

NOTE TO USERS

This reproduction is the best copy available.

UMI[®]

UNIVERSITY OF CINCINNATI

MAY 5

1942

I hereby recommend that the thesis prepared under my supervision by WILSON M. LAIRD

entitled THE STRATIGRAPHY OF THE UPPER DEVONIAN AND LOWER
MISSISSIPPIAN OF SOUTHWESTERN PENNSYLVANIA

be accepted as fulfilling this part of the requirements for the degree of DOCTOR OF PHILOSOPHY

Approved by:

Kenneth E. Carter
John L. Rich

THE STRATIGRAPHY OF
THE UPPER DEVONIAN AND
LOWER MISSISSIPPIAN
OF
SOUTHWESTERN PENNSYLVANIA

A dissertation submitted to the
Graduate School
of the University of Cincinnati
in partial fulfillment of the
requirements for the degree of
DOCTOR OF PHILOSOPHY

1942

by

Wilson M. Laird

A. B. Muskingum College 1936

A. M. University of North Carolina 1938

UNION
UNIVERSITY
LIBRARY

UMI Number: DP15873

INFORMATION TO USERS

The quality of this reproduction is dependent upon the quality of the copy submitted. Broken or indistinct print, colored or poor quality illustrations and photographs, print bleed-through, substandard margins, and improper alignment can adversely affect reproduction.

In the unlikely event that the author did not send a complete manuscript and there are missing pages, these will be noted. Also, if unauthorized copyright material had to be removed, a note will indicate the deletion.



UMI Microform DP15873
Copyright 2009 by ProQuest LLC
All rights reserved. This microform edition is protected against
unauthorized copying under Title 17, United States Code.

ProQuest LLC
789 East Eisenhower Parkway
P.O. Box 1346
Ann Arbor, MI 48106-1346

CONTENTS

INTRODUCTION	1
General Statement	1
Purpose of the study	1
Location	2
1. Summit (Chestnut Ridge) inlier	2
2. Youghiogheny gorge (Chestnut Ridge) inlier	3
3. Youghiogheny gorge (Laurel Hill) inlier	3
4. Conemaugh gorge (Chestnut Ridge) inlier	3
5. Conemaugh gorge (Laurel Hill) inlier	3
6. Allegheny Front near Altoona	4
7. Broad Top area	4
Acknowledgements	6
Methods of study	6
Stratigraphic nomenclature	8
Facies nomenclature and relationships	12
PREVIOUS WORK	21
Northwestern Pennsylvania	21
Southwestern Pennsylvania	23
Allegheny Front	34
Broad Top	37
DETAILED SECTIONS	43
General statement	43
Summit (Chestnut Ridge) inlier	43
Youghiogheny gorge (Chestnut Ridge) inlier	47

Youghiogheny gorge (Laurel Hill) inlier	52
Conemaugh gorge (Chestnut Ridge) inlier	62
Conemaugh gorge (Laurel Hill) inlier	65
Allegheny Front at Altoona	68
Riddlesburg (Broad Top area)	70
DETAILED STRATIGRAPHY	81
Preliminary statement	81
General correlations	82
DEVONIAN SYSTEM	83
CHAUTAUQUAN SERIES (?)	83
Name and definition	83
Conneaut stage (?)	84
Name and definition	84
Maple Summit member	84
Name and definition	84
Occurrence	85
Lithology	85
Thickness	87
Faciesology	87
Relations to adjacent members	89
Fauna	89
Correlation	90
Historical interpretation	91
CONEWANGO SERIES	92
Name and definition	92

Venango stage	93
Name and definition	93
Youghiogheny member	94
Name and definition	94
Occurrence	94
Lithology	95
Thickness	96
Structure	97
Faciesology	98
Relations to adjacent members	99
Fauna	99
Correlation	100
Historical interpretation	102
Watering Trough shale	102
Name and definition	102
Occurrence	103
Lithology	104
Thickness	105
Faciesology	105
Relations to adjacent members	107
Fauna	107
Correlation	108
Historical interpretation	109
Riceville stage (?)	110

Name and definition	110
Jumonville sandstone	112
Name and definition	112
Occurrence	113
Lithology	114
Thickness	114
Faciesology	116
Relations to adjacent members	116
Fauna	116
Correlation	120
Historical interpretation	121
MISSISSIPPIAN SYSTEM	122
OIL LAKE SERIES	122
Name and definition	122
Cussewago stage	124
Name and definition	124
Linderman sandstone	124
Name and definition	124
Occurrence	125
Lithology	125
Thickness	126
Relations to adjacent members	126
Fauna	126
Hopwood member	129

Name and definition	129
Occurrence	130
Lithology	131
Thickness	135
Relations to adjacent members	135
Correlation	135
Pine Knob member	135
Name and definition	135
Occurrence	136
Lithology	136
Thickness	137
Relations to adjacent members	137
Fauna	138
Ohiopyle sandstone	142
Name and definition	142
Occurrence	143
Lithology	143
Thickness	144
Relations to adjacent members	144
Fauna	145
Riddlesburg shale	147
General statement	147
Name and definition	147
Occurrence	147

Lithology	149
Thickness	149
Relations to adjacent members	150
Fauna	150
Correlation of the Cussewago members	153
General statement	153
Riddlesburg-northwestern Pennsylvania	
correlation	166
Lithologic similarities	166
Faunal similarities	167
Riddlesburg-southwestern Pennsylvania	
correlation	168
Lithologic similarities	168
Faunal similarities	168
Southwestern Pennsylvania-northwestern	
Pennsylvania correlation	170
Lithologic similarities	170
Faunal similarities	170
Historical interpretation of the Cussewago	
members	173
General statement	173
Movement of the shoreline	174
Source of the sediments	175
Other Lower Mississippian members in southwestern	
Pennsylvania	178

Lick Run conglomerate	178
Name and definition	178
Occurrence	179
Lithology	179
Thickness	180
Relations to adjacent members	180
Correlation	180
Historical interpretation	181
Chestnut Ridge sandstone	182
Name and definition	182
Occurrence	182
Lithology	183
Thickness	184
Relations to adjacent members	186
Fauna	187
Correlation	187
Historical interpretation	191
FAUNAS	195
General statement	195
Faunal break between the Devonian and the	
Mississippian	197
PALEOGEOGRAPHY	210
General statement	210
Upper Devonian paleogeography	219

Lower Mississippian paleogeography	222
BIBLIOGRAPHY	231

ILLUSTRATIONS

Plate 1. Stratigraphic sections along Line A - A' from Laurel Hill to the Broad Top area showing the edge of the "Catskill" delta, facing	219
2. Stratigraphic sections along Line B - B' from Rogersville to Altoona showing the edge of the "Catskill" delta, facing	219
3. Stratigraphic sections along Line C - C' from West Elizabeth to Smicksburg showing the edge of the "Catskill" delta, facing	219
4. Stratigraphic sections along Line D - D' from Winfield to Johnsonburg showing the edge of the "Catskill" delta, facing	219
5. Stratigraphic sections along Line E - E' along the seaward edge of the "Catskill" delta, facing . .	219
Figure 1. Sketch map showing locations of Devonian and Mississippian sections studied in the inlier and outlier areas of southwestern Pennsylvania	5
2. Facies components taken from Caster	15
3. Diagram showing facies relationships of the Upper Devonian in southwestern Pennsylvania	20
4. Summit (Chestnut Ridge) inlier section	74

Figure 5.	Youghiogheny gorge (Chestnut Ridge) inlier section	75
6.	Youghiogheny gorge (Laurel Hill) inlier section . .	76
7.	Conemaugh gorge (Chestnut Ridge) inlier section . .	77
8.	Conemaugh gorge (Laurel Hill) inlier section . . .	78
9.	Allegheny Front at Altoona section	79
10.	Riddlesburg (Broad Top area) section	80
11.	Type exposure of the Hopwood member showing the contorted nature of the base of the conglomerate. .	133
12.	Paleogeographic map showing approximate position of the Upper Devonian and Lower Mississippian shoreline	212
13.	Sketch map showing location of sections given in Plates 1 - 5.	219
14.	Isopach map of the reported occurrences of the "Pocono"	228

TABLES

Table 1.	Generalized table showing the various interpretations of the stratigraphy of southwestern Pennsylvania	25
2.	Correlation chart of the Upper Devonian and Lower Mississippian of western Pennsylvania	192
3.	Biotic chart of the Upper Devonian and Lower Mississippian of southwestern Pennsylvania	199

INTRODUCTION

General Statement

The problem of the age of the Upper Devonian and the Lower Mississippian of the anticlinal inliers in southwestern Pennsylvania was first called to the writer's attention in the spring of 1938 by Dr. K. E. Caster. Accordingly he spent the first part of the summer of 1938, all of the field season of 1939 and the greater part of the field season of 1940 in the field in the inlier area in southwestern Pennsylvania, along the Allegheny Front and in the Broad Top area. The latter part of the summer of 1940 was spent in identifying the fossils collected during the various field seasons.

In order to approach this problem with as unbiased a background as possible, the writer went into the field the first summer without extensively studying the literature. It was apparent, from the first, that little could be done with the stratigraphy unless the fossil content of the various beds was studied and guide fossils for each member found. Accordingly, nearly half a ton of fossils was collected during the course of the study. These have been tentatively identified and are now in the paleontology museum of the department of geology of the University of Cincinnati. No detailed systematic work was done on the fossils for they are neither as abundant nor as well preserved as the fauna of the stratigraphic correlates in northwestern Pennsylvania.

Purpose of the study

There are several problems involved in this study. (1) What is the exact age of the Devonian sequence in the southwestern Pennsyl-

vania inliers in terms of studied sections elsewhere in Pennsylvania? (2) What are the age and stratigraphic relationships of the "Pocono" formation of western Pennsylvania and can this formation be correlated with the "Pocono" of eastern Pennsylvania? (3) What were the paleogeographic conditions under which these Upper Devonian and Lower Mississippian sediments were deposited?

Location

The region involved in this study is situated almost entirely in the Allegheny Mountain section of the Appalachian Plateau province. The only area extensively studied outside this section is the Broad Top region, a plateau-like outlier of the Appalachian Plateau within the folded Appalachians. There are five main anticlinal inliers in southwestern Pennsylvania considered in this report. The three of these which show the best exposures and yield the best fossils are found in Fayette County. Two other localities occur in the gorges of the Conemaugh River where it cuts through Laurel Hill and Chestnut Ridge.

More precise locations and the names which are used in this report in referring to the inliers follow:

1. The Summit (Chestnut Ridge) inlier is located on the crest of Chestnut Ridge on Route 40 along the boundary line between North Union and South Union townships in Fayette County, Pennsylvania. The inlier is about $4\frac{1}{2}$ miles southeast of Uniontown and is in the west-central part of the Uniontown quadrangle.

2. The Youghiogheny gorge (Chestnut Ridge) inlier is located along the boundary line of Dunbar, Connellsville and Springfield townships of Fayette County where the Youghiogheny River cuts its gorge through Chestnut Ridge in the northeast corner of the Uniontown quadrangle. The center of the inlier is approximately 3 miles southeast of Connellsville. The exposures are found on both banks of the river along the Baltimore and Ohio Railroad and the Western Maryland Railroad.

3. The Youghiogheny gorge (Laurel Hill) inlier is located in the southeast corner of Stewart township in Fayette County where the Youghiogheny river cuts through Laurel Hill. The center of the inlier is about 3 miles east of the town of Chiopyle in the west-central part of the Confluence quadrangle. Outcrops are found on both sides of the river and the longest section seen in any of the inliers is found in this gorge.

4. Conemaugh gorge (Chestnut Ridge) inlier is located along the boundary line between Derry and Fairfield townships of Westmoreland County and Burrell township of Indiana County where the Conemaugh river cuts through Chestnut Ridge approximately 2 miles east of Torrance. The best exposures are found along the Pennsylvania Railroad on the south bank of the river. The gorge is located in the northwestern corner of the New Florence quadrangle.

5. Conemaugh gorge (Laurel Hill) inlier is located about 5 miles northwest of Johnstown at the point where Cambria, Indiana

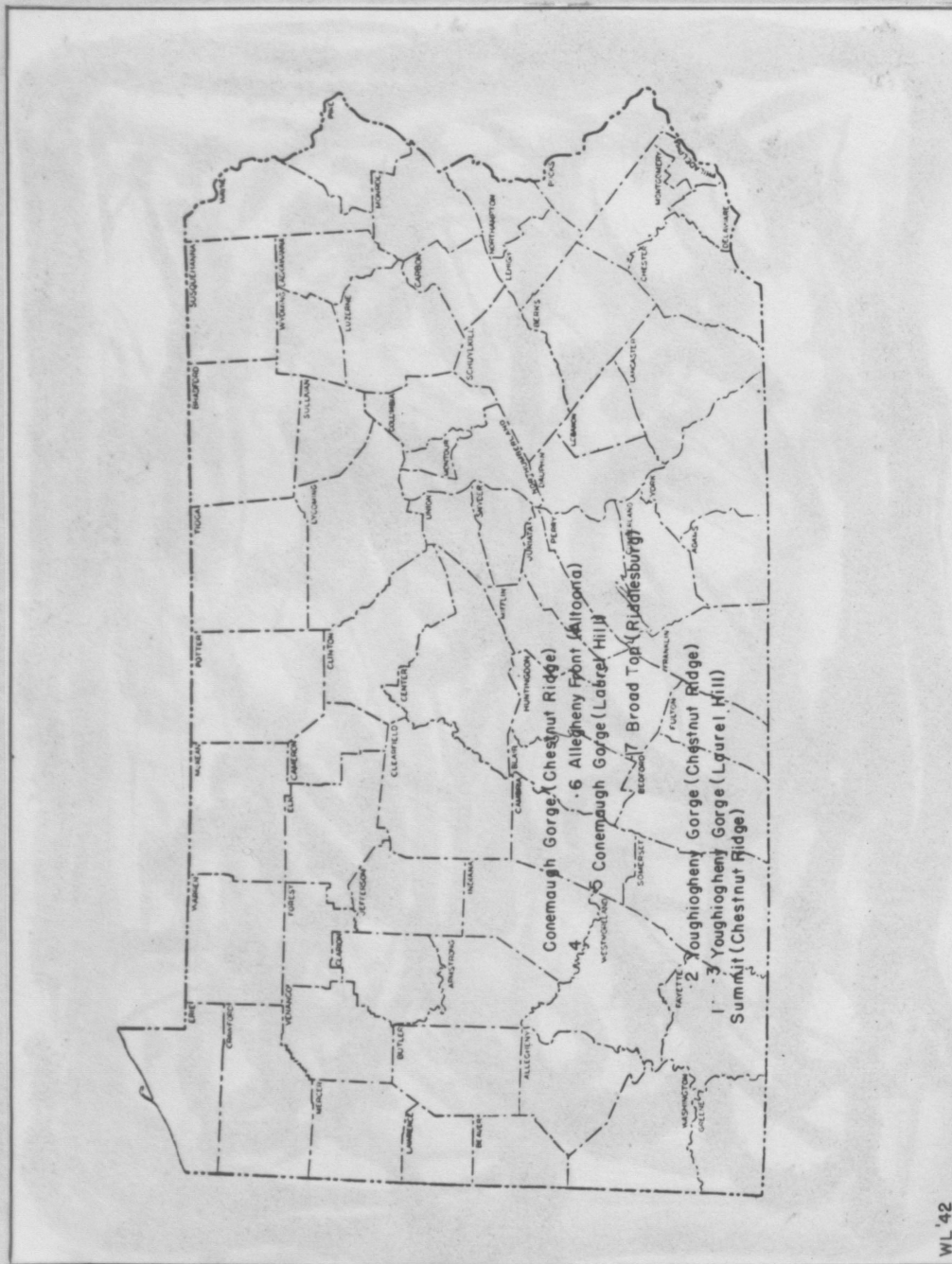
and Westmoreland counties meet. The gorge is located in the west-central part of the Johnstown quadrangle. The best exposures are found along the northeast bank of the river along the Pennsylvania Railroad.

Certain other localities were also studied. All are given numbers by which they are shown on the accompanying sketch map. (See fig. 1 .)

Fig. 1 . Sketch map showing the locations of Devonian and Mississippian sections studied in the inlier and outlier areas of southwestern Pennsylvania. The numbers of the sections on the map correspond to those in the text.

6. The Allegheny Front near Altoona was studied; particularly the section along the Pennsylvania Railroad in the northwestern part of Allegheny township of Blair County along Sugar Run. Other sections investigated are along the Front on Route 36 in the northwestern part of Logan township in Blair County and also along the road from Altoona to Wopsononock about $2\frac{1}{2}$ miles north of Route 36.

7. The Broad Top area was also rather carefully investigated. The section $2\frac{1}{2}$ miles north of the town of Riddlesburg near the eastern boundary of Liberty township in Bedford County is one of the best for study. Another good outcrop is located in the southeastern corner of Hopewell township in Huntingdon County 1 mile east of Saxton along Shoup Run. Less satisfactory exposures are located near



WL '42

Figure 1. Sketch map showing locations of Devonian and Mississippian sections studied in the inlier and outlier areas of southwestern Pennsylvania. The numbers of the sections on the map correspond to those in the text.

Kimmel, Cassville and in the gap of Great Trough Creek 4 miles east of Marklesburg. All of the last mentioned localities are in Huntingdon County.

Acknowledgements

The writer is much indebted to Mr. Fred I. Mason of Ohiopyle, Pennsylvania for extensive assistance in the field. Thanks go to Dr. K. E. Caster of the University of Cincinnati for assistance and suggestions in the field and in the preparation of the manuscript. Dr. W. H. Bucher of Columbia University (formerly of the University of Cincinnati) has been kind enough to read the manuscript and has offered many valuable suggestions, particularly in the matter of paleogeography. Grateful acknowledgement is made to Dr. J. S. Templeton of the University of Illinois (formerly of the University of North Dakota) and Dr. J.L. Rich of the University of Cincinnati for reading the manuscript. To my wife, Reba A. Laird and my secretaries, Miss Denise Meblin and Mrs. Grace Surprenant, thanks are due for the typing of the manuscript. Thanks also go to the American Association of Petroleum Geologists and to the Pennsylvania Geological Survey for financial assistance.

Methods of study

Stratigraphy is the detailed study of sedimentary deposits and their contained organisms, involving the determination of natural units, the geographic distribution, age, and interrelations of these deposits. ^{1/} One of the main tasks of stratigraphers is to try to

1/ Definition reworded from that given by Moore, R. C., Historical geology, p. 3, New York, McGraw-Hill Book Co., Inc., 1933.

correlate beds which are time equivalents over as wide areas as possible in order to decipher as completely as they can the geologic history of the world. Grabau (1924, p. 1129) lists the following means by which formations of different localities may be correlated:

1. Superposition
2. Stratigraphic continuity
3. Lithic characters
4. Organic contents
5. Unconformities or disconformities
6. Regional metamorphism
7. Diastrophism

Of these seven, only three, superposition, lithic characters, and organic remains, are applicable to correlation of the southwestern Pennsylvania Devonian and Mississippian with similar beds found in northwestern Pennsylvania and along the Allegheny Front. In fact, because of pronounced lithologic changes of facies in the rocks of both systems, correlation on the basis of lithology is practically impossible. Therefore the burden of the correlation in this report is placed primarily on fossils with superposition secondary in impor-

tance. While there are some^{2/} who do not agree that fossils are ade-

2/ See footnote by Parke A. Dickey in Laird, W. M., The Upper Devonian and Lower Mississippian of Southwestern Pennsylvania: Pennsylvania Geol. Survey, Progress Rept. 126, p. 4, 1941.

quate means of correlation, they still far surpass all other methods except "walking the outcrops" which is, of course, impossible in the case of the isolated inliers of southwestern Pennsylvania.

Stratigraphic nomenclature

The matter of stratigraphic nomenclature has been, and still is, a bone of contention among geologists. It appears that the problem is less often that of interpreting the rocks as they are seen in the field, than that of superimposing an artificial classification for the purposes of correlation.

Inasmuch as the rocks of the Upper Devonian and Lower Mississippian of northwestern Pennsylvania are the nearest occurrences with which the Upper Devonian and Lower Mississippian strata of southwestern Pennsylvania can be correlated, it is convenient to use the same scheme of classification in both areas. Caster (1934, p. 16-18) has followed the classification prescribed by the International Geological Congress of 1886 rather closely. The International stratigraphic units and their time equivalents are as follows:

<u>Stratigraphic Unit</u>		<u>Time equivalents</u>
Group		Era
System		Period
Series		Epoch
Stage		Age
Formation (sub-stage)		Phase
Member (beds)		
Zone		

The United States Geological Survey has never entirely followed the International classification. The "group" of the Survey corresponds to the "stage" in the International classification. In the interests of strict priority it would seem that "stage" should have preference over "group".

In 1933 a committee representing various geological societies was formed to attempt a standardization of procedure in the naming of stratigraphic units. That committee ^{3/} recommended the following class-

^{3/} Ashley, G. H., et. al., Classification and nomenclature of rock units: Geol. Soc. Am. Bull. Vol. 44, pp. 423-459, 1933, idem., Am. Assoc. Petroleum Geologists Bull. vol. 17, pp. 843-863, 1933.

ification:

No coordinate with Era

System

Series

Group

Formation

Member, lentil, tongue

Bed, stratum, layer

Zone

There are several objections to the 1933 revision. The first of these is the use of stage. The 1933 report (p. 849) says that in America this term has not been generally used as a rock term but primarily a time term for major subdivisions of the Pleistocene epoch. That not all geologists agree with the strictly time use of the term stage, is evident from a recent discussion (Schenck, Hedberg, etc. 1941, p. 2195-2211), from which it would appear that "stage" is still used as a stratigraphic term by European geologists and by a number of geologists in this country.

Certain of the authors (Schenck, et. al.) of the aforementioned discussion advocate the differentiation between time-stratigraphic units such as a stage and rock-stratigraphic units such as a formation. A formation is a lithologic unit, mappable in the field which may embrace part of a stage, a whole stage or more than one stage. This dual usage is helpful in that field workers can map easily recognizable "formations" and other workers can use this field information, fitting it into time units (stages), for the purposes of regional correlation. This rock-stratigraphic and time-stratigraphic usage is essentially what Caster means when he speaks of "parva-facies"

(that portion of a magnafacies within well-defined time lines such as a stage).

The writer does not agree with Hedberg (1941, p. 2209) in considering stages to be so flexible that they may overlap in time. Hedberg also says that the stages need not add up in time value to the total time value of a series. This would lead to a more confusing state than already exists in the literature and the writer suggests that stages be retained with a definite time age and that contemporaneous but different lithologic deposits within a stage be assigned a facies nomenclature as suggested by Caster, (1934, pp. 19-36).

An alternative to using the term "stage" would be to use "group" as suggested by the 1933 committee. Beside the already-mentioned fact that "group" is used in a larger sense than the subdivision of a series in the International System, there is one other objection. A member may be a sandstone in one locality but be equivalent to two sandstones separated by a shale interval a few miles away. It would be unreasonable to call the single sandstone member a "group" but the term "group" might reasonably be applied to the sandstone and shale sequence. Therefore, the writer thinks stage, which does not connote more than one component member, a better term than group, which must, according to the 1933 rules, have at least 2 members.

The second objection to the 1933 rules is the use of the term "formation". This term may have useful field application where lithology alone is considered, but as already has been noted, it can

vary considerably in time value. It was the mapping of the various facies of the Upper Devonian as "formations" which retarded a fuller understanding of the Upper Devonian in Pennsylvania and New York for so long a time. Therefore, because of this confusion as to the term "formation", the writer has, instead, used member as a subdivision of a stage. Where there is more than one lithology, such as an inter-bedded sandstone and shale as in the case of the Youghiogheny red beds, the sequence has been designated a member. If the sequence is dominantly one lithology as in the case of the Watering Trough shale, the beds are spoken of simply as the Watering Trough shale, member being implied.

In summary, the stratigraphic nomenclature being employed in this paper is as follows:

System

Series

Stage

Member

Bed, lentil

Facies nomenclature and relationships

The Upper Devonian deposits in Pennsylvania and New York provide one of the best examples known for studying the relationships of various sedimentary facies in front of an advancing (off-lap) shoreline. These Upper Devonian deposits have been much referred to in the literature as deltaic in nature, but they are not ordinary deltaic deposits. They

do not show the usual tripartite division usually thought of in connection with deltas, namely, the topset, foreset and bottomset beds. As Mencher (1939) has recently pointed out, much of the sedimentation of the Upper Devonian took place on a subaerial coastal plain. While recognizing that these coastal plain deposits lack customary criteria of deltas, we must also bear in mind the great thickness of the deposits, their relatively rapid accumulation, and their comparative aerial restriction. They are a localized concomitant expression of the Shickshockian orogeny, and are typical of what Marshall Kay (1941, p. 1912) recently terms delta geosynclinal deposits, a useful term. In view of the irregular boundary of the facies provinces, it would appear that this coastal alluvial plain was made up of a number of coalescing alluvial fans which had their apices in the highlands to the east and southeast. As Upper Devonian time progressed, these coastal plain sediments shifted ever westward and consequently moved out over the off-shore marine beds. This implies, of course, that the downsinking of the trough was no longer keeping pace with the amount of sediment being supplied the seaway. As the shore deposits shifted westward, so also did the marine beds off shore. These belts of varying lithology roughly parallel to the old shoreline Caster (1934, p. 19) has termed magnafacies.

As these magnafacies shifted westward, they also became younger in time. Thus the basal boundary of the more eastward development of these facies belts is older in time than the basal boundary of the western part of the same magnafacies. The boundaries of a magna-

facies must not be confused with time lines which separate definitely different stratigraphic members as magnafacies boundaries cross time lines. That part of a magnafacies which lies between two well-defined time lines (such as within the boundaries of a stage) is called a parvafacies. An example of a parvafacies is the Cattaraugus "formation" which is a parvafacies expression of the Smethport magnafacies within the bounds of the Venango stage. Reference should be made to figure 2 taken from Caster which illustrates this nomenclature.

Figure 2. Facies components taken from Caster.

Most of the miscorrelations and stratigraphic difficulties of the early workers in the Upper Devonian of Pennsylvania can be traced to their failure to recognize the facieologic nature of these deposits. They did not realize that one parvafacies of one lithology and faunal content might be the exact equivalent of another parvafacies of different lithology and faunal content to the east or west of it. Thus they did not correlate dissimilar but contemporaneous parvafacies but interpreted them as "formations" which either overlay or underlay one another. This miscorrelation is also partly due to the fact that the magnafacies boundaries are so often practically horizontal that the facies relationship is not clear unless studied over a large area, and partly to the fact that the early studies took in only isolated counties which did not clearly show the relationship. It is only through the study of large areas that the true facies nature of

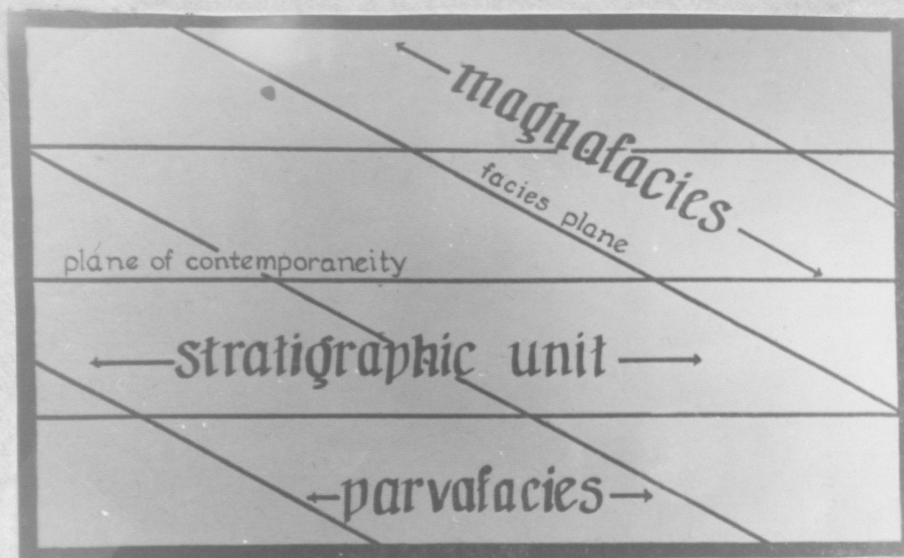


Figure 2. Facies components taken from Caster.

these deposits can be seen.

In southwestern Pennsylvania, only two of the magnafacies of northwestern Pennsylvania can be clearly distinguished: The continental, Catskill magnafacies and the marine, Big Bend magnafacies. Two other facies belts are occasionally suggested: The Cleveland, most seaward of the Upper Devonian magnafacies present in the area under consideration, and the Smethport, which sometimes intervenes between the Catskill and the Big Bend.

Caster (1934, p. 25) defines the Catskill magnafacies as consisting predominantly of red and green sandstones and shales which give way occasionally to coarse conglomeratic sandstone of red or green color. This description aptly describes the Catskill magnafacies as it occurs in southwestern Pennsylvania except that there fewer conglomeratic beds occur.

The Big Bend magnafacies has been described by Caster (1934, p. 27) as a sequence of alternating sandstones and shales containing many lenses of conglomerate. The beds have an olivaceous to brown color and are finer grained than the Smethport magnafacies immediately to the east. In southwestern Pennsylvania the Big Bend consists rather largely of fine-to-medium-grained sandstone with some interbedded shale where it occurs within the bounds of the Conneaut stage. Within the bounds of the Venango stage it is dominantly a grey to black shale with sandstone and conglomerate lenses. Within the bounds of the Riceville (?) stage of the inliers the Big Bend is primarily a rusty

brown sandstone with small amounts of conglomerate and shale.

The Smethport magnafacies has been described by Caster (1934, p. 27) as consisting of shales and sandstones which weather to a purple or chocolate color. Lenticular flat-pebble conglomerate and abundant marine faunas are also characteristic of this magnafacies. In Fayette County there occur 47 feet of fossiliferous beds of a red-brown color in the base of the Catskill magnafacies, which might reasonably be included in the Smethport but as there is such a small development here these beds are being included with the Catskill magnafacies.

The other magnafacies which is possibly locally developed in this area is the Cleveland. This has been defined by Caster (1934, p. 28) as a black, fissile shale which seems to have been a specialized, seaward type of deposit.^{4/} Toward the base of the Watering Trough shale

^{4/} Possibly in part comparable to Grabau's, 1940 (Rhythm of the Ages) "Huangho" deposits. Caster suggested that the black shale might have been derived from black soils (chernozem-like) of Devonian accumulation on the emergent crest of the Cincinnati arch. The calcareous facies of Upper Devonian time apparently occurs only west of the Cincinnati uplift.

approximately 20 feet of black shales occur which have such a lithology and which may represent a local development of Cleveland conditions somewhat east of the main mass of the Cleveland deposits. Normally the Chagrin magnafacies would intervene between the Big Bend and the Cleve-

land, but apparently it was not developed in southwestern Pennsylvania.

Since the magnafacies can be identified and the stratigraphic units which these magnafacies cut are also known, at least partial correlation with northwestern Pennsylvania parvafacies seems possible. It is unfortunate for purposes of correlation that only a few of the northwestern Pennsylvania parvafacies are named.

The Big Bend magnafacies (Caster, 1934) is developed in southwestern Pennsylvania. It cuts across strata being referred to the Conneaut, Venango and Riceville stages. The constituent parvafacies are all unnamed in northwestern Pennsylvania excepting the Allegany Park parvafacies of the Venango. As the base of the supposed Conneaut sequence is not seen in the inliers it does not seem desirable to propose a name from southwestern Pennsylvania to be used generally throughout the Penn-York embayment for this oldest facies of the Big Bend magnafacies. The oldest Conneaut (?) sequence in the inliers is being named the Maple Summit member and the name is used for convenience of description as the local Conneaut parvafacies. A similar situation prevails in the case of the Big Bend development of the supposed correlate of the Riceville stage in southwestern Pennsylvania. The exposures are none too good and the exact stratigraphic equivalence with the true Riceville of northwestern Pennsylvania is not proven so no formal name will be proposed for this parvafacies. As the Jumonville sandstone is the only stratigraphic unit in this parvafacies it is convenient to speak of the Jumonville "parvafacies" in southwestern Pennsylvania.

The Big Bend magnafacies in southwestern Pennsylvania laps back on itself as do several of the other magnafacies belts in other parts of Pennsylvania. This indicates that the sea before the end of the Upper Devonian progressed eastward.

Intercalated into the marine Big Bend magnafacies from the east and southeast is a tongue of red sediments which is undoubtedly a part of the Catskill magnafacies. (See Fig. 3.) The fossil evidence in-

Fig. 3. Diagram showing Upper Devonian facies relationships in southwestern Pennsylvania.

icates that this part of the Catskill magnafacies in southwestern Pennsylvania is all within the bounds of the Venango stage. Therefore this parvafacies may be correlated with the Potter parvafacies which has a similar stratigraphic position in northwestern Pennsylvania. When these red beds are traced eastward it is found that the expanded Catskill magnafacies along the Allegheny Front ranges in age from true Chemung to latest Upper Devonian. Due to lack of distinguishing characteristics there, no parvafacies can yet be delimited in this red unfossiliferous sequence of "Catskill".

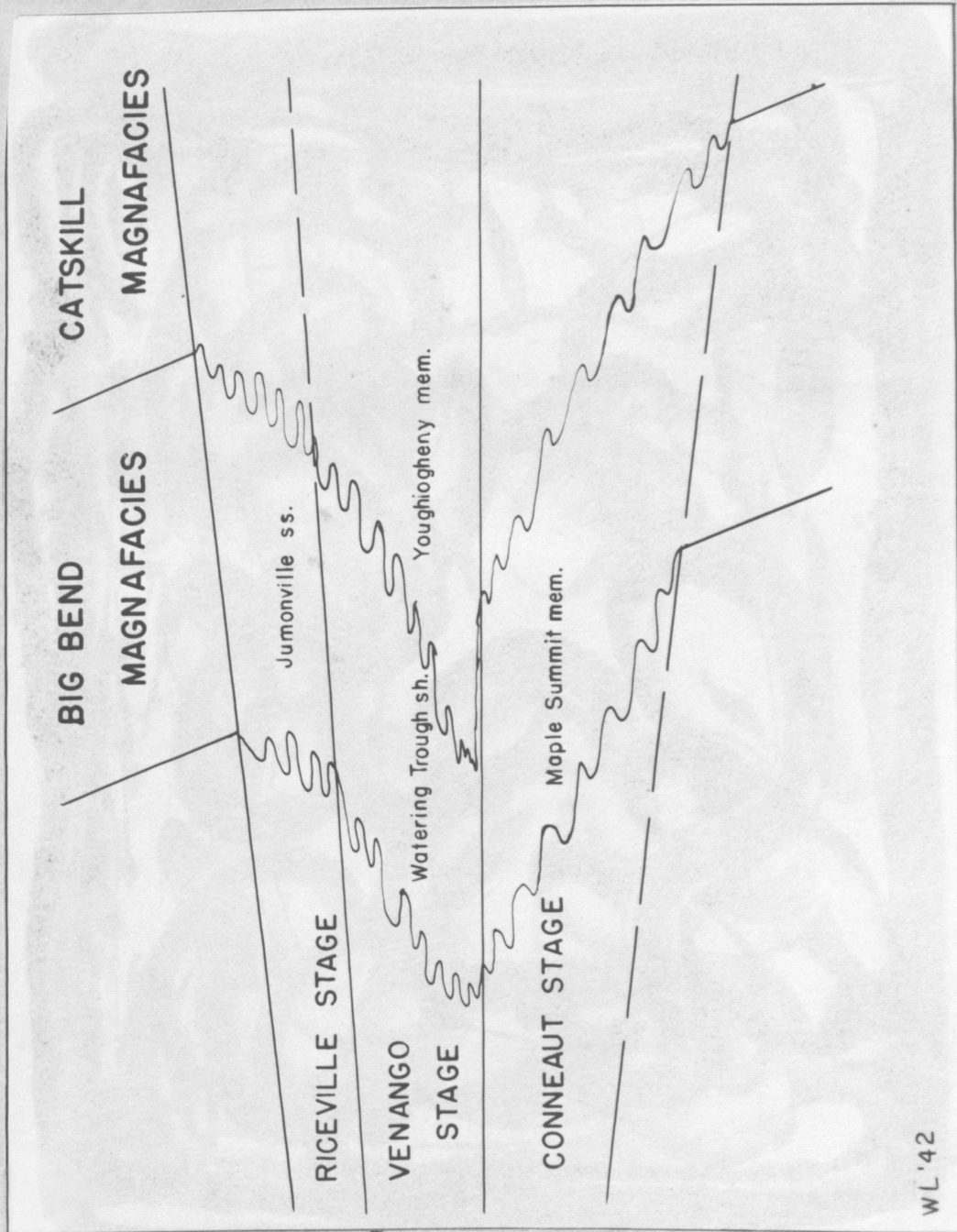


Figure 3. Diagram showing facies relationships of the Upper Devonian in southwestern Pennsylvania.

PREVIOUS WORK

Northwestern Pennsylvania

The most intensive study of the Upper Devonian and Lower Mississippian of Pennsylvania has centered in Warren and McKean Counties of the northwestern part of the State. The completeness of the stratigraphic record there lead to the proposal of a transition sequence (Bradfordian series of Girty) between the Devonian and Mississippian. The findings in northwestern Pennsylvania bear directly on the stratigraphy of southwestern Pennsylvania where it now develops that a similar condition prevails. However, as there are several excellent reports (Butts, 1908-1910), (Girty, 1904), (Chadwick, 1933), (Caster, 1934), (Fettke, 1938), (Willard, 1939), which deal with the stratigraphic details of the northwestern Pennsylvania Devonian and Mississippian, the history of the geologic study of that region need not concern us here. A generalized table (mainly from Caster) of the Devonian and Mississippian stratigraphic units of northwestern Pennsylvania is given below. Many of these units are recognized in southwestern Pennsylvania.

MISSISSIPPIAN SYSTEM

Kinderhook series

Shenango stage

Hempfield shale

Shenango sandstone

Meadville stage

Custards shale

French Creek limestone

Harvest Home Shale

Byham limestone

Sharpsville sandstone

West Mead limestone

Shaws sandstone

Orangeville shale

} Sharpsville formational suite

Oil Lake series

Berea stage

Corry sandstone

Cussewago stage

Hayfield shale

Littles Corner limestone

Tidioute shale

Cobham conglomerate

East Kane shale

Wetmore conglomerate

Kushequa shale

} Knapp formational suite

DEVONIAN SYSTEM

Conewango series

Riceville stage

Oswayo shale

Foystone coquinite

Venango stage

Woodcock sandstone

Hosmer Run conglomerate	
Tuna-Killbuck conglomerate	
Saegerstown shale	
Pope Hollow conglomerate	} Salamanca formational suite
North Warren shale	
Bimber Run conglomerate	
Amity shale	
Panama conglomerate	
Chautauquan series	
Conneaut stage	
Chadakoin beds	
Hinsdale sandstone	
Volusia shale	
Cuba sandstone	

Southwestern Pennsylvania

J. J. Stevenson (1877, pp. 54-60) was the first to report on the Devonian and Mississippian rocks of southwestern Pennsylvania. In this report, he touched only briefly on either system for they were judged to have little economic value. At the instance of J.P. Lesley, the State Geologist(fide Stevenson, 1878), the Devonian rocks were labelled "Catskill" in the Ligonier Valley report although Stevenson had found fossils in these "Catskill" rocks which in a later paper (1878, p. 423) he called "lower Chemung". (See Table 1 .) In this report he suggested the possibility that the "upper Chemung" and the

Table 1 . Generalized table showing the various interpretations of the stratigraphy of southwestern Pennsylvania. Data are based on literature surveys which have been checked in the field. The heavy (red) line indicates the Devonian-Mississippian boundary as interpreted by the various authors.

