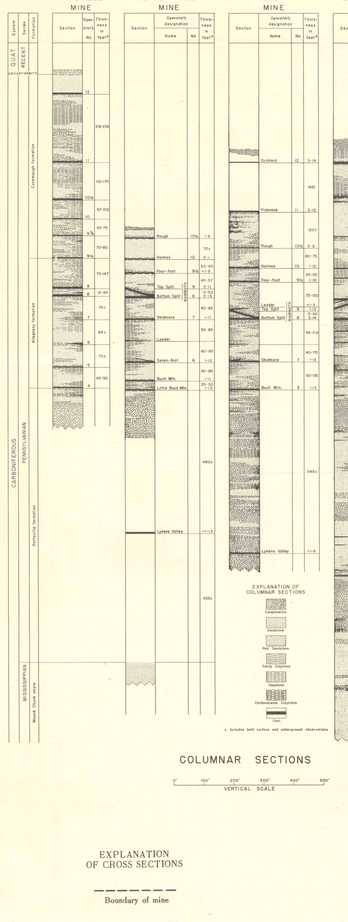

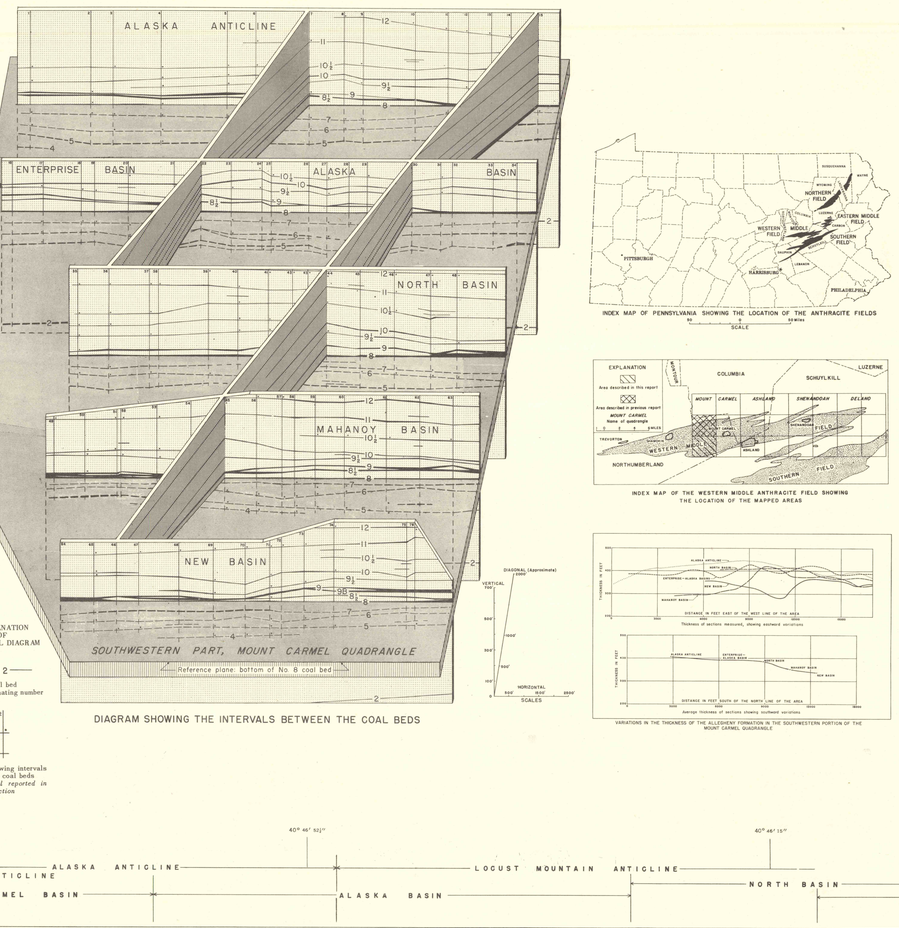

GEOLOGY OF ANTHRACITE IN THE SOUTHWESTERN PART OF THE MOUNT CARMEL QUADRANGLE, PENNSYLVANIA

INTRODUCTION

LOCATION

The Pennsylvania anthracite fields, the principal source of anthracite in North America, lie in the eastern half of the Appalachian mountains of Pennsylvania. Other large areas of Pennsylvania, sheet 1.) The coal measures of the roughly circle areas, called the Northern, Western Middle, Eastern Middle, and Southern fields, that trend northeastward and in echelon arrangement. The fields range in length from 24 to 66 miles and in width from a fraction of a mile to 10 miles, and include about 484 square miles of coal-bearing land. The area covered by this report is in the Western Middle field.

