Stratigraphic Classification of Rocks of Pennsylvanian Age in Indiana

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Abstract

Pennsylvanian rocks in Indiana exhibit rapid lateral and vertical variations. In order to divide these rocks at the formational level, certain requirements should be met, namely, homogeneity of type, distinctive lithology, reasonable lateral continuity, and appropriate thickness to be mappable and meet practical needs. In the formational classification of Pennsylvanian rocks these requirements must be compromised in that the formation may be heterogeneous but is readily recognized on the basis of marker beds at the top or bottom. Limestone and coal beds are the most distinctive and laterally persistent and therefore are most useful in marking the boundary of formational units. These distinctive beds, and certain sandstone beds have been designated as formal members. Each named member is one bed of a single lithology in some places but changes laterally and includes additional lithologic units in other places.

Introduction

Stratigraphic classification of rocks of Pennsylvanian age in Indiana is difficult because each rock unit exhibits rapid lateral and vertical variations. A classification is a generalization of these variations and it is a workable classification only if it includes the range of variation within a unit, but excludes characteristics of adjacent units.

History of Classification

Early classification of Pennsylvanian rocks in Indiana was simple (2):

Upper or barren coal measures
Middle or productive coal measures
Lower coal measures or millstone grit

This was not a bad beginning. This three-part classification was based on abundance and thickness of coal beds. The middle 500 feet of rocks does contain the widespread thick commercial coals; sandstone exposures of the lower rocks resemble the millstone grit near the base of coal-bearing rocks in England; and the upper part is devoid of coal thick enough to be of commercial importance and is barren in that sense. These units were not exactly defined or delimited but, in general, in Indiana the millstone grit corresponds to the Raccoon Creek Group of present terminology, the productive coal measures to the Carbondale Group, and the barren coal measures to the McLeansboro Group (Table 1).

About 90 percent of the Pennsylvanian rocks in Indiana are the common classics: mudstone, gray shale, siltstone, and sandstone; the remaining 10 percent are mostly underclay, coal, limestone, and black slaty shale. These latter four lithologic units are generally characterized

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TABLE 1

Names of rocks of Pennsylvanian age as used by various workers.

Lesquereaux 1862 Coal	Cox (3) 1869 Coal	Ashley (2) 1899 Division	Wier and Gray (7) 1961 Group	Formation
17		IX		Mattoon
16			McLeansboro	Bond
15		VIII		Patoka*
14		VII		
13		VII		Shelburn
12	N	VI		
11	M	V		Dugger
10	L			
9		IV	Carbondale	Petersburg
8	K			
7	J			
6	I	III		Linton
5	H			
	G	II		Staunton
4	F			
3	E			
	D		Raccoon*	Brazil
2	C		Creek	
1C	B			
1B		I		Mansfield
1A	A			

* New names (see Wier, C. E., in preparation. Stratigraphy of middle and upper Pennsylvanian rocks in southwestern Indiana. Indiana Geol. Survey Bull.)

by great lateral persistence and singly or in combination are useful stratigraphic markers as a means of identifying and classifying the rocks.

David Dale Owen simply numbered the coals from the bottom up in western Kentucky and Lesquereaux (6) followed his example and applied numbers to coals in southern Indiana. Later E. T. Cox (3) used a similar system for the northern part of the coal region and named the coals by letters. In 1896 when G. H. Ashley and his associates started a comprehensive survey of the coal-bearing rocks in Indiana the arabic number system of Lesquereaux for the southern area and the letter system of Cox for the northern area seemed incompatable. Ashley's solution was to use a new system and number the coals from the bottom up with Roman numerals (2). At the time of the Ashley survey many rock units of older systems in Indiana had formal group and formation names and it seemed desirable to divide the Pennsylvanian rocks in a similar manner. The apparent heterogeneity of the rocks seemed to defy division into units that were on the order of 100 feet in thickness, that were somewhat homogeneous, and were distinct from units above and below. Because the shales and sandstone beds are the most abundant rocks they should be utilized, but a sandstone or shale bed in one part of the stratigraphic sequence is similar to a sandstone or shale bed in many other positions in the column. Because of their economic significance the coal beds were given most attention by the early workers and the geographic distribution of the thicker coals was fairly well known. On the basis of this information Ashley (2) divided the Pennsylvanian rocks into divisions (Table 1) by utilizing coal beds to mark the upper boundaries of these divisions. Thus Division V contains Coals V, Va, and Vb. Later Fuller and Ashley in 1902 (5) and Cumings in 1922 (4) began dividing the Pennsylvanian rocks into groups and formations that were modifications of the divisions of Ashley.