"Catskill" might be missing in this area. He intimated that if the "Catskill" were present, it would probably be represented by what he called the "grey member". Stevenson considered his "grey member" the equivalent of Roger's "Vespertine" in the publications of the First Geological Survey of Pennsylvania, which did not cover the southwestern part of the State. In more recent writings, the "grey member" has been called "Pocono", the name which replaced "Vespertine".

When M. R. Campbell (1902, p. 6) mapped the Masontown-Uniontown quadrangles, he thought that the highest Devonian rocks exposed in the inliers of the Uniontown quadrangle were "Catskill" in age and the geologic map for that area was so engraved. Later, he changed his mind, for in the text of the folio he states that the highest rocks are of "Chemung" age and that no formation intervenes between them and the "Pocono". He also noted that the "Chemung" is fossiliferous right up to the base of the "Pocono". Campbell's usage of the term "Chemung" followed that of Hall (1843, p. 252, 278) and others on the Upper Devonian of the Penn-York Embayment in that he recognized as "Chemung" any part of the Conewangoan and Chautauquan marine se-

Stevenson 1877	Stevenson 1878	Campbell 1902	Stevenson 1903	Butts 1908	Willard 1933	Chadwick 1935	Caster 1935	Moyer 1937	Willard 1939	Hick and Moyer 1940	Laird 1942	
"Pocongo"	"Pocongo" or "Grey member" or "Catskill"	"Pocongo"	"Pocongo" White's Cussewago at base	Burgoon "Pocongo" "Cussewago" "Upper Catskill"	"Pocongo"	"Pocongo"	"Pocongo"	"Pocongo"	"Pocongo"	Burgoon Cuyahoga "Pocongo"	Chestnut Ridge Kinderhook Lick Run Cusse- wago	MISSISSIPPIAN
"Catskill"	"Catskill"	"Chemung"	Riceville --- "Pocongo"	"Pocongo" "Famous of Carbonifer- ous aspect"	"Pocongo" "Chemung"	"Pocongo" Canada	Cussewago	"Pocongo" L. Chemung	"Pocongo" U. Chemung	"Onawayo" of NW. Penna. Catawagus of NW. Penna. --- ?	Cussewago Venango Comeaut (?) Chautauquan	DEVONIAN

Table 1. Generalized table showing the various interpretations of the stratigraphy of southwestern Pennsylvania. Data are based on literature surveys which have been checked in the field. The red line indicates the Devonian-Mississippian boundary as interpreted by the various authors.

quence which underlies the red and green, usually continental, "Catskill" beds.

Stevenson, (1903, pp. 15-96) published the results of an extensive study of the Mississippian of the Appalachian Basin in which he referred only incidently to the Upper Devonian deposits in so far as they had bearing on the base of the "Pocono". He regarded the marine deposits of western Pennsylvania as "Chemung" and these deposits were supposedly overlaid by the "Catskill" formation.

Stevenson also wavered (1903, p. 43) as to the correct status of the "Catskill" for in one place he refers to it as a "condition" (facies presumably) while in another place he calls (1903, p. 87) it a "natural group". He believed (1903, p. 44) that the "Catskill" conditions spread ever westward and southwestward killing (sic) all the "Chemung" life in the sea which it invaded. He also states that there was no sedimentation going on in western Pennsylvania, Ohio, eastern Kentucky, West Virginia, and Tennessee during "Catskill" time. The "Chemung" fauna had, however, retreated to some locality from which it returned in Cuyahoga time spreading eastward, "no longer specifically identical with the old Chemung fauna, but related to it and retaining the Devonian facies" (italics inserted). It is interesting to note that even though his time relations of the lower "Pocono" are now considered wrong, Stevenson did note (1903, p. 44) an eastward overlapping of the "Cuyahoga" (i.e. Devonian) beds which interestingly enough he considered as a Devonian facies. This eastward progression of the

various magnafacies belts of the latest Upper Devonian in northeastern Ohio and northwestern Pennsylvania has been recently pointed out by Caster, (1934, pp. 29-30).

In discussing the "Pocono", Stevenson (1903, p. 40) gives many thicknesses and correlations over the whole Appalachian basin as far south as Alabama and as far west as Tennessee. By placing everything below the upper Meadville limestone in the Upper Devonian the impression of a very decided thinning of the "Pocono" to the west resulted. He says, "It must be clear, however,that the loss of thickness is due largely to the disappearance of the lower members of the section".

It is apparent from Stevenson's discussion that he regarded the Shenango sandstone as the most widespread member of the "Pocono" and he used it considerably for correlation in western Pennsylvania and eastern Ohio. When the "Pocono" was traced southward into Virginia, Stevenson believed that the sandstones of the "Pocono" tended to grade upward into the overlying limestone mass (the Greenbriar) and downward into what he regarded as Upper Devonian Grainger shales.

Even though many of Stevenson's correlations were incorrect, and although he only partially recognized the facies factor of the Upper Devonian deposits, he states (1903, p. 44) that "... in eastern Fayette... the bottom conglomerate of the Pocono, ('White's Cussewago') rests directly on the equivalent of the Riceville shales". This means that Stevenson repudiated his 1878 conclusion that there was a

considerable hiatus in southwestern Pennsylvania where much of the Upper Devonian was eroded.

Charles Butts, (1908, p. 198) after a faunal study, concluded that the uppermost Devonian rocks of the inliers are equivalent to the Conewango series of northwestern Pennsylvania. To him the problem of the age of the Conewango was the same for the southwestern part of the State as for the northwestern part. He realized that the Conewango series is part of one of the marine facies of the "Catskill Delta" but there was still some doubt in his mind whether or not the Conewango should be considered Upper Devonian, Lower Mississippian or bridge the two. He considered the Conewango faunas as having a Carboniferous aspect, however. (See Table 1.)

Butts (1910) accepted Girty's (1904) interpretation of the transitional Bradfordian series which bridged the Upper Devonian-Lower Mississippian boundary in his work on the Warren quadrangle. Recently the "Bradfordian series" has been attacked by Caster (1935) who had presented evidence (Caster, 1934) that a hiatus separates the Mississippian part of the Bradfordian from the Devonian portion.

Butts divided the "Pocono" of western Pennsylvania into the Burgoon sandstone at the top, the Cuyahoga shale in the middle and the Berea sandstone at the base. He states that the Berea and Cuyahoga are absent on the crest of Chestnut Ridge and that this indicates Chestnut Ridge must have been land at that time or the formations have been subsequently eroded. He places the discussion of the Conewango and "Catskill" formations under the heading of "Carboniferous"

system as shown in Table 1.

Bradford Willard, (1933) reopened the discussion of the age of the Devonian in southwestern Pennsylvania. In this paper, he essentially reasserted Stevenson's 1878 conclusion that a considerable disconformity exists between the Devonian and the Mississippian, and gave only a few amendments to Stevenson's faunal list. Willard considered the Devonian exposed in the Chestnut Ridge and Laurel Hill inliers as equivalent to the Cayuta formation (lower part of the true Chemung) of New York State. The Wellsburg or upper Chemung formation, the Canadaway and Conneaut stages of the Chautauquan series, as well as the entire Conewango series were therefore supposedly absent. He not only accepted, but built upon, Stevenson's concept of a disconformity of considerable magnitude amounting to (several hundred feet) between the Devonian and the Mississippian ("Pocono") in the inliers. It is evident from his recent (1939) Devonian treatise that Willard still holds to the view of his 1933 paper although there are slight indications of uncertainty. For example, he states (p. 268) "The fossils on Chestnut Ridge are probably of late Chemung age, but may be younger". (Italics inserted.) He still says, however, that there is no "Catskill" present and clings to the idea of a considerable hiatus between the Devonian and Mississippian.

In referring to the Chestnut Ridge fauna at Summit in Fayette County, Willard says (p. 250) "The fauna, containing elements of both pre- and post- Chemung significance, lies geographically intermediate between places where the Parkhead (older, to southeast) and Conewango

(younger, to northwest) are exposed. Supposing the usual northwestward off-lap to have taken place, we might assume a progressive faunal change with the dropping out of older and acquisition of younger faunal elements successively. These faunas did not arise by 'spontaneous generation' but lived long and migrated far. The lithology supports such a theory. Being a way station, we might reasonably expect that on Chestnut Ridge the fauna of the true Chemung would contain mingled elements of both younger and older groups." Precisely what Dr. Willard's views are, is not at once clear from this, for the fauna of the true Chemung (in New York State) is similarly intermediate in age and biota but there does not appear to be any bona fide "true Chemung" elements present in the inliers, since erosion seems not to have cut deeply enough to expose the correlates thereof of the "true Chemung".

G. H. Chadwick (1935) has ably presented his views on the age of this controversial sequence. From extensive literature studies and after having personally made casual collections at the Summit locality, he concluded that the uppermost Devonian exposed there is of Canadaway age. Thus, he too, implies that there is a considerable hiatus existing here between the Devonian and the Mississippian although of less magnitude than the disconformity postulated by Willard.

In 1935 Caster brought up again the question of the age of Devonian exposed in Fayette County. In this discussion Caster states his belief, from fossils which he collected from Willard's and Chadwick's locality in the Summit inlier, that these beds are Conewango

in age.

As a result of this statement by Caster that strata of Conewango age occur in the Devonian sequence of the Fayette County inliers, a discussion between Caster and Willard (1935) resulted. In this paper, Willard half-heartedly held to his original determination of the lower Chemung age of these strata, but admitted that he might be wrong. Caster presented a preliminary list of faunal determinations and reiterated his concurrence with Butts's 1908 conclusion that the Summit sequence definitely contains fossils which show close affinity to those in the Conewango series of northwestern Pennsylvania. Like Butts, he based his decision on several diagnostic fossils such as Ptychopteria, which so far has not been reported from any other strata than the Conewango. These fossils, incidentally, do not appear on either Stevenson's or Willard's faunal lists.

In a preliminary report on Fayette County, F. T. Moyer (1937) apparently concurred in Willard's age determinations for he lists the Devonian exposed in the inliers as "lower Chemung" with a footnote referring to Caster's and Willard's discussion. Moyer evidently did not feel in a position to evaluate these conflicting opinions so he left the age of these beds unsettled. It is evident from his sections and remarks elsewhere in his report that he did not make a critical faunal study. He states (p. 17) that the "Chemung" beds are fossiliferous right up to the base of the "Pocono" in the Chestnut Ridge inlier. However, he states, "on Laurel Hill, the Chemung is separated

from the Pocono by the Catskill series".

Recently the complete report on Fayette County has been printed.^{5/}

^{5/} Hickok, W. O., Moyer, F. T., Geology and Mineral Resources of Fayette County, Pennsylvania: Pennsylvania Geol. Survey, 4th ser., Bull. C 26, 530 pp., 1940. Proof loaned to the writer in advance of final publication through the courtesy of Dr. R. W. Stone, Assistant State Geologist.

In this Fayette County report there are several comments by the State Geologist, Dr. G. H. Ashley, which vary somewhat with the text as written by Hickok and Moyer. Clearly the facies nature of the Upper Devonian strata in southwestern Pennsylvania is misunderstood or underrated. Because of this, and because of the lack of adequate study of the paleontological materials available, there is considerable difference of opinion among Pennsylvania Survey geologists concerning the Devonian and Mississippian boundary.

There are a number of points in this Fayette County report with which the writer's findings are not in agreement, but not all of these points can be brought out at this place. To mention only a few points of disagreement: the thicknesses given for the Upper Devonian in the inliers of southwestern Pennsylvania do not agree with the measurements made during this study; (Hickok and Moyer) did not differentiate between the Upper Devonian and Lower Mississippian faunas of the inlier area; in their correlation chart (fig. 12), the Oswayo of northwestern

Pennsylvania is drawn so as to include everything from the base of the Berea to the base of the Venango, while the Cattaraugus is made to include most, if not all, the Chadakoin,-- a revision, the basis for which would be of great interest; the base of the Mississippian is placed at the base of the Berea sandstone instead of at the bottom of the underlying Knapp member as Caster (1934) proposed and as is being followed in the present report, (however, it should be noted that what they call (Hickok and Moyer) "Berea" is actually a Knapp equivalent); Hickok and Moyer illustrate a purported Devonian-Mississippian contact in Fayette County, page 36, but unfortunately Devonian fossils occur in the supposed Mississippian "Pocono" sandstone of the photograph. Actually the supposed contact is some 30 feet below the base of the Mississippian. Dr. Ashley expresses the opinion (p. 40) that the uppermost Devonian strata exposed in the inliers are of Conewango age.

In the Conemaugh gorge section through Laurel Hill, northwest of Johnstown, Willard (1935, p. 15) reported that the "Pocono" rests directly upon red beds (of Devonian age) on the east limb of the anticline while on the west limb the "Pocono" rests upon a brown sandstone containing a meagre fauna which he concluded was similar in age (i.e., "lower Chemung") to the Summit, Fayette County section. In his recent monograph, Willard (1939, p. 260-268) re-emphasizes this complete pinching out of the red beds on the west limb of the Laurel Hill anticline. These red beds Willard (p. 250) says are definitely older than the uppermost Devonian exposed in the inliers of Fayette County

to the southwest. Dr. G. H. Ashley, State Geologist of Pennsylvania,^{6/}

^{6/} Litt. October 13, 1939.

concur with the writer in taking exception to Dr. Willard's findings after he personally visited this Conemaugh gorge section and found that the red beds descend below the "Pocono" on both sides of the arch. In the Fayette County report (Hickok and Moyer, 1940, p. 40) Dr. Ashley states that the fossils which Willard found at Johnstown came from the lower part of the "Pocono" as identified by the Survey in that area and above the red beds.

Allegheny Front

The Devonian and Mississippian sequences along the Allegheny Front have never received the attention they deserve. There is much that is as yet unknown about these rocks. In order to provide a background for the understanding of the "Catskill"- "Pocono" boundary problem along the Front, it is necessary to review briefly part of the literature on these two "formations". Butts (1905, p. 3) reports the "Catskill" on the Allegheny Front as consisting of red shale, red to brown sandstone and grey or green shale and sandstone. He says that the formation is 2000 feet thick and is composed of about 80 per cent red shale and red or brown sandstone. The red shale predominates. He found no fossils in the "Catskill".

Butts recognizes the following sequence for the "Pocono" formation:

Loyalhanna limestone 40'

Burgoon sandstone 300'

Patton red shale 40'

Alternating shale and sandstone 530'

Coarse sandstone 180' with a thin bed of red
shale 50' from the bottom.

About 475 feet above the base of this section Butts found fragments of pelecypods and somewhat lower in the section brachiopods and "ferns". The fossils were examined by G. H. Girty with indefinite results, but he gave the opinion that these fossils exhibited Devonian rather than Carboniferous affinities. From this point where the brachiopods were found to the top of the red shale of the undoubted "Catskill" lithology, no fossils were found. Butts (1905, p. 3) says, "... it does not seem possible at present to fix, on paleontologic grounds, the bottom of the Pocono with any degree of definiteness. On lithologic grounds, however, there seems but one place to draw the boundary between that formation and the underlying Catskill, and that is the top of the red shale already described. The top of this shale lies stratigraphically about 380 feet below the clay bed in which the fossils occur ... As already stated, probably 80 per cent of the rocks from the top of this shale downward for 2000 feet are of red color, which sharply distinguishes them from the overlying and underlying rocks. For that reason the lower limit of the Pocono and the boundary between the Carboniferous and the Devonian is placed at the top of the red rocks".

Willard (1939, p. 260) draws the contact where the red and green sandstones and shale of the "Catskill" give way to the grey, usually conglomeratic, "Pocono" but states that in some cases, particularly where there are some non-red beds in the top of the "Catskill", the top cannot always be so easily drawn.

He mentions (p. 303) finding along the Allegheny Front certain marine faunules (above the "Catskill") which he suggests are correlates of the Riddlesburg shale of the Broad Top area. However, he fails to describe these faunas either as to content or location in the section and only mentions that they are apparently non-diagnostic. Willard also tentatively correlates the massive, green sandstones in the top of the "Catskill" along the Front with the Elk Mountain sandstone of northeastern Pennsylvania approximately 200 miles away which he in turn correlated (1936, p. 557) with the Oswayo shales of northwestern Pennsylvania. In summing up the "Pocono" situation on the Allegheny Front, Willard (1939, p. 302) says, "I believe that the Pocono formation here is much like the Pocono of the east, though a little finer-grained, thinner-bedded, and perhaps somewhat shalier. It rests upon beds of Elk Mountain or Oswayo lithology in rather sharp contact that is far from the traditional transition".

Butts (1906) has listed several faunas from the Devonian sequence at Altoona exposed along the famous Horseshoe Curve section. Both he and Kindle (1906) simply state that the highest fossiliferous Devonian below the red "Catskill" is Chemung. Willard (1933, p. 8) reexamined

this section and came to the conclusion that the highest marine Devonian is roughly equal to the lower Chemung (Cayuta) of New York. He says, however, that these pre-red beds probably "equal lower and middle Chemung in Maryland and so may run somewhat above the Cayuta".

From the foregoing it is evident that the boundary between the "Pocono" and the "Catskill" is a rather difficult one to determine on the basis of lithology alone. It will be shown later that where the Riddlesburg fauna can be found, the boundary can be located with near certainty. It seems highly probable that heretofore the boundary of the Devonian-Mississippian has usually been placed too low.

Lack of time and the desire to limit the scope of the problem, forbade extending this study along the Front into West Virginia, where it is obvious from a survey of the literature that fully as many stratigraphic problems there await solution as in Pennsylvania.

Broad Top

The Broad Top area is included in this study because of the important part that it plays as a connecting link between southwestern Pennsylvania, the Allegheny Front and northwestern Pennsylvania. In this area a fossiliferous shale in the basal part of the "Pocono" carries an interesting fauna whose affinities have been a matter of some discussion. Immediately below the basal "Pocono" is a Devonian series of red and green to grey sandstones and red shales which belong to the Catskill magnafacies. The highest reported (Chadwick, 1935, p. 143) marine fauna below these red beds is possibly true Chemung in age.

C. A. Ashburner (1878, p. 216) made a detailed instrumental survey

of the Sideling Hill section on the southeast flank of the Broad Top syncline near Kimmel, but Reger (1927, p. 404) indicated that certain inaccuracies are present and urges caution in its use. Ashburner reported 2135 feet of "Pocono" which he divided into three main divisions, an upper, massive and flaggy series, a middle series consisting of a coal sequence underlain by cross-bedded conglomerates, and a lower series of sandstones and shales. The horizon containing the marine fossils occurs in the upper part of his lower series. After correcting the inaccuracies in Ashburner's measurements Reger came to the conclusion that the fossils in the Kimmel section occur at approximately the same horizon recognized by I. C. White (1885, p. 88) in Terrace Mountain on the west limb of the Broad Top syncline.

Ashburner found a considerable thickness of red beds below the fossiliferous "Pocono" horizon. He states, (p. 28) "The horizon between the Pocono (X) and the Catskill (IX) is not very distinctly marked. The greatest distinction between the two formations is one of color, X being gray and IX being red". He records a thickness of 2630 feet (partly estimated) of "Catskill" east of Sideling Hill overlying the Chemung. At the base of the "Catskill" he found red beds interbedded with layers containing Chemung fossils. These beds he called transition beds.

J.J. Stevenson (1882) studied the "Pocono" and "Catskill" in Bedford and Fulton Counties but gives little detail concerning either member.

I. C. White's (1885) work in Huntingdon County attests his customary keen perception and in many respects his observations were superior to many of his contemporary workers. His stratigraphic sections in this report, both at Riddlesburg and along Shoup Run near Saxton, show the "Pocono" characteristics very well. He described (1885, p. 77) the "Pocono" saying, "It is composed of coarse, sometimes pebbly, greenish-gray, characteristically false-bedded, more or less massive sand rocks, interstratified with thinner gray shales, like those of the Productive coal measures, but without workable coal beds". (Italics White's)

White placed the base of the "Pocono" at a grey massive sandstone 100-140 feet thick, from 200 to 303 feet below the base of the fossiliferous shale (Riddlesburg shale of Reger). White's "Pocono" includes considerable red shale as well as some grey sandstones. In describing the "Catskill", White says, (p. 89) "Red shale predominates in the upper two-thirds of No. IX; but in some of the sections green sandstone beds are extensively interstratified with red shale, greatly reducing its amount;...".

White's reaction to the finding of fossils in the Devonian red beds above a conglomerate which he correlated with the Lackawaxen conglomerate of northeastern Pennsylvania is most interesting and highly enlightening. He states (p. 91) "where stratigraphy can be employed its authority is absolute, however fossils may arrange themselves;...". He realized that the fossiliferous red beds of the "Catskill" in the Broad Top area gave way to the greenish-gray beds

of the marine Upper Devonian of southwestern Pennsylvania. He felt, however, that these marine beds should retain the name "Catskill". He recognized (p. 98) the fact that, "animal life characteristic of the Chemung age became extinct at the beginning of the Catskill age in the northeast, but continued to exist in that age in the southwest; and longer and longer the farther southwest; so that in Fayette and Westmoreland counties Prof. Stevenson reports Chemung shells abundant at the very top of the Catskill (IX), or the base of the Pocono (X);...". It can be seen from these statements that White had practically grasped the facies relationships but stopped short of advocating that the "Chemung" is equivalent of part of the "Catskill".

D. B. Reger (1924) undertook an extended survey of the Mississippian of the Appalachian States during which he visited the Broad Top exposures. He remeasured several of the sections there and published his results in 1927. His measurements and analysis agree rather well with the work of I. C. White but less closely with that of Ashburner as has been mentioned before.

Reger gave the name Riddlesburg to the fossiliferous shale near the base of the "Pocono". The name is taken from a town $2\frac{1}{2}$ miles south of the type exposures on the west limb of the Broad Top syncline. His collection of Riddlesburg fossils was identified by G. H. Girty (1927) as Mississippian in age. Reger placed the base of the "Pocono" from 377 to 540 feet below the base of the Riddlesburg shale. Between the base of the Riddlesburg shale and the top of the "Catskill" is a series of alternating brown to red sandstones

and shales. Two of these sandstones Reger correlated with previously-named Mississippian formations. The uppermost, which is about 107 feet below the base of the Riddlesburg shale, he identified as his (1925, p. 778) Broad Ford sandstone which typically occurs on the Holston River between Smith and Tazewell Counties, north of Broad Ford village, Virginia, approximately 275 miles to the south of the Broad Top area. The lower sandstone he considered as the base of the Mississippian and identified it as the "Berea (Mount Pleasant?)" of Northwestern Pennsylvania and adjacent Ohio. The top of his "Berea" varies from 187 to 313 feet from the base of the Riddlesburg shale.

Willard (1936) has recently expressed the opinion that the Mount Pleasant is uppermost Devonian in northeastern Pennsylvania, when he identifies it above his supposed equivalents of the Oswayo in that area. This opinion we are in no position to evaluate. Willard is also convinced that the Mount Pleasant is cut out to the southwest by an unconformity and does not reach the part of Pennsylvania under consideration.

G. H. Chadwick (1935, p. 141) says that Girty studied the fossils of the Riddlesburg shale under the impression that they were Mississippian in age and therefore referred the forms to Mississippian genera, although actually several of the genera are common to the Upper Devonian and the Lower Mississippian (Waverly) beds. Chadwick admits,

however, that to fit this horizon into the Devonian sequence there would be inconvenient. Caster (1934, p. 38) also notes the lack of critical Mississippian forms in the Riddlesburg shale.

Willard (1939) accepts the Mississippian age of the Riddlesburg shale. He also states that Oswayo-like strata are present beneath the "Pocono" in Bedford County.

DETAILED SECTIONS

General Statement

The following detailed stratigraphic sections, one from each major locality mentioned in this report, are given to provide the reader with a general idea of the lithology of the various members discussed in detail elsewhere in this report. Two of the sections, the one along Sugar Run southwest of Altoona and the Riddlesburg section, have been published in Butts's reports (1905, p. 3) and Reger (1927, p. 399). However, the rule measurements made by the writer differ so much from previous accounts that republishing the sections seems desirable. The locations for the various sections have already been given.

Summit (Chestnut Ridge) Inlier

Remarks:

The rocks of this section are exposed in cuts along the north side of Route 40 where it ascends Chestnut Ridge. The basal part of the section is situated below the "Watering Trough Inn" about one mile west of the crest of the ridge.

MISSISSIPPIAN SYSTEM

Kinderhook series (?)

Shenango and Meadville stages(?)

Chestnut Ridge sandstone

16 Grey-brown sandstone weathering to a light, limonitic-brown color.

No fossils were found except for a few badly-macerated plant fragments. Most of this interval is covered so the measurements here are

	not as accurate as desirable. There is also some doubt if the	
	top of the member was seen in this section, observed.	225'
15	Cover with sandstone float.	49'
	<u>Total for Chestnut Ridge Sandstone.</u>	274'

Oil Lake series

Berea stage (?)

Lick Run conglomerate

- 14 Conglomerate composed of white quartz pebbles (4-5 mm. to 25mm. in diameter) imbedded in a matrix of medium-grained, grey-brown sandstone. Pebbles are not strikingly flat. The conglomerate is iron-stained and contains numerous iron-stone concretions. 11'

Disconformity - Chiopyle sandstone missing

Cussewago stage

Pine Knob member (type locality)

- 13 Grey-brown sandstone with a little interbedded grey shale. Occasional quartz pebble found in the sandstone. Partly covered. 16'6"
- 12 Brown sandstone and grey shale. Thin-bedded grey shale (4-5 feet thick) grading upward with slight unconformity into brown, indistinctly ripple-marked sandstone. Fossil genera found in this member include Athyris, Camarotoechia, Lingula, Orbiculoides, Schellwienella, Syringothyris, Edmondia, Leptodesma, Igoceras and Neocycloceras. 25'6"

Hopwood member (type locality)

- 11 Conglomerate composed of flat white quartz pebbles (3-10 mm. ap-

proximately in diameter) imbedded in a matrix of grey medium-grained micaceous sandstone. Occasional larger jasper pebbles are seen. Quartz pebbles grade upward from coarser at the bottom to finer toward the top. The base of this conglomerate has been contorted into large boulder-like masses between which some of the underlying shale has been forced. The conglomerate thins toward the west in this outcrop. 4'-8'

Unconformity

- | | | |
|----|---|---------|
| 10 | Thin-bedded grey shale which wedges out to the west in the unconformity beneath the conglomerate. | 0-3' |
| 9 | Grey-brown sandstone. Many clay galls and lenses of quartz pebbles are present in the sandstone. Most massive sandstones (4-5 feet without a bedding plane) are found near the middle of the member. Above and below this massive member are thinner sandstones exhibiting well developed cross bedding. Disconformities within the member appear to be present at several places but the cross bedding makes it difficult to tell with certainty. Base concealed by talus. | |
| | Exposed. | 15'-20' |
| | <u>Total for the Cussewago stage</u> | 73' |

Disconformity (?)

DEVONIAN SYSTEM

Conewango series

Riceville stage (?)

Jumonville sandstone (type locality)

- 8 Cover containing blocks of overlying sandstone and conglomerate. Slickensided fragments of shale and sandstone found in this interval might indicate the presence of unseen faults. The fact that this interval is covered would suggest that the rock here is a thin-bedded sandstone and shale sequence similar to that below 114'
- 7 Brown-grey sandstone. Beds 3 to 4 inches thick. Weathers readily to rusty color. Fossils abundantly preserved as molds covered with limonitic rust. Most abundant genera found include Athyris, Camarotoechia, Spirifer, Aviculopecten 11'
- 6 Green-grey, thin-bedded shale. Very fissile, especially when wet, making fossil collecting very difficult. The fossils found are very similar to those in sandstone above. 6'2"
- 5 Blue-grey, fine-grained sandstone. Lenses of white quartz pebble conglomerate are also present. Fossils similar to no. 7 above, but Pararca are more abundant. 4'4"
- Total for the Jumonville sandstone 135'6"

Venango stage

Watering Trough shale (type locality)

- 4 Green-grey, thin-bedded shale and a few interbedded lenticular sandstones. Near the base is a lense of blue, hard, limy sandstone 4 feet thick which lenses out to the east.

- Fossils apparently almost identical with overlying Jumonville but difficult to collect in both lithologies because the shale is so fissile and the sandstone is so hard 144'7"
- 3 Blue-grey, limy sandstone. Beds up 1 foot thick with some interbedded shale. "Worm" tubes and a *brevicom* cephalopod were observed vertical to the bedding. Fossils found primarily near the top of the member 4'8"
- 2 Grey, thin-bedded shale interbedded with brown sandstone containing clay-galls. The upper 20 feet is almost black shale which possibly represents a local development of the Cleveland magnafacies. Thin, brown-grey sandstone lenses present in shale near top of this member. 31'
- 1 Cover. The base of the Watering Trough member is not exposed but on the basis of the log from the Heyn No. 1 well near the crest of Chestnut Ridge the base of the member is very near the bottom of no. 2. No red beds outcrop at the surface on Chestnut Ridge.
- Total for the Watering Trough shale 180'5"
- Total for the Watering Trough and Jumonville 316'3"

Youghiogheny Gorge (Chestnut Ridge) Inlier

Remarks:

The following section is the most nearly continuous exposure of several in the Youghiogheny gorge through Chestnut Ridge. This outcrop is located on the east flank of the anticline along the Western

Maryland Railroad, south of the Y.M.C.A. Camp Shaw and opposite the mouth of Indian Creek. It is 6 miles by railroad southeast of Connells-ville.

MISSISSIPPIAN SYSTEM

Kinderhook series(?)

Shenango and Meadville stages(?)

Chestnut Ridge sandstone

33 Massive, medium-grained sandstone. Not well exposed in this section, but on the west flank of the anticline it measures about 224'

Oil Lake series

Berea stage (?)

Lick Run conglomerate

32 Conglomerate of flat and round quartz pebbles imbedded in medium-grained sandstone matrix. Member actually consists of beds of conglomerate interbedded with sandstone. Main conglomerate bed 3 feet thick with the rest of the member consisting of sandstone with only lenses of conglomerate . 18'

Cussewago stage

Chiopyle sandstone

31 Grey-brown sandstone and interbedded brown-gray shale. One sandstone layer contained abundant Palaeoneilo cf. concentricus Winchell and a few Syringothyris. Partly covered. 53' 8"

30	Grey-brown sandstone, massive at the bottom growing less massive toward the top. Only fossil fragments found. Top partly covered	30'
	<u>Total for the Ohiopyle sandstone.</u>	83'8"

Fine Knob member

29	Thin-bedded grey sandstone weathering brown. Only fossil fragments found. Partly covered	20'
28	Grey, thin-bedded shale and cover.	15'
27	Grey, thin-bedded sandstone weathering rusty. Fossil fragments found. Becomes more massive toward the top.	21'2"
26	Grey, nodular or spheroidal-weathering, thin-bedded shale. Contains limy concretions.	3'
25	Grey, limy, lenticular sandstone	2'6"
24	Grey, limy, thin-bedded shale weathering rusty	15'3"
	<u>Total for the Pine Knob</u>	77'

Hopwood member (?)

23	Grey, massive, slightly cross-bedded sandstone	5'
22	Conglomerate composed of flat quartz pebbles (3-8 mm. in diameter) and clay galls. The pebbles tend to be alligned in layers with long diameters parallel.	4'
21	Reddish, thin-bedded shale	3'6"
20	Grey-brown, massive, cross-bedded sandstone. Slightly limy. Weathers to a white or a brown color	11'
	<u>Total for the Hopwood</u>	23'6"
	<u>Total for the Cussewago stage</u>	184'2"

Disconformity

DEVONIAN SYSTEM

Conewango series

Riceville stage (?)

Jumonville sandstone

- | | | |
|----|--|-------|
| 19 | Grey, thin-bedded limy shale. Tends to weather to a white or slightly reddish color | 6' 6" |
| 18 | Grey, rather fine-grained sandstone | 6' |
| 17 | Grey, limy, thin-bedded shale weathers to white or slightly reddish color. Vertical worm burrows noted. | 5' |
| 16 | Brown-grey sandstone. More massive at the top, more shaly and thin-bedded at the bottom. Apparently slightly limy. . . | 6' |
| 15 | Grey, thin-bedded limy shale interbedded with hard, blue irregularly bedded sandy limestone. Shale tends to weather to a whitish color | 14' |
| 14 | Green-grey, medium-grained sandstone. The sandstone is massive and cross-bedded. Slightly limy so when weathered the planes of cross-bedding tend to stand out. | 24' |
| 13 | Grey, clay gall and quartz pebble conglomerate. Tends to weather slightly red | 3' 2" |
| 12 | Grey, thin-bedded sandstone interbedded with grey and slightly red thin-bedded shale. Sandstone tends to weather red. Faulting here in this member makes thickness somewhat unreliable | 10' |
| 11 | Grey, massive, cross-bedded sandstone containing some clay | |

galls. Bottom of member where it rests on shale has a slightly lumpy appearance due probably to differential movement between the sandstone and the shale. , 17'

Unconformity

- 10 Grey-green, thin-bedded sandstone interbedded with green, sandy shale. Shale weathers to a rusty color 6'3"
- 9 Grey, sandy micaceous shale. Thin-bedded. Weathers to a slightly reddish color 12'
- 8 Red, thin-bedded shale 2'6"
- 7 Grey sandstone weathering to a brown. Weathers out in blocks 5'
- 6 Grey, thin-bedded, ripple-marked shale. Some slightly red beds interbedded with the grey shale. Tends to grade into the overlying sandstone. 10'
- 5 Grey, hard, massive sandstone weathering to a dark brown color. Contains an abundant well-preserved fauna, Pararca, Spirifer disjunctus, Camarotoechia and Grammysia common. 9'
- Total for the Jumonville. 136'5"

Venango stage

Watering Trough shale

- 4 Cover. This covered interval has caused the writer a great deal of trouble because he is not certain whether or not faulting has occurred here. Judging from the faulting which

is known to occur on either side of this space there is considerable doubt if the true stratigraphic interval is as thick as is here given. However, no better measurement of this cover is known. The distance was paced and what was thought to be the most reliable measurement of several was taken. The thickness was then computed trigonometrically from different angles on adjacent exposures. . 315'

3	Grey, sandy shale and interbedded grey sandstone. Poorly exposed. <u>Spirifer disjunctus</u> gens abundant throughout . . .	60'
2	Grey-green, massive, micaceous sandstone weathering to a thin-bedded condition	7'
1	Grey, limy shale grading upward into grey, micaceous sandstone. In the lower part of the fine-grained shale is a large fauna of pelecypods almost impossible to collect due to fissility. Some clay gall "conglomerates" present in the sandstone portion of the member	24'
	<u>Total for the Watering Trough.</u>	406'
	<u>Total for the Watering Trough and Jumonville</u>	542' 5"

Youghiogheny Gorge (Laurel Hill) Inlier

Remarks:

This section shows the most complete exposure of the strata discussed in this report. Numbers 3 to 10 inclusive are not exposed on the west limb of the Laurel Hill anticline but are found in the correct stratigraphic interval on the east limb. By piecing

the exposures together in this way a more complete section was obtained.

MISSISSIPPIAN SYSTEM

Kinderhook series (?)

Shenango and Meadville stages (?)

The first part of this section is measured on the west bank of Rock Springs Run and on the north bank of the Youghiogheny river along the Baltimore and Ohio Railroad west of Victoria.

Chestnut Ridge sandstone

71 Grey-brown, massive, cross-bedded sandstones and interbedded, grey shales. Weathers from a grey-brown to a rusty-brown color. Unfossiliferous except for macerated plant remains. Makes steep cliffs along Rock Springs Run north of Victoria known as the "Mary Day Cliffs". This sandstone is much thinner here than in the other inliers probably because of a large erosional disconformity at the top 142'

Oil Lake series

Berea stage (?)

Lick Run conglomerate

70 Type locality. The best exposure for study is found along the road from Rock Springs School to Victoria. Grey, massive, cross-bedded, flat, quartz-pebble conglomerate. The long dimension of the pebbles is usually aligned with the bedding or cross-bedding planes. The conglomerate is thicker on the south bank of the Youghiogheny River than

on the north bank 20'-23'

Cussewago stage

Ohiopyle sandstone

- 69 (Type Locality) Best exposures for study are found along
the road from Rock Springs School to Victoria. This cov-
ered interval was measured on the south bank of the river
and tied in with a better section exposed along the Balti-
more and Ohio Railroad on the north bank. Some discrepan-
cies might result from this procedure. 35'
- 68 Green-grey, micaceous sandstone. Cross-bedding noticeable.
Sandstone weathers to a rusty brown. Fossils found in-
clude Leptodesma, Syringothyris and crinoid stems and many
shell fragments 12'
- 67 Cover 3' 6"
- 66 Grey-green sandstone weathering brown-black. Fossil
fragments present 3' 6"
- 65 Cover 3'
- 64 Thin-bedded sandstone with interbedded shale near its base.
Weathers rusty-brown. Few fossil fragments 4' 8"
- 63 Grey-green to brown, shaly sandstone. Shale more abundant
at the base grading upward into more massive sandstone to-
ward the top. 3'
- 62 Grey-green, ripple-marked sandstone. Weathers to a brown-
black color 1'
- 61 Grey, sandy shale weathering rusty-brown. 3'

60	Grey-green to brown massive sandstone. Has two beds containing small cross-bedding. Micaceous, weathers rusty-brown	6'
	Total for the Ohiopyle sandstone	74' 6"

Pine Knob member

59	Grey, thin-bedded shale weathering whitish, interbedded with grey-brown sandstone	2' 6"
58	Brown-grey, cross-bedded sandstone tending to be reddish on weathering. Becomes thin-bedded and weathers whitish toward the top where it is a little shalier	5' 6"
57	Grey shale, badly weathered to a white color.	3'
56	Brown-grey, irregularly cross-bedded sandstone. Very few fossil fragments. Surface of bedding planes ripple-marked and covered with "worm" burrows	6'
55	Grey shale	3'
54	Irregularly-bedded, grey-brown sandstone.	5' 6"
53	Grey, thin-bedded shale weathering dirty white.	3'
52	Brown-grey, sandy shale. Partly covered.	4'
51	Grey, thin, irregularly-bedded shale weathering dirty white. "Worm burrows" abundant. <u>Eumetria scansa</u> only fossil well preserved. A fragment of <u>Bradfordoceras</u> , <u>Camarotoechia</u> , <u>Athyris cf. angelica</u> and a <u>Palaeoneilo</u> sp. have come from near or at this horizon.	8'
	<u>Total for the Pine Knob member.</u>	49' 6"

Linderman sandstone

- 50 Type Locality. Brown-grey, cross-bedded, calcite-cemented sandstone. The cross-bedding is quite noticeable. Weathers to a soft, friable rusty-brown sandstone with the fossils found only as fragments. The type locality of the Linderman is found along the road from Rock Springs School to Victoria. It is not well exposed along the B. & O. track. Fossils from this member are abundant in a field on Linderman's farm which is located about $\frac{1}{2}$ mile east of the above measured locality 2'-5' 6"
- Total for Cussewago stage. 117'

Unconformity

DEVONIAN SYSTEM

Conewango series

Riceville and Venango stages

Jumonville sandstone and Watering Trough shales

The section is continued on the south bank of the Youghiogheny River along the Western Maryland Railroad.