The boundaries of the coal-bearing areas that constitute the anthracite fields are considered to be the outcrops of the oldest of the Lykens Valley coal beds. In the Western Middle field, however, the coal beds are underlain by the Eastern Middle field, which contains several closely spaced but discontinuous coal-bearing areas. The approximate boundaries of the fields are generally indicated by outcrops of the conglomeratic formations of the red rocks of the Mauch Chunk shale below the Pottsville.

The mapped area here described is near the middle of the Western Middle field and consists of the southwestern part of the area included in the United States Geological Survey Mount Carmel quadrangle, bounded by lines of the index map of the Survey's Middle field, sheet 1.). This part of the quadrangle is between latitudes 40° 45′ 00″ and 40° 47′ 30″ N., a distance of 2.87 miles, and longitudes 76° 38′ 15″ and 76° 50′ 00″ W., a distance of 8.35 miles, and is almost entirely in Northumberland County. The town of Locust Gap is near the center of its eastern boundary.

PURPOSE

This report is the second to be prepared as a result of a geologic investigation of the anthracite fields of Pennsylvania begun after consultation with the Bureau of Topographic and Geologic Surveys of the Commonwealth of Pennsylvania. This report and others in preparation will show (1) the location of coal beds, (2) the depth, pitch, and other structural features of representative areas, (3) the character of the coal beds, including their physical and chemical relationships between the various coal beds, and (4) the correlation of the beds, the stratigraphic intervals between them, and the thickness, continuity, and other physical characteristics of the beds. The reports will bring up to date and amplify the Grand Atlas of the Anthracite Fields published by the Second Geological Survey of Pennsylvania in 1884-1885, and the reports that supplemented that atlas. It is expected that the reports will aid operators who are mining either on the surface or underground, or who are formulating plans for control of mine water. It is hoped that these reports will also direct attention to overlooked or little-developed resources.

A preceding report describes the sedimentary part of the Mount Carmel quadrangle (Rothrock et al., 1950) and it is planned to publish similar reports on other unit areas as they are completed.

METHODS OF WORK AND ACKNOWLEDGMENTS

The methods used in preparing this report are similar to those described in the first report. Extensive use was made of the coal companies' surface and mine maps and structural cross sections, generally drawn to a scale of 1 inch = 200 feet. The generous use of these records by the Pennsylvania Coal Company and the Susquehanna Collieries Company in permitting the use of their records is gratefully acknowledged.

GEOLOGY

STRATIGRAPHY

The rocks that crop out in the mapped area belong to the Carboniferous and Quaternary systems. The Carboniferous comprises the Pottsville formation, the Mauch Chunk formation, all of the Allegheny formation, and the lower part of the Conemaugh formation of the Pennsylvanian series, and alluvial deposits of the Pleistocene (?) and Recent (Quaternary) age. (See column sections, sheet 3.) On the south side of Mahanoy Mountain, a small area of the Pocono formation (Carboniferous) is exposed below the Pottsville formation. The coal beds considered to be the Buck Mountain (No. 7) coal bed at the base of the Allegheny and the Holmes (No. 10) coal bed at the base of the Conemaugh (Lobman, 1937, p. 56). The successive two coal beds immediately above the Buck Mountain in the areal distribution of the Allegheny and Conemaugh formations and of the top of the Pottsville formation. Data for the Mauch Chunk formation are meager, and obtained from field observations and from the study of many mine cross sections, drawn to a scale of 1 inch = 200 feet, and from a few exploratory drill holes. The black areas in the cross sections (sheet 3) indicate that reliable information concerning this lithology was not available.

PENNSYLVANIAN ROCKS

The Pennsylvanian rocks are of continental origin and consist of lenticular deposits of conglomerate, sandstone, siltstone, and claystone (generally called slate by the miners), and coal beds. The Pottsville and the greatest part of the Allegheny formation, was studied. Stratigraphic cross sections, measured at places of approximately equal dip, were prepared and their thicknesses averaged for each principal structure. The dip of the rocks at the places where the sections were measured was also determined, and averaged for each structure. Comparison of these data shows that the Allegheny formation thins as the degree of folding increases. This trend is expressed quantitatively in the following table:

RELATIONSHIP BETWEEN THE THICKNESS AND THE DIP OF STRATA IN THE ALLEGHENY FORMATION IN THE SOUTHWESTERN PART OF THE MOUNT CARMEL QUADRANGLE

Structure	Average dip of the beds where measurements were made	Average thickness of the formation	Percentage decrease in thickness in Alaska anticline
Alaska anticline	19°	406	6.0
Enterprise and Alaska basins	27°	393	3.2
North basin	33°	386	9.3
Mahanoy basin	34°	351	
New basin	45°	357	17.0

The relationship between stratigraphic thickness and degree of deformation is also indicated on the accompanying cross sections. Measurements of the thickness of the Allegheny formation and the thickness of this formation varies irregularly along the Buck Mountain anticline, which is a definite trend in this direction. The degree of irregularity, however, is greater in the southern, more closely folded basins, than in the northern structures.