The cyclothemic concept became somewhat in vogue in the 1930's and 1940's and was extensively applied in adjacent states but only sparingly in Indiana. This system allows the lumping of all rocks in a cyclic unit of deposition. Ideally the base of a cyclothem is the unconformable base of a sandstone and the cyclothem contains 10 units: 1 sandstone bed, 4 shale beds, 3 limestone beds, 1 underclay bed, and 1 coal bed. It is not uncommon for a cyclothem to contain only four beds and it is uncommon to find a place where all 10 beds are present. If the basal sandstone is not well developed in the cyclothem or in the overlying cyclothem the boundaries are hard to find and it is difficult to plot the distribution of a cyclothem on a map. Although many cyclothems would make acceptable formational units, others are too thin or too irregular in distribution. In present practice two or more cyclothems may be lumped together to form a formation.

Formations

The formation is generally accepted as the basic rock unit and the definition of each formation may utilize marker beds such as coal and limestone. According to the "code of stratigraphic nomenclature" (1) a formation should have internal lithologic homogeneity and be mappable. If homogeneity were used as the major criterion then the 1600 feet of Pennsylvanian rocks in Indiana would be divided into about 300 formations many of which would be less than a foot thick. Obviously this is impractical from the mapping standpoint. It is impossible to divide these rocks into formations in such a manner that they are homogeneous, have a distinctive lithology different from formations above and below, are continuous, and are of appropriate thickness to be mappable and meet practical needs. These requirements must be compromised such that a formation is heterogeneous but is readily recognized on the basis of marker beds at the top or bottom or both. The limestone and coal beds are the most distinctive and laterally persistent and are most useful in marking the boundary of formational units. It may be difficult to distinguish an individual coal bed from another but the fact that a coal is bright, dull, well banded or poorly banded or contains well defined shale partings or lacks shale partings is distinctive. Other criteria are the recognition of underclay and limestone below the coal and black fissile shale and limestone above or the lack thereof. Thus present day formations are defined in much the same manner as the divisions of Ashley.

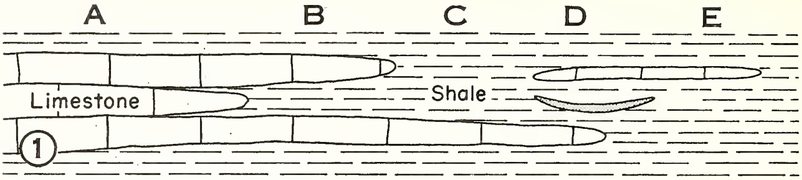
Members

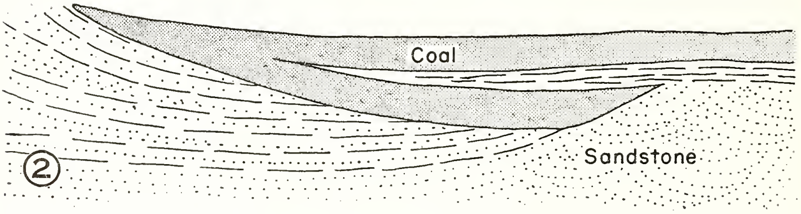
Many beds of coal and limestone are distinctive and easily recognized and have been designated as named members; underclays and black slaty shales also are distinctive but they commonly are present immediately below and above coals and can be described in relationship to the coal without adding to the multitude of names. Many sandstone beds also have been named. Sandstone is more resistent to erosion than shale and thus crops out as spectacular bluffs and in some areas sandstone may be the only rock exposed even though it is less than half of the total rocks. Thus names were applied by early workers and most of these names have been retained.

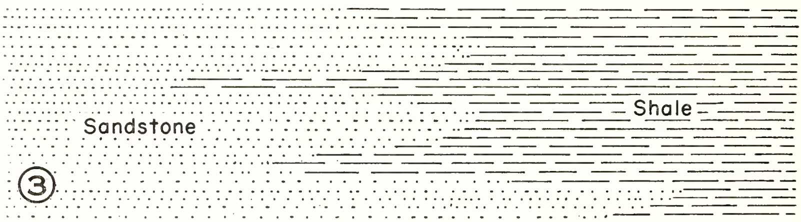
Each of these members is one bed of a single lithology in some places but may change laterally and include additional lithologic units or may be absent. Because of this lateral variation a lithologic member may contain impurities in that it includes minor amounts of other kinds of rocks. The degree of variation and the amount of impurities that one can allow apply the lithologic member name poses a difficult question.