- 49 Blue-grey, micaceous, interbedded sandstone and shale. . . . 12'
- 48 Blue, irregularly-bedded sandstone. Marks the beginning of a steep cliff 12'
- 47 Grey sandstone and shale 12'
- 46 Grey-brown, rather massive sandstone. Bottom part the most massive making a steep cliff. 18'

45	Grey, slightly sandy, thin-bedded shale. Weathers to elongated fragments resembling pencils.	4'
44	Grey-brown sandstone	4'
43	Grey, thin-bedded shale.	6'
42	Grey, almost white, quartzitic sandstone containing a few plant fragments. Makes a sharp steep cliff	14' 6"
41	Grey-brown, interbedded sandstone and sandy shale. Very sparsely fossiliferous	30'
40	Cover. No red beds apparent in this interval	159' 6"
	<u>Total for Jumonville and Watering Trough</u>	<u>272'</u>

Youghiogheny member (type locality)

39	Green-grey to red, rather massive sandstone. Cross-bedded but weathers to thin plates. Slightly shaly with inter-bedded red shale and sandstone toward the top . . .	72'
38	Cover	54'
37	Grey-green and red, thin-bedded shale weathering a rusty color. Small fold in this member	12'
36	Grey-green sandstone weathering rusty. Some inter-bedded shale. Some of the red sandstone changes laterally to green sandstone.. . . .	18' 6"
35	Green sandstone interbedded with green and red shale. This is a zone of locally-severe, eastward thrusting which makes measurements here unreliable. The rapid lateral change from red to green and vice versa makes	

the tracing of individual members across the faulted zone
difficult, estimated 48'

- 34 Grey, thin-bedded, limy shale. Interbedded are cross-
bedded sandstone lenses. The sandstone is more prominent
toward the top of the member 16'₄

Disconformity

- 33 Grey, rather massive, cross-bedded sandstone with some in-
terbedded shale 18'
- 32 Cover and red sandstone. 20'

Disconformity

- 31 Very bright, brick-red shale with some interbedded thin
sandstone toward the middle of the member. Many green
spots and streaks through the shale 20'

Disconformity

- 30 Red and green, rather massive, yet platy, sandstone.
Brown cross-bedded sandstone at the bottom. 12'

Disconformity

- 29 Greenish shale and sandstone with some lensing sandstone
layers. Some interbedded red shale 18'
- 28 Red to green platy sandstone containing some clay galls.
Ripple cross-bedding noted 7'
- 27 Red, thin-bedded shale with green streaks 6' 6"
- 26 Grey, massive sandstone weathering red. Channel fillings
noted on bottom surface 26'

- 25 Red shale with thin-bedded red sandstones 1 to 6 inches
thick interbedded. Some of the red shale quite massive.
Green shale bed near the top of the member 26'

Disconformity

- 24 Green-grey, massive sandstone weathering red. Cross-
bedding present and there are several disconformities
within the member. Ptychopteria sp. and plant fragments
found in the bottom of the bed 24'
- 23 Red, rather thin-bedded shale and sandstone interbedded
with some green shale. Very micaceous. This bed on the
north bank of the river contains a poorly preserved but
abundant cephalopod and pelecypod fauna. 47'
- Total for Youghiogheny 422'

Chautauquan series

Conneaut stage (?)

Maple Summit member

The section now continues along the north bank of the river
east of Victoria along the Baltimore and Ohio tracks.

- 22 Green, thin-bedded shale. 11'
- 21 Green-grey, massive, micaceous sandstone weathering to a
rusty color. Contains layers of clay-gall conglomerate
with some grey, sandy shale interbedded. Few fossils.
Makes almost vertical cliff 22'
- 20 Grey, thin-bedded shale with some few grey-brown inter-

- bedded sandstone layers. Few rounded quartz pebbles present. Layers of limonitic concretions noted. "Worm burrows" and spheroidal weathering noticeable 41'
- 19 Green-grey, massive, micaceous sandstone containing some clay galls 4'
- 18 Grey-green, thin-bedded shale weathering rusty. 6'
- 17 Grey-green, micaceous sandstone tending to show cross-bedding. Ironstone concretions present. The fossils found in this member are preserved as internal and external molds covered with dark limonitic stain. Schizodus very abundant. 6'
- 16 Green sandstone growing shaly toward the top with interbedded shale. More thin-bedded toward the top. 19'
- 15 Grey-green, massive sandstone containing clay galls. Fine-to-medium-grained texture. Sandstone tends to fracture conchoidally. Suggestions of vertical worm tubes. Sandstone weathers rusty brown. 21' 3"
- 14 Cover 4'
- 13 Grey, massive quartz-pebble conglomerate tending to be more thin-bedded toward the top. Quartz pebbles are about of pea size and tend to be oriented along the bedding planes. 6'
- 12 Grey, thin-bedded, sandy, micaceous shale. Tends toward massiveness and stands out as a cliff. Weathers to a brown color. The shale has a slightly laminated appearance with

	ripple cross-bedding indistinctly developed. Heavy sand-	
	stone layer 2 feet thick near the base.	15'
11	Grey, medium-grained sandstone containing occasional quartz pebbles (pea size) and clay galls. Cross-bedding noted. Many disconformities are present in the member. The sand-	
	stone tends to grade upward into the overlying shale. . . .	8'
10	Cover with shale and sandstone blocks	61'
9	Grey-green to brown, micaceous sandstone weathering rusty colored	5'
8	Cover	27'
7	Reddish-grey sandstone with layers of reddish shale. Weathers rusty on joint planes. Exposed.	6'
6	Cover and green-brown shale	3' $\frac{1}{2}$
5	Reddish, rusty-colored shale with carbonaceous films on some weathered surfaces. Some red shale mud chips or clay galls present	2' $\frac{1}{2}$
4	Grey, mottled sandstone more massive toward the bottom, becoming less so at the top. Some macerated plant frag- ments present	22'
3	Cover	85'
2	Coarse, grey-white sandstone interbedded with quartz- pebble and clay-gall conglomerate. <u>Camarotoechia</u> , <u>Leptodesma</u> and <u>Ptychopteria (?)</u> found	8'
1	Grey, thin-bedded shale weathering rusty colored.	4'

Total for Maple Summit 386' 3"

Conemaugh Gorge (Chestnut Ridge) Inlier

Remarks:

The section exposed in this inlier is the least known of all the inlier sections. The sequence given is on the south bank of the river on the west flank of the Chestnut Ridge anticline along the Pennsylvania Railroad.

MISSISSIPPIAN SYSTEM

Kinderhook series(?)

Shenango and Meadville stages (?)

Chestnut Ridge sandstone

- 25 Grey-brown, massive, cross-bedded sandstone slightly shaly toward the top. Tends to weather in thin plates . . . 54'
- 24 Grey sandy shale 8'
- 23 Grey, massive, cross-bedded sandstone. 58'

Disconformity

- 22 Grey, massive, cross-bedded sandstone. In one very cross-bedded layer the planes of cross-bedding are at a 45 degree angle to the regular bedding 15'

Unconformity

- 21 Grey, sandy, lenticular, micaceous shale 0-15'

Disconformity

- 20 Grey, very massive and very coarse-grained sandstone 90'
- 19 Very light-grey, massive, cross-bedded sandstone. The

upper part of this member is more shaly than the rest.

Several disconformities are present within this member . . . 60'

- 18 Very light grey, irregularly bedded sandstone. 14' 6"
- 17 Grey-brown, massive, cross-bedded sandstone. Beds have a
slightly laminated appearance but are very massive 60'
- 16 Grey, thin-bedded, sandy shale 9' 6"
- 15 Grey-brown, massive, cross-bedded sandstone. Extreme cross-
bedding may make this measurement somewhat inaccurate. . . . 76' 6"
- 14 Grey, sandy, micaceous, spheroidal-weathering shale . . . , 17' 6"
- Total for the known Chestnut Ridge sandstone. 478'

Oil Lake series (?)

Berea and Cussewago stages (?)

- 13 Cover. This cover is being placed within these stages
as it is about the interval that these two stages occupy
in other localities. 171'
- 12 Brown-grey, fairly fine-grained fossiliferous sandstone.
Fossils include Productella sp. Palaeoneilo aff. consimilis
and Camarotoechia cf. contracta, and Pleurotomaria sp. The
lithology and general faunal appearance of this member sug-
gests a stratigraphic position near to that of the Pine
Knob sandstone and shale. It does not have the appearance
of the basal Mississippian faunas noted in the rest of
southwestern Pennsylvania. Exposed 12-15'
- 11 Cover and sandstone blocks almost in place near the bottom.

This interval is being tentatively placed in the Mississippian. 55'

Total for the Berea and Cussewago stages (?). 241'

Total for the Chestnut Ridge and Cussewago stage. 719'

DEVONIAN SYSTEM

Conewango series

Riceville (?) and Venango stages

Jumonville (?) sandstone and Watering Trough shale

- 10 Whitish-brown, fine-grained sandstone. Massive at the bottom, grading upward into grey, thin-bedded sandstones which are irregularly ripple-marked 17'
- 9 Grey, thin-bedded shales with thin interbedded sandstone. Sandstone weathers brown. 14' 6"
- 8 Brown, rather massive sandstone. Some grey, irregularly-bedded shale weathering rusty interbedded with the sandstone .. 6' 6"
- 7 Grey, thin-bedded shale grading upward into overlying sandstone 7'
- 6 Brown, massive sandstone 4'
- 5 Grey, thin-bedded sandstone and shale. Similar to no. 3 below 15'
- 4 Grey, irregularly bedded sandstone. Weathers to a white color. Gradational contact above and below 3' 6"
- 3 Grey, thin-bedded shale interbedded with thin grey sandstone. Fossiliferous. Fossils include Spirifer disjunctus, Camarotoechia sappho, Aviculopecten sp. Other forms present

	but poorly preserved	44'
2	Grey-green, massive, cross-bedded sandstone containing some clay galls. This member is involved in a fold on the east limb and a thrust on the west limb, in both cases the stress was apparently from the east. Grey-green sandstone beds at the top are more massive, $1\frac{1}{2}$ to 2 feet in thickness	17'
1	Cover to center of anticline	87'
	<u>Total for the exposed Upper Devonian</u>	214' 6"

Conemaugh Gorge (Laurel Hill) Inlier

Remarks:

This section was measured on the northwest flank of the Laurel Hill anticline on the northeast bank of the river along the Pennsylvania Railroad. Only the "Pocono" portion and the exposed Upper Devonian are given in the following sections.

MISSISSIPPIAN SYSTEM

Kinderhook series (?)

Shenango and Meadville stages (?)

Chestnut Ridge sandstone

22	White, massive, cross-bedded sandstone similar in appearance to Loyahanna but without the lime content. Some beds of this member have abundant clay galls. Bottom partly covered. Exposed.	72'
----	--	-----

21 Cover. Probably similar to member above judging by float . . 43'

Disconformity

- 20 Grey, thin-bedded, shaly, micaceous sandstone. Tends
to weather to pencil-like forms with spheroidal weath-
ering also noticeable 30'
- 19 Green-grey, massive, cross-bedded sandstone. Bottom poorly
exposed. This and extreme cross-bedding might make
measurements inaccurate, about... . 180'
- 18 Grey, thin-bedded, sandy shale and cover 24'
- 17 Grey, massive sandstone 9'
- 16 Grey shale partly covered 10'
- 15 Grey, cross-bedded sandstone with a small amount of in-
terbedded grey shale toward the top 54'
- 14 Grey-brown, lenticular shale and lenticular sandstone
masses 7' 6"
- 13 Grey-brown sandstone 15'

Disconformity

- 12 Grey, thin-bedded, shaly sandstone. Spheroidal weather-
ing noticeable. Exposed. 8' 6"
- 11 Cover. The contact between the Chestnut Ridge sandstone
and the Berea and Cussewago stages is undoubtedly in this
interval but cannot be seen 248'

Oil Lake series

Cussewago stage (known)

- 10 Green-gray, massive, cross-bedded sandstone with
layers of quartz pebbles. Partly covered 25'
- 9 Grey-green, thin-bedded shale. Fossils found 16'
from the top of the member in a layer apparently
limy. Fossils poorly preserved but have the appear-
ance of the basal Linderman fossils of the Fayette
County inliers 24'
- Total for the exposed Chestnut Ridge and
fossiliferous Lower Mississippian 750'

DEVONIAN SYSTEM

Conewango series

Riceville (?) and Venango stages

Jumonville sandstone (?) and Watering Trough shale

- 8 Green-grey shale and cover 34'
- 7 Green-grey, massive, micaceous sandstone 6' 3"

Disconformity

- 6 Grey, thin-bedded, shaly sandstone containing poorly
preserved fossils of Conewango aspect. Primarily
Spirifer disjunctus found 30'
- 5 Grey, thin-bedded sandstone interbedded with grey shale. 17'

Disconformity

- 4 Grey, massive, cross-bedded sandstone. 10-12'

Disconformity

- 3 Grey-brown, massive sandstone interbedded with shale
at the top. Base of many of the sandstone layers

	show results of interstratal flowage. Cumulative	
	ripple marks also noticeable	38'
2	Cover	82'
	Total of non-red Upper Devonian.	219' 3"
1	Cover. Red Soil indicates that red Devonian "Catskill"	
	beds outcrop in this interval but are not seen. Cover	
	to center of anticline	305'
	Total of Upper Devonian	524' 3"

Allegheny Front at Altoona

Remarks:

This section is located along the banks of Sugar Run where it descends the Allegheny Front about 5 miles southwest of Altoona. The section is found in the cuts on the north bank of the run along the main line of the Pennsylvania Railroad. Only the "Pocono" portion and the upper part of the Upper Devonian are given in the following section.

MISSISSIPPIAN SYSTEM

Kinderhook series (?)

Chestnut Ridge sandstone

- 15 Brown, massive, cross-bedded, quartzitic sandstone which makes a sharp cliff. This is part of the "Burgoon" sandstone of Butts. The thickness given may be somewhat inaccurate due to the cross-

bedding, about 162'

large disconformity

- 14 Brown-grey shale and sandstone. Partly covered. 30'
- 13 Grey-brown, cross-bedded sandstone 11'
- 12 Grey, thin-bedded shale, grey-brown sandstone and
cover 16'
- 11 Grey, very massive, cross-bedded sandstone inter-
bedded with some few shale beds. Many minor dis-
conformities present within the member 54'
- 10 Cover. 78'
- 9 Grey-brown, cross-bedded, micaceous sandstone with
some interbedded grey shale. 18'
- 8 Grey shale and cover 7'
- 7 Grey, massive, sandy shale which is quite micaceous.
Weathers spheroidally. Individual beds are about
1 inch thick or less 72'
- 6 Grey-brown, massive sandstone. The bottom of the bed
has noticeable channel fillings in it. Noticeably
cross-bedded 36'

Disconformity

- 5 Grey, thin-bedded, lenticular shale. Weathers to a
rusty color. 0-8'

Disconformity

- 4 Grey, massive, cross-bedded sandstone with inter-

bedded lenticular masses of shale 38'

Disconformity

Riddlesburg shale

3 Grey-brown, fine-grained sandy shale weathering rusty colored. The bottom 14 inches of this member consists of a limy sandstone containing the typical Riddlesburg shale fauna which is found better developed about 3 miles due north of this outcrop along Route 36.

Rhipodomella huntingdonensis Girty is the most abundant fossil

33' 6"

Disconformity

Total for the Chestnut Ridge and Riddlesburg shale

(old "Pocono").. . . . 563' 6"

DEVONIAN SYSTEM

Conewango series (?)

2 Massive, cross-bedded, micaceous, green-brown sandstone. Cross-bedding makes exact measurement difficult. This member might be part of the Oswayo as Willard has suggested.

75'

Disconformity

1 Thin-bedded, micaceous, brown-grey shale and sandstone . . 6'
Red Upper Devonian "Catskill" beds.

Riddlesburg (Broad Top Area)

Remarks:

This section is exposed along the east bank of the Raystown branch of the Juniata River. The best exposures are in the cuts along the Huntingdon and Broad Top Mountain Railroad about $2\frac{1}{2}$ miles north of the town of Riddlesburg in the northeast part of the Everett quadrangle. This section has been measured before by White and Reger, but the writer's remeasurements and notations fail to agree in all respects with either White or Reger.

MISSISSIPPIAN SYSTEM

Kinderhook series (?)

Shenango and Meadville stages (?)

Chestnut Ridge sandstone

12	Cover	117'
11	Grey, massive, cross-bedded, coarse-grained sandstone. Considerable folding and thrusting in this member. Reger, (1927) found this interval to be 85 feet	114'
10	Cover	69'
0	Grey, massive, cross-bedded sandstone similar to no. 11. The member is folded and faulted with some of the interbedded grey shale badly squeezed. Reason- able allowance was made in the measurement for the effects of the folding. More shale than sandstone appears in the member toward the bottom.	242'
8	Cover and brown to reddish sandy shale.	70'

7	Grey, massive, cross-bedded sandstone	56'	6"
6	Rusty-brown to grey, sandy shale.	17'	
5	Grey-brown, massive, coarse-grained sandstone	10'	

Riddlesburg shale (Type locality)

4	Grey-brown, thin-bedded sandstone and interbedded grey shale.	42'	
3	Thin-bedded, grey shale which has very distinct spheroidal weathering. Fossiliferous only in the basal 25-30 feet where the dominant fossils are <u>Rhipodomella huntingdonensis</u> , <u>Camarotoechia</u> cf. <u>contracta</u> , <u>Chonetes acutiliratus</u> and <u>Cypricardinia</u> <u>consimilis</u>	66'	
	<u>Total for the Chestnut Ridge sandstone and</u> <u>Riddlesburg shale</u>	803'	5"

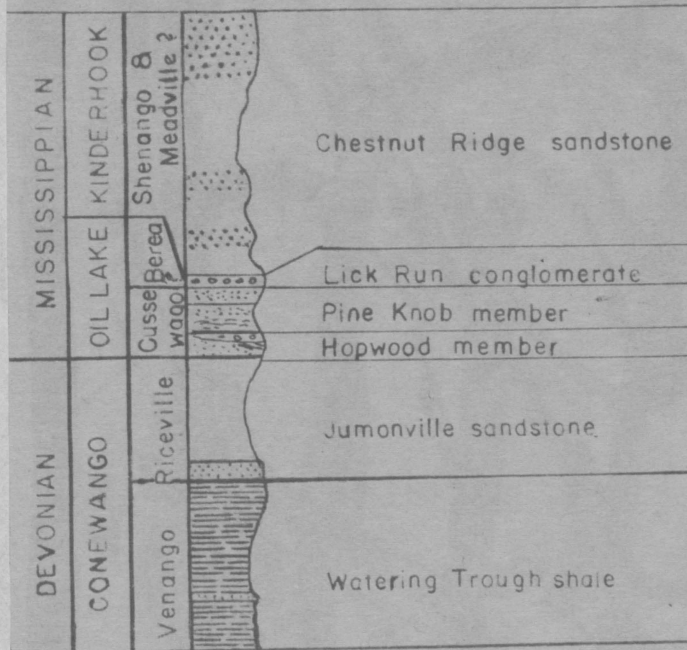
DEVONIAN SYSTEM

2	Heavy, massive brown sandstone.	17'	
---	---	-----	--

Disconformity

1	Upper Devonian "Catskill" red beds.		
---	-------------------------------------	--	--

- Figure 4 . Summit (Chestnut Ridge) inlier section.
- Figure 5 . Youghiogheny gorge (Chestnut Ridge) inlier section.
- Figure 6 . Youghiogheny gorge (Laurel Hill) inlier section.
- Figure 7 . Conemaugh gorge (Chestnut Ridge) inlier section.
- Figure 8 . Conemaugh gorge (Laurel Hill) inlier section.
- Figure 9 . Allegheny Front at Altoona section.
- Figure 10 . Riddlesburg (Broad Top area) section.



WL '42

Figure 4. Summit (Chestnut Ridge) Inlier section.

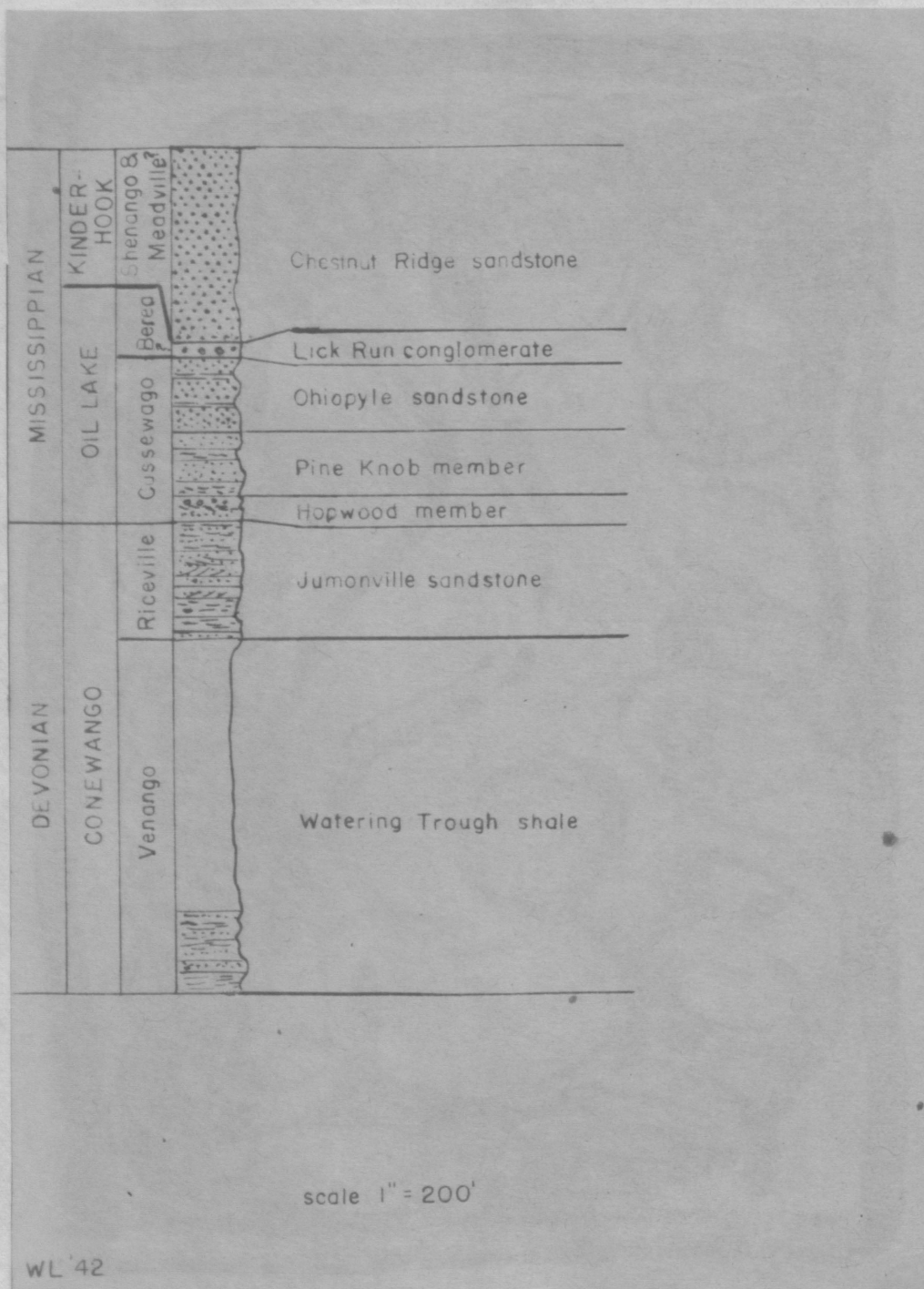
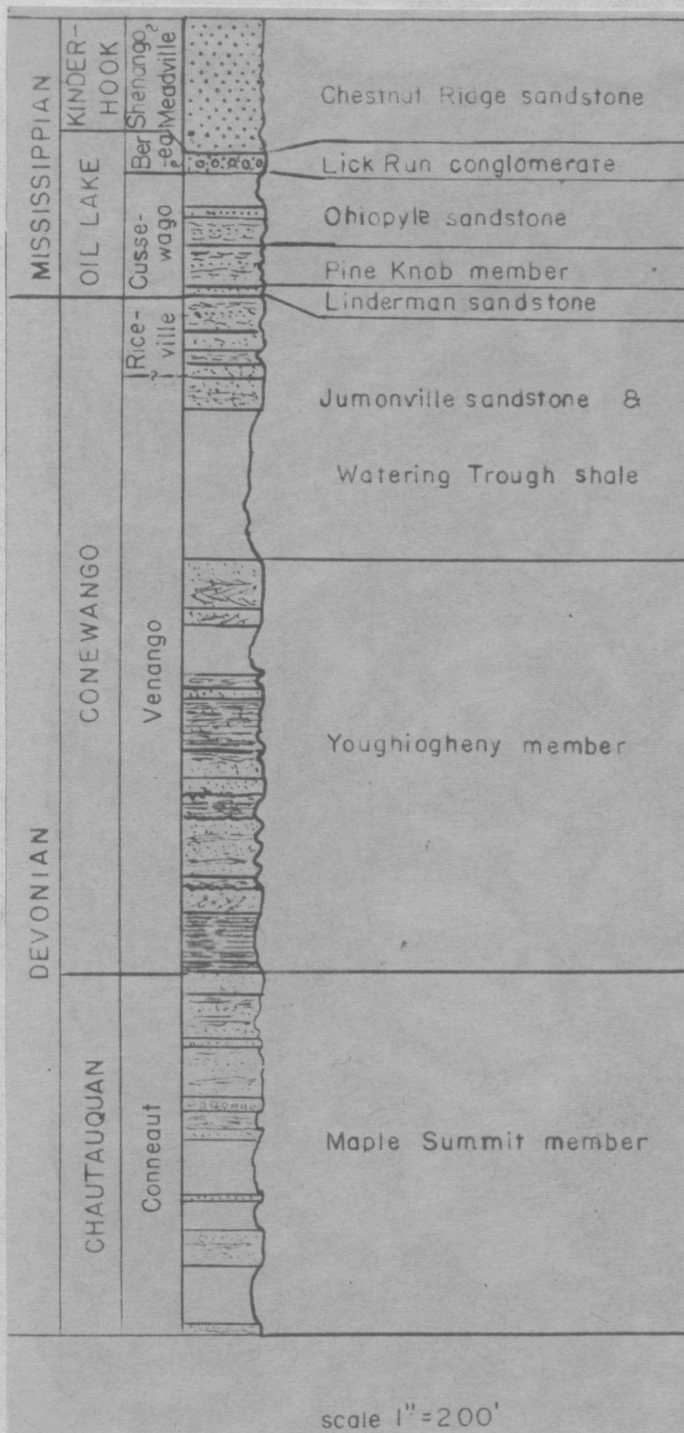


Figure 5. Youghiogheny gorge (Chestnut Ridge) Inlier section.



WL '42

Figure 6. Youghiogheny gorge (Laurel Hill) Inlier Section.

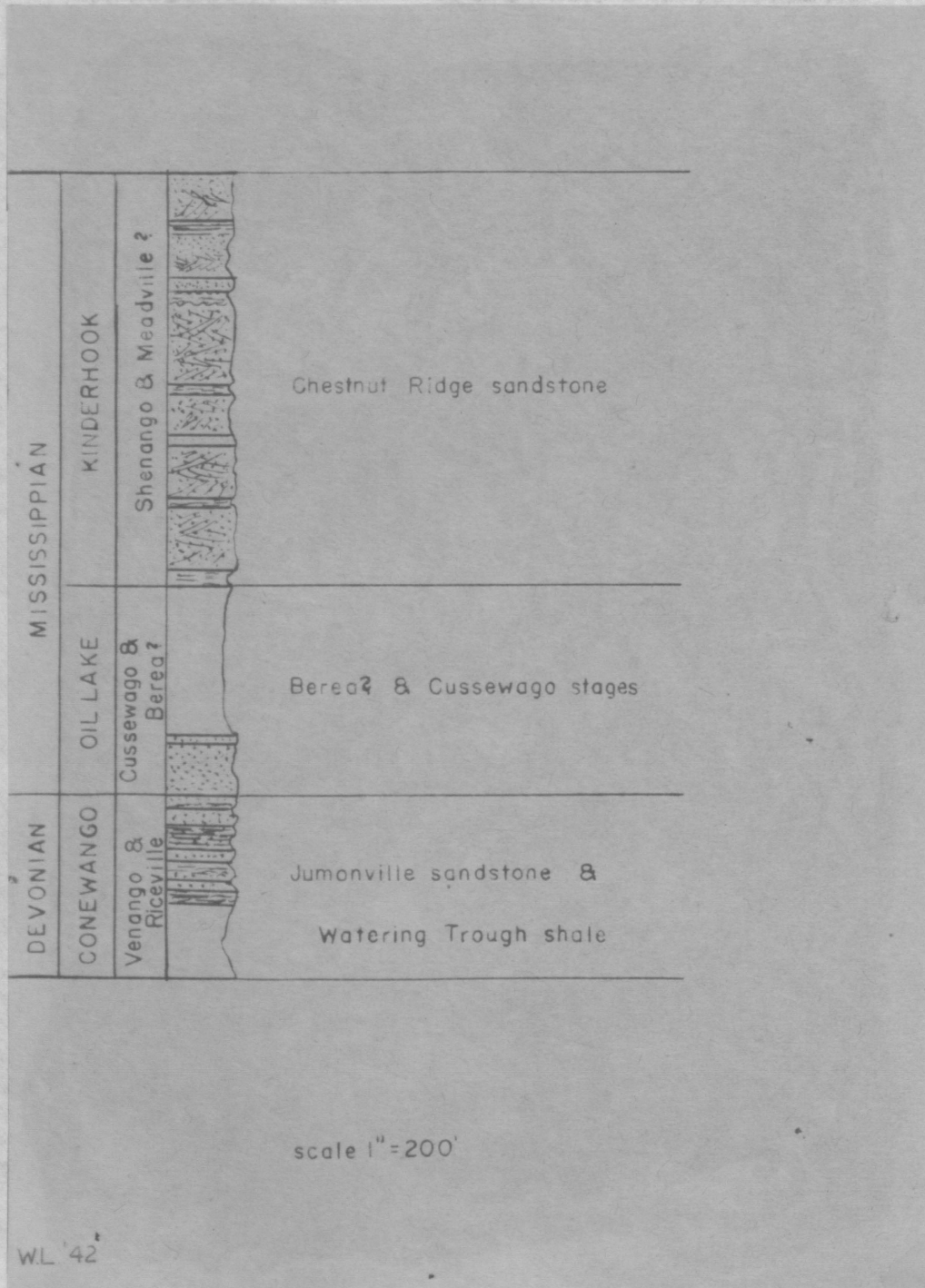


Figure 7. . Conemaugh gorge (Chestnut Ridge) Inlier section.

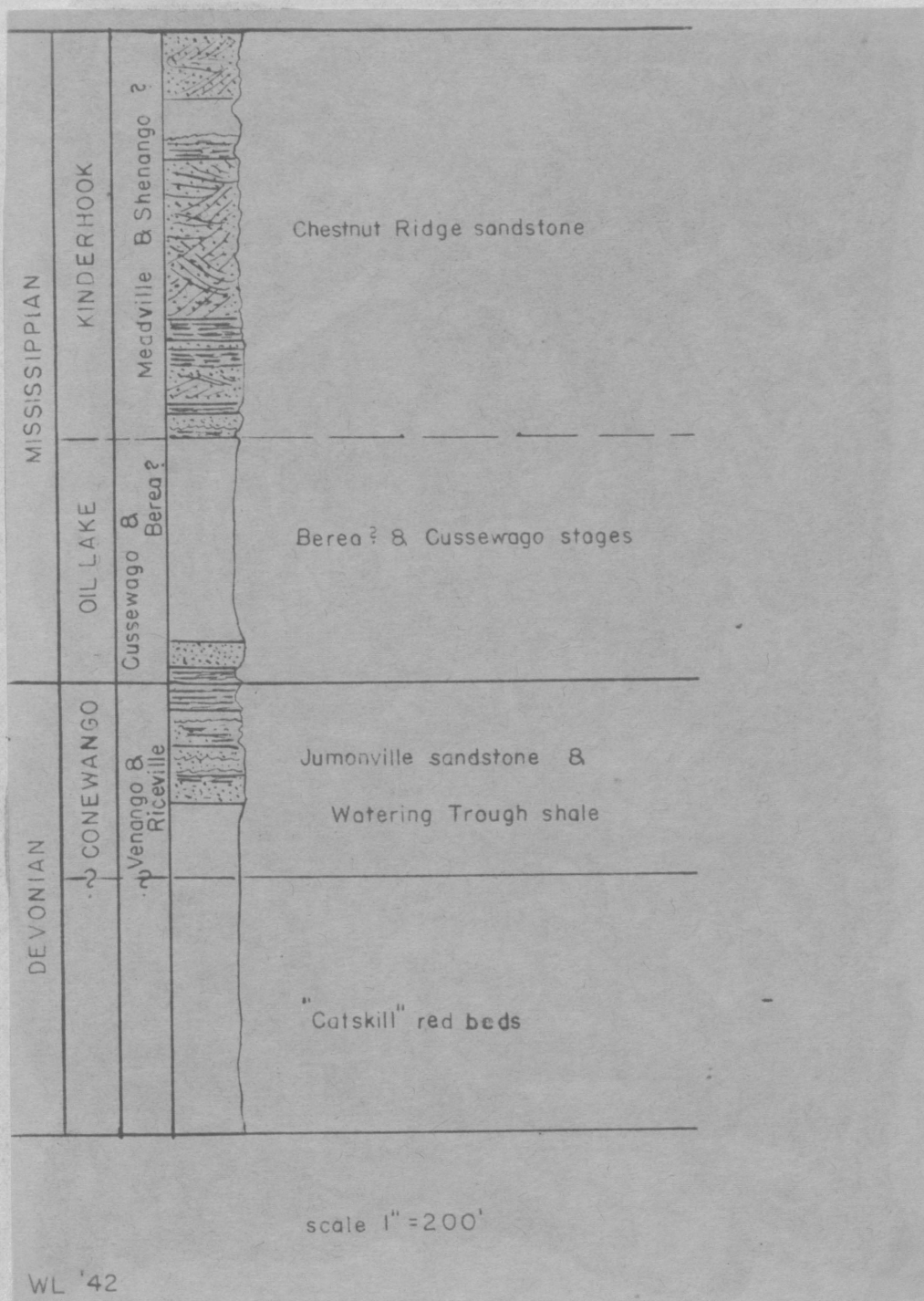


Figure 8. Conemaugh gorge (Laurel Hill) Inlier section.

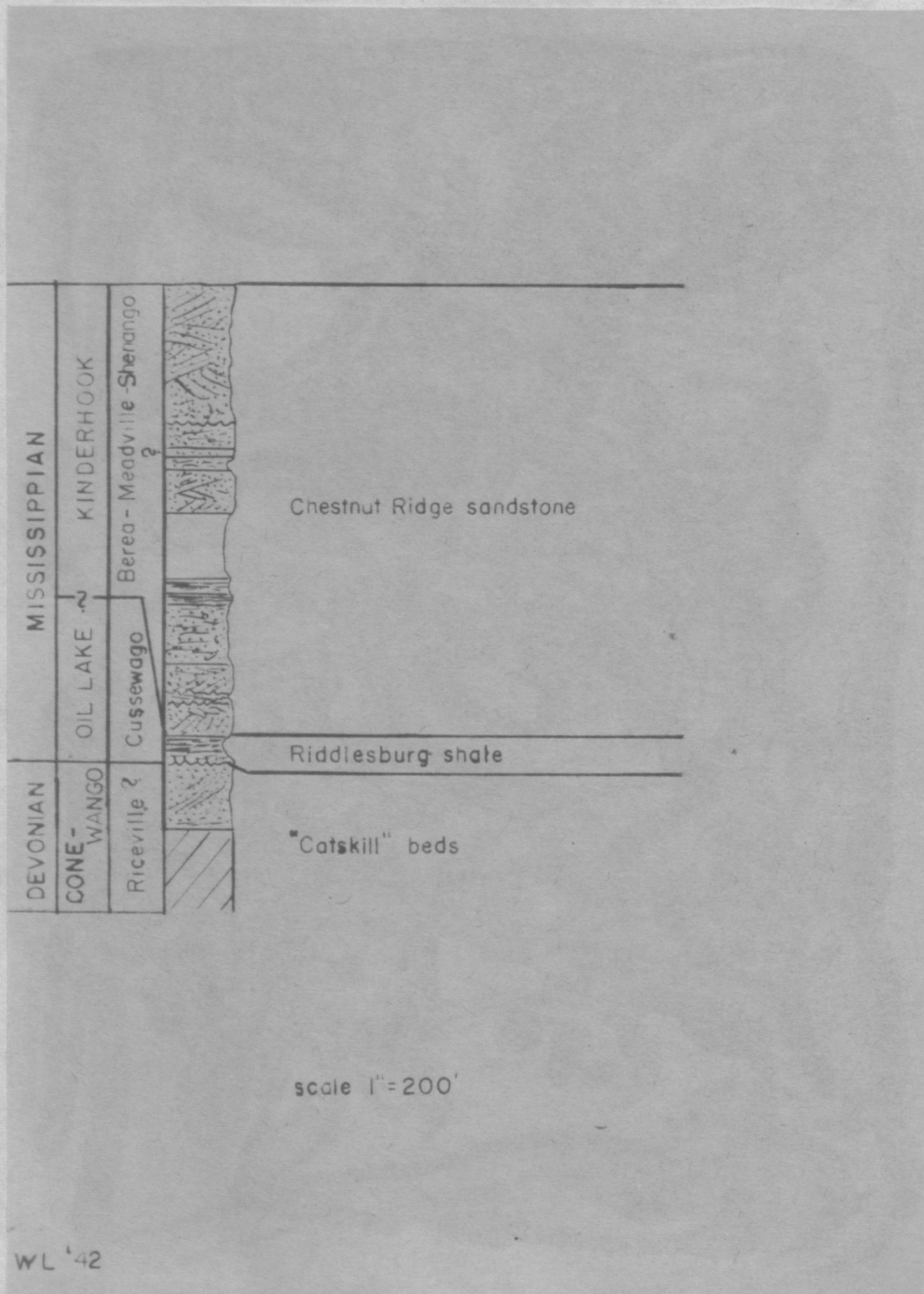


Figure 9. Allegheny Front at Altoona section.