COAL BEDS

NOMENCLATURE AND CORRELATION OF THE COAL BEDS

Coal beds in the anthracite fields are generally known as veins, following very early custom. The term "vein," in scientific usage, refers to tabular mineral deposits that are foreign to, and younger than, the rocks in which they occur, and so in geology is not properly applicable to deposits of coal. In this report the coal deposits are called coal "beds."

The coal beds of a mine are designated by names or numbers, or by both, but the nomenclature is not generally standardized. Great progress, however, has been made since the early days of mining, when names were given to beds in isolated mines before correlation could be made. Other factors contributing to this lack of uniformity are the complexity of structure and lithology, the scarcity of outcrops, and the difficulty of changing established records.

The names of the coal beds used in this report were chosen to conform to the numerous underground measurements made by the operators. They were chosen to indicate the normal thickness of the bed and its included coal in unit areas 2000 feet square. Wherever possible, at least four measurements were averaged for each unit area. Measurements that were considered to be abnormally affected by structural deformation, such as faulting, pinching, or swelling, were not used; hence, extreme dimensions of the beds are not included. The following table shows the number, average thickness, and range in thickness of the beds in the mapped area. The ranges in thickness shown in this table, however, may be less than the ranges shown on the column sections on sheet 3 because, in preparing the latter, measurements were averaged over overlapping, and by greater compression of the folds. These processes probably alternated with each other until the fault planes became so flexed that further movement along them was impossible. Subsequent deformation of the stabilized mass, which took place chiefly by folding, represents the third stage.

Deformation in the Enterprise basin is considered to be representative of the second stage of deformation in the three-stage hypothesis. The folds are of low amplitude, and the fault planes are flexed but not displaced. Movement took place at low angles or follows bedding planes; the younger beds moved relatively northward. (See cross section A-A′, sheet 3.) The movement pivoted on the east end of the faulted plane where segments of the Enterprise fault terminate near Locust Gap and half a mile southeast of Maysville No. 1 slope. (See sheet 1.) These two segments can be traced westward into the adjoining area through workings in the Mammoth bed, where they are shown to be the same fault. The third stage of deformation is represented in the Alaska basin and anticline.

This three-stage hypothesis is not thoroughly substantiated. More evidence bearing upon it will be obtained during the extension of the current studies to other parts of the anthracite fields.

Subsidiary faults and shear zones. There is no clear line of demarcation between subsidiary (local) faults and principal faults because of interpenetration of the two types.

In many places mining operations are more directly affected by subsidiary faults than by principal faults. Bedding-plane faults cause much local disturbance in the roof. The features that miners call "slips," and probably some that they call "joints," are bedding-plane faults, in contrast to the term "rock fault," which denotes a fault whose offset is transverse to the bed and greater than its thickness.

Oblique faults, also subsidiary, are common in the mines. They generally trend at angles of about 45° with the longitudinal trend of the stratum, and may cut one or more beds. They may be associated with shear zones (see sheet 3) or with the principal faults, and they are probably genetically related to them in the development of these faults. Some of these faults offset rivers of folds, and so were formed later than the folding that established these axes.

Shear zones also are subsidiary structures that affect mining adversely. Bands of sheared coal occur in places in most of the beds, and large areas of some beds are sheared, but neither condition may be extensive enough to make the bed unminable. In some areas, however, the coal is so extensively sheared that it is not worth mining. Shear zones are a characteristic feature of the current cycle of orogeny appears to be inadequate to form such a deposit.

Recent deposits. The deposits of Recent age are similar to those in the western-central part of the Mount Carmel quadrangle, where they are described as consisting of "silt, sand, gravel, boulders, and water-borne or alluvial mine refuse" (Rothrock, et al., 1950, sheet 3). These materials occur chiefly in the lower valleys, where alluvial mine refuse generally forms the top layer of the deposit. The silt, sand, and gravel have been covered by ice during the Pleistocene epoch of the Quaternary period (Ashley, 1915), it is possible that some of the alluvium is of Pleistocene age.

STRUCTURE

GENERAL DESCRIPTION

Each of the Pennsylvania anthracite fields is a composite syncline consisting of a group of roughly parallel folds, some of which have been faulted. The general trend of these structures is northeastward. The principal axes are called basins in mines, a practice that is followed in this report. The term "basin" generally designates a complex syncline, consisting of a trough and two limbs, but in some places it is applied to parallel synclines that have been truncated by faulting, or to a single trough or limb.

