to the immediate needs of the Commonwealth was and still is a primary responsibility of the Geologic Survey, but Ashley recognized that a more systematic program was needed to answer future needs. Foremost in Ashley's overall plan was to produce a new Atlas of Pennsylvania, comprising both a topographic and a geologic map of each quadrangle. A start had already been made. Mapping was

being actively pursued, not only by U. S. Geological Survey geologists (e.g.,

Foremost in Ashley's overall plan was to produce a new Atlas of Pennsylvania.

Charles Butts, M. R. Campbell, George W. Stose, and M. J. Munn), but also by academics (e.g., Florence Bascom, Eleanora Bliss, and Benjamin L. Miller). Their efforts were concentrated in the crystalline rocks in the southeastern part of the state, and the coal measures of the Carboniferous and Permian rocks of southwestern Pennsylvania.

Ashley needed a staff to carry out such an ambitious mapping program—by the end of the first year, he had hired four geologists and five support staff. Ten years later the number of geologists had grown to nine, a size at which the survey remained through the ensuing 25 years. One of the better known staff members was Bradford Willard, a paleontologist and Devonian expert throughout the 1930's and 40's. Another staff member was Ralph W. Stone who wrote, among other reports, *Building Stones of Pennsylvania*. In the 1920's, Charles H. Behre extensively studied the slate industry in Pennsylvania. Marchant N. Shaffner produced 3 atlases in the bituminous coal district. Anna I. Jonas worked through the 1920's and 30's in southeastern Pennsylvania and was, along with Stose, an enthusiastic and vociferous proponent of the overthrust concept as applied in the Piedmont and Reading Prong.

But, as effective as this staff was, it was not enough, and in the early years of the Fourth Survey, Ashley contracted with 13 cooperating geologists to produce geologic maps. These geologists including such luminaries as Bascom, Miller, Edgar Wherry, and Charles Fettke. Cooperative projects with the U.S. Geological Survey involved Stose, Munn, Richardson, and Johnson, among others.

**including such
luminaries as Bascom,
Miller, Edgar Wherry,
and Charles Fettke.**

Not having topographic maps (which provide an accurate base) was a major disadvantage under which the Second Survey worked, and this may explain Ashley's intent on completing the topographic mapping of the state as soon as possible. When he took office, only 56 percent of the state had been mapped and thus the choices for geologic mapping were somewhat restricted. As a consequence, Ashley continued the cooperative program with the U.S. Geological Survey (see Sevon, this issue), in which the federal survey produced the maps, and the state shared in the costs.

Dissemination of the geologic information is as important as the gleaning of it from the rocks, soils, and landscape, a fact that was thoroughly understood by Ashley. However, publishing at first was frustrated by a very slow state printing office, so much of the early material was issued in mimeographed form. By the end of the survey's first decade, nearly 100 of these Bulletins (now called Pro-

gress Reports) had been printed, along with 6 Atlases and 12 Mineral Resource reports, which included coal (both bituminous and anthracite), lead and zinc ores, oil and gas, slate, fire clays, limestones, and silica refractories.

In lieu of a completed Atlas of Pennsylvania, Ashley planned a single geologic map of the entire state which was finally published in 1931, done largely by cooperative geologists (Stose and Ljungstedt, 1931). Much of this map was taken directly from the work of the Second Survey, but it also included the new work in the crystalline terrane of southeastern Pennsylvania, and the extensive mapping in the bituminous fields in the southwestern portion of the state.

Ground water is the principal source of much of the water that is used in Pennsylvania, a fact not lost on Ashley. In 1923, a cooperative program with the U.S. Geological Survey was initiated to ascertain the ground water resources for the entire state. Six regional reports, and a state-wide report, were completed over the next 18 years, volumes that are still in use today.

George H. Ashley retired from the Pennsylvania Geological Survey on August 31, 1946, ending a 27 year career as State Geologist. By this time the topographic mapping of the state at the 1:62,500 scale was nearly complete. His plan for an Atlas of the entire state was much further from fruition, but geologic mapping is perforce a much slower activity. Even so, eleven atlases and six county reports were published, along with 19 general geology reports, 27 on mineral resources, 7 on ground water, and 130 progress reports.