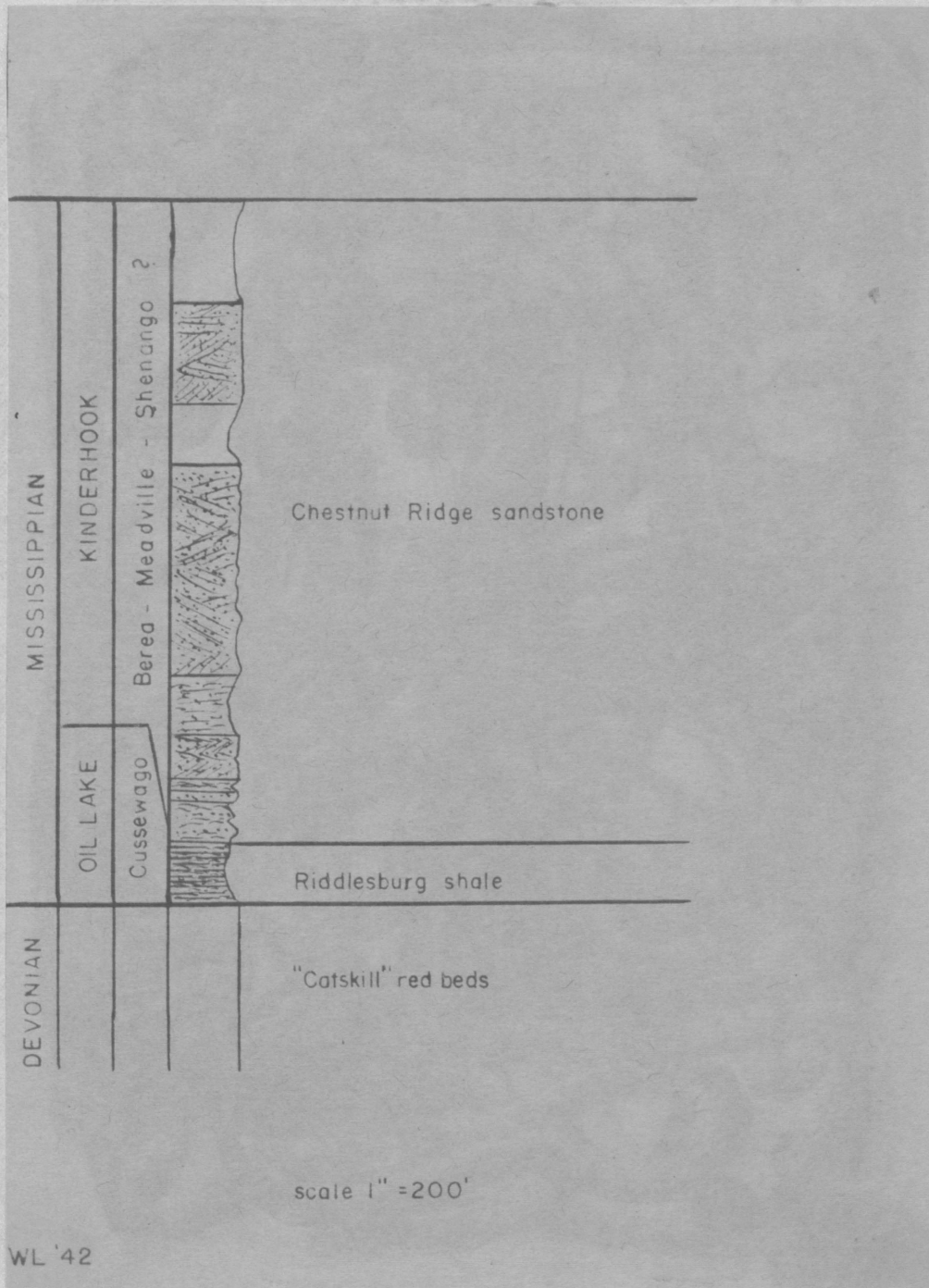


Figure 10. Riddlesburg (Broed Top area) section.

DETAILED STRATIGRAPHY

Preliminary statement

The Devonian and Mississippian beds of southwestern Pennsylvania occur as isolated inliers separated from areas of similar stratigraphic relationships by considerable distances. This fact makes it impossible to "walk out" the contacts from areas of known relationships to the inliers. Therefore, it is necessary to rely on other less direct methods of correlation. The methods used in this study were primarily paleontology and stratigraphic position. With due regard in ecologic factors, paleontology has proved to be the more dependable of the two.

However, regional correlation by the use of fossils in the Upper Devonian and Lower Mississippian of western Pennsylvania is not without its difficulties. The hardship is not a lack of paleontologic materials but of adequate systematic descriptions of them. A number of the faunas, particularly in the Upper Devonian, have been superficially studied, occasionally to result in more harm than good. Due to hasty determination, some fossils have been given much too long a geologic range, while others have been given generic and specific names, such as "*Spirifer disjunctus*", which include several species, if not more than one genus. Thus mere faunal lists dissociated from the specimens on which they were based usually have little correlation value.

In this study, the fossils from the inlier areas have been directly compared, in so far as possible, with fossils from known

stratigraphic horizons in northwestern Pennsylvania. The writer was fortunate in having access to Dr. Caster's undescribed collections from the Upper Devonian and Lower Mississippian from northwestern Pennsylvania in the University of Cincinnati Museum.

General Correlations

The lowest beds of the Upper Devonian exposed in the inliers have tentatively been correlated with the Conneaut (Chadakoin) stage of northwestern Pennsylvania. The main body of the Devonian deposits can be definitely correlated with the Conewango series. The two divisions of the Conewango which are being delimited are the Venango and Riceville stages. The correlation of the Venango stage with similar beds in northwestern Pennsylvania is fairly certain but the correlation of the Riceville stage of the Conewango series of southwestern Pennsylvania with the Riceville of northwestern Pennsylvania is, as yet, tentative.

In the lower Mississippian, beds not hitherto reported from the inliers have been found. These appear to be equivalents of the Cussewago stage. It is not unlikely that these beds have formerly been included in the Upper Devonian; a correlation justifiable from lithic similarity, but disproved by scrutiny of the biota.

The following list gives a summary of stratigraphic units which have been delimited in the foregoing sections in the Upper Devonian and Lower Mississippian of southwestern Pennsylvania.

MISSISSIPPIAN SYSTEM

Kinderhook series?

Shenango and Meadville stages (?)

Chestnut Ridge sandstone

Oil Lake series

Berea stage (?)

Lick Run conglomerate

Cussewago stage

Ohiopyle sandstone

Pine Knob member

Linderman sandstone and Hopwood member

DEVONIAN SYSTEM

Conewango series

Riceville stage (?)

Jumonville sandstone

Venango stage

Watering Trough shale

Youghiogheny member

Chautauquan series (?)

Conneaut stage (?)

Maple Summit member

DEVONIAN SYSTEM

CHAUTAUQUAN SERIES (?)

Name and definition

The Chautauquan series was originally proposed by J. M. Clarke and C. Schuchert (1899) for the uppermost Devonian rocks exposed in Chautauquan County, New York. It was proposed to include the Chemung beds and the Catskill sandstone. Chadwick (1935, p. 352) argues that the type Chemung is an eastern facies of the type Portage and would limit the Chautauquan series to the Canadaway and Conneaut stages which he designates as "groups". He places the remainder of the Upper Devonian (the Conewango series) in a Devono-Mississippian transition series which Girty (1904) had named the Bradfordian series.

Conneaut stage (?)

Name and definition

This stage was erected by Chadwick (1935, p. 351) to include those rocks in northwestern Pennsylvania between the base of the Cuba sandstone and the base of the Wolf Creek, or Panama conglomerate, (see page 21 for stratigraphic section of northwestern Pennsylvania). In southwestern Pennsylvania, the Conneaut stage is doubtfully identified and if present, is represented at the base of the section, by the Maple Summit member.

Maple Summit member

Name and definition

The name Maple Summit member ^{7/} is being proposed for the oldest

^{7/} Termed Sandstone A by the writer in Progress Report 126, Pennsylvania Geol. Survey, p. 8, 1941.

Upper Devonian strata exposed in the inliers. The base of the member is not exposed. It is overlain by the Youghiogheny red sandstone and shale. The name is taken, for lack of a nearer unoccupied geographic name, from a school three miles north of the type locality, which is near Victoria a flagstop on the Baltimore and Ohio Railroad in the gorge of the Youghiogheny River through Laurel Hill. The gorge is located in the southeastern part of Stewart township in Fayette County.

Occurrence

The Maple Summit sandstone is exposed only at the type locality as erosion has not proceeded far enough in the other inliers to expose it. In the Youghiogheny gorge (Laurel Hill) inlier the member is exposed for about two miles along the Baltimore and Ohio Railroad on the north bank of the river.

Lithology

The Maple Summit member consists of grey-green to brown sandstones interbedded with green and some rusty-colored shales. The sandstones are fine to medium-grained, contain abundant mica flakes, and are fairly well sorted. The sandstones are massive (2-3 feet thick) and often cross-bedded although they become thinner bedded (2-3 inches thick) toward the top of some of the beds where they intergrade with an overlying shale. The shales contain small amounts of sand and abundant small mica flakes and are as a rule thin-bedded (2 inches or less in thickness) but certain of the shales such as no. 12 in the Youghiogheny gorge (Laurel Hill) section (See detailed stratigraphic section p. 60) stand out massively on weathering. Some of the sandstones are but lenticular

masses surrounded by shale.

One conglomerate bed, 6 feet thick, (no. 13 in the above mentioned section) consists of round, white-quartz pebbles of about 5 mm. in diameter imbedded in a matrix of grey, fine-grained sandstone. The quartz pebbles are usually oriented parallel with the bedding planes. This conglomerate and the presence of occasional quartz pebbles and clay galls in some of the sandstone members suggest imperfect sorting.

The term clay gall is used in this report for small flat pieces or chips of shale or mud one to two inches in diameter and smaller which are incorporated in the sandstones and conglomerates. The origin of these chips is an interesting problem in itself but cannot be dealt with in detail in this paper. They may represent small pebbles eroded from a shale bed although it seems improbable that such pebbles in this member could withstand the wave and current action to which they probably were subjected. Another hypothesis (Twenhofel, 1926, p. 497) which has been suggested and which might be applicable in this instance is that the clay galls were originally mud curls which were transported to the water from dried mud flats. Subsequent to deposition they became flattened to their present form by the weight of the overlying sediments.

Hantzschel (1939, p. 202) notes the occurrence of mud flakes or pebbles in tidal flat deposits. He says, "... the mud when partially dried may form flakes or pebbles that may be transported by currents and deposited in other places — for instance, in sand areas".^{8/}

8/ For a picture of the mud flakes about which Hantzschel writes see Bucher, W. H., Key to papers published by an institute for the study of modern sediments in shallow seas: Jour. Geol. vol. 46, p. 735, 1938.

The bedding planes of the member are usually conformable but sometimes the sandstones are separated from the shales by irregularities which might represent local breaks in sedimentation or such features as channel fillings or interstratal flowage.

The sandstones of this member weather grey to grey-brown; the shales weather grey to rusty-brown. Due to the discoloration of the outcrops by train smoke, the exact weathering color cannot always be easily determined. As would be expected, the weathered sandstones stand out more prominently than the shales. However, several of the shales even though thin-bedded, stand out quite massively.

Thickness

The total exposed thickness of the Maple Summit member is 386 feet. Since the base does not outcrop, the actual thickness may be much greater. Unfortunately, of the 386 feet exposed there are covered intervals totalling 150 feet scattered throughout the measured thickness. The exact lithologic content of these intervals cannot be determined, but it seems likely that they are shale.

Facieology

Upon comparison of this lithology with similar lithology in north-

western Pennsylvania (see Caster 1934, p. 27) it appears probable that the Maple Summit member is a parvafacies expression of the Big Bend magnafacies ^{9/} within the boundaries of the Conneaut stage of the

9/ See the section of this report entitled "Facies Nomenclature". Also fig. 3. p. 20.

Chautauquan series. This parvafacies has not been named in northwestern Pennsylvania and since the basal part is not exposed in the southwestern Pennsylvania inliers, it does not seem advisable to name it here. However, for purposes of discussion in this paper, it will be called the Maple Summit parvafacies as that is the only stratigraphic unit being delimited in the Conneaut expression of the Big Bend magnafacies in southwestern Pennsylvania. The geographic extent of this parvafacies is unknown. It does not persist as far as 35 miles eastward, for on the Allegheny Front the stratigraphic position occupied by the Maple Summit parvafacies is taken by another and unnamed parvafacies of unknown boundaries within the Catskill magnafacies.

It is interesting to note that the Maple Summit parvafacies is much more coarsely clastic than the parvafacies expression of the Big Bend magnafacies within the boundaries of the overlying Venango stage in the inlier area. This suggests that the Maple Summit parvafacies was deposited much closer to the ancient Upper Devonian shoreline, ^{10/} i. e., was a more shoreward subfacies expression, than the finer-

10/ See Caster, K. E. Marine fauna in the seaward phase of the Catskill magnafacies: Geol. Soc. America, Proc. 1934, p. 363, 1935.

grained overlying Watering Trough parvafacies.

Relation to adjacent members

As has been noted above, the base of the Maple Summit member does not outcrop in the inliers. The contact with the overlying Youghiogheny red member is apparently conformable and sharp. This sharp break corresponds perhaps also in time and nature, to the contact in northwestern Pennsylvania between the Conneaut and the overlying Conewango.

Fauna

The fauna of the Maple Summit member does not present very satisfactory paleontological material because of poor preservation. In all cases the fossils are preserved as casts covered with limonitic stain. No original or replaced shell material was found. In a fauna found 84 feet from the top of the member, the fossils are preserved as casts covered with a very dark brown limonitic stain in a light green-grey sandstone. With the exception of the fossils from this bed, most of the remains are small in size and scarce in number. Inasmuch as these shales and sandstones are possibly near-shore deposits, it seems quite likely that the larger forms, if ever present, were broken up by wave action before they could be preserved. This latter hypothesis is borne out by the fragmentary nature of many of the fossils.

The fauna is composed dominantly of pelecypods with a few gast-

ropods and brachiopods. Only two species of brachiopods, Camarotochia aff. contracta and "Spirifer" disjunctus gens, were collected. These two forms are not diagnostic of the age of the member as they are found widely in the other Devonian members and in the base of the Mississippian beds of the inliers. The best preserved forms occur in the sandstone bed, 84 feet from the top of the member. The fauna consists of the following pelecypods:

palaeonatina solenoides Hall

Pteronites cf. profundus Hall

Oleanella sp.

Schizodus aff. appressus (Conrad)

S. aff. chemungensis (Conrad)

S. aff. chemungensis var. quadrangularis Hall

Sphenotus contractus Hall

Correlation

This assemblage of fossils is a difficult one to correlate with any other known Devonian fauna in Pennsylvania, or elsewhere, as it contains several diverse faunal elements which apparently represent both the Conneaut and Venango stages. On the basis of Chadwick's (1935) study of the literature on Upper Devonian faunas, it would appear that the forms of Schizodus are not particularly diagnostic but that they are more common below the Conewango than in it. Schizodus chemungensis and S. chemungensis var. quadrangularis make their first appearance in the Naples group (Ithaca) and are listed (p. 316, 322) as transient into the Chemung group. Neither are mentioned in the

Conneaut. Schizodus chemungensis var. quadrangularis is listed (p. 331) as making its final appearance in the Conewango. Schizodus chemungensis is given (p. 336) in a mixed Oswayo-Knapp fauna of Butts. Two forms rather similar in appearance to the above mentioned Schizodus forms are Schizodus oblatum and S. rhombeus. The first of these is noted (pp. 328, 331) as last appearing in the Conneaut while the latter form is listed as a transient through the Conneaut, making its last appearance in the Conewango.

Chadwick reports (p. 330) Palaeonatina solenoides as restricted to the Conewango but Pteronites profundus is given (p. 327) as being diagnostic of the Conneaut. Chadwick records (pp. 325, 331) Sphenotus contractus as making its first appearance in the Canadaway and its last appearance in the Conewango. The Oleanella sp. is not well enough preserved to be diagnostic.

The faunal evidence for placing the Maple Summit member in the Conneaut stage is indecisive. However, the fauna is quite different in appearance from the definitely-known Venango fauna above. This fact taken in conjunction with the striking difference in lithology between the Maple Summit member and the overlying Youghiogheny red beds and the Watering Trough shale make it seem advisable, tentatively at least, to place the Maple Summit member in the Conneaut stage.

Historical interpretation

As described elsewhere (p. 88), the Maple Summit parafacies is more coarsely clastic than the overlying Watering Trough parafacies. This would suggest (1) that the land mass to the east and

southeast which furnished sediments to this part of the Penn-York Embayment or "delta geosyncline"^{11/} was beginning to rise quite rapidly

^{11/} Key, G. Marshall, Allegheny synclinorium and Appalachian geosynclines: Geol. Soc. America Bull., vol. 52, p. 1912, 1941.

in Maple Summit time, or (2) that the effects of an earlier rise were just reaching this area in Maple Summit time. The late Devonian orogenic movement apparently was a pulsating one which was stronger at one time than another. During periods of greater uplift of the nearby land mass, large quantities of sand and other clastics were deposited in the embayment making sandstones and conglomerates. The sandy shales of the member seem to represent periods of relative quiescence. Finally, however, the uplift became great enough that continental conditions (now represented by the overlying Youghiogheny red shales and sandstones) encroached on this part of the embayment, moving the shore westward and closing the Conneaut stage of sedimentation.

CONEWANGO SERIES

Name and definition

The name Conewango was first used by Butts (1908, p. 199) in a report of the Pennsylvania Geological Survey for the "western aspect of the Catskill rocks". However, Butts actually proposed the term Conewango formation in 1910 (p. 4) when he defined it as 550 feet of rock between the top of the "Chemung" and the base of the Knapp for-

mation exposed along the banks of Conewango Creek in Warren County, Pennsylvania. He assigned to it a Devono-Mississippian age.

G. H. Chadwick (1924, p. 157; 1933, p. 195) correlated the Conewango with the Riceville shale and the Venango beds extending to the base of the Le Boeuf sandstone, (Panama conglomerate, see p.).

K. E. Caster (1934, p. 76) applied the term Conewango (as a series) to beds extending from the top of the Riceville shale to the base of the Panama conglomerate.

Venango stage

Name and definition

C. A. Ashburner (1880 first used the term Venango oil sand group for the beds between the base of the Riceville shale and the base of the Panama conglomerate. J. F. Carll (1880, pl. 11) used the term Venango when he designated the rocks lying between the base of the Crawford (Meadville) shales and the top of the Warren oil sand group (Conneaut?) as the Venango oil sand group. I. C. White (1881, pp. 99-110) used the term Venango group or Venango oil sand group for those rocks between the base of the Riceville shale and the top of the "Chemung" (Conneaut) beds. G. H. Chadwick (1924, p. 157) defined the Venango group as including all beds between the base of the Riceville shale to the base of the Le Boeuf sandstone. K. E. Caster (1934) included in the Venango stage all beds between the base of the Riceville shale and the base of the Panama conglomerate. This usage is followed in this report.

Youghiogheny Member

Name and definition

The name Youghiogheny member^{12/} is being proposed for the red sand-

^{12/} Termed Sandstone B by the writer in Progress Report 126, Pennsylvania Geological Survey, p. 9, 1941.

stone and shale sequence lying above the Maple Summit member and below and partially equivalent to the Watering Trough shale. The name is taken from the Youghiogheny River along which the member is best exposed in the gorge through Laurel Hill, southeastern Stewart township, Fayette County.

Occurrence

The best section for study of the Youghiogheny member is in the Laurel Hill gorge on the southern bank of the River along the Western Maryland Railroad. These red beds do not crop out at the surface west of the type area except for about 10 feet revealed by a small fault in the Youghiogheny gorge (Chestnut Ridge) section southeast of Connellsville, Pennsylvania. The member is reported by Fettke (1940, p. 3, 4, 9, 10) from several gas wells in northeastern South Union township in Fayette County on the crest of Chestnut Ridge. What probably is a continuation of this member or of similar lithologic conditions is found in the Conemaugh gorge (Laurel Hill) northwest of Johnstown, Pennsyl-

vania. As the Youghiogheny member is a parafacies expression of the Catskill magnafacies within the bounds of the Venango stage, it probably outcrops on the Allegheny Front but its limits there are unknown.

Lithology

The Youghiogheny member consists of a series of red and green sandstones interbedded with red and green shales. The sandstones are fine-to-medium-grained and are fairly well sorted. In common with many, if not most, of the sediments of the inlier region small mica flakes are abundant both in the sandstone and shales.

The sandstones vary in thickness from massive beds (1-2 feet thick) to thin, platy beds (2 inches or less) interbedded with the shales. Many of the sandstones show cross-bedding. The shales are uniformly thin-bedded.

The coloration of the red beds in the Youghiogheny member is an interesting problem. Several possible reasons for the coloration of these beds have been suggested in this report under the heading of Paleogeography. One of the most striking features seen in the type section is the rapid lateral change, within a distance of 3 or 4 feet, from a green sandstone to a red sandstone or vice versa. The reason for this rapid change is not apparent. The phenomenon may represent the original colors of the two types of sediment or may be a secondary feature developed by (1) ancient or modern percolating ground water or (2) surface weathering.

In the first case, the downward-percolating ground water would tend to reduce the red color of the sandstone and in the second case the atmosphere would oxidize a green-colored sandstone to a red sandstone.

Since the red color is not merely a surficial feature as it appears in well cuttings, the writer does not favor the modern weathering hypothesis. Percolating ground water would have to be uniformly thorough in its reducing effect to produce these fairly extensive green sandstones. This, however, is not impossible and may be the solution to the problem. The reducing effect of the ground water and plant fragments is noted in the red beds immediately adjacent to joints and immediately surrounding plant remains. In the case of the joints, the red shales and sandstones are reduced to a green color for an inch more or less on either side of the joint. In the case of plant fragments, they are often in the center of a green halo in a ground mass of red. The size of this reduced halo area apparently depends largely on the size of the plant fragment.

In the type section, the bedding of the member is quite irregular. The sandstone beds are sometimes lenticular and disconformities are abundant as can be seen in figure 6 (p.76)

The sandstones and shales do not change color greatly on weathering, and the resultant red soil is useful in mapping the member where exposures are poor.

Thickness

The Youghiogheny member is 422 feet thick in the type section. Fettke (1941, pp. 3, 4) reports a thickness of 400 feet of red beds in the Leo Heyn No. 1 well on Chestnut Ridge, and (p. 9-10) 348 feet of red beds in the John R. Thompson well about $\frac{1}{2}$ mile northeast of the

Heyn well. On the Allegheny Front 2000 feet of red "Catskill" beds are exposed. It is not known how much of this is equivalent of the Youghiogheny member. Probably, however, the Youghiogheny member thickens in an eastward and southeastward direction as do most of the Upper Devonian members in Pennsylvania.

Structure

In the type section of the Youghiogheny member there occurs a zone of locally severe, eastward thrust-faulting consisting of at least 2 thrust planes which dip approximately 17° and 37° northwestward. Due to the rapid lateral color change from green to red and vice versa in some of the sandstones, it is somewhat difficult to trace a key bed across this zone of faulting. Consequently any stratigraphic sequence given for this section, and any estimate of stratigraphic displacement is apt to prove erroneous. Making as careful measurements and correlations as possible, it was found that there is apparently 35 to 40 feet of stratigraphic displacement in this fault zone which was mapped northeastward from the type section for about 5 miles until cover prevented further tracing.

The discussion of structural problems is not within the scope of this paper. The fact that the thrust planes dip northwestward would seem to indicate either that the overthrusting came from the west and northwest or that there was an underthrust from the southeast. Deeper seated thrusts have been reported from Chestnut Ridge by Fettke, (1940, p. 17).

Sherrill (1934) notes the asymmetry of Chestnut Ridge and Laurel Hill to the southeast and apparently favors the hypothesis that the thrust causing the asymmetry of the folds and also the reverse faulting was an underthrust from the southeast.

Facieology

It is obvious that the greater part if not all the member belongs within the bounds of the Catskill magnafacies. From the evidence, it appears that in southwestern Pennsylvania the Catskill grades westward into the Big Bend magnafacies (see figure 3) with very little of the intervening Smethport magnafacies being present. In northwestern Pennsylvania, the Smethport magnafacies normally intervenes between the Catskill and the Big Bend magnafacies according to Caster, (1934, p.27)

Caster reports (p. 27) that typically the Smethport consists of purple to chocolate-weathering shales and sandstones with some lenses of flat pebble conglomerate, and is ordinarily fossiliferous. The only part of the Youghiogheny member possibly assignable to this magnafacies is the basal 47 feet which carries an abundant pelecypod and cephalopod fauna. Because it is so poorly developed in the inliers, the Smethport has not been differentiated from the Catskill.

From the fauna at the base of the member it appears that the Youghiogheny member is within the stratigraphic limits of the Venango stage. In northwestern Pennsylvania a similar sequence in the same stratigraphic and facieologic setting has been named the Potter parva-facies by Caster (p. 31).

Relations to adjacent members

As has been noted, the contact of the Youghiogheny member with the underlying Maple Summit member is sharply defined. As the Youghiogheny member and the Watering trough shale are both parvafacies within the limits of the Venango stage they are equivalent in time. The facies contact between these two parvafacies is an irregular, interdigitating one. The contact with the overlying Jumonville sandstone was not seen in the inliers.

Fauna

As has been noted in the discussion of the facieology of this member, only the basal 47 feet of the Youghiogheny member contain a marine fauna. The rest of the member is unfossiliferous except for a few poorly preserved plant remains. The fauna of the basal zone consists dominantly of pelecypods as can be seen from the following list:

Lingula sp.

"Elymella"*cf. chadwicki Caster

"Elymella"*sp. no. 1

"Elymella"*sp. no. 2

Leptodesma sp. no. 2

Modiola cf. praecedens Hall

Schizodus aff. patulus (Hall)

Sphenotus aff. clavalus Hall

Sphenotus sp.

Pelecypod indet.

Bradfordoceras sp.

Fish scales

"Worm burrows"

* Undescribed genus.

Correlation

It can be seen by the above list that most of the forms have been identified only comparatively or have been designated as possible new species. This is due largely to the undescribed state of many of these western Pennsylvania Upper Devonian faunas. The preservation of this fauna is none too good and the fossils occur only as molds.

It will be noted that the brachiopods are represented only by one poorly preserved specimen of a non-diagnostic Lingula. From the standpoint of the number of different species, the molluscs are the dominant element, among which the pelecypod "Elymella" and the cephalopod Bradfordoceras are most common. Most abundant are the various species referred with doubt by Caster (1930, p. 88) to the genus Elymella. Elymella ? chadwicki is reported by Caster from the Berea equivalents in northwestern Pennsylvania (Caster, 1934) which Ver Weibe designated (1916, 1917) in part as the "Venango First Oil Sand". Apparently it ranges much lower in the stratigraphic section. The other two species of "Elymella", being undescribed, have less value in regional correlation. Modiola (Mytilops) praecedens is reported by Chadwick (1935, p. 330) as being diagnostic of the Conewango. Butts (1903, p. 993) lists Modiola (Mytilops) praecedens from the Wolf Creek (Panama) conglomerate. Schizodus patulus is cited by Hall (1885, p.

457) from the "Chemung" (possibly true Chemung) group near Tioga, Pennsylvania. Sphenotus clavulus, according to Chadwick (1935, pp. 325, 331) first appears in the Canadaway and last appears in the Conewango. Bradfordaceras⁰ sp. is a very common form in this fauna but is usually poorly preserved. This genus ranges through the Conewango and probably into the Knapp of the northwestern Pennsylvania "oil region", but it is an especially abundant form in the Lewis Run sandstone of Caster (1935, in Flower and Caster; Hanley sandstone of Fettke, 1938, p. 37) which is very close to the base of the Conewango.

The Lewis Run sandstone was examined at the type locality and large collections of the fauna were available at the University of Cincinnati Museum. Direct comparison of the fauna of the basal Youghiogheny with the Lewis Run fauna (See Caster, 1936, abstract) shows very close similarity. As most of the Lewis Run fauna has not been carefully studied or published, no comparisons other than those mentioned can be made here. Thus faunal evidence and stratigraphic position of the Youghiogheny member indicate that it corresponds most closely to the lower part of the Conewango series of northwestern Pennsylvania. It seems probable that it carries equivalents of the Amity shale and the sandstones and conglomerates included therein, of which the Lewis Run sandstone (Hanley sandstone) is one, and the Dutchmans conglomerate is another. (See p.21 for stratigraphic section of northwestern Pennsylvania). It also probably carries time equivalent of the persistent basal sandstone or conglomerate of the Conewango, (the Panama - Wolf Creek - Venango third oil sand).

Historical Interpretation

As has been mentioned on p. 92 in the discussion of the Maple Summit member, the sedimentation in this part of the Penn-York Embayment appears to have accelerated toward the end of Maple Summit time. At the beginning of Youghiogheny-Watering Trough time, the Laurel Hill area apparently was very near the shoreline for here the fossils are incorporated in a red sandstone (assuming, of course, that the main focus of red deposition was in the coastal plain). After the basal 47 feet of fossiliferous sandstone was deposited, the shoreline moved westward bringing continental barren (red bed) conditions into this area. The cross-bedding, numerous disconformities and macerated plant remains found in the upper part of the Youghiogheny member would seem to indicate that this part was deposited under non-marine conditions. However, toward the end of Youghiogheny-Watering Trough time, rapid red-bed sedimentation slowed down and the Upper Devonian shoreline began to recede eastward. (See figure 3).

Watering Trough shale

Name and definition

The name Watering Trough shale ^{13/} is being proposed for the shale

^{13/} Termed Shale C by the author in Progress Rept. 126, Pennsylvania Geol. Survey, p. 11, 1941.

and sandstone sequence which is the more seaward equivalent of the

Youghiogheny red beds. The base of the Watering Trough shale (equivalent to the fossil zone of the Youghiogheny) is not well exposed in any of the sections but apparently the red beds replace the shale very rapidly in an eastward and southeastward direction. The Watering Trough beds are overlain by the Jumonville sandstone of the Riceville stage. The shale takes its name from the Watering Trough Inn and spring located on Route 40 on the west side of Chestnut Ridge in the southeastern corner of North Union township, about 2 miles east of Hopwood. The shale is well revealed at the type locality above and below the Watering Trough Inn.

Occurrence

The Watering Trough shale also outcrops, although not as well as at the type locality, in the Youghiogheny gorge (Laurel Hill) in southeastern Stewart township, Fayette County, on both sides of the river, particularly on Lick Run and Rock Springs Run.

In the Youghiogheny gorge (Chestnut Ridge) in northern Dunbar township, Fayette County, the Watering Trough shales are poorly exhibited on both banks of the river.

In the Conemaugh gorge (Laurel Hill) marine Upper Devonian beds are found on the northeast bank of the river along the Pennsylvania Railroad, in the southeastern corner of East Wheatfield township, Indiana County, but it is questionable if they are the exact equivalent of the Watering Trough shale.

In the Conemaugh gorge (Chestnut Ridge) in the southeastern part

of Burrell township, Indiana County, marine Upper Devonian beds are also exposed, but, here too, the exact equivalents of the Watering Trough beds are not known. The best outcrops in this locality are along the Pennsylvania Railroad on the south bank of the Conemaugh river.

Lithology

The Watering Trough shales consist predominantly of grey to blue, thin-bedded shale interbedded with grey-blue limy sandstone and quartz pebble and clay-gall conglomerates. The shales are primarily grey in color but near the base of the type exposure, the grey gives way to a dark blue or black color. The shales contain considerable quantities of mica.

The interbedded sandstones are blue-grey in color and contain small amounts of lime. The conglomerates are the only beds which show poor sorting. In these beds white quartz pebbles (5mm. more or less in diameter) and clay galls (10 mm. more or less in long diameter) are imbedded in a matrix of medium-grained sandstone.

The shale is thin-bedded and the bedding planes are regular except where the lenticular masses of sandstone and conglomerate occur. The lenticular sandstones and conglomerates average from 6 to 12 inches in the thickest part, thinning out to zero. The basal surfaces of some of these sandstone and conglomerate lenses are irregular, suggesting perhaps interstratal flowage between the sandstone and the underlying shale.

The shales apparently do not change color greatly on weathering. In the road cuts in the type locality where constantly renewed by road work, the shale stands in rather steep cliffs, weathering back a little below each conglomeritic or sandstone bed. In other places, as in the Youghiogheny gorge (Chestnut Ridge), the shale intervals are never exposed. The sandstones and conglomerates weather to a dark brown from a light grey to blue color.

Thickness

In the type locality the Watering Trough shale measures 181 feet. The base cannot be seen. About 1 mile farther west on Route 40, part of the same sequence is revealed but is badly disturbed by local faulting. Here it measures 137 feet in thickness.

In the Youghiogheny gorge (Chestnut Ridge) the Watering Trough beds are apparently much thicker. Here the interval measures 406 feet, but inasmuch as the greater part of the outcrop was covered there is reasonable doubt if this is the correct thickness.

In the Youghiogheny gorge (Laurel Hill) the outcrops of the Watering Trough are not good enough to give a thickness for the Watering Trough alone. However, the Watering Trough and the overlying Jumonville total only 272 feet, of which approximately one half appears to be Jumonville. Apparently the replacement of the Watering Trough by the Youghiogheny takes place quite rapidly between Chestnut Ridge and Laurel Hill.

Facieology

The Watering Trough shale appears, on the basis of lithology, to

be primarily within the facies limits of the Big Bend magnafacies of northwestern Pennsylvania. (See figure 3, p. 20). Since the fossils indicate that the Watering Trough is within the stratigraphic bounds of the Venango stage, it seems likely that this shale is equivalent to the Allegheny Park parvafacies of Caster (1934, pp. 24-28) in northwestern Pennsylvania. As has been noted in the discussion of the Youghiogheny above, the Watering Trough shale is equivalent to the red Youghiogheny member (Catskill magnafacies) to the east.

Near the base of the type exposure of the Watering Trough shale are about 20 feet of blue-black shale which suggest the lithology of the Cleveland magnafacies. This magnafacies has its typical development west of the Chagrin magnafacies, which intervenes in northeastern Ohio and adjacent New York and Pennsylvania between the Cleveland and the Big Bend magnafacies. Apparently here Cleveland conditions were either locally developed somewhat east of the main Cleveland environment during Venango time or we have a record of a brief eastward invasion of the Cleveland environment beyond its average environs during the Upper Devonian. This is the explanation given by Caster^{14/} for the black shale beds and lenses in the Chagrin magnafacies in north-

^{14/} Personal communication.

western Pennsylvania and this same explanation appears to be applicable to southwestern Pennsylvania. Apparently the Chagrin magnafacies is not well enough developed to be recognized in the exposed sections in

southwestern Pennsylvania, and, as a matter of fact, this facies belt would lie to the west of the inliers for that portion of Devonian time revealed in the inlier pictures -- providing the magnafacies belts were of approximately the same breadth in southwestern Pennsylvania as reported in northwestern Pennsylvania.

Relations to adjacent members

It has been noted that the Watering Trough shale is equivalent to the Youghiogheny parafacies. The Youghiogheny replaces the Watering Trough shale quite rapidly to the southeast and east and therefore the contact between the two is one of interdigitating beds of red and green color. The contact of the Watering Trough with the overlying Jumonville sandstone is a sharp, apparently conformable contact.

Fauna

Fossils are present in the Watering Trough shale, but are very difficult to collect. Due to the fissility of the shale, the fossils break apart readily. The only readily identifiable forms are found in the sandstone and conglomerate lenses and these, too, offer collection difficulties unless the sandstone and conglomerate are weathered.

The fauna of the Watering Trough follows:

"Camarotoechia (?) sappho Hall"

"Spirifer" disjunctus Sowerby

"S." disjunctus var. warrensis Caster (m.s.)

Leptodesma c.f. potens Hall

Neocycloceras obliquum Flower and Caster

Pteropod

Correlation

The scarcity of this fauna makes correlation of the Watering Trough member on faunal evidence alone somewhat difficult. "Camarotoechia^{15/} sappho" is listed questionably by Chadwick (1935, p. 331) as last ap-

15/ Chadwick says in a footnote (p. 331): "Neither Caster nor the writer is convinced that C. sappho of the Hamilton occurs here".

pearing in the Conewango. The "Spirifer" disjunctus gens particularly "S." disjunctus var. warrensis is very abundant in the upper part of the Conewango^{16/} in northwestern Pennsylvania. Leptodesma potens is

16/ K. E. Caster, collections, University of Cincinnati.

listed by Chadwick (p. 327) as last appearing in the Conneaut. However, the nature of these Leptodema makes them almost indeterminate and therefore no great store should be placed on either the present or previous reports of this species. Neocycloceras obliquum is reported thus far only from the Lewis Run sandstone of the lower Conewango.

Although the faunal evidence here presented leaves much to be desired, it seems certain that this is a Conewango fauna. Since the lower part of the Watering Trough interfingers with the Youghiogheny member, which carries a fairly definite lower Conewango fauna in its lower portion, (which in time is therefore other than the lower exposures of the type Watering Trough) it appears that the exposed

Watering Trough of Fayette County is probably equivalent to the upper part of the Conewango in northwestern Pennsylvania. In northwestern Pennsylvania a number of members have been delimited in the Venango, but such detailed differentiation has not seemed warranted in southwestern Pennsylvania.

Historical Interpretation

It has been noted previously that the Watering Trough member is within the bounds of the Big Bend magnafacies. However, it appears to be a finer-grained subfacies expression than the Maple Summit parafacies in the same facies belt. This might mean that the Watering Trough shale was deposited farther off shore where finer clastics were accumulating at a slower rate or this shale might represent a near shore tidal flat deposit similar to those reported by Häntzschel (1939, p. 195-205) off the coast of northwest Germany at Wilhelmshaven.

The presence of the lenticular masses of sandstone and conglomerate in the shale suggests channel fillings. Perhaps these coarser sandstones and conglomerates were deposited in channels in an area with large tidal range where considerable quantities of clastic material were being introduced to the zone of deposition. The coarser material was concentrated where the currents were swifter, as in the channels, while the finer material was washed away and deposited elsewhere. This combination of factors, large tidal interval and coarse and fine materials would give rise, according to Bucher,^{17/} to a com-

^{17/} Litt., December 19, 1942

plicated set of bars and barriers with shifting inlets.

The replacement of the Youghiogheny member eastward (see figure 3.) by the Watering Trough shale would indicate that toward the end of the Watering Trough time there was an eastward progression of the strand line. This is a reversal of the dominant westward trend of shoreline movement in Upper Devonian time. This trend appears to have continued on into Jumonville time.

Riceville stage (?)

Name and definition

The beds (in part) comprising the Riceville stage were first designated by I. C. White (1881, pp. 97-98) as the Riceville shales. He states these shales contain "Chemung" fossils, underlie the Cussewago sandstone (Knapp beds) and overlie the Venango oil sand group. The shale is well exposed on bluff on Oil Creek just west of Riceville, Crawford County, Pennsylvania.