The composite syncline that contains the Western Middle field is 45 miles wide in the western part of the Mount Carmel quadrangle and has a maximum relief of about 2,200 feet, as measured from the highest outcrops of the Lykens Valley coal bed to its greatest depth (as projected) in the Shamokin basin. The deeper parts of the syncline are near its middle and along its southern margin. The trough near the middle is composed of three closely folded and moderately faulted synclines, which are separated by anticlines that are less faulted. The axes of the mapped area and the Pennsylvania basin north of it. The axial plane of the Pennsylvania basin is approximately vertical, but that of the Shamokin basin and part of that of the Mount Carmel basin dip 70° to 80° southeast. The trough near the southern margin of the composite syncline of the Western Middle field is also composed, consisting of the New, Mahanoy, and North basins, but it is more extensively faulted and its folds are generally more asymmetrical than its northern counterpart. The axial planes of the anticlines that separate these basins are vertical. The southern trough widens northeastward and becomes the predominant structural feature of the eastern part of the Western Middle field.

The area between the two major troughs is dominated by the Locust Mountain anticline which, near the western edge of the mapped area, is almost as high as the margins of the Western Middle field. The anticline plunges gradually northeastward from this locality, being about 500 feet lower at the eastern edge of the mapped area. Subsidiary folds are numerous on the northwestern limb of the anticline, and include a series of folds of low relief, containing the Alaska and Big Mountain basins. The Locust Mountain anticline appears to have constituted a barrier to the deformational forces, which folded the rocks closely on the south but affected those north of it to a much lesser degree.

FOLDS

All the rocks in the area have been folded in patterns suggestive of the type called parallel folding. The principal folds range in degree of compression from almost flat folds such as the Enterprise basin and the Big Mountain anticline, whose limbs enclose angles ranging from 110° to 160°, to moderately acute folds such as the Shamokin and Mount Carmel basins and the basins in the southern trough, whose limbs enclose angles ranging from 75° to 90°. Extremely acute folds are very uncommon, and are generally associated with faults.

The axial planes of the folds are either vertical or declined a few degrees southward. The axial planes of the folds in the Western Middle field and North basin and in the Shamokin anticline is nearly assumed, but it can be demonstrated in parts of the Mahanoy and Shamokin basins and the Locust Mountain anticline. None of the large folds exhibits the degree of asymmetry that resulted in overturning, sometimes called "inversion," such as that shown in the Locust Gap area on maps of the reports of the Second Geological Survey of Pennsylvania (Sadtler, 1883). Subsequent mining has shown that this structure, as well as several similar structures, is a fault, generally of the type of the Locust Gap fault, described in the following. Overturned folds occur locally, however, as drag folds along faults, and inverted dips are present in some places along the steeply dipping north limb of the New basin.

FAULTS

All the observed faults in the area are genetically those shown that dip at angles ranging from vertical to horizontal. The planes of the faults are relatively flat, as in the Mount Carmel basin, or are curved, like the Enterprise, Locust Gap, and Locust Spring faults. (See cross sections, sheet 3.)

Principal faults. The principal faults generally cut the beds at angles of about 45°, but in many places they follow the bedding. (See Enterprise fault, cross section A-A′, sheet 3.) Outcrops of the principal faults are few. One of the best can be observed in the field where the Locust Spring fault cuts the west end of the New Basin. The curvature of the faults and the folds of the strata are similar, and the faults are considered to be genetically related to the folds and to mechanically are normal faults. (See southern outcrop of Locust Spring fault, sheet 1.)

Evidence relating to the time and method of formation of the curved faults is not complete. It is possible that they were formed well in advance of appreciable folding and produced overlapping sheets or planes of but slightly folded strata. When the area could no longer be compressed by faulting, the stabilized fault planes, as well as the overlapping planes, were folded.

The Locust Gap fault is considered to have formed instead of two principal stages, however, is supported by evidence. According to this hypothesis the first stage resulted in moderate folding such as that in the western part of the Appalachian Valley and Ridge province, west of Hills Gap, Pennsylvania, and in the adjoining Allegheny Plateau province (Pittsburgh Geological Society, 1948).

The second stage began when compression was relieved partly by shearing and overthrusting and partly by folding. Shearing probably took place on the Locust Gap fault, and folding on the axes of the folds in the mapped area. But faulting was deferred until the folds were extensively compressed or overturned. After faulting began, deformation proceeded both by additional folding and overthrusting, and by greater compression of the folds. These processes probably alternated with each other until the fault planes became so flexed that further movement along them was impossible. Subsequent deformation of the stabilized mass, which took place chiefly by folding, represents the third stage.

The cross section A-A′, sheet 3.) The movement pivoted on the east end of the faulted plane where segments of the Enterprise fault terminate near Locust Gap and half a mile southeast of Maysville No. 1 slope. (See sheet 1.) These two segments can be traced westward into the adjoining area through workings in the Mammoth bed, where they are shown to be the same fault. The third stage of deformation is represented in the Alaska basin and anticline.

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