INTERREGNUM

Stanley H. Cathcart was the next State Geologist, taking office on January 1, 1947, at the end of Ralph W. Stone's largely ceremonial four months as chief geologist of the survey. Cathcart's earliest experience, with the U.S. Geological Survey, was in metalliferous geology, but his subsequent years in overseas oil exploration with several oil companies provided him with a strong background when he joined the Fourth Survey in 1938.

Oil and gas studies had been an important part of the Survey's activity over the years, in which Cathcart had been an major contributor. Charles Fettke continued his studies, particularly on the Bradford oil field. Innumerable wells have been drilled for oil, and more

Cathcart instituted a series of annual reports listing the data from the recently drilled deep wells.

recently for gas, since 1857, when Drake spudded the first producing well in the United States. Since the inception of the Fourth Survey, an effort has been made to record the locations and characteristics of every petroleum well drilled in Pennsylvania. So many relatively shallow wells have been drilled over the years that publishing the data on all of them would be of little interest to most geologists. However, as drilling reached deeper unexposed formations, interest in these deeper wells has increased. In 1950, Cathcart instituted a series of annual reports listing the data from the recently drilled deep wells. Also begun at this time was an annual report on the production of minerals in Pennsylvania. Both of these reports have continued as important contributions to the Survey's information output.

Stanley Cathcart died in 1953. Ralph Stone once again stepped in as acting State Geologist for seven months until the next State Geologist was appointed.



Figure 2. Stanley H. Cathcart, second director and State Geologist of the Fourth Pennsylvania Geological Survey (1947-1953).

REORGANIZATION

Carlyle Gray, a member of the staff since 1949, became acting State Geologist in October of 1953, and was formally appointed as State Geologist in October, 1955. It was during this time that a change in focus and structure of the Pennsylvania Geological Survey occurred, with new objectives being defined.

The depression and the ensuing war years had brought most of the quadrangle mapping in Pennsylvania to a halt. Finally in the mid-1950's, a determined program of Atlas mapping was restarted at the instigation of Carlyle Gray. Perhaps most important was the change of mapping scale to that of the new 7½ minute series of topographic maps. Mapping at this larger, 1:24,000 scale permitted much greater detail and accuracy, and has been standard since.



Figure 3. Carlyle Gray, third director and State Geologist of the Fourth Pennsylvania Geological Survey (1953-1961).

The carbonates of the Great Valley in Lebanon County were the first target because of their importance to the steel industry that was present and growing there. It was also decided to map two corridors across the Valley and Ridge province, one north-south and the other east-west because so little work had been done in the central part of the state. Mapping in the bituminous fields (which had occupied so much effort in the early part of the century) was continued, centering on Clearfield County.

Mapping was not the only activity that accelerated during the latter part of the 1950's. An extensive study on the Cornwall

iron mines was commenced, along with a variety of other geologic subjects: the geology of Bucks County; chromite mining; paleontology of the Bloomsburg Formation; and the glacial geology of northwestern Pennsylvania.

Two new volumes were brought out in the late 1950's, designed for the amateur as well as professional geologist. These two volumes, *Mineral Collecting in Pennsylvania* and *Fossil Collecting in Pennsylvania*, describe the locations where minerals and fossils can be collected in Pennsylvania. They are the Survey's two perennial 'best sellers', and have been revised and updated a number of times over the years.

The most recent geologic map of the state at this time was by Stose and Ljungstedt (1931), much of which was based on Second Survey work. Gray did not want a new version to be based on such dated material, but despite all the work the Fourth Survey had done up to that time, large areas of the state had not been evaluated since before the turn of the century. Accordingly, the entire geologic staff reconnaissance mapped the entire state, and compiled the new data on 15-minute quadrangle maps. From these maps,

a new geologic map (Gray and others, 1960) was assembled, more detailed and colorful than any of its kind before.

**a new geologic map...
was assembled, more
detailed and colorful
than any of its kind
before.**

Ground water studies in Pennsylvania tapered off in the early 1940's. A few reports were published in the next ten years, but it wasn't until the late 1950's that studies on ground water became widespread across the state. Since then a steady stream of ground water reports have appeared, for specific formations, for quadrangles and counties, and specific lithologies.

With Carlyle Gray's resignation in September, 1961, Alan R. Geyer stepped in as acting State Geologist for the next three months.