Ver Wiebe (1917, p. 40) says that White considered this interval of shales as lying between the first sand of the Venango group and the overlying Corry (Berea) sandstone. Ver Wiebe says this shale should be considered an integral part of the underlying oil sand group. However, his correlations for the whole Upper Devonian and Lower Mississippian are very confusing (See Caster, 1934). He regards (1916, p. 55) the Knapp formation as the northern representative of the Cussewago series and as underlying the Riceville shale. The whole sequence he regards as Bradfordian in age. The Bradfordian is, according to

Ver Wiebe (1917, p. 43) the western equivalent of the upper part of the Catskill and is "Upper Chemung" in age.

Chadwick (1923, pp. 68-69; 1924, pp. 155, 157; 1925, p. 464) correlated the Riceville shale with the Oswayo formation, called the underlying beds Venango group and the overlying beds the Cussewago sandstone. He treated both the Riceville and the Venango as basal Bradfordian.

Caster (1933, pp. 202-203) restricted the term Riceville formation to the lower part of the Riceville formation of previous reports. The new Riceville was correlated with all of the Oswayo formation. The member was underlain by the members of the Venango group and overlain by the Smethport shale member of the Knapp formation. The Smethport shale was the Mississippian part of the former Riceville formation.

In 1933, Chadwick (pp. 195, 197, 281) agreed to Caster's restricted Riceville and included the same in the top of the Conewango.

The term Riceville stage was used by Caster (1934, p. 96-102) for the restricted Riceville shales of I. C. White. He divided the stage into the Oswayo shale member and the Roystone coquinite zone. The Mississippian portion of the old Riceville formation he renamed Kushequa shale (formerly the Smethport shale, see above). He excluded the Riceville from the Venango and erected it as a separate stage. This stage marked the end of the Devonian in Pennsylvania.

Chadwick (1935, p. 329-338) included the Riceville in the upper member of the Conewango series. The Conewango series and the overlying Cussewago beds, "including also the false 'Berea' of Pennsylvania", (p. 338) he classified with some question as belonging to the Bradford-

ian and as such constituting the closing epoch of the Upper Devonian.

The Bradfordian was originally proposed by Girty (1904, p. 24-25) for a Devonian-Mississippian transition series which included the Cattaraugus and Oswayo of the Conewango series and the Knapp beds of the overlying Mississippian. It was also subsequently suggested in Bailey Willis' index (1912, p. 421) that it is all Devonian. Certain geologists^{18/}

^{18/} S. G. Hartnagle, C. A., Classification of the geologic formations of the State of New York: New York State Mus. Handbook 19, 1912, and, Goldring, W., Handbook of paleontology for beginners and amateurs, Part 2: The Formations: New York State Handbook 10, 1931.

still regard the Bradfordian as entirely Mississippian. An excellent summary of the status of the Bradfordian up to 1934 is given by Caster (1934, p. 42-45). In this publication, Caster discarded the term "Bradfordian". The lower part, the Conewango series, is placed in the Upper Devonian and the upper part, the Cussewago stage of the Oil Lake series, is placed in the Lower Mississippian. In a subsequent discussion, Caster (1935, pp. 912-915) restated his views as to the dual nature of the "Bradfordian" whereas Chadwick in this discussion expressed the belief (p. 915) that the Cussewago beds should be classified as "Bradfordian" and Devonian in age.

Jumonville sandstone

Name and definition

^{19/}
The name Jumonville sandstone is being proposed for the sandstone

19/ Termed Sandstone D by the author in Progress Rept. 126, Pennsylvania Geol. Survey, p. 11-12, 1941.

sequence overlying the Watering Trough shale and underlying the Mississippian Linderman sandstone. It takes its name, for lack of a nearer suitable geographic name, from a small settlement 2 miles north of the type locality which is on Chestnut Ridge along the National Pike (Route 40) in the southeastern part of North Union township in Fayette County, Pennsylvania.

Occurrence

The Jumonville sandstone is exposed at the type locality in cuts along the north side of the road, particularly in the vicinity of Watering Trough Inn. It also outcrops about $1\frac{1}{2}$ miles west of Watering Trough Inn along the National Pike at Milepost 59, but the strata there are disturbed somewhat by faulting.

In the Youghiogheny gorge (Chestnut Ridge), the Jumonville sandstone is well exposed along the Western Maryland Railroad on the south bank of the river along the northern boundary of Dunbar Township, Fayette County, Pennsylvania, opposite the mouth of Indian Creek.

In the Youghiogheny gorge (Laurel Hill), the Jumonville is exposed poorly. It is found primarily in southeastern Stewart township, Fayette County, Pennsylvania, along the south bank of the river northwest of Long Run and in the valley of Rock Springs Run entering the Youghiogheny River from the north opposite Long Run.

What appears to be the equivalent of the Jumonville sandstone has been found in both of the Conemaugh gorges, but due to lack of adequate outcrop and well-preserved fossils, it is not known how much of the exposed marine Upper Devonian above the red Upper Devonian is Jumonville.

Lithology

The Jumonville sandstone consists primarily of brown-grey and blue-grey sandstone interbedded with some brown and grey shales and some few clay-gall and quartz-pebble conglomerates. The sandstone is fine-to-medium-grained and has a fair degree of sorting. The shales contain considerable mica as do most of the members.

The conglomerates consist of white quartz pebbles (5 mm. in diameter and less) imbedded in a matrix of grey to brown fine-to-medium-grained sandstone. The clay-gall conglomerates are very similar to conglomerates found in the Maple Summit member. The galls are from less than 1 inch to 2 inches in diameter and are sometimes imbedded with the quartz pebbles in a brown sandstone matrix.

While most of the shales are thin-bedded, the sandstone and conglomerate beds may be a foot or more in thickness but average from 3 to 4 inches. The bedding surfaces of the sandstones and conglomerates are irregular and some of the beds are lenticular.

On weathering, the Jumonville sandstone changes from a brown-grey and blue-grey to a rusty brown color. As the underlying Watering Trough shales do not so readily change color on weathering, there is a notable color change at the contact.

Thickness

The Jumonville sandstone at its type locality measures 135 feet in thickness but its upper 114 feet are covered. This would seem to afford insufficient evidence on which to erect a member but in naming the member two other exposures showing the same stratigraphic interval were considered. One of these was the exposure in the Youghiogheny gorge (Chestnut Ridge) about 10 miles to the northeast of the type locality, which shows a complete section of the sandstone (135 feet) but is only sparsely fossiliferous. The other outcrop is located about $1\frac{1}{2}$ miles west of the type locality along the National Road where the Jumonville measures 185 feet in thickness. At this latter locality, however, there is a considerable amount of locally-severe thrust faulting which possibly makes the thickness given too large. The locality chosen for a type was the one which contained the largest amount of the fossils which are characteristic of the member. In reality all three of the exposures mentioned were considered in the delineation of the Jumonville sandstone. As has been mentioned before (p.113) the exact thickness of the Jumonville on the Youghiogheny gorge (Laurel Hill) is not known due to poor exposures. The interval of the Jumonville and Watering Trough totals 272 feet, probably one half of which is Jumonville.

Non-red beds above the Devonian red beds are also exposed in the Conemaugh gorges through Laurel Hill and Chestnut Ridge, but the thickness there is 215-236 feet. Either the sandstone thickens in a northeasterly direction or part of the underlying Watering Trough shale has been included in the measurement. As the exposures are none too good and as the fossils are not well preserved this latter possibility

should be seriously considered.

Facieology

The Jumonville sandstone is the terminal parvafacies development of the Big Bend magnafacies of the Upper Devonian of southwestern Pennsylvania. Although faunal evidence suggests that this sandstone is a correlative of the Oswayo of northwestern Pennsylvania, it is evident from a comparison of the Jumonville sandstone with the Oswayo that they were deposited under somewhat different environmental conditions. The Oswayo suggests according to Caster (1934, p. 96-97) "quiescent, near-shore conditions, if not brackish, marine-deltaic". The Jumonville shows more complete sorting, has no well-defined coquinite beds and contains less carbonaceous material than the Oswayo. This suggests a more seaward environment than that shown by the Oswayo. Thus it seems probable that some of the faunal differences between the Jumonville and Oswayo could be explained on an ecologic basis.

Relations to adjacent members

The contact of the Jumonville sandstone with the underlying Watering Trough shale has been described as being sharp but apparently conformable. The contact of the overlying Linderman sandstone is usually a disconformity but is an angular unconformity in the Youghiogheny gorge (Laurel Hill) one quarter mile west of Victoria.

Fauna

The Jumonville sandstone is richly fossiliferous and since the preservation of the fossils is much better than in the underlying Watering Trough shale, most of the Devonian fossils reported from the inliers

have come from it. As can be seen from the following list, the Jumonville fauna is dominantly one of brachiopods and pelecypods.

- † Athyris cf. angelica Hall
- * Camarotoechia aff. Allegania Williams
- *** C. contracta Hall
- † C. aff. contracta Hall
- † C. (?) sappho Hall
- * C. aff. sappho Hall
- * Chonetes sp.
- * Crania (?) sp.
- ** Lingula sp.
- *** Oehlertella (?) cf. pleurites Meek
- *** Orbiculoidea aff. randalli Hall
- * O. sp.
- *** Productella cf. hirsuta Hall
- * Schuchutella chemungensis (Conrad)
- † "Spirifer" disjunctus Sowerby
- ** "Spirifer" disjunctus var. warrensis Caster ms.
- * Strophalosia muricata (Hall)
- * Aviculopecten aff. duplicatus Hall
- * A. patulus Hall
- * A. striatus Hall
- * A. sp. (large and smooth)
- * A. sp.
- † Edmondia cf. subovata Hall

- * Goniophora cf. chemungensis Vanuxim
- * Grammysia communis Hall
- * G. aff. duplicata Hall
- * G. cf. subarcuata Hall
- * G. cf. undata Hall
- * G. (?) sp. (long form)
- * Leptodesma aff. dispanle Hall
- * L. maclurii Hall
- * L. cf. mortoni Hall
- ** L. orodes Hall
- ** L. potens Hall
- ** L. cf. sociale Hall
- * L. cf. stephani Hall
- * L. sp. 3
- * L. sp. (immature)
- *** Palaeoneilo cf. brevis Hall
- * P. elongata Hall
- * P. sp. (Dev.)
- * Pararca neglecta Hall
- * P. sao Hall
- * P. transversa Hall
- *** Paracyclas (?) sp.
- * Prorhynchus quadratum Hall
- * Ptychopteria cf. beecheri Hall
- * P. cf. eucrate Hall
- * P. cf. sao Hall

- * Sanguinolites undulatus Hall
- ** Schizodus aff. chemungensis var. quadrangularis Hall
- *** S. cf. contractus Hall
- * Sphenotus clavulus Hall
- ** S. aff. clavulus Hall
- ** S. contractus Hall
- *** S. aff. contractus Hall
- * S. palmerae Caster
- * S. sp. (new genus?)
- ** Pelecypod indet. (no. 1)
- * Pelecypod indet. (large)
- * Pectenoid pelecypod
- ** Bellerophon sp.
- † Pleurotomaria sp. no. 1 (small)
- * P. sp. no. 2 (large)
- † Neocycloceras obliquum Flower and Caster
- *** Cephalopod (Nautiloid?)
- * Echinocaris socialis Beecher
- * Bryozoa, Trepostomata
- *** Bryozoa, frondose
- * Bryozoa, encrusting
- † Bryozoa, ramose
- ** Fish scales
- *** Crinoid stems
- ** "Worm" burrows

-
- * Found in Jumonville only.
 - ** Found also below Jumonville, but not above.
 - *** Found also above Jumonville, but not below.
 - † Found above and below Jumonville.
-

As can be seen from this list, 43 of these fossils were found only in the Jumonville. Twelve forms were found in the Jumonville and below. Eleven forms were found in the Jumonville and beds above the Jumonville, and eight fossils were found both above and below the Jumonville sandstone. The list shows that many of the fossils were identified only comparatively; others were not specifically identified. No more positive identification could be made of many of the forms for two reasons: (1) the fauna has not been adequately studied in western Pennsylvania and many of the forms are undescribed; or (2) the fossils are too poorly preserved in many cases to make accurate identification.

Correlation

A comparison of this fauna with the fossils listed by Chadwick (1935, pp. 329-333) as being diagnostic of the Conewango shows unmistakably the Conewango affinities of the Jumonville sandstone. Typical upper Conewango forms found in this fauna are Pararca neglecta, Pararca sao, Pararca transversa, Prorhynchus quadratum, Ptychopteria cf. beecheri, Ptychopteria cf. eucrate, Ptychopteria cf. sao, Sphenotus palmerae, "Spirifer" disjunctus var. warrensis, and Camarotoechia cf. allegania.

As the regional correlation of this member depends almost entirely on the fossils, the fauna of the Jumonville sandstone has been compared with the faunal list prepared by Caster (1934, pp. 70-75) for the Oswayo of northwestern Pennsylvania. He lists numerous forms apparently characteristic of the Oswayo but so many of them are new and as yet undescribed species that it is impossible to cite them for correlation. However, it was found that there are three forms confined to the Jumonville and the Oswayo: Camarotoechia allegania, Leptodesma disparile, and Pararca neglecta. Therefore, until more detailed faunal study is made of this and other Upper Devonian faunas in western Pennsylvania, the Jumonville sandstone is being tentatively correlated with the Oswayo shale of the Riceville stage of northwestern Pennsylvania. If the Jumonville sandstone is the equivalent of the Oswayo shale then it may also possibly be the equivalent of the heavy green sandstone beds at the top of the "Catskill" red beds on the Allegheny Front. These green sandstones have, according to Willard, (1939, pp. 301-302) an Elk Mountain lithology (northeastern Pennsylvania) and are possible correlates of the Oswayo of northwestern Pennsylvania.

Historical Interpretation

As has been noted in the discussion of the facieology, the Jumonville sandstone because of its better sorting and lack of abundant carbonaceous material, seems to represent a more seaward type of deposit than the Oswayo of northwestern Pennsylvania. This sandstone appears to extend farther east than the underlying Watering Trough shale. If the Jumonville is a correlative of the Oswayo these beds

grade eastward into the heavy massive green sandstones of "Elk Mountain" lithology, which are apparently non-marine. These sandstones are present on the Allegheny Front immediately below the overlying "Pocono" sandstone of Mississippian age and lie above the Devonian red beds. This fact plus the fact that the Watering Trough shale is replaced rapidly eastward by the red Catskill magnafacies suggests strongly the eastward migration of the Upper Devonian shoreline just before the end of Upper Devonian time. This eastward progression of the magnafacies belts has already been suggested by Caster (1934, pp. 30,151).

If the shoreline was migrating eastward as has been noted, it suggests that the Upper Devonian Acadian or Shickshockian orogeny which has been furnishing abundant sediments to this portion of the Penn-York Embayment was dying out as far as this area is concerned. Initial Mississippian sedimentation in central Pennsylvania indicates that eastern land masses remained at low relief at least until the beginning of the new period.

MISSISSIPPIAN SYSTEM

OIL LAKE SERIES

Name and definition

The term Oil Lake group was used by J. P. Lesley (White, 1881, p. ix.) for approximately the sequence herein included in the Oil Lake Series. His name was a substitution for I. C. White's (1881, p. ix) more cumbersome Oil Creek Lake group. In his report White was not consistent in his usage of the term, particularly in regard to the beds

included in the basal part of the sequence. In one place he gives (p. 67) a thickness of 162 feet for the Oil Lake group. This obviously included the Riceville shale (see figure 7, p. 66 of his report). He discusses (pp. 97-98) the Riceville shale in the same report, placing the discussion in a separate chapter between the chapters on the Venango Oil sand group of the Devonian and the Oil Lake group. In this new chapter he notes the "Chemung" characteristics of the Riceville fossils. On page 70 of this same report White puts the Riceville with the Venango; on page 71 he includes it with the Cussewago of the Oil Lake group. On page 91 he gives a thickness of 130' for the group on Oil Creek Lake (apparently the type locality) which would appear to leave out the Riceville.

White divides the Oil Lake group into the following members:

Corry sandstone	20'
Cussewago Upper shales	5'
Cussewago limestone	2'
Cussewago middle shales	
and flags	30'
Cussewago sandstone	25'

The Oil Lake group underlies the Orangeville shales and apparently overlies the Riceville shale.

Caster (1934, p. 46) follows the usage of White but more definitely delimits the boundaries of the series. He includes in the Oil Lake series the Berea (Corry) and the Cussewago stages. The Oil Lake series of Caster is underlain by the Riceville shales of the Conewango

series of the Devonian and is overlain by the Orangeville shale of the Meadville stage of the Kinderhook series of the Mississippian.

Cussewago stage

Name and definition

The term Cussewago stage was first proposed by Caster (p. 52) for all of the Oil Lake strata below the Corry (Berea) sandstone in western Pennsylvania. The term Cussewago was used long before, however, by White (1881, pp. 66, 70, 94, 95) for essentially the same strata except he named the members below the Corry sandstone in descending order as follows: Cussewago limestone, Cussewago shales, Cussewago sandstone. In one place he brackets (p. 70) these members together as if he considered them one formation. Because of the close relationship of all the members of the Cussewago stage in southwestern Pennsylvania, their correlation with other areas, their faciology and historical interpretation will be considered in a special section following the discussion of the individual members.

Linderman sandstone

Name and definition

The name Linderman sandstone ^{20/} is being proposed for the basal mem-

^{20/} Termed Sandstone E by the writer in Progress Rept. 126, Pennsylvania Geol. Survey, p. 12, 1941.

ber of the Cussewago stage in the inliers. This sandstone overlies the Jumonville sandstone and underlies the Pine Knob shale. For lack of a

nearby suitable geographic name, the sandstone is named for the Linderman farm, near which it is typically exposed, located about 1 mile northeast of Victoria in southeastern Stewart township in Fayette County, Pennsylvania.

Occurrence

The Linderman sandstone occurs typically along Rock Springs Run in the Youghiogheny gorge in southeastern Stewart township in Fayette County, Pennsylvania. It is found in place along the road from Rock Springs Run to Victoria and along the road from Rock Springs school to the Linderman farm, but in these outcrops the fossils are not abundant. In the field northeast of Linderman's farmhouse abundant fossils from this member occur in loose blocks in the field but no outcrop is found there.

The Linderman sandstone is also found outcropping in the Youghiogheny gorge (Chestnut Ridge) along the southeast bank of the river along the western Maryland Railroad track about 2-3/4 miles southeast of Connellsville, Pennsylvania. Here the fossils are abundant both in number and species.

Lithology

The Linderman sandstone is a fine-to-medium-grained, grey-brown sandstone cemented with calcite. It is well sorted for the most part. Some of the sandstone beds composing this member are massive (up to $1\frac{1}{2}$ feet in thickness) but part of the member is thin-bedded (2 inches or less in thickness). The bedding surfaces are irregular but beds are apparently not strikingly lenticular. The Linderman sandstone weathers readily due to the lime cement so that the member usually appears on

outcrop as a limonitic, loosely-cemented, friable sandstone.

Thickness

The Linderman sandstone is a very thin member, having a thickness of $2\frac{1}{2}$ to 5 feet wherever exposed.

Relation to adjacent members

The contact of the Linderman sandstone with the Jumonville sandstone has been described as a disconformity in most places. One quarter mile west of Victoria in Youghiogheny gorge (Laurel Hill) there is an angular unconformity at what appears to be the contact between the two members. However, as the fossils are so poorly preserved here, it is difficult to determine exactly where the contact is. The contact with the overlying Pine Knob is apparently conformable wherever observed.

Fauna

The fauna of the Linderman sandstone is a dominantly one of brachiopods and pelecypods. The fauna is particularly characterized by large numbers, both of individuals and varieties, of the aviculoid pelecypod, Leptodesma mentor.

The Linderman fauna follows:

- + Athyris cf. angelica Hall
- * A. angelica var. nov.
- + Camarotoechia contracta Hall
- * C. cf. contracta Hall
- + C. aff. contracta Hall
- ** C. (?) sappho Hall
- *** Chonetes sp. no. 2

- *** Eumetria scansa (Hall)
- * Lingula randalli Girty
- † Oehlertella (?) cf. pleurites Meek
- *** O. sp.
- † Orbiculoidea aff. randalli Hall
- * Orthotetes sp.
- *** Productella cf. speciosa Hall
- * P. sp.
- *** Schellwienella sp.
- * Schuchertella (?) sp.
- ** "Soirifer" disjunctus Sowerby
- *** Syringothyris cf. angulata Simpson
- * Goniophora cf. alata Hall
- * G. aff. chemungensis Vanuxem
- * G. aff. glaucus Hall
- * G. sp.
- *** Grammysia cf. hannabalensis (Shumard)
- *** Leptodesma mentor var. alpha Caster ^{1/}
- *** L. mentor var. maxima Caster
- *** L. mentor var. orodes Hall
- *** L. mentor var. sulcata Caster
- *** Leptodesma aff. sociale Hall
- * L. sp. no. 4
- * Modiola (Mytilops) praecedens Hall

- *** Mytilarca cf. simplex Hall
- † Palaeoneilo cf. brevis Hall
- *** P. aff. maxima (Conrad)
- *** P. sp. no. 1
- *** P. sp. no. 2
- * P. sp. no. 3
- * P. sp. no. 4
- * P. sp. no. 5
- † Paracyclas (?) sp.
- ** Schizodus aff. appressus (Conrad)
- ** S. aff. contractus Hall
- * Palaeosolen sp.
- ** Sphenotus cf. contractus Hall
- * Pelecypod indet no. 2
- *** Pelecypod indet no. 3
- ** Bellerophon sp.
- * Loxenema sp.
- ** Pleurotomaria sp. 1 (small)
- † Pteropod (?)
- ** Bradfordoceras sp.
- † Neocycloceras obliquum Flower and Caster
- * N. (?) sp.
- † Bryozoa (frondose)
- * Rhopalonaria sp.^{2/}
- * Ctenodus nelsoni New.

*** Dictyosponge

** "Protolimulus" trail

+ Plants

-
- * Found in Linderman sandstone only.
 - ** Found also below Linderman sandstone, but not above.
 - *** Found also above Linderman sandstone, but not below.
 - + Found above and below Linderman.
 - 1/ Similar to form shown by Caster as var. orodes but apparently not Hall's orodes.
 - 2/ Specimen identified by Miss Helen Duncan, graduate student in paleontology, at the University of Cincinnati.
-

This list shows that 21 of these fossils are found only in the Linderman. There were 9 forms that were found in the Linderman sandstone and below. Eighteen fossils were found in the Linderman and overlying members and 11 forms were found both above and below the Linderman. It is necessary to mention again that the unstudied nature of these faunas and their almost uniformly poor preservation make specific identification very difficult.

Hopwood member

Name and definition

21/
The name Hopwood member is being proposed for an unusual con-

21/ Termed Conglomerate F by the writer in Progress Rept. 126, Pennsylvania Geol. Survey, p. 5, 14, 1941.

glomerate and sandstone sequence which apparently overlies the Jumonville sandstone and underlies the Pine Knob member. It occupies the stratigraphic position of the Linderman sandstone elsewhere. The Linderman sandstone appears to be equivalent to all or at least part of the Hopwood. The member, for lack of a nearer suitable unoccupied geographic name, takes its name from the town of Hopwood about 2 miles west of the type locality, which is at the scenic lookout below the Summit Hotel near the crest of Chestnut Ridge along Route 40 in the southeastern corner of North Union township, Fayette County, Pennsylvania.

Occurrence

This member is found outcropping at the type locality and also about $1\frac{1}{2}$ miles west on the west limb of the Chestnut Ridge anticline. However, in the latter locality the conglomerate is so badly shattered by a local thrust fault that exact delimitation of the member has proved impossible. The lithology of the member is also reported by Fettke (1940, p. 3) in the Leo Heyn No. 1 well cuttings.

It should be noted here that the thicknesses given by Fettke for this member and for other members lower in the geologic column do not agree exactly in thickness with the measured outcrop sections. This discrepancy is probably due in some degree to structural disturbances

in this area.

Lithology

The Hopwood member consists of two lithologies, a lower sandstone and an upper lenticular conglomerate. The sandstones are brownish-grey in color, micaceous and fine-to-medium-grained with a fair degree of sorting. The sorting is not everywhere perfect for there are local lenses of white quartz pebble conglomerate (5 mm. $\pm$ in diameter) present toward the base of the member. Grey clay galls (1 inch $\pm$ in diameter) are rather indiscriminately distributed throughout the whole member. The sandstone is most massive in the middle; about 4-5 feet with no trace of bedding surfaces have been observed. Above and below this massive layer are thinner, cross-bedded sandstones (1 foot or less in thickness). The cross-bedding in these members has an amplitude of 1 foot or less and the foresets average about 2 feet in length.

Overlying the sandstone on the eastern end of the outcrop is a grey, thin-bedded shale. This shale disconformably overlies the sandstones described above and unconformably underlies the conglomerate described below. The shale wedges out to the west beneath the conglomerate.

The most unusual part of the Hopwood member is the conglomerate which forms the upper part. This is blue-grey to brown in color and consists of white quartz pebbles 5 to 10 mm. in diameter (more often flat than round) imbedded in a matrix of medium-grained sandstone. The pebbles become smaller toward the top of the conglomerate where

they are about 3-5 mm. in diameter. Occasional jasper pebbles (20-50 mm. in diameter) were also noted. Apparently the sorting in this conglomerate was not complete.

The basal portion of the conglomerate has the appearance of being comprised of large elliptical or rounded boulders as much as 6 feet in diameter. (See figure 11). Where these "boulders" rest on the underlying shale, the latter has been forced upward into the crevices between them. The shale now breaks along thinly spaced joints which are roughly concentric to the outline of the boulder. These concentric shells are not parallel to the bedding of the shale but cut across the bedding at an angle, causing the shale immediately adjacent to the boulder to break in pencil-like forms.

Figure . Type exposure of the Hopwood member showing the contorted nature of the base of the conglomerate.

Chadwick (1931, p. 242) has termed this type of phenomenon "storm rollers" but it is hard to imagine how a storm could produce such features. A more plausible explanation for these irregular boulder-like masses is that they are a result of interstratal flowage or readjustment of the conglomerate to the formerly plastic shale beneath it. Another possible explanation is that the conglomerate represents a submarine landslide and that the "boulders" are a result of that movement.



Figure 11. Type exposure of the Hopwood member showing the contorted nature of the base of the conglomerate.

the "boulders".

Both the sandstone and conglomerate of the Hopwood member weather to a rusty brown color. The thin shale lens on weathering retains its grey color. Both members stand out as cliffs but as the type exposure is a fresh road cut, it is difficult to tell how these members would weather under natural conditions.

Thickness

The thickness of the entire member is about 32 feet, but varies in the type exposure due in part to the lensing of the grey shale. The lower sandstone of the Hopwood is 20 feet thick and the conglomerate varies from 4 to 8 feet in thickness. The conglomerate thins to the westward in the type section, becoming sandier and less conglomeratic in that direction.

Relation to adjacent members

The base of the Hopwood member has not been seen. It conformably underlies the Pine Knob shale.

Correlation

From position only, the Hopwood member is tentatively considered as at least a partial correlate of the Linderman sandstone. No faunal data are available.

Pine Knob member

Name and definition

The name Pine Knob member ^{23/} is being proposed for a sandstone and

23/ Termed Sandstone G by the writer in Progress Rept. 126, Pennsylvania Geol. Survey, p. 14, 1941.

shale sequence overlying the Linderman sandstone and the Hopwood conglomerate and underlying the Ohio pyle sandstone. Although not exposed there, the member derives its name from Pine Knob, a small hill about $1\frac{1}{4}$ miles from the type locality. The type locality is at the scenic lookout along Route 40 below Summit Hotel in the southeastern corner of North Union township in Fayette County, Pennsylvania, about 2 miles west of Hopwood.

Occurrence

The Pine Knob member was differentiated from the rest of the Mississippian only in Fayette County. It outcrops at the type locality and about 1 mile west along Route 40, near milepost 59, where the member is badly disturbed due to faulting and is not well exposed. The Pine Knob is also found in the Youghiogheny gorge, (Chestnut Ridge) opposite Indian Creek, in the northern part of Dunbar township, Fayette County, but due to its high shale content there it is badly slumped and is not well shown. The Pine Knob also outcrops in the Youghiogheny gorge (Laurel Hill) along the Baltimore and Ohio Railroad on the north bank of the river about one-half mile west of Victoria.

Lithology.

The Pine Knob member consists primarily of sandstone and sandy

shale. The shale is grey to brown in color, micaceous, fine-grained (clay-to-fine-sand size) and apparently well sorted. Beds are thin, 1 inch or less, and moderately persistent. The bedding surfaces often show indistinct ripple-marks and other irregular markings which are perhaps due to settling or interstratal flowage.

The shales dominate the base of the member, but grade upward into brown-grey sandstone interbedded with some shale. The sandstones are well-sorted, fine-grained and in many cases quite friable. The beds are relatively thin, averaging about 3 or 4 inches in thickness, with irregular bedding planes, due largely to indistinct ripple-marking. At the type locality there is a minor but distinct angular unconformity in the basal part of the Pine Knob.

Both the shale and the sandstone weather to a light rusty-brown color. The shales, however, retain their original greyish color longer. At the type locality the member stands as a cliff due to road operations at that point. In every other natural exposure the shale weathers readily so that the stratigraphic interval of this member is quite often covered by slump.

Thickness

At the type locality the Pine Knob member is 42 feet thick and in the Youghiogheny gorge at Laurel Hill it is 46 feet thick. In the Youghiogheny gorge at Chestnut Ridge it measures 77 feet. It appears that the member thickens to the north.

Relations to adjacent members

The contact of the Pine Knob with the underlying Linderman and Hopwood is conformable if not gradational. The contact of the Pine Knob with the overlying Ohiopyle is disconformable wherever observed.

Fauna

The fauna of the Pine Knob is abundant and similar to that of the Linderman in that it is primarily one of pelecypods and brachiopods. The main reason for differentiating the two members as separate units is the addition of several new forms not found in the Linderman.

The preservation of the fossils in the Pine Knob is not much better than in the Linderman. The sandstones provide a better medium for preservation than the shales, but usually in both the forms are preserved mainly as internal and external molds. However, the Orbiculoid forms, having a calcareo-phosphatic shell, are sometimes found with the shell material intact.

The fauna of the Pine Knob follows:

- ** Athyris cf. angelica Hall
- † Camarotoechia contracta Hall
- ** Chonetes sp. 2
- ** Eumetria scansa (Hall)
- * Lingula cf. scutella Hall
- † Oehlertella (?) cf. pleurites Meek
- ** Orbiculoides aff. randalli Hall
- * Productella cf. onusta Hall
- ** P. cf. speciosa Hall

- † Schellwienella sp.
- *** "Spirifer" disjunctus var. "pine-knobensis" Laird ms.
- † Syringothyris cf. angulata Simpson
- * Aviculonecten aff. celsus Hall
- * A. aff. patulus Hall
- * Edmondia cf. burlingtonensis (White & Whitfield)
- * E. ellipsus Hall
- * E. cf. ellipsus Hall ^{24/}
- * E. cf. phillipi Hall
- ** E. cf. subovata Hall
- *** Grammysia cf. hannabalensis (Shumard)
- * G. sp.
- ** Leptodesma mentor var. alpha Caster
- ** L. mentor var. maxima Caster
- ** L. mentor var. orodes Caster ^{25/}
- ** L. mentor var. sulcata Caster
- ** L. aff. sociale Hall
- * Modiomorpha aff. concentricas (Conrad)
- † Mytilarca cf. simplex Hall
- ** Palaeoneilo cf. brevis Hall
- *** P. cf. elongata Hall
- ** P. aff. maxima (Conrad)
- ** P. sp. 1
- ** P. sp. 2

- * P. sp. 6
- * P. sp. 7
- * P. sp. 8
- * P. sp. 9
- * Pararca cf. sao Hall
- * P. cf. venusta Hall
- * P. sp.
- * Paracyclas rotunda (Hall)
- † Pelecypod indet no. 3
- * Igoceras cf. breve Simpson
- † Pteropod (?)
- ** Neocycloceras obliquum Flower and Caster
- + Bryozoa, frondose
- † Bryozoa, ramose
- † Crinoid stems
- ** Dictyosponge
- † Plants

* Found in Pine Knob only.

** Found also below, but not above.

*** Found also above, but not below.

+ Found above and below.

24/ This pelecypod of Edmondia aspect may be a new genus. It is possible that all forms of "Edmondia" identified in southwestern

Pennsylvania may belong to an undescribed genus.

- 25/ Similar to form shown by Caster as var. orodes, but apparently not Hall's orodes.
-

A total of 50 forms is included in this list. Of these 19 are found only in the Pine Knob member. Eighteen fossils are found in the Pine Knob and below, but 12 of these forms are found only in the Linderman and Pine Knob. Only 2 forms are found in the Pine Knob and above. Eleven forms are found both above and below.

The faunas of the Pine Knob and Linderman are similar but there are some notable new additions to the latter. One form particularly important in assigning Mississippian age to these beds is Eumetria scansa which is found in both the Linderman and Pine Knob. Notable new additions to the Pine Knob fauna are Productella cf. onusta, Aviculopecten aff. patulus, Pararca cf. venusta, Pararca cf. sao, several species of Edmondia, several species of Palaeoneilo and the gastropod Igoceras.

Pelecypods commonly attributed to Edmondia are important in identifying the member in the inliers. It has been noted in a footnote that these forms possibly belong to an undescribed genus.

Another genus which is very useful in identifying the Pine Knob in the inliers is Palaeoneilo. Numerous species have been differentiated, but most are apparently undescribed. Therefore these species, while useful locally, cannot be used for long range correlation.

These forms were particularly useful in deciphering the structure of the small thrust on the west limb of the Chestnut Ridge anticline along the National Road which has already been mentioned in connection with the Hopwood member.

Undoubtedly the capulid snail, Igoceras cf. breve, is the most interesting of the fossils found in the Pine Knob member. This form is poorly preserved and not abundant. It is noteworthy because of its value in regional correlation which will be discussed later in this report. Igoceras breve has been reported by Caster (1934, p. 118) as occurring only in the Tidioute shale of northwestern Pennsylvania.

Ohiopyle sandstone

Name and definition

26/

The name Ohiopyle sandstone is being proposed for a sandstone

26/ Termed Sandstone H by the writer in Progress Rept. 126, Pennsylvania Geol. Survey, p. 15, 1941.

sequence which overlies the Pine Knob member and underlies the Lick Run conglomerate. The sandstone takes its name, for lack of a nearer unoccupied geographic name, from a town situated $2\frac{1}{2}$ miles west of the type locality. The type locality is along the road from Rock Springs school to Victoria, about three-quarters of a mile below the schoolhouse in the valley of Rock Springs Run in southeastern Stewart town-

ship, Fayette County, Pennsylvania.

Occurrence

Beside the type locality, this sandstone is found primarily in the form of talus blocks along the south bank of the Youghiogheny gorge and also along the banks of both Rock Springs Run and Lick Run in southeastern Stewart township. It is also found as talus in a small inlier in northeastern Stewart township, about 1 mile west of Maple Summit school and about 4 miles north of the Youghiogheny gorge (Laurel Hill) localities, and is also poorly exposed in the Youghiogheny gorge (Chestnut Ridge) in the northern part of Dunbar township, opposite Indian Creek.

This sandstone furnishes much of the talus littering the hillsides below its outcrop in the inliers. Because of this it was extensively used in the early days for the construction of stone fences. These and old stone piles in the fields, today provide the best fossil-collecting grounds.

Lithology

The Ohiopyle sandstone is a light-brown to white, quartzose sandstone. It is a fine-to-medium-grained, quite pure, quartz sand and is well sorted. Some interbedded sandy shale is also present but not abundant. The individual beds vary from 1 foot to 6" in thickness and are quite regular. There does not appear to be much lenticularity in this member although lack of adequate well-exposed sections makes this difficult to determine. The bedding surfaces are irregular but ripple-

marks are not well developed.

The Ohiopyle sandstone does not change color greatly on weathering, but tends to retain its light-brown to grey color. In decidedly weathered fragments, the iron coloration has apparently been entirely bleached out leaving the surface of the rock fragments with a dirty grey color. As has been noted, the sandstone is found most commonly as talus blocks and seldom as an outcrop. This may be due in part to the weathering of the interbedded and underlying sandy shale allowing the sandstone blocks to creep down the slope.

Thickness

In the type locality, the exposed Ohiopyle measures 36 feet. The base is unfortunately covered. At the Summit scenic lookout exposure, along the National Road 2 miles west of Hopwood, the sandstone is absent from the section. In the Youghiogheny gorge (Chestnut Ridge) opposite the mouth of Indian Creek a thickness of 83 feet has been assigned to this sandstone although slumped exposures here may cause error in measurement. This member has not been recognized outside of the Fayette County inliers.

Relations to adjacent members

The contact of the Ohiopyle sandstone with the Pine Knob member has been observed only in the Youghiogheny gorge (Chestnut Ridge) opposite the mouth of the Indian Creek. Here it is conformable. The contact with the overlying Lick Run conglomerate is a disconformity of some magnitude. This disconformity can be seen in the type locality

of the Chiopyle sandstone along the road from Rock Springs school to Victoria in southeastern Stewart township. At the scenic lookout, below Summit Hotel, near the crest of Chestnut Ridge along Route 40, the Chiopyle sandstone is missing from the section altogether and the Lick Run conglomerate rests directly on the Pine Knob member.

Fauna

The fauna of the Chiopyle sandstone is the most abundant from the standpoint of the number of specimens of all the faunas of the inlier area. The fauna is dominantly one of brachiopods and pelecypods, preserved as interior and exterior molds. No specimens were found which retained any of the original shell material.

The fauna of the Chiopyle sandstone follows:

- ** Camarotoechia contracta Hall
- * Chonetes scitulus Hall
- ** Productella cf. hirsuta Hall
- * Rhipidomella cf. huntingdonensis Girty
- *** Schellwienella sp.
- ** S. disjunctus var. "pine-knobensis" Laird ms.
- * S. sp. (immature form?)
- *** Syringothyris cf. angulata Simpson
- * S. cf. randalli Simpson
- * Cypricardinia cf. consimilis Hall
- * C. aff. consimilis Hall
- * Leptodesma aff. matheri Hall

- ** Mytilarca cf. simplex Hall
- * Palaeoneilo aff. brevis Hall
- † P. concentricus Winchell var. 1
- * P. concentricus Winchell var. 2
- * P. concentricus Winchell var. 3
- *** P. cf. elongata Hall
- ** Schizodus aff. chemungensis (Conrad)
- † Conularia sp.
- ** Pteropod
- * Bradfordoceras sp.
- ** Nautiloid cephalopod
- * Titusvillia sp. nov.?

-
- * Found in Ohiopyle sandstone only.
 - ** Found in Ohiopyle sandstone and below.
 - *** Found in Ohiopyle sandstone, below and in Riddlesburg shale.
 - † Found in Ohiopyle sandstone and Riddlesburg shale.
-

The fossils identified from this member total 24. Of these 12 were found only in the Ohiopyle, 7 were found in the Ohiopyle and below, 3 were found in the Ohiopyle, the Riddlesburg shale and below the Ohiopyle, and 2 forms were common to both the Ohiopyle and the Riddlesburg. Several of the forms common in the Riddlesburg such as Rhipidomella huntingdonensis, Cypricardinia consimilis, and Palaeoneilo

concentricus were identified comparatively in the Chiopyle sandstone, It is likely that if a more detailed faunal study were made, it would be found that the forms are the same and that the relationship between the Chiopyle and the Riddlesburg is closer than it appears from the faunal list.