Limestone members are difficult to define precisely. In some areas a named limestone member may consist of a single lithologic unit that is easily defined and delimited, but it may vary laterally and in other areas be a fossiliferous, calcareous shale or two limestone beds separated by shale (Figure 1). If a named limestone member varies laterally and, in local areas, is a shaly limestone or a fossiliferous shale the limestone member name is retained for this local variation in lithology as far as it can be traced. If the limestone contains a thin gray shale parting the shale parting is also included in the formal member (Figure 1, B). In the case of the West Franklin Limestone Member of the Shelburn Formation and Livingston Limestone Member of the Bond Formation, where one to three limestone beds are present separated by several feet of shale, some flexibility is necessary. If only one bed of limestone is present (Figure 1, A, C, E) then the limestone member consists of a single limestone bed even though the bed in one place may not be equivalent to a bed elsewhere. If two or more limestone beds are present, the upper and lower limestone beds and the intervening rocks are included in the limestone member (Figure 1 A, B, D). At one locality a thin coal is present in the medial shale of the West Franklin Limestone Member. This raises the question as to the position of the overlying and underlying beds of limestone in a cyclothem and raises the question as to how much impurities one will allow in a member, but for practical reasons the theoretical question is here ignored and the coal is included in the West Franklin Limestone Member.

Coal Members also are not pure coal in the lithologic sense; commonly they contain small amounts of shale and pryite in horizontal partings and pyrite, gypsum, calcite, and clay in thin vertical films. In some areas a thin shale parting may increase in thickness until it is







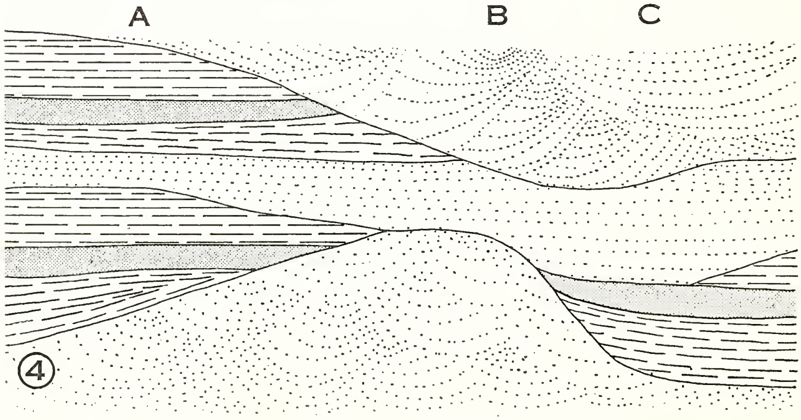


Figure 1. Diagrammatic section showing variation in a limestone member.

Figure 2. Diagrammatic section showing variation in a coal member.

Figure 3. Diagrammatic section showing interfingering of sandstone and shale members.

Figure 4. Diagrammatic section showing the irregularities of sandstone members.

more than a foot thick, or, locally, may be thicker than the combined overlying and underlying coal beds (Figure 2). If both parts of the split coal bed are recognized as parts of a single member, the included shale is part of the coal member. If the lower part is absent, only the upper bed can be identified as the named member.

Because sandstone beds provide some of the best exposures, many sandstone units have been formally designated as members. Sandstones are the disruptive lithologic units and many problems become apparent when one tries to define sandstone members precisely. There is no problem where a sandstone is massive and obviously comprises one sandstone unit and thus is one member, or where the unit is entirely shale and thus the sandstone member is absent (Figure 3). Questions arise, however, where the interval consists of alternating sandstone and shale beds or shaly sandstone that grades into sandy shale. As used here formally named sandstone members are laterally restricted to areas where sandstone is the dominant rock of the interval and is thick enough to be useful, either stratigraphically or economically. For subsurface studies this means that the sandstone member must be on the order of 10 feet or more in thickness. In some localities the sediments overlying a sandstone may be eroded and sandstone deposited on top of sandstone (Figure 4). If drilling information is available only at either location B or C (Figure 4) it would be difficult to separate the three sandstone members. If factual data is available in adjacent areas the picture may develop such that the position of each sandstone body as related to the coal and shale beds is clear (Figure 4A). If a limestone or coal member cannot be identified above and below a sandstone member the identification of the sandstone member is subject to error.

Summary

In summary, the most practical system of classification of the rocks of Pennsylvanian age in Indiana is dependent on recognizable and extensive key beds. Using selected key beds as boundaries the rocks are divided into formations that are a sequence of lithologic units that total 100 feet or more in thickness and contain named and unnamed members. Formations are lumped together into three groups mostly on the basis that the formations in the middle group contain thick widespread commercial coals and those in the upper and lower groups contain coals that are thin or local in extent.

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