GROWTH TO THE PRESENT

Arthur A. Socolow was named State Geologist at the end of 1961, having worked at the Pennsylvania Geological Survey since 1957. During the ensuing 25 years, the Survey continued to grow, and expand its activities into new areas of research and evaluation. Throughout most of its history, the Fourth Survey was a bureau within the Department of Internal Affairs. In 1971, the Topographic and Geologic Survey was transferred to its present administrative home, the Office of Resource Management of the Department of Environmental Resources.

Geologic mapping has remained the cornerstone of the Fourth Survey's activities. The study of the carbonates in the Great Valley in eastern and south-central Pennsylvania continued. During the 1960's and 70's, mapping in the Valley and Ridge province in central Pennsylvania focused on the major population centers of Williamsport and Altoona. Early in Socolow's tenure it was decided that additional mapping was needed to complete the northern parts of the bituminous coal fields. And in the late 1960's, mapping was begun in eastern Pennsylvania because



Figure 4. Vincent C. Shepps, geologist and editor for the Fourth Pennsylvania Geological Survey, measuring slickensides on a wrench-fault in Clearfield County during the summer of 1959. (Photo by A. R. Geyer).



Figure 5. Arthur A. Socolow, fourth director and State Geologist of the Fourth Pennsylvania Geological Survey (1961-1986).

of the expanding population growth there, and has been continued into the northeastern part of the state where virtually no work had been done since the Second Survey.

The Fourth Survey did not work in the Anthracite region in eastern Pennsylvania or in the southwestern part of the state, because of the large cooperative mapping program with the U.S. Geological Survey. In the late 1970's, a coal exploration model was developed by analyzing a small coal basin. Also at this time, the federal survey developed the National Coal Resource Data System (NCRDS), a computer-based program for storing detailed data on coals, from which coal quality and thickness maps could be

generated. The Pennsylvania Survey's coal section has devoted its time and efforts since then to gathering and storing in this computer system the voluminous coal data from western Pennsylvania.

Perhaps one could say that 1972 was a watershed year for the Survey. For decades it occupied offices in Harrisburg, on the sixth floor of the South Office building. In March of 1966, the offices were moved to the Old Museum Building, but six years later expansion of the adjacent Governor's offices pushed the Survey out—into a building on an old flood plain of the Susquehanna River. No sooner had the Survey settled in when Agnes, the errant tropical hurricane, arrived in Pennsylvania, and stayed, and stayed, until the Survey's offices (and much else along the Susquehanna) were totally submerged. It took a while for the Survey to recover, but projects were soon underway again. Just as importantly, the generosity of many individuals went a long way in rebuilding the library, which had been totally destroyed.

Agnes, the errant tropical hurricane, arrived in Pennsylvania, and stayed, and stayed.

A just-completed study of the Reading Prong has provided invaluable data for evaluating the recently recognized radon hazard.

Figure 6. Offices of the Fourth Pennsylvania Geological Survey, underwater on June 23, 1972.



By the mid-1970's it was felt that sufficient modern mapping had been done that a revision of the 1960 Geologic map of Pennsylvania was in order. A number of the Survey's staff were engaged in this effort, which included a fair amount of reconnaissance work, utilizing air photographs extensively. After several years' effort, the map was published (Berg and others, 1980). Three years later, the first correlation chart for Pennsylvania was printed.

Mineral studies have been in the forefront of the Survey activities. In fact, one could argue that supplying geologic information for the extraction of the mineral resources is the ultimate justification for any Survey. Coal, and oil and gas, are the most valuable commodities in Pennsylvania, but numerous other minerals have been studied over the years, such as manganese and chromite. More recent studies have been done on zinc and lead deposits, copper and uranium, carbonate whitening, barite, and high-purity silica, among other mineral commodities. A just-completed study of the Reading Prong has provided invaluable data for evaluating the recently recognized radon hazard.

Much of the work by the Oil and Gas Division in the early Socolow years involved petroleum evaluations in various quadrangles of the western part of the state, in addition to an important stratigraphic

study of the Lower Paleozoic formations in western and central Pennsylvania. Specific drilling target horizons, such as the Medina sandstone, were also evaluated. Late in the 1960's, a new series of maps was created, and periodically updated. This series includes every quadrangle in northern and western Pennsylvania that contains an oil or gas well, and shows the locations of these wells as well as the field/pool limits.