Riddlesburg shale

General statement

The Riddlesburg shale although considerably removed geographically from the southwestern Pennsylvania inlier area must be considered in this report because of the bearing it appears to have on the correlation of the Mississippian of southwestern Pennsylvania with that of northwestern Pennsylvania.

Name and definition

The name Riddlesburg shale was first proposed by Reger (1927, pp. 156-157) for a faunal zone in the Pocono series of the Mississippian in the Broadtop Basin of Pennsylvania. In his abstract he did not give the type locality, but in a later more detailed account Reger (1927, A. p. 397-419) gives the type locality as $2\frac{1}{2}$ miles north of Riddlesburg, Bedford County, Pennsylvania along the Huntingdon and Broadtop Mountain Railroad. He gives the thickness of the member as 75 feet and locates it 473 feet above what he classifies as the base of the Pocono.

Occurrence

The Riddlesburg shale is exposed in numerous places in the Broad-

top synclinal area in Bedford, Fulton and Huntingdon Counties, Pennsylvania. In addition to the type locality, the shale is also exposed on (1) the northwestern limb (Terrace Mountain) of the Broadtop syncline at the following localities: (2) Hopewell, along the Raystown Branch of the Juniata River south of the abandoned bridge leading to Hopewell, along a private road in the eastern part of Hopewell township, Bedford County: (3) along Shoup Run 1 mile east of Saxton, along the Huntingdon and Broadtop Mountain Railroad in the southwestern corner of Hopewell township in Huntingdon County: (4) and in the gap of Great Trough Creek where it cuts through Terrace Mountain in the northwestern corner of Tod township, Huntingdon County, 4 miles east of Marklesburg. The shale outcrops on the southeastern limb (Sideling Hill) of the Broad Top syncline in the following localities: (5) on state route 76, 1 mile southeast of Cassville in the central part of Cass township, Huntingdon County; (6) a highway exposure a little east of Kimmel above and east of a tunnel on the Broadtop Railroad, near the western boundary of Clay township, Huntingdon County; (7) and along a state road 1-3/4 miles west of Hiram near the eastern boundary of Wells township in Fulton County.

The Riddlesburg also occurs along the Allegheny Front near Altoona: (8) along Route 36, about $3\frac{1}{2}$ miles west of Altoona, where that road ascends the Front through the gorge of Mill Run in the western part of Logan township, Blair County; (9) along the road to Wopsononock, 2 miles north of the above outcrop; (10) A much reduced

thickness of the shale occurs along the Front section of the Pennsylvania Railroad in Sugar Run gorge, $4\frac{1}{2}$ miles west-southwest of Altoona.

Lithology

The Riddlesburg shale is a grey, fine-grained shale with some few interbedded sandy layers. In the lower 25 or 30 feet of the member there are massive (1-2 feet thick), sandy, limy zones which contain abundant fossils. The sand in this zone is fine-to-medium-grained and looks like a grey, sandy limestone in the unweathered state. This zone is particularly pronounced in the Allegheny Front exposures. Bedding planes are well developed in the shale but are less distinct in the sandy layers toward the base. The grey color of the shale persists in the weathered state with the addition of a limonitic coating on talus fragments. The shale tends to weather in large spheroidal masses from which roughly concentric layers break off, creating pencil-like talus. This type of weathering makes fossil collecting somewhat difficult. The sandy, limy layers at the base of the Riddlesburg, weather readily to a reddish-brown friable sandstone replete with molds of fossils.

Thickness

Reger gives a thickness of 75-95 feet for the Riddlesburg shale on Terrace Mountain. The average of the exposures the writer visited and measured, including those on the Allegheny Front, is 93 feet with the limits running from 72 feet to 108 feet. In obtaining the above average the thicknesses from the following localities were used: type 108 feet, (3) 100 feet, (5) 90 feet, (6) 102 feet, (8) 72 feet,

(9) 88 feet. These localities were chosen as they showed the best complete exposures. The fact that these outcrops are all on the flanks of large folds and that faulting has been noted in some of the other members in the same locality makes the true thickness of the member uncertain.

Relations to adjacent members

The Riddlesburg is separated from the underlying Upper Devonian beds by a disconformity. It is usually separated from the overlying Chestnut Ridge sandstone by a disconformity of some magnitude. Along the Allegheny Front the Riddlesburg has been found in several localities, mainly between Altoona and the point where Route 30 (Lincoln Highway) crosses the Front. The Riddlesburg shale is apparently missing elsewhere along the Front due probably to erosion subsequent to its deposition and prior to Chestnut Ridge sedimentation. In the type locality the contact is more gradational, grading upward through sandy shales into the heavy, massive Chestnut Ridge sandstone.

Fauna

The fauna of the Riddlesburg shale has been studied and described by Girty (1927). The following list contains only the fossils collected from the Riddlesburg and identified by the writer:

- ** Camarotoechia contracta Hall
- ** C. aff. contracta Hall
- ** C. aff. sappho Hall
- * Chonetes acutiliratus Girty

- ** Oehlertella (?) cf. pleurites Meek
- ** O. sp.
- ** Orbiculoidea sp.
- * Rhipidomella huntingdonensis Girty
- ** Schellwienella sp.
- * Schuchertella (?) sp.
- ** Syringothyris cf. angulata Simpson
- * S. sp.
- * Cypricardinia consimilis Hall
- * C. sp. 1
- * Leda aff. spatulata Herrick
- * Palaeoneilo concentricus Winchell
- † P. concentricus Winchell var. 1
- ** P. cf. elongata Hall
- ** Paracyclas (?) sp.
- ** Pelecypod indet no. 3
- † Conularia sp.
- * Pleurotomaria aff. hickmanensis Winchell
- * "Spirorbis" sp.
- ** Bryozoa, ramose
- * Scaphiocrinus sp.
- ** Crinoid stems
- * Ostracods (?)
- ** Plants

-
- * Found in Riddlesburg shale only.
 - ** Found in Riddlesburg and below.
 - + Found in Riddlesburg and Ohiopyle only.
-

To the above list should be added those forms identified by Girty which were not found in this study.

Scapioocrinus kirkanus Girty

Stenopora ? sp.

Lingulodiscina newberryi (Hall)?

Schuchertella chemungensis Conrad

Cranaena sp.

Spirifer *compositus* Girty

Nucula aff. *N. houghtoni* Stevens

Glossites ? sp.

Loxonema sp.

Orthoceras sp.

Cytherellina ? sp.

Kirkbya ? sp.

The fauna of the Riddlesburg almost without exception is found in the basal 25 or 30 feet of the member. While fossils occur in the shale, they are more commonly found in the sandy layers. In fact some of the sandy layers are so packed with fossils as to constitute coquinities. Occasionally a comparable abundance has been observed

in the shale. Much of the lime present in the basal part of the Riddlesburg may be derived from the organisms.

The most abundant forms found in this fauna are Chonetes acutiliratus, Rhipidomella huntingdonensis, Palaeoneilo concentricus, and Cypricardinia consimilis. The last three fossils compare closely with specimens from the Chiopyle sandstone.

Correlation of the Cussewago members

General statement

The correlation of the various members of the Cussewago stage can best be considered in one place because of their close inter-relationship. Many problems are yet to be solved, but unfortunately their exact solutions will be delayed until a complete revisionary faunal study has been made of all Mississippian faunas in western Pennsylvania. However, enough is known that the general correlations can be outlined. The proof for the correlations lies primarily in the faunal evidence. Therefore the following parallel faunal lists have been prepared giving the Kushequa-Knapp-Tidioute fauna as listed by Caster (1934, pp. 70-75) on the left and the Linderman-Pine Knob-Chiopyle-Riddlesburg fauna, as identified by the writer, on the right. While the study was not as complete as desirable, the southwestern Pennsylvania forms were compared with such northwestern Pennsylvania fossils as were available in the collections at the University of Cincinnati. Specimens from the type localities in northwestern Pennsylvania were also seen in the field in the company of Dr. Caster.

Kushequa-Knapp-Tidioute fauna
(From Caster)

Calathospongia carlli Hall

Clathrospongia abacus Hall

Ectenodictya implexa Hall

Hydnoceras nodusum Hall

* Prismodictya prismatica Hall

* Cystids (2 undescribed)

* Crinoids (several undescribed)

* Aulurold, n. gen. (?) n. sp.

Asteroid, n. sp.

* Hyattechinus beecheri Jackson

* H. pentagonalis Jackson

* H. rarispira (Hall)

* Lepedesthes warrenensis Cooper

Rich bryozoan fauna, undescribed

Linderman-Pine Knob-Chiopyle-
Riddlesburg fauna

1,2/
Dictyosponge

3/
Titusvillia n. sp.

4/
Scaphiocrinus sp.
2,4/
Crinoid stems

1,2/
Bryozoa, frondose

Bryozoa, ramose ^{2,4/}
1/
 Rhopalonaria sp.

Vermes trails, several forms

Athyris cf. angelica Hall ^{1,2/}
1/
 A. angelica var. nov. ^{1,2,3,4/}
 Camarotoechia contracta Hall ^{1/}
 C. cf. contracta Hall ^{1,4/}
 C. aff. contracta Hall

Camarotoechia contracta Hall gens

C. orbicularis Hall

C. n. sp. 2

C. (?) sappho Hall ^{1/}
4/
 C. aff. sappho Hall

Chonetes lepidus (?) Hall

Chonetes acutiliratus Girty ^{4/}
3/
 C. scitulus Hall ^{1,2/}
 C. sp. 2 ^{1/}
 Lingula randalli Girty ^{2/}
 L. cf. scutella Hall

Oehlertella pleurites Meek

Oehlertella (?) cf. pleurites Meek $\frac{1,2,4}{1,4/}$

O. sp.

Orbiculoidea aff. randalli Hall $\frac{1,2}{4/}$

O. sp.

Orthotetes crenistria Phillips

Orthotetes sp. $\frac{1}{/}$

Productella bialveata Hall

P. hirsuta var. rectispina Hall

P. lachrymosa Conrad

Productella cf. hirsuta Hall $\frac{3}{2/}$

P. cf. onusta Hall

P. cf. speciosa Hall $\frac{1,2}{1/}$

P. sp.

Productus sp.

Rhipidomella burlingtonensis ? Hall

R. leucosia var. pennsylvanica Hall

R. ? pennsylvanica Simpson

Rhipidomella huntingdonensis Girty $\frac{4}{3/}$

R. cf. huntingdonensis Girty

Rhynchospirina (?) scansa Hall and Clarke

Schellwienella chemungensis Conrad

Schuchertella n. sp.

Spirifer disjunctus Sowerby, gens

S. disjunctus mut. 1 nov.

S. disjunctus mut. 2 nov.

Syringothyris angulata Simpson

S. randalli

* S. texta (Hall)

S. n. sp.

Aviculopecten celsus Hall

A. patulus Hall

1,2/
Eumetria scansa Hall
1,2,3,4/
Schellwienella sp.

1/
Schuchertella ? sp.
4/
Spirifer compositus Girty
1/
"Spirifer" disjunctus Sowerby

S. disjunctus var. pine-knobensis 2,3/
Laird ms.
3/
S. sp. (immature)
1,2,3,4/
Syringothyris cf. angulata Simpson
3/
S. cf. randalli Simpson

4/
S. sp.
2/
Aviculopecten aff. celsus Hall
2/
A. aff. patulus Hall

A. striatus (?) Hall

* *A. n. sp. 2*

Crenipecten winchelli (?) Hall

C. n. sp.

Cypricardina consimilis Hall ^{4/}

C. cf. consimilis Hall ^{3/}

C. aff. consimilis Hall ^{3/}

C. sp. 1 ^{4/}

Edmondia rhomboidea Hall

E. (?) n. sp.

Edmondia burlingtonensis ^{2/}
(White and Whitfield)

E. ellipsus Hall ^{2/}

E. cf. ellipsus Hall ^{2/}

E. cf. phillipi Hall ^{2/}

E. cf. subovata Hall ^{2/}

Glossites amygdalinus (?) Winchell

Goniophore cf. alata Hall ^{1/}

Grammysia (genus?) n. sp.

G. aff. chemungensis Vanuxem ^{1/}
G. cf. glaucus Hall ^{1/}
G. sp. ^{1/}

Grammysia cf. hannabalensis (Shumard) ^{1,2/}
^{2/}

G. sp. ^{4/}
Leda aff. spatula Herrick

Leptodesma cariniferum Caster

Leptodesma aff. matheri Hall ^{3/}

L. mentor Hall

L. mentor var. alpha Caster ^{1,2/}

L. mentor var. biton Hall

L. mentor var. maclurii Hall

L. mentor var. maximum Caster

L. mentor var. orodes Hall

L. mentor var. sulcatum Caster

L. mentor var. rude Hall

L. mentor var. maxima Caster ^{1,2/}

L. mentor var. orodes Caster ^{1,2/}

L. mentor var. sulcata Caster ^{1,2/}

L. mytiliforme Hall

L. ruedemanni Caster

* L. n. sp.

Nucula (?) globularis Hall

N. n. sp.

Palaeonatina solenoides Hall

Palaeoneillo (?) genus) (Many n. sp.)

L. aff. sociale Hall $\frac{1,2}{1}$

L. sp. $\frac{4}{1}$

Modiola (Mytilops) praecedens Hall $\frac{1}{2}$

Modiomorpha aff. concentricus (Conrad) $\frac{1,2}{2}$

Mytilarca cf. simplex Hall

Palaeoneillo cf. brevis Hall $\frac{1,2}{3}$

P. aff. brevis Hall $\frac{4}{3}$

P. concentricus Winchell $\frac{3,4}{1}$

P. concentricus Winchell var. 1 $\frac{3}{2}$

P. concentricus Winchell var. 2 $\frac{3}{3}$

P. concentricus Winchell var. 3 $\frac{2,3,4}{3}$

P. cf. elongata Hall

P. aff. maxima (Conrad) $\overline{11.2/}$
 P. sp. 1 $\overline{1.2/}$
 P. sp. 2 $\overline{1.2/}$
 P. sp. 3 $\overline{1/}$
 P. sp. 4 $\overline{1/}$
 P. sp. 5 $\overline{1/}$
 P. sp. 6 $\overline{2/}$
 P. sp. 7 $\overline{2/}$
 P. sp. 8 $\overline{2/}$
 P. sp. 9 $\overline{2/}$
 Paleosolen sp. $\overline{1/}$

Paracyclas erecta Hall

Paracyclas rotunda (Hall) $\overline{2/}$
 $\overline{1.4/}$
 P. (?) sp.

Pararca neglecta Hall

Pararca cf. sao Hall $\overline{2/}$
 P. cf. venusta Hall $\overline{2/}$
 P. sp. $\overline{2/}$

Pararca venusta Hall

Prorhynchus harrisi Caster

P. paeneplanum Caster

Pterinopecten suborbicularis Hall

Ptychopteria vanuxemi Hall

P. (several n. sp.)

Schizodus aff. *appressus* (Conrad) $\frac{1}{3}$
S. aff. *chemungensis* (Conrad) $\frac{1}{3}$
S. cf. *contractus* Hall $\frac{1}{3}$

Schizodus rhombeus Hall

Sphenotus cf. *aeolus* (n. sp.)

S. *clavulus* Hall

S. *contractus* gens.

S. *palmerae* Caster

Sphenotus cf. *contractus* Hall $\frac{1}{3}$

Pelecypod indet. no. 2 $\frac{1}{1,2,4}$
Pelecypod indet. no. 3

Spirodonus insignis Beecher

Bellerophon n. sp.

^{1/}
Bellerophon sp.
^{3,4/}
Conularia sp.

Gyroma (?) sp.

* Igoceras breve Simpson ^{2/}

* I. dorsale Simpson

* I. striatum Simpson (n. sub. gen)

^{1/}
Loxenema sp.

Platyceras erectum Hall

* P. inaequale Simpson

* P. mitelliforme Simpson

* P. varians Simpson

P. n. sp. 1

P. n. sp. 2

^{4/}
Pleurotomaria aff. hickmanensis Winchell
^{1/}
P. sp. 1. (small)
^{4/}
"Spirorbis" sp.

Straparolus (?) hecale Hall

^{1,2,3/}
Pteropod (?)

Bradfordoceras sp. ^{1/}
^{3/}
 B. (?) sp.
 Neocycloceras obliquum Flower and Caster ^{1,2/}
^{1/}
 N. (?) sp.
^{3/}
 Cephalopod (Nautiloid)

Echinocaris randalli Beecher

Tropidocaris alternatus Beecher

Protolimulus eriensis (Williams)

P. n. sp.

Cladodes carinatus (Newberry)

Ctenacanthus randalli Newberry

C. n. sp.

Ctenodus minutus

Dinichthys tuberculatus Newberry

Gyracanthus sherwoodi Newberry

Thinopus antiquus Marsh

Ctenodus nelsoni Newb. ^{1/}

Ostracodes (?) ^{4/}
^{1/}
 Protolimulus trail

^{1,2,4/}
 Plants

-
- * Tidioute fauna
 - 1. Linderman fauna
 - 2. Pine Knob fauna
 - 3. Ohiopyle fauna
 - 4. Riddlesburg fauna
-

As can be seen from the above lists, neither fauna is particularly satisfactory for correlation purposes due to the large number of undescribed forms. The genus Palaeoneilo is an excellent example of this. The writer has listed 17 Palaeoneilid forms from southwestern Pennsylvania, at least 9 of which are apparently not described, whereas Caster simply lists a number of forms as Palaeoneilo (?genus) (many n. sp.)

The following list gives the forms which the two faunas have in common:

Athyris angelica

Camarotoechia contracta

Rhipidomella pennsylvanica (Probably equals *R. huntingdonensis*)²⁷

Eumetria scansa

"*Spirifer*" *disjunctus* gens

Syringothyris angulata

S. randalli

Aviculopecten celsus

A. patulus

Leptodesma mentor var. *maxima*

L. mentor var. *orodes*

L. mentor var. *sulcata*

Pararca venusta

Igoceras breve

Protolimulus

27/ *R. pennsylvanica* is the older of the two names and therefore has priority.

Of these forms common to both faunas, 10 are found in the Linderman, 12 are found in the Pine Knob, 3 are found in the Ohio pyle and 4 are found in the Riddlesburg.

Riddlesburg - Northwestern Pennsylvania correlation

Lithologic similarities

The fauna of the Riddlesburg shale occurs usually within 25 or 30 feet of the base of the member. With few exceptions, the fossils are preserved as internal and external molds in a friable sandy matrix. Where these sandy layers are unweathered they consist of a blue-grey, sandy limestone in which the fossil shells are found so abundantly that the rock can be called a coquinite. The upper portions of the Riddlesburg shale consist of thin-bedded, blue-grey shale which is practically unfossiliferous. Occasionally above the basal 25 or 30 feet thin layers of shale consisting almost entirely of fossil molds are found, but these

are the exception rather than the rule.

In northwestern Pennsylvania the basal Knapp beds or the Kushequa sandy shale contain interbedded, sandy limestone layers, a concentration of which are identified by Caster (1934) as the Marvin Creek limestone zone.^{28/} At Kushequa, McKean County, and at Johnsonburg, in Elk County, about 10 miles northeast of Ridgeway, the Knapp zone was shown to the writer by Dr. Caster. The lithologic as well as faunal resemblance of this sandy limestone at Johnsonburg, especially, to the basal sandy limestone of the Riddlesburg shale west of Altoona was striking.

^{28/} Fettke, C. R., maintains this name should be applied to Oswayo coquinites.

This resemblance is worthy of note as the Johnsonburg outcrop is the nearest northwestern Pennsylvania locality to Altoona.

Faunal similarities

There are four fossils which are common to both the northwestern Pennsylvania basal Mississippian and Riddlesburg faunas. These are Camarotoechia contracta, Oehlertella pleurites, Syringothyris angulata and Rhipidemella pennsylvanica (which apparently equals Rhipidomella huntingdonensis Girty of the Broad Top area). R. huntingdonensis is the most abundant fossil in the Riddlesburg shale both in the Broad Top area and the Allegheny Front. Its counterpart, R. pennsylvanica, was also very common in the Knapp sandstones and Marvin Creek limestone

zone of the Johnsonburg locality. Therefore, because of its faunal and lithologic similarities, the basal part of the Riddlesburg shale is being correlated with the Marvin Creek limestone zone of the Kushequa shale (basal Oil Lake series of the Mississippian northwestern Pennsylvania).

Riddlesburg - Southwestern Pennsylvania correlation

Lithologic similarities

The basal calcareous phase of the Riddlesburg shale finds expression in the southwestern Pennsylvania inliers in the Linderman sandstone. However, in general, the lithologic similarity ends here as the dominant type of sedimentation in the inliers after the initial calcareous phase of the Linderman, and prior to Chestnut Ridge deposition, was that of fine-to-medium-grained sandstone and sandy shale. In the Broad Top area, after the initial basal limy phase and prior to Chestnut Ridge deposition the dominant type of sedimentation was micaceous clay shale.

Faunal similarities

In southwestern Pennsylvania there are two distinct faunas, the Linderman-Pine Knob and the Ohiopyle. The Linderman-Pine Knob occurs in limy sandstone and sandy shale. The Ohiopyle uniformly occurs in a white to grey quartzose sandstone. The Linderman-Pine Knob fauna is characterized by numerous species and by the large number of individuals of these species. Leptodesma is very abundant. The Ohiopyle is characterized by a small number of different species but a large number of individuals of these species, Palaeoneilo is the most abundant genus. As these two faunas are definitely distinct, the problem arises

as to which is the more like the fauna of the Riddlesburg.

Upon comparison of the Riddlesburg fauna with the Linderman-Pine Knob fauna, it was found that they have ten forms in common. Four of these, such as crinoid stems, were too indeterminate to use for correlation purposes; four species are found also in the overlying Ohio pyle. There remain two fossils, Oehlertella (?) cf. pleurites and Paracyclas sp. which are found only in the Riddlesburg and the Linderman-Pine Knob. Neither of these fossils are distinctive enough that long-range correlation should be based on them.

When the faunas of the Riddlesburg and the Ohio pyle were compared it was found that there were eight forms in common, only two of which could not be specifically identified. Four of the eight were found also in the underlying Linderman-Pine Knob. These four also are not common in the Ohio pyle. The remaining four forms, three of which are also the most abundant fossils in the Ohio pyle, are found only in the Riddlesburg and Ohio pyle. These are Rhipidomella huntingdonensis, ^{29/}Cypricardinia ^{30/}consimilis, Palaeoneilo concentricus and Conularia sp. This

^{29/} Comparatively identified in Ohio pyle, but probably same form.

^{30/} At least three varieties of this fossil are found in the Ohio pyle.

last named form is not abundant. This faunal similarity is interesting in view of the difference in lithologic facies between the Riddlesburg area and the southwestern Pennsylvania inliers. Therefore, because of their faunal similarity, the Ohio pyle sandstone and the basal part of

the Riddlesburg shale are being tentatively correlated. As will be brought out later in this report, the possibility that the Ohiopyle is slightly younger than the Riddlesburg should also be considered. By correlating the basal Riddlesburg (which has already been correlated with the basal Kushequa of northwestern Pennsylvania) with the Ohiopyle, the problem of the stratigraphic position of the underlying Pine Knob and Linderman members arises. This problem is discussed in the following section of this report.

Southwestern Pennsylvania - Northwestern Pennsylvania correlation
Lithologic similarities

As has been noted above, the basal limy phase was apparently quite common in western Pennsylvania in early Mississippian time. In northwestern Pennsylvania this phase is called the Marvin Creek limestone zone of the Kushequa shale. In Fayette County it is the Linderman calcareous sandstone. In southwestern Pennsylvania the sedimentation after the initial limy phase consisted dominantly of fine-to-medium-grained sands and shales with a few conglomeratic lenses, the most outstanding of which is the Hopwood conglomerate. In northwestern Pennsylvania much the same type of sedimentation took place except there several massive Knapp conglomerate lenses, (for example, the Cobham conglomerate of the Warren area) were deposited.

Faunal similarities

When the faunal lists are consulted it will be seen that there are 14 forms that are common to the Linderman-Pine Knob and the Kushequa-Knapp-Tidioute faunas of northwestern Pennsylvania. There would un-

doubtedly be many more if the Palaeoneilid forms were included. One outstanding fossil found in the Pine Knob member is Igoceras cf. breve. These Igocerid forms have never been reported from any Pennsylvania beds except the Tidioute shale, which adds weight to the correlation between the Linderman-Pine Knob and the Knapp-Tidioute faunas. The abundance and striking resemblance of the Leptodesma mentor gens of the Linderman to those of the "Devils Den" fauna of the Knapp of northwestern Pennsylvania also seems noteworthy. One form that is strikingly absent from the Linderman-Pine Knob material is Rhipidomella Muntingdonensis or R.
^{31/}pennsylvanica. From this faunal evidence (see p.154 for faunal lists)

^{31/} Dr. K. E. Caster informs me that this species increases to the southward in the northwestern Pennsylvania exposures and is clearly facieologically controlled.

it would appear that the Linderman-Pine Knob fauna is equivalent to the Kushequa-Knapp-Tidioute fauna of northwestern Pennsylvania. This is confusing as we have already attempted to show that the Ohio pyle, which overlies the Linderman-Pine Knob in southwestern Pennsylvania is to be correlated with the Riddlesburg while the Riddlesburg is correlated with the Kushequa of northwestern Pennsylvania. The exact solution to this problem awaits adequate collecting and detailed faunal study of these Early Mississippian faunas.

However, from the evidence at hand, certain conclusions can be tentatively drawn. From the fauna it would appear that the Linderman-Pine

Knob fauna was very similar to the Knapp-Tidioute fauna except that the latter fauna was more cosmopolitan and contained a number of forms not found in the Linderman-Pine Knob fauna.

As is noted elsewhere in this report, an eastward progression of the shoreline of the Penn-York Embayment began in the latest Upper Devonian and apparently continued into the Mississippian. The fine grain of the Riddlesburg in general suggests a setting of accumulation that was either adjacent to a region of relatively low relief or at some distance from the source of sediment. With this transgression, certain forms such as Rhipidomella pennsylvanica already established in certain ecologic niches in northwestern Pennsylvania, migrated eastward and southeastward into a broader development of this environment. If this is the correct interpretation, - then only a few species of the northwestern Pennsylvania faunas, however, were suited to this expanded environment, for the Riddlesburg fauna is not large in species. Finally, this fauna migrating southeastward by way of what is now the Allegheny Front region reached the Broad Top area and ultimately made its way westward again where it was incorporated in the Ohiopyle sandstone of Fayette County. Thus due to its migration eastward and then back westward again, this Riddlesburg-Ohiopyle fauna actually in Fayette County overlies and is younger than the Linderman-Pine Knob fauna with which it was originally, in Early Mississippian time in northwestern Pennsylvania, approximately contemporaneous. This westward trend may be associated with a resumption of the westward migration of the strand which apparently took place slightly before or soon after the end of Riddles-

burg-Ohio pyle sedimentation.

If the above conclusion is valid, it would suggest that the basal Mississippian in the Broad Top area and the Allegheny Front may be somewhat younger than the basal Mississippian to the west. Another possibility which should be considered, is that perhaps some of the heavy and barren sandstones which underlie the Riddlesburg shale on the Allegheny Front and in the Broad Top area are Mississippian instead of Upper Devonian in age.

Historical Interpretation of the Cussewago members

General Statement

Obviously the historical interpretation of the Cussewago stage in southwestern Pennsylvania is predicated upon the validity of the correlations made in the preceding section.

Inasmuch as there is a great deal said in the following and preceding pages concerning shorelines, it might be well to consider some of the criteria of shorelines and shoreline deposits. Twenhofel (1932, p. 835) cites the following characteristics of littoral deposits:

1. Stratigraphic position of such deposits is at the base and the top of each marine deposit made between an advance and retreat of the sea.
2. Littoral deposits may contain mud cracks, ripple marks and tracks of land and water animals.
3. Irregular stratification of and usually cross-bedded conditions of coarse materials.
4. Marine shells common, some land animals probable, but both

in fragmentary condition.

5. Fine sediments may be evenly laminated and may contain shells and other organic materials in an excellent state of preservation.

To the author the above criteria seem little more characteristic of littoral deposits than of neritic deposits. However, the more regular stratification and thinner lamination of the Riddlesburg shale suggest a location somewhat removed from the littoral zone. Certain of the coarser basal Mississippian beds in western Pennsylvania such as the Cobham conglomerate of the Warren area and the Hopwood conglomerate of the Fayette County area suggest a nearer-shore environment.

Movement of the Shoreline

As has been brought out in the discussion of the Upper Devonian members of this report, the dominant trend of the southwestern Pennsylvania shoreline during latest Devonian time was in a westerly direction. It has also been noted that apparently just before the close of Upper Devonian time there was a reversal of this westward trend and the latest Upper Devonian facies progressively overlap the facies previously deposited. This eastward progression has already been described by Caster (1934, pp. 29-30) and additional proof of this fact has been shown in the present report.

Apparently the eastward trend of the shoreline continued into the Lower Mississippian for Early Mississippian marine faunas have been found far east of the latest Upper Devonian marine faunas. This can be seen in the Broad Top area and on the Allegheny Front where the

Riddlesburg shale of the basal Mississippian rests on Upper Devonian continental red beds which are 2000 feet thick. Marine waters probably had not been in these areas since true Chemung time, as these are the highest reported Devonian marine faunas of the Allegheny Front and Broad Top areas.

It has already been suggested in the previous section on correlation that after the initial eastward flooding of the Early Mississippian sea the shore began to progress westward once more causing the Riddlesburg fauna to migrate westward where it was incorporated in the Ohio shale sandstone of southwestern Pennsylvania. This westward shift was apparently associated in part at least with the renewal of the land mass to the southeast as a source of sediment for the rest of the early Mississippian ("Pocono") southwestern Pennsylvania.

Source of sediments

Roughly the basal Mississippian of central and western Pennsylvania can be divided into two lithologic facies provinces, the finer-grained shale facies in the east and the coarser-grained, limy, sandy facies in the west. This size gradation from fine-grain on the east to coarser-grain on the west is a reversal of the usual size distribution of the Upper Devonian and Lower Mississippian.

The basal Mississippian in the western part of Pennsylvania consists of fine-to-coarse-grained sediments mainly sandstones and sandy shales with occasional flat-pebble conglomerate lenses. Limestones are also locally developed in northwestern Pennsylvania (Marvin Creek limestone zone of the Kushequa shale) but in Fayette County and far-

ther east this limy zone is represented by a limy sandstone.

The basal limy phase is widespread in western Pennsylvania, extending eastward as far as the Allegheny Front with only occasional thin, limy sands carrying as far eastward as the northeast side of the Broad Top basin. Caster (p. 159) states that the Kushequa shale represents a normal neritic phase in northwestern Pennsylvania. Judging from the abundant fauna of this limy phase, living conditions here must have been nearly optimum for many forms particularly brachiopods, pelecypods and certain of the Echinodermata. That this initial limy phase was deposited in shallow water not too far distant from the shore is also suggested by many scattered pebbles and thin conglomerate layers as well as the fact that the closely-associated, massive, flat-pebble conglomerates such as the Cobham and the Hopwood overlie or are gradational with it. Surely these conglomerates were not deposited far distant from their source. Caster (p. 156) has suggested that the Gussewago sandstone of northwestern Pennsylvania was presumably deposited along and south of an uneven east-west shoreline. J. L. Rich^{32/}

^{32/} Personal communication.

has noted that certain features of the Berea sandstone of northern Ohio give the impression of being spit-like deposits extending southward from an east-west trending shoreline.

All of these features, the coarsening of the sediments northward, the presence of thick, flat-pebble conglomerate beds, the spit-

like nature of later beds (the Berea), point to a northward source for much of the sediment for western Pennsylvania in earliest Mississippian time. Possibly the Canadian Shield was furnishing sediments to this area during this period.

It has been noted that the basal Mississippian along the Allegheny Front and in the Broad Top ~~area~~ is considerably finer-grained than its western Pennsylvania equivalents. Probably much of this sediment was also derived from the northwest. It seems peculiar that some sediment was not derived from the southeast in view of the fact that it was from that direction that most of the Upper Devonian sediments came. However, the fine grain of the sediments would seem to indicate no active nearby southeastern source.

The evidence obtained from the fossils and lithology in the Riddlesburg suggests certain hypotheses of origin for the shale. The fossils, while numerous, are confined to the basal part of the shale. They also are confined to beds so tightly packed with fossil remains that the rock can be termed a coquinite. These coquinite beds are often separated by dense nonfossiliferous shale. This suggests that although the shale probably can be classed as being within the neritic type of marine environment it was fairly far out from shore near the bathyal zone. This would mean that the fossils of the Riddlesburg were nearer the center of the seaway and that the southeastern shoreline was still a considerable distance away.

Another hypothesis which might be entertained is that the basal Mississippian sea transgressed an area of fairly low relief which had

been baseleveled in late Upper Devonian time. This land mass to the southeast was so low that it was furnishing little clastic sediment to the seaway to the northwest. The fossils of the Riddlesburg then could be living quite near shore in a shale environment on the southeast side of the Penn-York Embayment.

It is evident from the number of fossils that certain of the early Mississippian forms such as Rhipidomella and Palaeoneilo were well adapted to this mud environment. As has already been suggested, they moved eastward with the advancing shoreline, leaving most of the associated early Mississippian forms in the limy sandy facies of western Pennsylvania. Gradually, however, even these hardy forms were forced westward again due perhaps to a renewal of erosion to the southeast which pushed the shoreline westward again. The Riddlesburg forms moved westward where they accomodated themselves to the sandy facies of the Ohio pyle sandstone. This sandstone also apparently afforded optimum living conditions for a few types, judging from the abundance of certain forms.

Other Lower Mississippian Members in Southwestern Pennsylvania

Lick Run conglomerate

Name and definition

33/

The name Lick Run conglomerate is being proposed for a barren

33/ Termed Conglomerate I by the author in Progress Rept. 126, Pennsylvania Geol. Survey, p. 16, 1941.

quartz pebble conglomerate which is widely exposed in Fayette County.

Pennsylvania. The conglomerate takes its name from Lick Run which enters the Youghiogheny River from the north at Bidwell, in southeastern Stewart township, Fayette County, Pennsylvania. It is well exposed on several of the hillsides in the Youghiogheny Gorge (Laurel Hill) inlier. It is disconformably underlain by the Ohio pyle sandstone and overlain disconformably by the Chestnut Ridge sandstone.

Occurrence

The Lick Run conglomerate is the most widely exposed of the Lower Mississippian members in the inliers of southwestern Pennsylvania. The member is best seen in the area described above, particularly along the road about $\frac{1}{2}$ mile south of Rock Springs school, which is the type section, and on the south bank of the Youghiogheny River, near the mouth of Long Run. It is also found in the road cut at the scenic lookout along Route 40 below and west of Summit Hotel in the southeastern corner of North Union township, Fayette County. The conglomerate also occurs in the Youghiogheny Gorge (Chestnut Ridge) inlier on both sides of the Chestnut Ridge anticline. The best exposures here are found on the south bank of the river along the Western Maryland Railroad, particularly opposite the mouth of Indian Creek. Some cuts also are found on the north bank of the river along the Baltimore and Ohio Railroad.

The Lick Run conglomerate could not be certainly differentiated from the overlying Chestnut Ridge sandstone in the Conemaugh gorge inliers and along the Allegheny Front.

Lithology

The Lick Run conglomerate is a grey to grey-brown conglomerate

consisting of white and occasional rose quartz pebbles imbedded in a matrix of medium-to-coarse-grained sandstone. The quartz pebbles average about pea size (4-5 mm.) but some are larger. They are round to oval in shape and tend to be oriented in the conglomerate with their long dimension parallel to the bedding plane or more often the cross-bedding plane. Sometimes the sand content of the conglomerate is greater than the quartz pebble content. When this situation prevails, the pebbles are found as conglomeratic lenses in a coarse sandstone.

The member is massively bedded with the average thickness of beds being over $1\frac{1}{2}$ feet. Bedding planes are less prominent than the cross-bedding planes.

The Lick Run weathers to a grey color which is not much different from its unweathered color.

Thickness

In the type area the conglomerate ranges from 20 to 28 feet in thickness. The average thickness is about 20 feet.

Relations to adjacent members

The contact of the Lick Run conglomerate with the underlying Ohio-pyle sandstone has already been described as a disconformity of some magnitude. In this disconformity the entire Ohio-pyle may be cut out so that the Lick Run rests directly on the Pine Knob member. The contact with the overlying Chestnut Ridge is also a disconformity but of less magnitude.

Correlation

The lack of fossils in this member and the fact that the member is

so isolated that it is impossible to trace it any distance, make it almost impossible to correlate this member regionally. From its stratigraphic position alone it might be tentatively suggested that the Lick Run is a correlative of the Berea (Corry) sandstone.

The correlation of the member with any member on the Allegheny Front or in the Broad Top area is at present impossible. The Lick Run may be represented by some of the heavy sandstones in the base of the Chestnut Ridge sandstone of those areas. Willard (1936, p. 573) has indicated that the "Pocono" of central Pennsylvania north of Harrisburg can be divided into three members, the "Berea" at the base, the Peters Mountain formation in the middle, and the "Burgoon" at the top. Due to the lack of connecting outcrops and to the uncertain age of this sequence it does not seem reasonable to try to correlate the Lick Run Conglomerate with this "Berea".

Historical Interpretation

The flat nature of some of the quartz pebbles would suggest a littoral or shoreline type of deposit for this conglomerate. If it were a shoreline type of deposit it is possible that the shells of animals which lived there were so ground up by wave action that no fossil remains can be found.

In view of the fact that this conglomerate appears to be rather closely associated with the overlying, apparently continental Chestnut Ridge sandstone, it may be that they were derived from the same source, namely some land mass to the southeast. In this respect these beds differ from their northwestern Pennsylvania approximate equivalents

which were apparently derived from a source to the northwest.

Chestnut Ridge sandstone

Name and definition

The name Chestnut Ridge sandstone^{34/} is herein being proposed for

^{34/} Termed Sandstone J by the author in Progress Rept. 126, Pennsylvania Geol. Survey, p. 16, 1941.

the massive sandstone beds between the Lick Run conglomerate and the Loyalhanna sandy limestone in the inlier areas of Fayette County. In the Broad Top area, the name is applied to the massive sandstones between the top of the Riddlesburg shale and the base of the Mauch Chunk shale. On the Allegheny Front the Chestnut Ridge beds are those between the top of the Riddlesburg shale (where present) and the base of the Loyalhanna sandy limestone, or the base of the Mauch Chunk where the Loyalhanna is absent. Where the Riddlesburg is absent along the Front, the basal contact is difficult to draw due to the gradational appearance of "Pocono"-like beds in the top of the Catskill sequences of the Upper Devonian. (These "Pocono" beds are in reality the next sourceward magnafacies from the Catskill belt.)

Occurrence

The Chestnut Ridge sandstone is widely exposed. It occurs on both flanks of the Chestnut Ridge and Laurel Hill anticlines. Particularly good exposures are found in the Youghiogheny gorge (Laurel Hill) in southeastern Stewart township; Youghiogheny gorge (Chestnut Ridge)

along the northern edge of Dunbar township; Summit (Chestnut Ridge) inlier in southeastern North Union township, all in Fayette County. The exposure of the Chestnut Ridge sandstone in the Summit inlier on Route 40 near the "Turkey Nest Inn", about $1\frac{1}{2}$ miles east of Hopwood, is the type locality. The Conemaugh gorge (Chestnut Ridge) in northern Derry and Fairfield townships of Westmoreland County, and southeastern Burrell township of Indiana County; and the Conemaugh gorge northwest of Johnstown, where Westmoreland, Indiana and Cambria Counties join, also shows good exposures of the Chestnut Ridge beds.

The Chestnut Ridge sandstone is also well exposed in many places along the Allegheny Front. Particularly good outcrops for study are found west of Altoona along Route 36 in western Logan township in Blair County, and along the Pennsylvania Railroad where it ascends the Front south of Route 36 in the same township.

In the Broad Top area, several exposures occur on both sides of the Broad Top syncline. Excellent exposures are noted along the Huntingdon and Broad Top Mountain Railroad on the western flank of the syncline, $2\frac{1}{2}$ miles north of Riddlesburg, in eastern Liberty township in Bedford County. Another good section, also on the western flank of the syncline, occurs along Shoup Run 1 mile east of Saxton, in the southwestern corner of Hopewell township, Huntingdon County.

Lithology

The Chestnut Ridge sandstone is dominantly a brown-grey, micaceous sandstone with some interbedded grey shales. The sandstones are fine- to-medium-grained, and exhibit a fair degree of sorting in most places;

clay galls are occasionally found. The individual beds of the member are massive (from 1 to 5 feet thick) and the bedding surfaces are very irregular. Disconformities, indicating an irregular mode of deposition, are numerous. Cross-bedding is abundant with some of the cross-bedding planes having amplitudes of approximately 2 feet.

Some of the interbedded shales are very micaceous and also quite thin-bedded (1 inch or less). The shales found near the base of the Chestnut Ridge member in the Summit (Chestnut Ridge) inlier resemble the Riddlesburg shale very closely but are devoid of fossils.

Most of the good exposures of the Chestnut Ridge sandstone occur on the flanks of large folds, consequently they show numerous faults, both reverse and normal, as well as many small folds. Faulting, particularly interbed faulting, make it difficult to deduce the correct stratigraphic relationships and thicknesses of the various beds of the member. The shale beds are often faulted out or badly squeezed and distorted. Structural and stratigraphic relationships of this type are well shown in the deep cut along Route 40 in the Summit inlier 1 mile east of Hopwood near the "Turkey Nest Inn".

Thickness

The thickness of the Chestnut Ridge varies considerably. In the Youghiogheny gorge (Laurel Hill) in Fayette County, the sandstone is only 142 feet thick, but this is so much less than thicknesses found elsewhere that erosion subsequent to its deposition must be considered a likely cause. In the Youghiogheny gorge (Chestnut Ridge) in Fayette

County it is 569 feet thick.

The member apparently thickens northeastward, for in the Conemaugh gorge (Chestnut Ridge) a thickness of 478 feet is exposed. In the Conemaugh gorge (Laurel Hill) northwest of Johnstown, the Chestnut Ridge member measures 700 feet.

From the Conemaugh gorges eastward there is a decrease in thickness to the Allegheny Front, for along the Pennsylvania Railroad west of Altoona the sandstone measures 530 feet exclusive of the Riddlesburg shale. Interestingly enough, there appears to be a thinning of the Chestnut Ridge southwestward along the Allegheny Front. In the western part of Juniata township, Bedford County, at the point where Route 30 crosses the Allegheny Front, 40 miles southeast of Altoona, it is only 229 feet thick. This thinning continues southward to Keystone (approximately 23 miles south of Route 30) in the southwestern corner of Larimer township, Somerset County, on the north bank of Flaugherty Creek along the Baltimore and Ohio Railroad, where the beds which can be without question assigned to the Chestnut Ridge total only 54 feet.

Approximately 12 miles southeast of Keystone, along the Western Maryland Railroad near Corriganville in the northeast corner of Mount Savage township, Allegheny County, Maryland, the Chestnut Ridge is 137 feet thick. The thinness of this member in these more southern outcrops presents a problem. No detailed studies were made here, due to lack of time, but several important aspects of these sandstones and associated beds are noteworthy.

One feature noted was the assumption of a dark red color (similar to the color of the Mauch Chunk shale) by the overlying cross-bedded Loyalhanna sandy limestone. This phenomenon was particularly seen in the Keystone and Corriganville sections. This color rather sharply delimits it from the underlying grey sandstone of the Chestnut Ridge member. Another feature noted was the occurrence in, or just below the basal boundary of the Chestnut Ridge, of shale beds which had a slightly red coloration. The problem here is where should the exact base be drawn - whether or not some of the red shale should be included in the Chestnut Ridge. Consistently, the author has excluded all red beds from the basal part of the old "Pocono" formation because no place where the basal Mississippian, Riddlesburg shale intervenes between the Chestnut Ridge and the Upper Devonian red beds, have red beds been seen in the Chestnut Ridge. Therefore all red shales were excluded from the base of the Chestnut Ridge here, although no Riddlesburg shale is present.

Relation to adjacent members

The Chestnut Ridge sandstone is in disconformable relationship with the Lick Run conglomerate in Fayette County. On the Allegheny Front, where the contact has been observed, it is sharp but apparently conformable with the top of the Riddlesburg shale. When the Riddlesburg shale is absent the contact with the Upper Devonian is, of course, disconformable, but hard to determine due to the presence of beds of similar lithology in the top of the "Catskill" red beds. In the Broad Top area the contact has been seen both as a slightly gradational contact

and as a sharp but apparently conformable one.

The contact with the overlying Loyalhanna is sometimes gradational and sometimes disconformable. A disconformable contact can be seen along the Western Maryland track in the Youghiogheny gorge (Chestnut Ridge), approximately 2 miles southeast of Connelsville in Fayette County. An apparently gradational contact can be seen along the Pennsylvania Railroad where it ascends the Allegheny Front through the gorge of Sugar Run several miles southeast of Altoona.

Fauna

No marine fossils were found in the Chestnut Ridge sandstone. Scarce and poorly preserved plant fragments were occasionally seen.

Correlation

The sandstone beds herein called the Chestnut Ridge constitute the bulk of what was formerly called the "Pocono" in western Pennsylvania. The "Pocono" has been generally regarded^{35/} as basal Mississippian in age.

^{35/} For example, see Schuchert, C., and Dunbar, C., Textbook of Geology, Part II — Historical Geology, p. 230; New York, John Wiley and Sons, Inc., 1941, and Moore, R. C., Historical Geology, p. 267, 270; New York, McGraw Hill Book Co., Inc., 1933.

but recent works (e. g. Caster, 1941, pp. 145-148; Chadwick, 1935, pp. 133-143) have pointed out that the type area of the "Pocono" in the Pocono Plateau in reality contains in the main, if not entirely, rocks

which can with certainty be assigned to the Upper Devonian.

In terms of the type Mississippian section, Schuchert and Dunbar (Table, p. 230) indicate that the "Pocono" of the Appalachian region is approximately equivalent to the Kinderhook group of the Iowan series. On the margin of this table the "Pocono" is represented as extending from basal Kinderhookian upward to approximately the base of the St. Genevieve limestone with the upper boundary indefinite.

There are several reasons for discarding the term "Pocono" in favor of the term Chestnut Ridge for these western Pennsylvania sandstones. (1) The implied as well as the expressed statements of several reports dealing with this area have been that the unfossiliferous "Pocono" is the base of the Mississippian, particularly in the inlier area of Fayette County. The present study has shown that fossiliferous Mississippian strata occur almost everywhere in southwestern Pennsylvania below the old "Pocono" beds. Therefore the old name did not always entirely cover the basal Mississippian sequence. (2) Because of the doubt as to the age of the "Pocono" of the type area, it does not seem advisable to continue the term. (3) The suggestion has been made by both Caster and Chadwick that the eastern "Pocono" of northeastern and central Pennsylvania probably is a facies phenomenon of the Upper Devonian. This is also suggested at least by an isopach map of the reported occurrences of the "Pocono" made during the course of this study, (Figure 14). The isopachs show two zones of thickening, one in eastern Pennsylvania and the other just west of and

roughly parallel to the Allegheny Front, separated by a zone of thinning which roughly parallels the Appalachian structural front. This thickening and thinning is peculiar in a formation which is supposed theoretically to thicken eastward as a delta deposit.^{36/} (4) In some

^{36/} op. cit., Schuchert and Dunbar, p. 230.

cases, red shales and some "Pocono"-like sandstone beds have been included in the base of the old "Pocono" formation (Butts, 1905, p. 3). This has lead to many difficulties in the exact delimitation of the member. (5) The term "Pocono" has also been used (Butts, idem.) in a rather inclusive formational sense which included the Loyalhanna sandy limestone as a member. While the Loyalhanna is closely associated with the beds herein named Chestnut Ridge, it is definitely a separate member and should not be included with the underlying sandstones. (6) The term "Burgoon" has been used by Butts for approximately the upper 300 feet of the old "Pocono". This member has been widely used for correlation purposes in western Pennsylvania in the oil fields.^{37/} In the well

^{37/} See the various U. S. Geological Survey folios for western Pennsylvania.

records it is called the "Burgoon" or the "Big Injun Sand" but often, particularly in the more western parts of Pennsylvania where the Mauch

Chunk and the Loyalhanna are absent, the Pottsville sandstone of the Pennsylvanian system is included in the upper part of the "Burgoon" on the well records. (7) Willard (1936, p. 573) has divided the "Pocono" of central Pennsylvania north of Harrisburg into three members. These are: the "Berea" at the base, the Peters Mountain in the middle, and the "Burgoon" at the top. Due to the lack of connecting outcrops and to the doubt as to whether or not these central Pennsylvania beds are actually the correlates of their namesakes or Mississippian in age, it does not seem reasonable to attempt at this time any correlations between these "Pocono" beds and the western Pennsylvania basal Mississippian.

Because of the foregoing objections, it seems advisable to introduce a new and meaningful stratigraphic term for the sandstone beds which lie between the top of the Riddlesburg shale or the top of the Lick Run conglomerate and the base of the Loyalhanna sandy limestone or the base of the Mauch Chunk shale where the Loyalhanna is absent. The name Chestnut Ridge has been chosen because of the good exposures of the sandstone in numerous transverse streams cutting this anticlinal structure.

Due to the lack of fossil remains, the regional correlation of this member presents considerable difficulty. Also, the relationship of this member to localities where fossils are preserved has not been as yet carefully studied. The difficulty is magnified somewhat along the Allegheny Front and in the Broad Top area because the exact equiva-

lents of the upper part of the underlying Riddlesburg shale in terms of the northwestern Pennsylvania section are not known, nor can this be immediately determined because of lack of fossils in the upper part of the Riddlesburg.

The Riddlesburg shale as a whole is tentatively correlated with the greater part of the Oil Lake series with the possible exception of the Berea stage. Therefore it appears probable, on the basis of stratigraphic position alone, that in terms of the northwestern Pennsylvania section, the Chestnut Ridge terrane embraces stratigraphic equivalents from possibly basal Berea upward including perhaps the Shenango and Meadville stages of the Kinderhook series. (See Table 2 for correlations.)

Table 2. Correlation chart of the Upper Devonian and Lower Mississippian of western Pennsylvania.

Historical Interpretation

For several reasons, noted later, it seems apparent that these beds are continental in origin. However, it is difficult to tell in exactly what type of environment they were deposited.

The deposits of the Chestnut Ridge are variable in thickness but apparently tend to thicken generally in an eastward direction. Part of this variation is due probably to erosion subsequent to deposition. The apparent coarsening and thickening of the sandstone in an easterly

			Northwestern Pennsylvania	Southwestern Pennsylvania	Allegheny Front Broad Top
MISSISSIPPIAN SYSTEM	Kinderhook	Shenango	Hempfield shale Shenango sandstone	Chestnut Ridge sandstone	Chestnut Ridge sandstone
		Headville	Custards shale French Creek limestone Harvest Home shale Byham limestone Sharpsville sandstone West Mead limestone Shaws sandstone Orangeville shale		
	Oil Lake	Berea	Corry sandstone	Lick Run conglomerate	Riddlesburg shale
		Cussewago	Hayfield shale Littles Corner limestone Tidioute shale Cobham conglomerate East Kane shale Wetmore conglomerate Kushequa shale	Chiopyle sandstone Pine Knob member Linderman sandstone (Hopwood member)	
DEVONIAN SYSTEM	Conewango	Riceville	Oswayo shale Roystone coquinite	Jumonville sandstone	"Catskill" red beds
		Venango	Woodcock sandstone Hosmer Run conglomerate Tuna-Killbuck conglomerate Saegerstown shale Pope Hollow conglomerate North Warren shale Bimber Run conglomerate Amity shale Dutchman's conglomerate Panama conglomerate	Watering Trough shale Youghiogheny member	
	Chautauquan	Conneaut	Chadakoin beds Hinsdale sandstone Volusia shale Cuba sandstone	Maple Summit member	

Table 2. Correlation chart of the Upper Devonian and Lower Mississippian of western Pennsylvania.

direction would suggest that the source of sediments for the Chestnut Ridge and probably also the Lick Run conglomerate was somewhat to the east and southeast. It has been noted in another part of this report that the eastern Pennsylvania equivalents of what have been called "Pocono" may be actually near-source facies expressions of the Upper Devonian. If this is the case it does not seem unlikely that their erosion should have furnished sediments for the western Pennsylvania Chestnut Ridge sandstone which would strongly resemble the eastern Pennsylvania beds (of Upper Devonian age). This is a matter which can probably be solved by sedimentary petrography.

Twenhofel (1932, p. 803) has listed the characteristics of sediments deposited on a piedmont. A number of the criteria listed do not appear applicable to the Chestnut Ridge sandstone, yet the lack of fossils, the presence of plant fragments, the cross-bedding and to a certain extent the sometimes irregular bedding surfaces suggest that the Chestnut Ridge has been deposited in a continental environment. Therefore it is tentatively suggested that the Chestnut Ridge was deposited on land in the form of numerous coalescing piedmont, alluvial fans.

In certain places the Chestnut Ridge sandstones are fairly well sorted except for occasional clay galls which may have been derived locally. This degree of sorting is not usually found on a piedmont alluvial fan. If, however, the sediments were derived from pre-existing, well-sorted sandstones, the sorting of the present member could

be expected.

Twenhofel (p. 802) notes that small basins may form on a piedmont surface due to the coalescence of two fans along their lower outer margins. In these basins lakes or swamps may form whose deposits might dovetail with the rest of the alluvial deposits. Such basins might be the source of the clay galls which are found in the sandstone. In these depressions also, coals may have formed. Coals possibly of this type have been reported by Grimsley (1916, p. 346) from the "Pocono" of West Virginia. No coals were found by the writer in the "Pocono" of Pennsylvania although thin coals have been reported from the Sideling Hill section of the "Pocono".

It would, therefore, appear that this piedmont deposit was formed on the west side of an upland area which was rapidly furnishing sediments to the alluvial plain to the west. This source had temporarily been quiescent during the early part of the Mississippian when the Riddlesburg shale was deposited. After the initial quiescent period sediments were abundantly supplied to the southeastern and eastern edge of the Penn-York Embayment, causing the shoreline to again move westward.

FAUNAS

General Statement

This study was concerned primarily with the stratigraphic aspects of the Upper Devonian and Lower Mississippian of southwestern Pennsylvania. While the lithology of the various members delimited in southwestern Pennsylvania was fairly distinct, it was necessary to use the faunas they contained for precise correlation. When regional correlations were attempted the organic remains of the various members offered the only reliable means.

The unstudied nature of these Upper Devonian and particularly the Lower Mississippian faunas in western Pennsylvania was forcibly brought to the writer's attention when he endeavored to identify the fossils collected during this study. While by no means completely studied, the Conewango faunas are in better shape than the other faunas of the area.^{38/}

^{38/} See Flower, R. H., Caster, K. E., The stratigraphy and paleontology of northwestern Pennsylvania, Part II, Paleontology, Section A; The cephalopod fauna of the Conewango series of the Upper Devonian in New York and Pennsylvania: Bull. Am. Paleontology, vol. 22, p. 1-74, 1935.

Caster, K. E., Higher fossil faunas of the upper Allegheny: Bull. Am. Paleontology, vol. 15, p. 1-174, 1930.

See also James Hall's numerous volumes on the Paleontology of New York.

Chadwick (1935, pp. 326, 328) has called attention to the fact that both the Conneaut and Canadaway have small reported faunas due to the fact they have not been adequately collected. The Lower Mississippian faunas are in even worse shape from the standpoint of systematic description as practically no work has been done on them. Therefore, because of lack of description or because many of the early descriptions were so inadequate, it was necessary to compare the southwestern Pennsylvania forms directly with fossils collected from known northwestern Pennsylvania localities before any correlations could be attempted. Fortunately there were available in the paleontology museum of the department of Geology of the University of Cincinnati, collections from northwestern Pennsylvania with which such comparisons could be made.

From the foregoing it is hardly necessary to point out that faunal lists separated from the specimens on which they were based have little value in correlation in the Upper Devonian and Lower Mississippian of western Pennsylvania. This has been one of the major difficulties in this area and has lead to many stratigraphic miscorrelations. It should also be pointed out here that further refined stratigraphic studies await adequate systematic faunal studies. In the Upper Devonian, particularly where there are rapid lithologic facial changes, fossils provide the only adequate means of precise correlation. It is hoped that monographic treatment of these faunas will soon be completed.

It will be noted on the accompanying biotic chart that many of the forms are only comparatively or tentatively identified. Some lack

specific labels. This is occasionally due to poor preservation but in many cases it is due to the undescribed nature of the faunas. Thus the faunal list is as accurate as it is possible to make it, but probably, like many faunal lists, it will have little value to anyone but the writer. However, it does serve to call attention to the faunal break between the Devonian and the Mississippian in southwestern Pennsylvania.

Faunal break between the Devonian and Mississippian

In preparation of the following chart only those fossils collected during the course of this study were used. The faunal lists of other authors were not used because (1) in many instances the definite stratigraphic horizon from which the fossils were derived was not given, and (2) in most cases the faunal lists were of a most generalized sort and since they were unaccompanied by either descriptions or figures, it is impossible to tell exactly what fossil the author had before him. Considerable care must be taken to catch subtle differences between certain of the uppermost Devonian and basal Mississippian fossils. Others are so obvious that it is hard to understand how they fail to appear in earlier faunal lists.

In order to determine the magnitude of the faunal break between the Devonian and Mississippian of southwestern Pennsylvania, a faunal count was made of those fossils which carry through from one system to the other, those which drop out at the end of the Devonian and those which start at the beginning of the Mississippian. In the accompanying bio-

tic chart, certain forms are questionably identified due to poor preservation or immaturity. Because of their indeterminate nature, they are not included in the faunal count.

After the questionable fossils were eliminated from the count, there remained 165 forms. Twenty-two of these carried through from the Devonian into the Mississippian. Sixty-three of the fossils are confined to the Devonian and 80 are found only in the Mississippian. Thus it appears that there is as significant a faunal break between the Devonian and Mississippian in southwestern Pennsylvania as between these systems in northwestern Pennsylvania. This systemic break in southwestern Pennsylvania is also marked by a lithologic disconformity, but it is so slight that it would hardly be noticed if the fossils were disregarded.

Table 3. Biotic chart of the Upper Devonian and Lower Mississippian of southwestern Pennsylvania.

Table 3

Biotic chart of the Upper Devonian and Lower Mississippian
of southwestern Pennsylvania

	Maple Summit	Youghiogeny & Watering Trough	Jumonville	Linderman	Pine Knob	Chiopyle	Riddlesburg
<i>Athyris</i> cf. <i>angelica</i> Hall		x	x	x	x		
<i>A. angelica</i> var. nov				x			
<i>Camarotoechia</i> aff. <i>allegania</i> (Williams)			x				
<i>C. contracta</i> Hall			x	x	x	x	x
<i>C. cf. contracta</i> Hall				x			
<i>C. aff. contracta</i> Hall	x		x	x			x
" <i>C. (?) sappho</i> Hall"		x	x	x			
<i>C. aff. sappho</i> Hall			x				x
<i>Chonetes acutiliratus</i> Girty							x
<i>C. scitulus</i> Hall						x	
<i>C. sp. 1</i>			x				
<i>C. sp. 2</i>				x	x		
<i>Crania (?) sp.</i>			x				
<i>Eumetria scansa</i> (Hall)				x	x		
<i>Lingula randalli</i> Girty				x			

	Maple Summit	Youghiogheny & Watering Trough	Jumonville	Linderman	Pine Knob	Chiopyle	Riddlesburg
<i>L. cf. scutella</i> Hall					x		
<i>L. sp.</i>		x	x				
<i>Oehlertella</i> (?) <i>cf. pleurites</i> Meek			x	x	x		x
<i>O. sp.</i>				x			x
<i>Orbiculoidea aff. randalli</i> Hall			x	x	x		
<i>O. sp.</i>			x				x
<i>Orthotetes sp.</i>				x			
<i>Productella cf. hirsuta</i> Hall			x			x	
<i>P. cf. onusta</i> Hall					x		
<i>P. cf. speciosa</i> Hall				x	x		
<i>P. sp.</i>				x			
<i>Rhipidomella huntingdonensis</i> Girty							x
<i>R. cf. huntingdonensis</i> Girty						x	
<i>Schellwienella sp.</i>				x	x	x	x
<i>Schuchertella chemungensis</i> (Conrad)			x				
<u>2/</u> <i>S. ? sp.</i>				x			
<i>Spirifer compositus</i> Girty							x
" <i>S. disjunctus</i> " Sowerby	x	x	x	x			

	Maple Summit	Youghiogheny & Watering Trough	Jumonville	Linderman	Pine Knob	Chiopyle	Riddlesburg
<i>S. disjunctus</i> var. "warrensis" Caster ms.		x	x				
<i>S. disjunctus</i> var. "pine-knobensis" Laird ms.					x	x	
<i>S. sp.</i> (immature) ^{2/}						x	
<i>Strophalosia muricata</i> (Hall)			x				
<i>Syringothyris</i> cf. <i>angulata</i> Simpson				x	x	x	x
<i>S. cf. randalli</i> Simpson						x	
<i>S. sp.</i>							x
<i>Aviculopecten</i> aff. <i>duplicatus</i> (Hall)			x				
<i>A. aff. celsus</i> Hall					x		
<i>A. patulus</i> Hall			x				
<i>A. aff. patulus</i> Hall					x		
<i>A. striatus</i> Hall			x				
<i>A. sp.</i> (large smooth)			x				
<i>A. sp.</i>			x				
<i>Cypricardinia consimilis</i> Hall							x
<i>C. cf. consimilis</i> Hall						x	
<i>C. aff. consimilis</i> Hall						x	

	Maple Summit	Youghiogheny & Watering Trough	Jumonville	Linderman	Pine Knob	Chiopyle	Riddlesburg
C. sp. 1							x
Edmondia cf. burlingtonensis (White & Whitfield)					x		
E. ellipsus Hall					x		
E. cf. ellipsus Hall ^{3/}					x		
E. cf. phillipi Hall					x		
E. cf. subovata Hall			x		x		
"Elymella" cf. chadwicki Caster		x					
"E." sp. 1		x					
"E." sp. 2		x					
Goniophora cf. alata Hall				x			
G. cf. chemungensis Vanuxem			x				
G. aff. chemungensis Vanuxem				x			
G. cf. glaucus Hall				x			
G. sp.				x			
Grammysia communis Hall			x				
G. aff. duplicata Hall			x				
G. cf. hannabalensis (Shumard)				x	x		

	Maple Summit	Youghiogheny & Watering Trough	Jumonville	Linderman	Pine Knob	Chiopyle	Riddlesburg
<i>G. cf. subarcuata</i> (Hall)			x				
<i>G. aff. undata</i> Hall			x				
<i>G. sp.</i>					x		
<i>G. (?) sp. (long form)</i>			x				
<i>Leda aff. spatulata</i> Herrick ^{4/}							x
<i>Leptodesma aff. disparile</i> Hall			x				
<i>L. aff. jason</i> Hall	x						
<i>L. aff. lichas</i> Hall	x						
<i>L. maclurii</i> Hall			x				
<i>L. aff. matheri</i> Hall						x	
<i>L. mentor</i> var. <i>alpha</i> Caster				x	x		
<i>L. mentor</i> var. <i>maxima</i> Caster				x	x		
<i>L. mentor</i> var. <i>orodes</i> (Hall) ^{5/}				x	x		
<i>L. mentor</i> var. <i>sulcata</i> Caster				x	x		
<i>L. cf. mortoni</i> Hall			x				
<i>L. orodes</i> Hall	x		x				
<i>L. cf. orodes</i> Hall	x						
<i>L. cf. potens</i> Hall		x	x				
<i>L. cf. sociale</i> Hall	x		x				

	Maple Summit	Youghiogheny & Watering Trough	Jumonville	Linderman	Pine Knob	Ohio	Riddlesburg
<i>L. aff. sociale</i> Hall				x	x		
<i>L. cf. stephani</i> Hall			x				
<i>L. sp. 1</i>	x						
<i>L. sp. 2</i>		x					
<i>L. sp. 3</i>			x				
<i>L. sp. 4</i>				x			
<i>L. sp. (immature)</i> ^{2/}			x				
<i>Modiola (Mytilops) praecedens</i> Hall				x			
<i>M. cf. praecedens</i> Hall		x					
<i>Modiomorpha aff. concentrica</i> (Conrad)					x		
<i>Mytilarca cf. simplex</i> Hall				x	x	x	
<i>Oleanella sp.</i>	x						
<i>Palaeonatina solenoides</i> Hall	x						
<i>Palaeoneilo cf. brevis</i> Hall			x	x	x		
<i>P. aff. brevis</i> Hall						x	
<i>P. concentricus</i> Winchell							x
<i>P. concentricus</i> Winchell var. 1						x	x
<i>P. concentricus</i> Winchell var. 2,3						x	
<i>P. elongata</i> Hall			x				

	Maple Summit	Youghiogheny & Watering Trough	Jumonville	Linderman	Pine Knob	Chiopyle	Riddlesburg
<i>P. cf. elongata</i> Hall					x	x	x
<i>P. aff. maxima</i> (Conrad)				x?	x		
<i>P. sp.</i> 1, ^{6/} 2				x	x		
<i>P. sp.</i> 3, 4, 5				x			
<i>P. sp.</i> 6, 7, 8, 9					x		
<i>P. sp.</i> (Dev.)			x				
<i>Pararca neglecta</i> Hall			x				
<i>P. sao</i> Hall			x				
<i>P. cf. sao</i> Hall					x		
<i>P. transversa</i> Hall			x				
<i>P. cf. venusta</i> Hall					x		
<i>P. sp.</i>					x		
<i>Paracyclas rotunda</i> (Hall)					x		
<i>P. (?) sp.</i> ^{2/}			x	x			x
<i>Prorhynchus quadratum</i> Hall			x				
<i>Pteronites cf. profundus</i> Hall	x						
<i>P. (?) sp.</i> ^{2/}	x						
<i>Ptychopteria cf. beecheri</i> Hall			x				

	Maple Summit	Youghiogheny & Watering Trough	Jumonville	Linderman	Pine Knob	Oni opyle	Riddlesburg
<i>P. cf. eucrate</i> Hall			x				
<i>P. cf. sao</i> Hall			x				
<i>Sanguinolites undulatus</i> Hall			x				
<i>Schizodus aff. appressus</i> (Conrad)	x			x			
<i>S. aff. chemungensis</i> (Conrad)	x					x	
<i>S. aff. chemungensis</i> var. <i>quadrangularis</i> Hall	x		x				
<i>S. cf. contractus</i> Hall			x	x			
<i>S. aff. patulus</i> (Hall)		x					
<i>S. sp. 1, 2</i>	x						
<i>Paleosolen sp.</i>				x			
<i>Sphenotus cf. arcuatus</i> Hall	x						
<i>S. clavulus</i> Hall			x				
<i>S. aff. clavulus</i> Hall		x	x				
<i>S. contractus</i> Hall	x		x				
<i>S. cf. contractus</i> Hall			x	x			
<i>S. palmerae</i> Caster			x				
<i>S. sp.</i>		x					
<i>S. sp. (new genus?)</i>			x				

	Maple Summit	Youghiogheny & Watering Trough	Jumonville		Linderman	Pine Knob	Chiopyle	Riddlesburg
Pelecypod indet. no. 1 ^{2/}		x	x					
Pelecypod indet. no. 2 ^{2/}					x			
Pelecypod indet. no. 3 ^{2/}					x	x		x
Pelecypod (large) ^{2/}			x					
Pectinoid pelecypod ^{2/}			x					
Bellerophon sp			x		x			
Conularia sp.							x	x
Igoceras cf. breve Simpson						x		
Loxenema sp.					x			
Pleurotomaria aff. hickmanensis Winchell ^{4/}								x
P. sp. 1 (small)	x		x		x			
P. sp. 2 (large)			x					
"Spirorbis" sp.								x
Pteropod		x			x	x	x	
Bradfordoceras sp.		x			x			
E. (?) sp.							x	
Neocycloceras obliquum Flower & Caster		x	x		x	x		

	Maple Summit	Youghiogheny & Watering Trough	Jumonville	Linderman	Pine Knob	Chiopyle	Riddlesburg
N. (?) sp. ^{2/}				x			
Cephalopod (Nautiloid)? ^{2/}			x			x	
Bryozoa, Trepostomata ^{2/}			x				
Bryozoa, frondose ^{2/}			x	x	x		
Bryozoa, incrusting ^{2/}			x				
Bryozoa, ramose ^{2/}	x		x		x		x
Rhopalonaria sp.				x			
Otenodus nelsoni Newb.				x			
Fish scales		x	x				
Scaphiocrinus sp.							x
Crinoid stems ^{2/}			x		x		x
Titusvillia sp. nov						x	
Dictyosponge				x	x		
"Protolimulus" trail		x		x			
"Worm" burrows	x	x	x				
Ostracods? ^{2/}							x
Echinocaris socialie Beecher			x				
Plants ^{2/}	x			x	x		x

- 1/ Maple Summit member is being assigned only tentatively to the Conneaut stage.
- 2/ Form excluded from faunal count because of indeterminate nature.
- 3/ This pelecypod of Edmondia aspect may be a new genus. It is possible that all forms of "Edmondia" identified in southwestern Pennsylvania may belong to an undescribed genus.
- 4/ Girty, 1927.
- 5/ Similar to form shown by Caster as var. orodes but apparently not Hall's orodes.
- 6/ The Palaeoneilo species which are numbered may be assignable to a new genus of Protobranchiate mollusca. The dentition has not been determined from any of the material.

PALEOGEOGRAPHY

General Statement

One of the aims of stratigraphic research is to decipher, insofar as possible, the geologic history of the region under consideration. To do this it is necessary to delimit the ancient lands and seas of the time and if possible to determine the conditions under which the various rocks in the area under consideration were formed.

It is well known that the Appalachian geosyncline was, by Upper Devonian time, fairly well filled and that continental sediments were pushing rapidly westward at the expense of the marine sediments. As has been shown by a number of authors (Barrell, 1913, 1914; Caster, 1934, p. 1-185; Mencher, 1939, p. 1761-1794; Willard, 1939) this westward progression started in Hamilton or even Onondagan time and continued with only minor eastward progressions until the end of Devonian time.

According to Caster (1934, p. 20) the Upper Devonian sea was centered in the west and mid-western parts of North America and an embayment, or "delta geosyncline" (Kay, 1941) which Caster termed the Penn-York, extended eastward across southern New York and northeastward across Pennsylvania. The exact northward limits of this embayment are not known as all sediments in that direction have been eroded.

This estuary in a somewhat modified form existed in the very earliest Mississippian, but shortly after the deposition of the basal Mississippian sediments it was filled as the sea was driven westward and

the embayment ceased to exist as an area of marine sedimentation.

While there is a systemic break in the sediments of the areas under discussion, it must be emphasized that the Upper Devonian and Lower Mississippian sediments are closely related. This is particularly shown in their faunal relationships. However, the faunas are sufficiently distinct that there should be no confusion regarding them.

Figure 12. Paleogeographic map showing approximate position of the Upper Devonian and Lower Mississippian shorelines. The Upper Devonian shoreline was drawn primarily on the basis of the westernmost extension of red beds at the very end of Upper Devonian time. The possible Lower Mississippian shoreline was drawn primarily on the basis of the easternmost fossils found in the Lower Mississippian beds.

Upper Devonian Paleogeography

A complete picture of the Upper Devonian facies deposits must also include something about the highland undergoing erosion to furnish the sediments to the seaway and the alluvial plain between the highland and the inland sea. This highland was, according to Barrell, (1913, 1914) being eroded under semi-arid conditions. The rivers of this upland area poured a flood of sediments into the low areas to the west and northwest. Part of the sediment came to rest on an alluvial plain at the foot of the mountains while the rest was deposited in a shallow sea west of the alluvial plain. Barrell pictures subaerial deltas

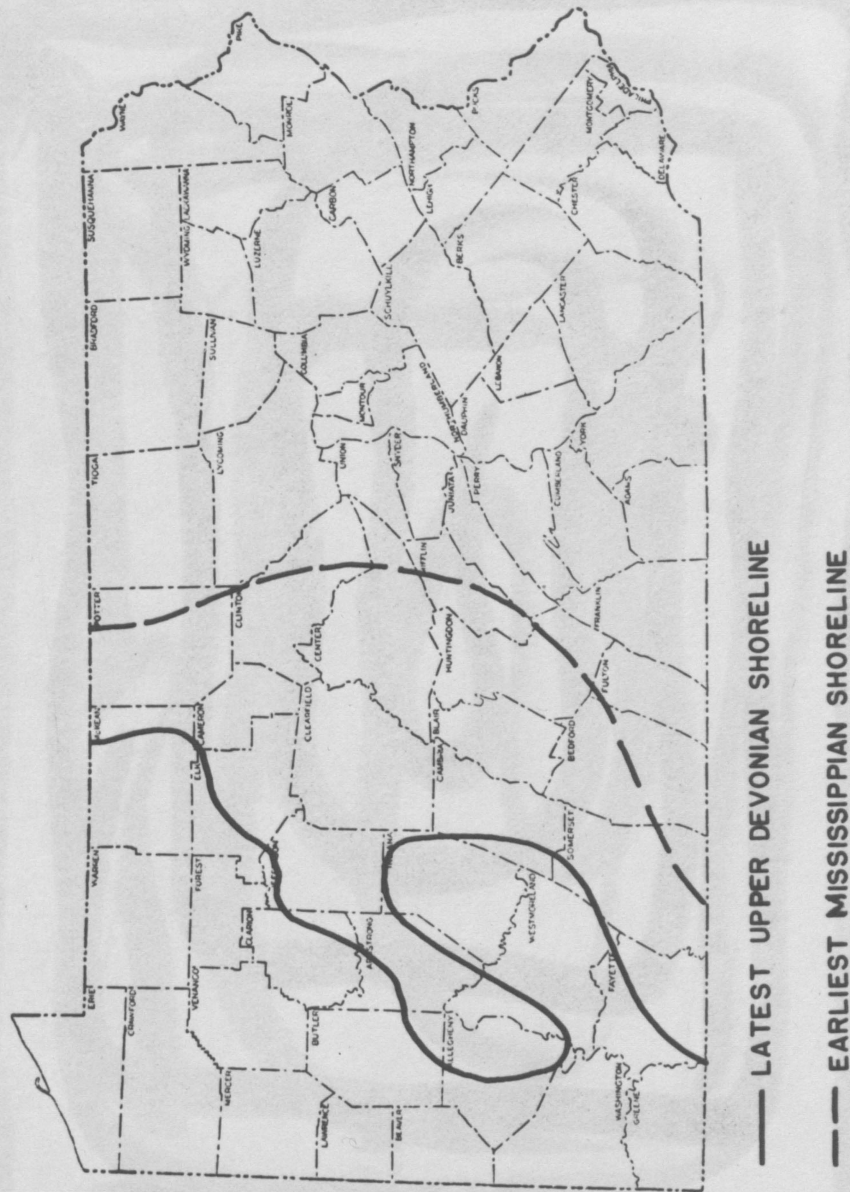


Figure 12. Paleogeographic map showing approximate position of the Upper Devonian and Lower Mississippian shorelines. The Upper Devonian shoreline was drawn primarily on the basis of the westernmost extension of red beds at the end of Upper Devonian time. The possible Lower Mississippian shoreline was drawn primarily on the basis of the easternmost fossils found in the Lower Mississippian beds.

growing out of the highlands to the east, northeast, and southeast, making what he termed a confluent piedmont plain and delta front. Mencher (1939, p. 1786) has recently pointed out that these deposits are not deltaic in the ordinary sense of the word as the term "delta" "... usually implies the deposition of stream-carried material in a standing body of water such as a lake or sea." These "Catskill" beds, Mencher maintains, were deposited for the most part on an alluvial plain under subaerial conditions between the mountains and the inland sea to the west.

The red color of the "Catskill" sediments has been a problem for some time. Barrell postulated a semi-arid climate with a succession of wet and dry seasons. During the wet seasons, the streams from the highlands on the east and southeast carried considerable amounts of sediment to the alluvial coastal plain and the inland sea to the west. Then, during the dry season, the small amount of ferrous iron in the sediments deposited on land oxidized, changed to a ferric state, and thus the sediments received their red color. Willard, (1939, p. 375) citing Raymond (1927, p. 234-251) primarily, indicated that the climate need not have been semi-arid to produce the red color and points to the abundance of plant and animal remains (particularly fish remains) as evidences of abundant plant and river animal life of that period. He postulated that the sediments collected under humid climatic conditions. As an evidence that red soils accumulate under humid conditions, he points to the red lateritic soils of the southern Appalachian region.

Therefore, Willard believes that the red color of the sediments was derived from red soils eroded from the deeply decayed regolith lying on the old land surface to the east and southeast. Thus Willard holds to a primary origin of the red color of these sediments and Barrell held to a secondary origin of the coloration.

Mencher offers two possibilities as to the climate during the deposition of the red beds. (1) He thinks that the abundance of greywacke indicates that the climate was not arid all the year and that the red beds may have been deposited on the flood plain or on the top of the subaerial delta where they were exposed for a long time to the atmospheric action. He also believes that these deposits may have been in the rain shadow of the Devonian highlands so that even though the climate was relatively humid elsewhere, it was semi-arid here. (2) His other statement (p. 1784) is simply that "there is basis for assuming a semi-arid condition for a short period in the Later Devonian". He does not amplify this. The difficulty with such statements or any statements regarding the climate of past geologic ages is that we do not have enough evidence to postulate wind direction, etc., as we do not know whether or not the planetary wind systems were like those of today.