The need to examine and anticipate the effects of man's activities on our environment, and the geological factors involved has steadily increased over the years, and led to the creation of the Environmental Geology Division in 1968. The engineering properties of the various rocks of Pennsylvania was the first product of this new division. The Division has also engaged in water studies, the first of which was for the Susquehanna River Basin Commission. Other activities of the division have included studies on landside potential, sink hole development, and environmental geology of metropolitan areas.

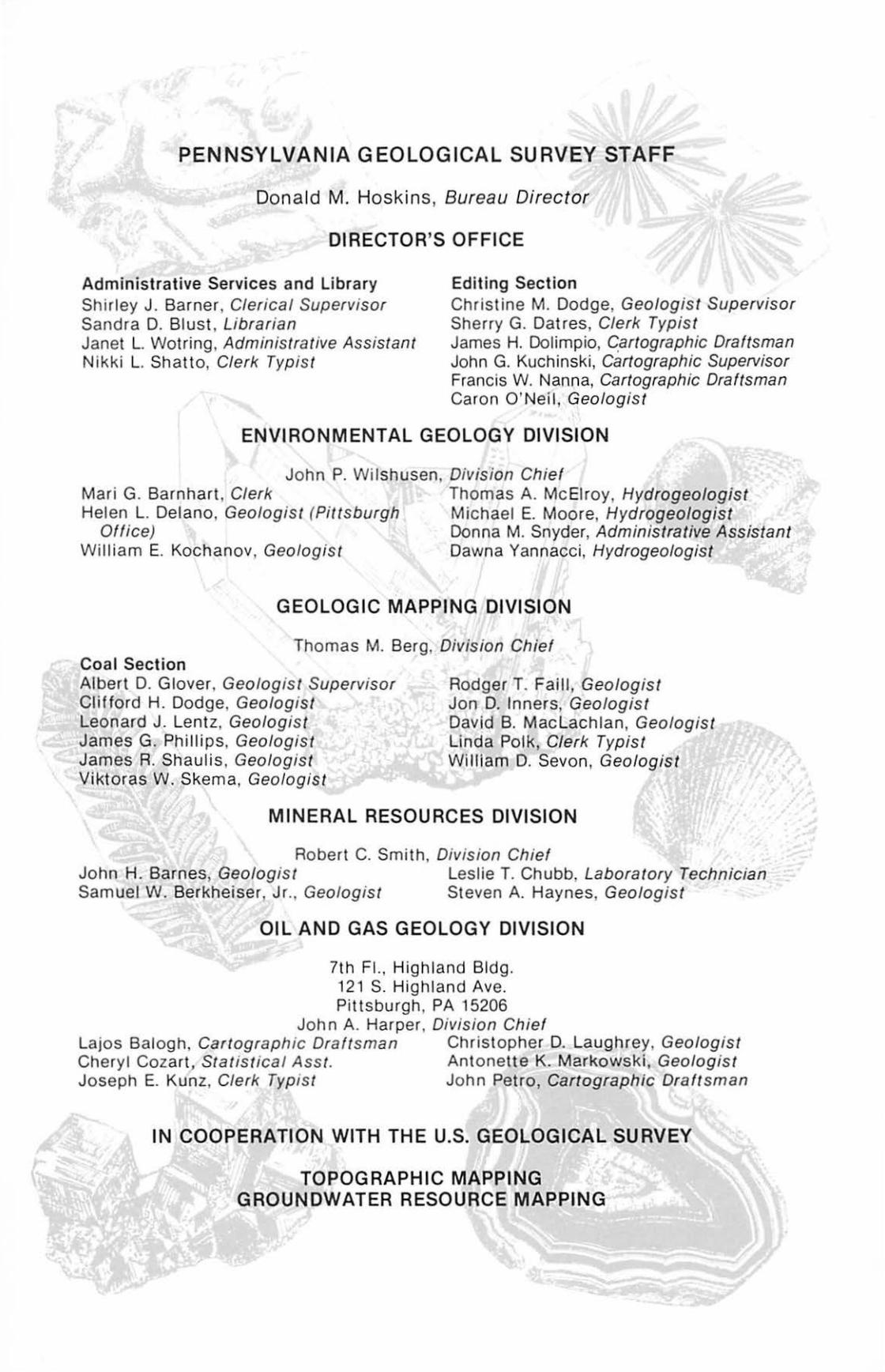
In keeping with the desire to disseminate as widely as possible the geologic information the Survey generates, Socolow instituted three new publications series that have proved to be as popular as they are informative. *Pennsylvania Geology*, a bimonthly magazine begun in 1969, provides timely announcements and geologic descriptions for both professional and amateur geologists, and interested laymen. The Educational Series, begun in 1962, discusses in non-technical terms, broad aspects of geology, such as coal, the ice age, ground water, and geologic hazards. The Geologic Park Guides were begun in 1969 and now number 19. These guides describe in non-technical language the geology within and surrounding various state parks throughout the state.

Arthur A. Socolow retired in August of 1986, leaving a Survey with a staff of 43, which had accomplished a remarkable amount of work during his long tenure.

After serving as acting State Geologist for five months, Donald M. Hoskins was appointed the fifth State Geologist of The Fourth Survey on January 8, 1987.

REFERENCES CITED

- Berg, T. M., and others, 1980, Geologic Map of Pennsylvania: Pennsylvania Geologic Survey, 4th ser., Map 1.
Gray, C., and others, 1960, Geologic Map of Pennsylvania: Pennsylvania Geologic Survey, 4th ser., Map 1.
Stose, G. W., and Ljungstedt, O. A., 1931, Geologic Map of Pennsylvania: Pennsylvania Geologic Survey, 4th ser., Map 1.



PENNSYLVANIA GEOLOGICAL SURVEY STAFF

Donald M. Hoskins, *Bureau Director*

DIRECTOR'S OFFICE

Administrative Services and Library

Shirley J. Barner, *Clerical Supervisor*
Sandra D. Blust, *Librarian*
Janet L. Wotring, *Administrative Assistant*
Nikki L. Shatto, *Clerk Typist*

Editing Section

Christine M. Dodge, *Geologist Supervisor*
Sherry G. Dattres, *Clerk Typist*
James H. Dolimpio, *Cartographic Draftsman*
John G. Kuchinski, *Cartographic Supervisor*
Francis W. Nanna, *Cartographic Draftsman*
Caron O'Neil, *Geologist*

ENVIRONMENTAL GEOLOGY DIVISION

John P. Wilshusen, *Division Chief*

Mari G. Barnhart, *Clerk*
Helen L. Delano, *Geologist (Pittsburgh Office)*
William E. Kochanov, *Geologist*

Thomas A. McElroy, *Hydrogeologist*
Michael E. Moore, *Hydrogeologist*
Donna M. Snyder, *Administrative Assistant*
Dawna Yannacci, *Hydrogeologist*

GEOLOGIC MAPPING DIVISION

Thomas M. Berg, *Division Chief*

Coal Section

Albert D. Glover, *Geologist Supervisor*
Clifford H. Dodge, *Geologist*
Leonard J. Lentz, *Geologist*
James G. Phillips, *Geologist*
James R. Shaulis, *Geologist*
Viktoras W. Skema, *Geologist*

Rodger T. Faill, *Geologist*
Jon D. Inners, *Geologist*
David B. MacLachlan, *Geologist*
Linda Polk, *Clerk Typist*
William D. Sevon, *Geologist*

MINERAL RESOURCES DIVISION

Robert C. Smith, *Division Chief*

John H. Barnes, *Geologist*
Samuel W. Berkheiser, Jr., *Geologist*

Leslie T. Chubb, *Laboratory Technician*
Steven A. Haynes, *Geologist*

OIL AND GAS GEOLOGY DIVISION

7th Fl., Highland Bldg.
121 S. Highland Ave.
Pittsburgh, PA 15206

John A. Harper, *Division Chief*

Lajos Balogh, *Cartographic Draftsman*
Cheryl Cozart, *Statistical Asst.*
Joseph E. Kunz, *Clerk Typist*

Christopher D. Laughrey, *Geologist*
Antonette K. Markowski, *Geologist*
John Petro, *Cartographic Draftsman*

IN COOPERATION WITH THE U.S. GEOLOGICAL SURVEY

TOPOGRAPHIC MAPPING
GROUNDWATER RESOURCE MAPPING