It is a well-known fact that non-red marine beds were accumulating westward of the Catskill magnafacies. It is less well-known, although several times pointed out by Caster (1934, p. 22-23) and Chadwick (1936, pp. 92-94, Fig. 3,4) that there were also non-red sediments collecting to the eastward of the red Catskill magnafacies. Willard (1939, p.376)

has postulated that as Upper Devonian time progressed, the erosion of the eastern highlands cut through the decayed regolith of red color and exposed to view the fresher, less-weathered material which had yet to be oxidized to a red color. As has been noted, this red material formed the Catskill magnafacies. The fresher material was less weathered and therefore coarser and was deposited nearer the source. Thus one or more facies belts intergrading with and lying east of the red Catskill belt was formed near the base of the highlands. This eastern non-red belt Caster has divided into two magnafacies, the "Pocono" (lying farthest east) and the Tioga. Chadwick does not make this division and calls the whole belt the "Pocono" facies. The recognition of the Devonian age of this material east of the Catskill magnafacies is most controversial, and traditionally, these non-red coarser beds have been regarded as Mississippian in age as they overlies as well as intergrade with the red "Catskill" beds. The gradational contact is a strong suggestion that this is not a stratigraphic time division, but rather a facies contact.

^{39/}
To Dr. W. H. Bucher the idea of the fresher material being de-

^{39/} Oral communication.

posited nearer the source while the red material is carried farther out does not seem reasonable. His reasoning is along the following lines. He notes that color of residual clay almost everywhere outside of the

glacial areas is a red to red-brown color. Erosion outside the glacial areas proceeds slowly enough that a considerable quantity of chemically decomposed products can be produced. Dr. Bucher says he does not know why any particular type of sediment should be limited to a belt as in the case of the various magnafacies of the Upper Devonian, but he does not know of any hydrologic fact that would allow the accumulation of grey beds only in the upper reaches of a normal stream if there is any sedimentation going on at all in the lower part of the stream.

Bucher offers two geographic possibilities which might give rise to different belts of sediments. In one type there is a highland undergoing erosion in a relatively humid environment. The sediments when eroded from the mountains pass into a zone of sedimentation where there is abundant precipitation and therefore plenty of organic matter. Due to the abundance of organic matter, any sediments deposited here are in a reducing environment provided that bacterial action is not rapid enough to destroy all organic matter as soon as it dies. If these provisions are fulfilled any sediments accumulating here would be green or grey rather than red in color. Beyond this zone of abundant precipitation and vegetation and farthest from the highlands is a region of semi-desert where there is insufficient vegetation to act as a reducing agent on the sediments which are carried that far. Therefore any sediment deposited in this zone will, in time, become red in color because oxidation rather than reduction of the iron content of the sediments is the dominant process.

In the other possibility, Bucher postulates a highland being eroded in a region with a monsoonal climate. The sediments are first deposited in a region having a semi-tropical climate with abundant vegetable matter growing. Bacteria are also abundant in this region but not plentiful enough to destroy all the organic matter as soon as the plants die. This is, therefore, a reducing environment and the sediments are green to grey in color. The next zone beyond the semi-tropical zone and farthest from the mountains is a region of tropical heat with not only an abundance of growing vegetable matter, but also a superabundance of bacteria which totally destroys the organic matter as soon as it dies. The result of this would be the production of a red lateritic soil such as is seen in the tropics today. This is, therefore, an oxidizing environment and the deposits here will consequently have a red color.

In general, these easternmost continental facies of the Upper Devonian of the Penn-York Embayment can be roughly divided into two main lobes, one centering in the Catskill Mountain area and the other centering in south-central Pennsylvania, Maryland, and eastern West Virginia. The latter lobe, which is apparently the larger of the two, increases in thickness to the southeastward in Pennsylvania and Maryland. While it is thicker in eastern Pennsylvania than in Maryland, Barrell (1913, 1914) points out that the great bulk of the Maryland sediments which would have been the equivalent of the thickest Pennsylvania sediments have been eroded away. These red beds can be

traced westward by outcrop and by well record (Tucker, 1936) as far as central West Virginia where they die out, their place being apparently taken by marine beds.

When the available exposures of the Upper Devonian in southwestern Pennsylvania and some of the well logs are studied the nature of the western edge of the Pennsylvania lobe can be seen. From this study it can be noted that the edge of the continental deposits was decidedly irregular as might be expected. No doubt if more data were available it would be even more irregular. One feature of this shoreline which is quite prominent is the small but distinct estuary off the main Penn-York embayment in southwestern Pennsylvania in which the marine sediments are somewhat thicker than elsewhere to the north, east and south. (See figure 12 for paleogeographic map.) Another feature shown in the well logs and outcrops is an eastward extension of marine beds somewhat farther east and overlying the farthest westward advance of the continental red beds. This would suggest that there was an eastward progression of marine conditions somewhat prior to the end of the Upper Devonian in western Pennsylvania. (See Plates 1 - 5.) This fact has already been suggested by Caster (1934, p. 30) from data derived from his northwestern Pennsylvania studies. The eastward trend of the shoreline apparently continued on into the Lower Mississippian.

Indentation of the shoreline of the sort indicated for southwestern Pennsylvania are to be expected and these may be due to a variety

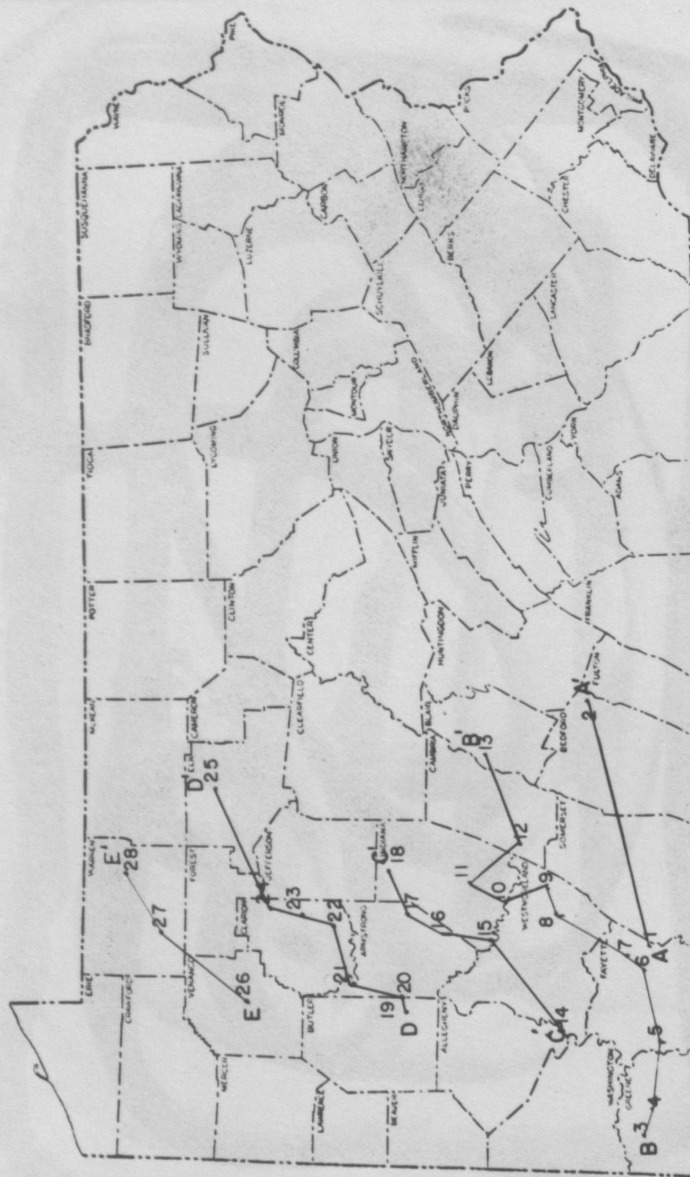


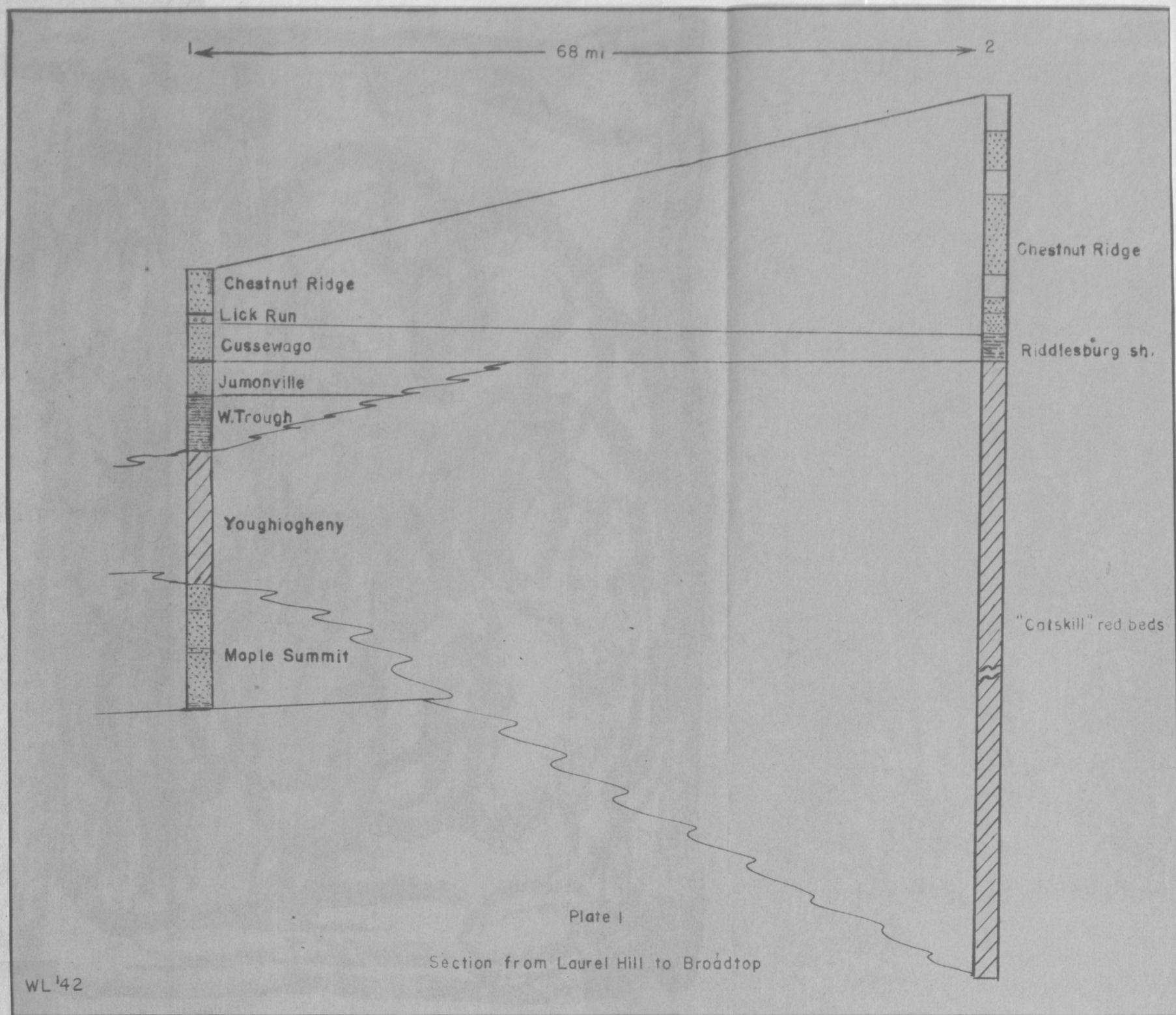
Figure 13. Sketch map showing location of sections given in Plates 1 - 5.

Figure 12. Sketch map showing location of sections given in Plates 1 - 5.

Plate I. Stratigraphic sections along Line A - A' from Laurel Hill to the Broad Top area showing the edge of the "Catskill" delta. Vertical scale 1 inch equals 400 feet. Oblique lining represents red beds.

Section 1 is located in the Youghiogheny gorge (Laurel Hill) along the Baltimore and Ohio Railroad and Western Maryland Railroad near Victoria in the southeastern part of Stewart township, Fayette County. Measured by the writer in 1940. Section 2 is located $2\frac{1}{2}$ miles north of Riddlesburg in Bedford County along the Huntingdon and Broad Top Mountain Railroad on the northwest flank of the Broad Top syncline. Measured by the writer in 1940.

Plate II. Stratigraphic sections along Line B - B' from Rogersville to Altoona showing the edge of the "Catskill" delta. Vertical scale 1 inch equals 400 feet. Oblique lining represents red beds. The Devonian-Mississippian boundary was picked more or less arbitrarily by the writer in sections 4, 8, 9, and 11. Section 3 was taken from the log of the William Millikan no. 2 well given in the Rogersville folio (no. 146). Section 4 was taken from the log of the E. M. Sayers well as given in the Waynesburg folio (no. 121). Section 5 was taken from the log of the S. T. Gray well on Cats Run 3/4 of a mile southeast of Masontown as given in the Masontown-Uniontown folio (no. 82). Section 6 was measured by the writer in 1940 at the Summit (Chestnut Ridge) inlier along Route 40 in the southeastern corner of North Union township, Fayette County, about 2 miles east of Hopwood. Section 7 was measured by the writer in 1939 in the Youghiogheny gorge (Chestnut Ridge) in northern Dunbar township, Fayette County. Section 8 was taken from the log of the McClelland no. 1 well as given in the Latrobe folio (no. 110). Section 9 was taken from the log of the Booth and Flinn well no. 3, 4 miles northwest of Ligonier in Westmoreland County as given in the Somerset-Windber folio (no. 224), p. 12. Section 10 was measured by the writer in 1940 in the Conemaugh gorge (Chestnut Ridge) in the northeastern corner of Derry township, Westmoreland County, along the Pennsylvania Railroad 2 miles east of Torrance. Section 11 was taken from the log of the St. Clair well 1 mile south of Indiana, as given in the Indiana folio (no. 102). Section 12 was measured by the writer in



1940 in the Conemaugh gorge (Laurel Hill) in the southeastern corner of East Wheatfield township in Indiana County along the Pennsylvania Railroad. Section 13 was measured by the writer in 1940 along the Allegheny Front (Altoona) along the Pennsylvania Railroad in the gorge of Sugar Run in northeastern Allegheny township, Blair County.

3 ← 9 mi. → 4 ← 20 mi. → 5 ← 12 mi. → 6 ← 11 mi. → 7 ← 28 mi. → 8 ← 7 mi. → 9 ← 9 mi. → 10 ← 13 mi. → 11 ← 17 mi. → 12 ← 25 mi. → 13

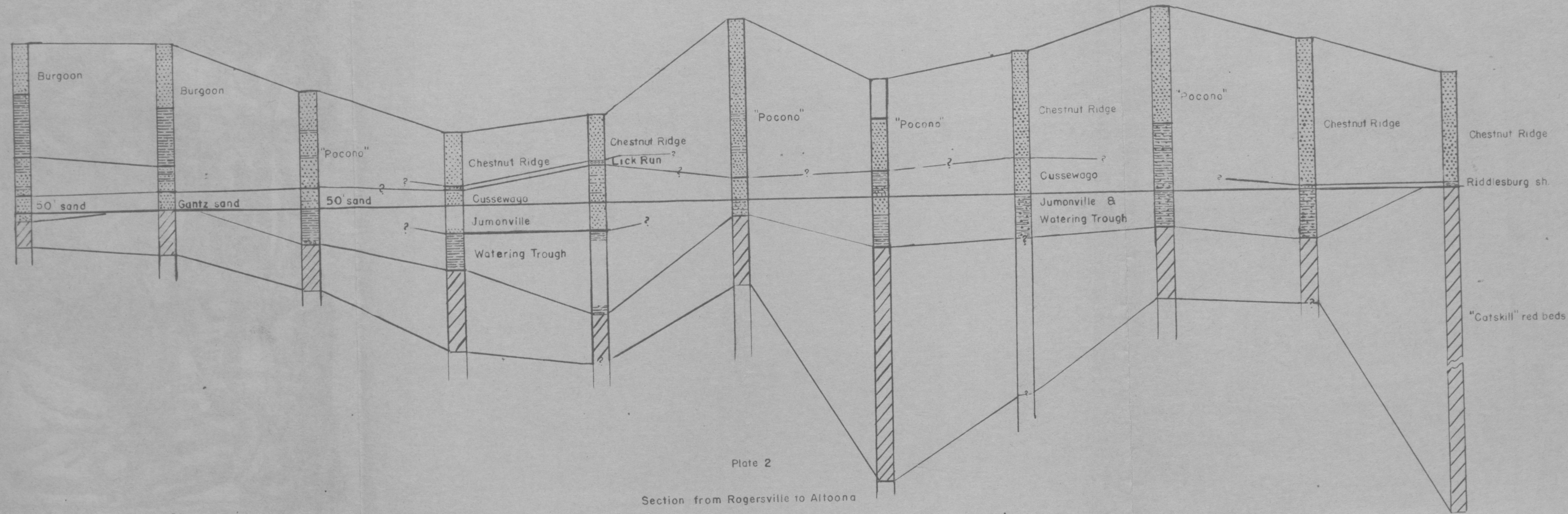
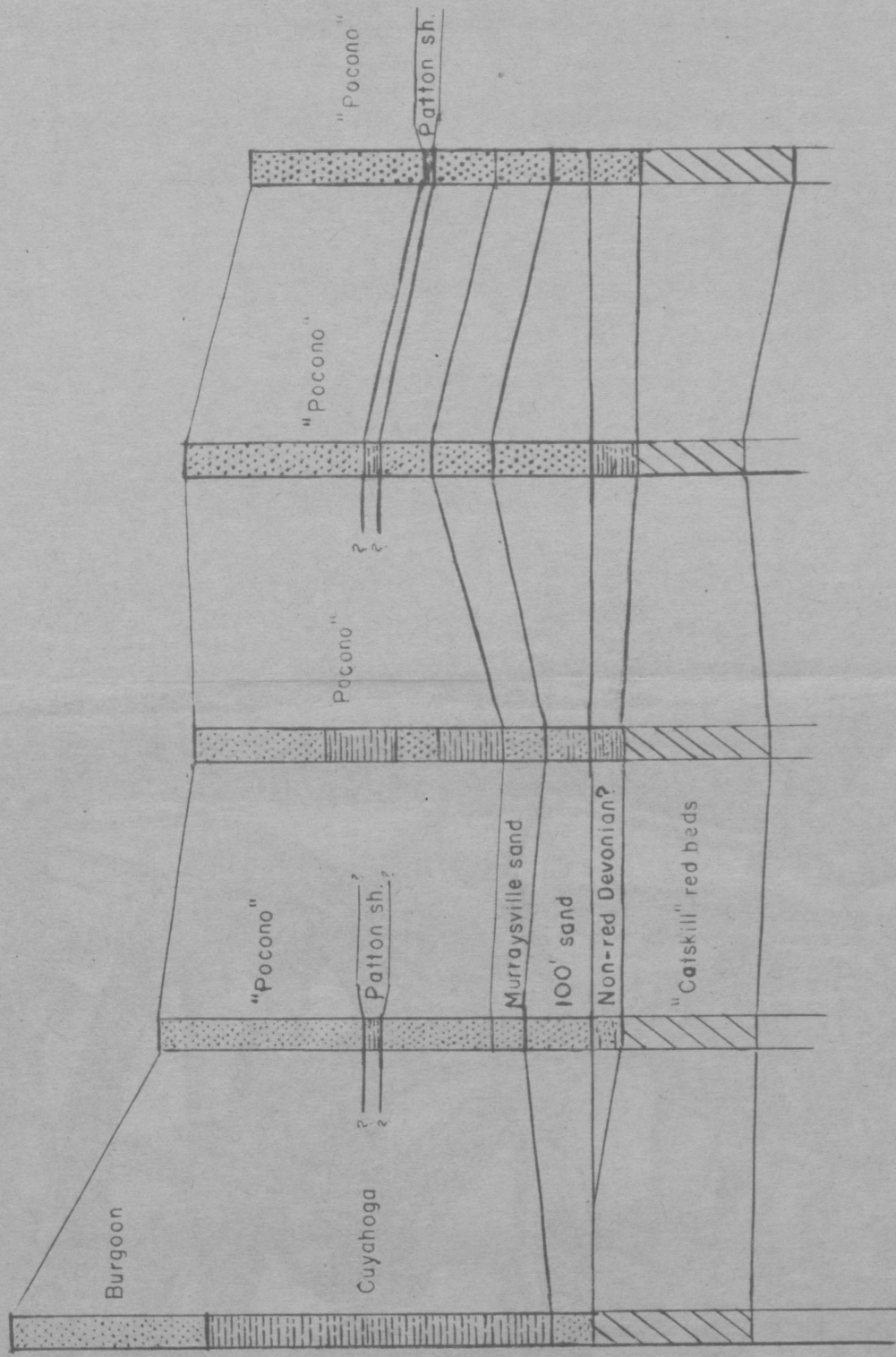


Plate 2

Section from Rogersville to Altoona

Plate III. Stratigraphic sections along Line C - C' from West Elizabeth to Smicksburg showing the edge of the "Catskill" delta. Vertical scale 1 inch equals 400 feet. Oblique lining represents red beds. The Devonian-Mississippian boundary was picked more or less arbitrarily by the writer in sections 15, 16, 17, and 18. Section 14 is taken from the log of the Bedell well at West Elizabeth as given by Butts (1908). Section 15 is taken from the log of the Sheet Steel Mill well at the mouth of Blacklegs Creek given in the Elders Ridge folio (no. 123). Section 16 is taken from the log of the King well 2 miles west of South Bend as given in the Elders Ridge folio (no. 123). Section 17 is taken from the log of the N. Reifer well 2 miles north of Elderton as given in the Elders Ridge folio (no. 123). Section 18 is taken from the generalized section given by Schaffner (1939) in the Pennsylvania Geol. Survey Bull. 121.

14 ← 28 mi. → 15 ← 9 mi. → 16 ← 8 mi. → 17 ← 16 mi. → 18

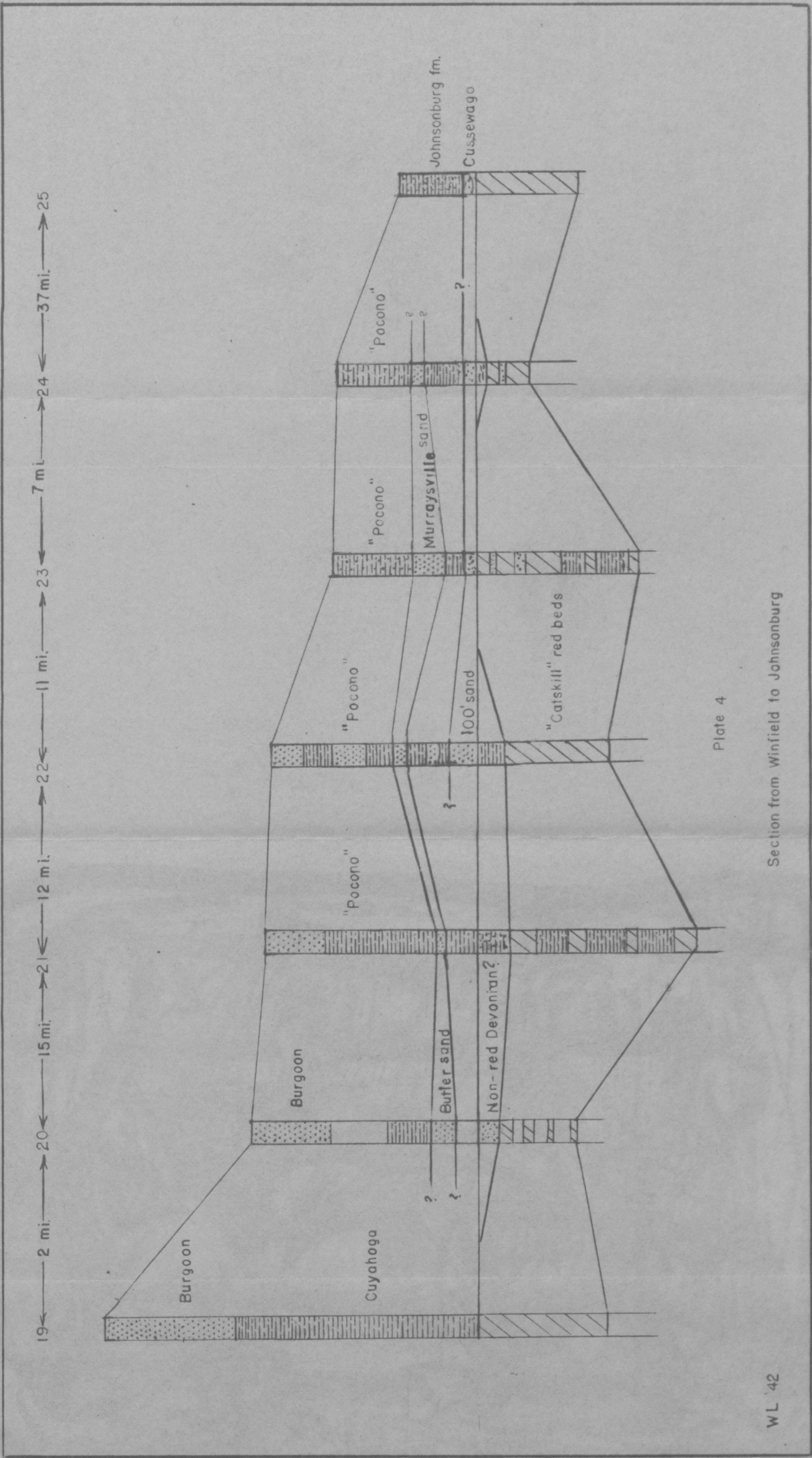


WL '42

Plate 3

Section from West Elizabeth to Smicksburg

Plate IV. Stratigraphic sections along Line D - D' from Winfield to Johnsonburg showing the edge of the "Catskill" delta. Vertical scale 1 inch equals 400 feet. Oblique lining represents red beds. The Devonian-Mississippian boundary was drawn more or less arbitrarily by the writer in sections 20, 21, 22, 23, and 24. As the Pottsville is not always clearly differentiated from the "Pocono" in the well records there is a possibility that there may have been some Pottsville included in the "Pocono" measurement of sections 20, 21, 22, 23 and 24. Section 19 is taken from the log of the Smith well at Winfield as given by Butts (1908). Section 20 is taken from the log of the Robert Smith well as given in the Kittanning folio (no. 115). Section 21 is taken from the log of the Mary and G. W. Kepple no. 1 well as given in the Kittanning folio (no. 115). Section 22 is taken from the log of the Blair Calvin No. 1 well, $\frac{1}{4}$ mile north of Blair School as given in the Foxburg-Clarion folio (no. 178). Section 23 is taken from the log of the G. E. and G. R. Spur well, 1 mile east-northeast of Greenville as given in the Foxburg-Clarion folio (no. 178). Section 24 is taken from the log of the George Wood no. 1 well, $1\frac{1}{2}$ miles northeast of Mill Creek as given in the Foxburg-Clarion folio (no. 178). Section 25 is taken from Caster (1934) p. 110 and is the section exposed in the Yingling-Martin quarry in the southern suburb of Johnsonburg, Pennsylvania.



WL '42

Plate 4

Section from Winfield to Johnsonburg

Plate V. Stratigraphic sections along Line E - E' from Foster to Warren along the seaward edge of the "Catskill" delta. Vertical scale 1 inch equals 400 feet. Section 26 is taken from the log of the Conway well at Foster as given by Butts (1908). Section 27 is taken from Caster (1934) p. 119-120 and is the section exposed on Dennis Run, Tidioute, Pennsylvania. Section 28 is taken from Caster (1934) and is his composite section for the northwestern Pennsylvania region near Warren.

26 ← 30 mi. → 27 ← 18 mi. → 28

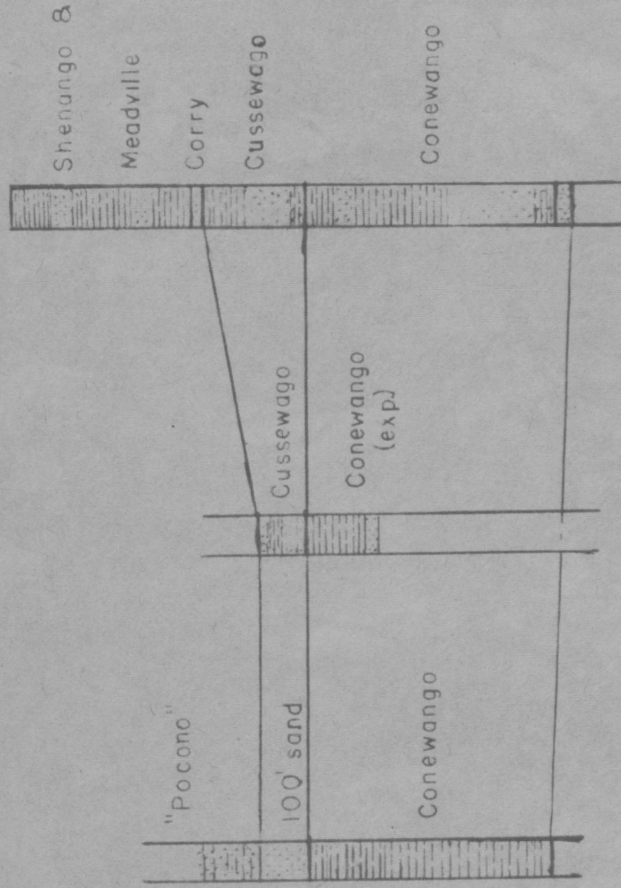


Plate 5

Section from Foster to Warren

WL'42

of causes. One explanation might be that estuaries would exist between lobes of continental sediments and that in these estuaries marine sediments were collecting while continental sediments accumulated on either side. The lobate nature of the Upper Devonian deposits in eastern Pennsylvania and southward have already been mentioned. Another possibility is that there may have been places along the shore where tongue-like streamers of red sediments were being deposited in the water while non-red sediments were deposited between them. From the fossils which are incorporated in some of the red beds we know that at least some of the red beds were deposited in an environment which was marine, or that the red beds received their coloration subsequent to their deposition. However, the great number of disconformities, the presence of plant fragments, abundant cross-bedding, and occasional ripple marks (although these last could also be common in marine beds), mud cracks, as well as rapid lateral changes from one type of sediment to another would seem to indicate a continental origin for most of the red sediments.

The source of the Upper Devonian red sediments has been a problem which has interested many. Recently Mencher (1939, pp. 1179-1182) has attempted to determine the source of the red sediments of the Devonian in the Catskill Mountains of New York State. His paper provides an excellent review of the literature of the Upper Devonian from eastern New York State northward. Mencher shows that the Acadian orogeny which began in the Gaspé region in lower Devonian time had by Middle Devonian time progressed southward and uplifted the Taconic region so it fur-

nished sediments to the adjacent Catskill Mountain area. He believes, however, that part of the Catskill sediments, particularly those of the Pennsylvania region, were probably derived from a more southerly or southeasterly source. These facts, he believes, indicate a progressive movement to the southeast of the Acadian orogeny. He also thinks that there was a southwesterly trending highland bounding the Upper Devonian inland sea on the east and southeast. This latter postulated highland fits in well with the postulated Penn-York Embayment.

In view of Mencher's conclusions as to the southwestward shift of the Acadian orogeny in New England and in view of the fact that it can be demonstrated that marine conditions prevailed in northwestern Pennsylvania while non-marine conditions held sway in south-central Pennsylvania, western Maryland and eastern West Virginia, it seems reasonable to assume that the uplift continued its trend to the southwest and died out somewhere east of the present site of Baltimore. Beyond that point the sediments give little or no evidence of any further southwestward shift of the Acadian orogeny.

In considering this southwestward shift of the Acadian orogeny it must also be remembered that there are also indications of an eastward shift of the shoreline immediately prior to the end of the Upper Devonian. This would suggest that after the maximum uplift there followed a subsidence. Perhaps as the orogeny shifted southwestward the shoreline sank behind it and allowed a flooding of marine conditions eastward.

Lower Mississippian Paleogeography

The interruption of sedimentation between the Upper Devonian and the Lower Mississippian in western Pennsylvania was very slight, as has been noted by a number of workers. (Girty, 1904; Chadwick, 1933; Caster, 1934; Willard, 1939) Very slight disconformable and unconformable contacts can be seen between the two systems in southwestern Pennsylvania, but their faunas show some degree of similarity.

As has been noted in the discussion of the Upper Devonian paleogeography, the shore progressed westward at the expense of the sea in latest Devonian time except for a short interval just before the close of the Devonian when the shore regressed eastward. Apparently this eastward trend continued into Mississippian time for marine Mississippian beds are found far east of the latest Upper Devonian marine beds. It is known with certainty that marine conditions prevailed as far eastward as the Broad Top area where there had been no marine deposits at least as far back as the true Chemung. How much farther east these marine conditions prevailed is not known and the exact extent of true Mississippian sediments in that direction is not known. Willard, (1936, p. 596) primarily on lithologic as well as some paleobotanical evidence, correlated the Griswolds Gap conglomerate of northeastern Pennsylvania with the basal Knapp of northwestern Pennsylvania. If such a correlation were correct it might extend the shoreline somewhat farther eastward than is shown on figure 12, although Willard states no marine beds are present in the eastern "Pocono".

The exact facieologic details of the Early Mississippian in Pennsylvania have not been worked out in great detail. There were apparently at least two facies provinces which were approximately contemporaneous and which intergraded with one another. The westernmost of these provinces in Pennsylvania consisted of a limy sandstone lithology which in some places, for example the Marvin Creek limestone zone, was a fairly pure limestone. This facies is extremely fossiliferous and contains many forms which were undoubtedly adapted primarily to a neritic environment. Living conditions must have been excellent for not only are there many different species but also large numbers of individual fossils.

This limy, sandy facies province graded eastward into a shale facies province which is represented by the Riddlesburg shale in south-central Pennsylvania. This is a dark-grey, fine-grained shale which is quite micaceous. Its rather uniform thin-bedding would suggest that it had been deposited some distance from shore or, if near a shore, no large amounts of coarse clastic sediments were being deposited here. In the basal part of this facies, particularly on the Allegheny Front, are some sandy, limy beds which probably are eastward extensions of the western facies province into the more eastern shale facies. In this shale facies, living conditions must have been advantageous for certain forms only for the fauna found in this shale is relatively small in the number of different species.

Following this earliest Mississippian deposition there was a change

of facies particularly in the southwestern and south-central part of Pennsylvania. Overlying the Riddlesburg shale facies province in the south-central part of the State and the Gussewago members of southwestern Pennsylvania, is a massive, apparently continental sandstone which in this report is called the Chestnut Ridge sandstone. This sandstone evidently had its source in the east and southeast for it coarsens and thickens in those directions. Simultaneously or approximately so with the deposition of this sandy facies in the southwestern and south-central parts of the State, there was sandstone and shale deposition (Shenango and Meadville stages) going on in the northwestern part of the State. These latter beds differed from the facies represented by the Chestnut Ridge for they are marine for the most part and apparently had their source to the northwest.

As has been referred to above, there appear to have been at least two possible sources for these earliest Mississippian sediments, one on either side of the embayment. The source of the northwest, possibly the Canadian Shield, appears to have been most active in the opening of the Mississippian for there seems to be a coarsening of the sediments in that direction. This is shown in the change from the Riddlesburg shale on the southeast to some of the coarser Knapp members on the northwest. Not only is this source suggested by the coarsening of the sediments in that direction, but also by certain features of the Berea sandstone of northern Ohio which give the impression of being spit-like deposits extending southward from an east-west trending shoreline some-

^{40/} where to the north. The fossils also of northwestern Pennsylvania give

^{40/} Oral communication from Dr. J. L. Rich.

the appearance of being relatively near-shore forms as contrasted to those found in the Riddlesburg which do not have a typical near-shore appearance. It seems strange that the Riddlesburg shale which is the nearest deposit geographically to the old land mass which furnished the bulk of the Upper Devonian sediments should not contain more coarse clastic material. However, as it doesn't we are forced to conclude that particular positive area was quiescent during the first part of the Mississippian.

After the earliest stage of the Mississippian when the sandy limy facies and the shale facies were deposited, there were two sources of sediments for the western part of Pennsylvania. One of these was the area to the northwest which had been furnishing sediment to northwestern Pennsylvania during the earliest Mississippian time. The other source was the old land mass to the southeast and east which had furnished so much sediment during the Upper Devonian. This latter source again became active and flooded south-central and southwestern Pennsylvania with large amounts of sand which was probably deposited on land. Meanwhile the northwestern source was furnishing sediment to the remainder of the marine embayment which still occupied the northwestern corner of Pennsylvania. This southeastern and eastern source remained

active and furnished sediments for most of the rest of the Mississippian in Pennsylvania.

It is interesting to speculate on the origin and source of the materials which make up the Chestnut Ridge sandstone, the Loyalhanna limy sandstone and the red Mauch Chunk shale. As the great bulk of the Upper Devonian red beds and their eastern non-red equivalents are eroded in the southeastern part of Pennsylvania and in the eastern part of Maryland, it seems likely that they may have furnished much if not all of the sediment which goes to make up the Chestnut Ridge, the Loyalhanna and the Mauch Chunk. As the Chestnut Ridge and the Loyalhanna underlie the Mauch Chunk, the author wonders if these beds were not derived from the eastern non-red equivalents of the "Catskill" beds. When the non-red magnafacies belts were worn through the red "Catskill" was exposed to erosion and it in turn, furnished the sediments for the Mauch Chunk. Admittedly all these foregoing statements are highly speculative and need much field and laboratory work to either disprove or substantiate them. Particularly important in this study would be a petrographic study of the heavy minerals from these members.

During the course of this study an isopach map was drawn to obtain some idea of the distribution and relative thicknesses of the reported "Pocono" formation. There are several difficulties inherent in this procedure. (1) It is difficult to tell from the literature just what is meant by "Pocono" and whether all rocks so labelled are actually Mississippian in age. Undoubtedly all that is labelled "Pocono" in east-

ern Pennsylvania is not Mississippian in age. (2) The exact equivalents of the central and southwestern Pennsylvania "Pocono" are not known in the northwestern part of the State. (3) In some of the well records in western Pennsylvania, the "Pocono" is not clearly differentiated from the Pennsylvanian Pottsville so a division had to be made arbitrarily in such instances. However, when all possible corrections were made in the well logs and when beds which are definitely known not to be Mississippian in age were taken out, a very interesting map resulted. (See figure 14.)

Figure 14. Isopach map of the reported occurrences of the "Pocono".

It was found that there were two areas where the "Pocono" beds were thicker than elsewhere. These two areas were separated by a thinner zone which approximately parallels the present Appalachian structural front as delimited by Price (1931). One area of thicker deposition occurs in a line running northeast-southwest through northern Dauphin, Schuylkill and Carbon Counties in east-central Pennsylvania. This zone probably ran farther southwestward, but nothing can be postulated concerning it in that direction because it has been eroded away. The other zone of thickening runs northeast-southwest through Clearfield, Indiana, and Westmoreland Counties just west of and approximately parallel to the Allegheny Front.

This problem needs much more study before anything very definite

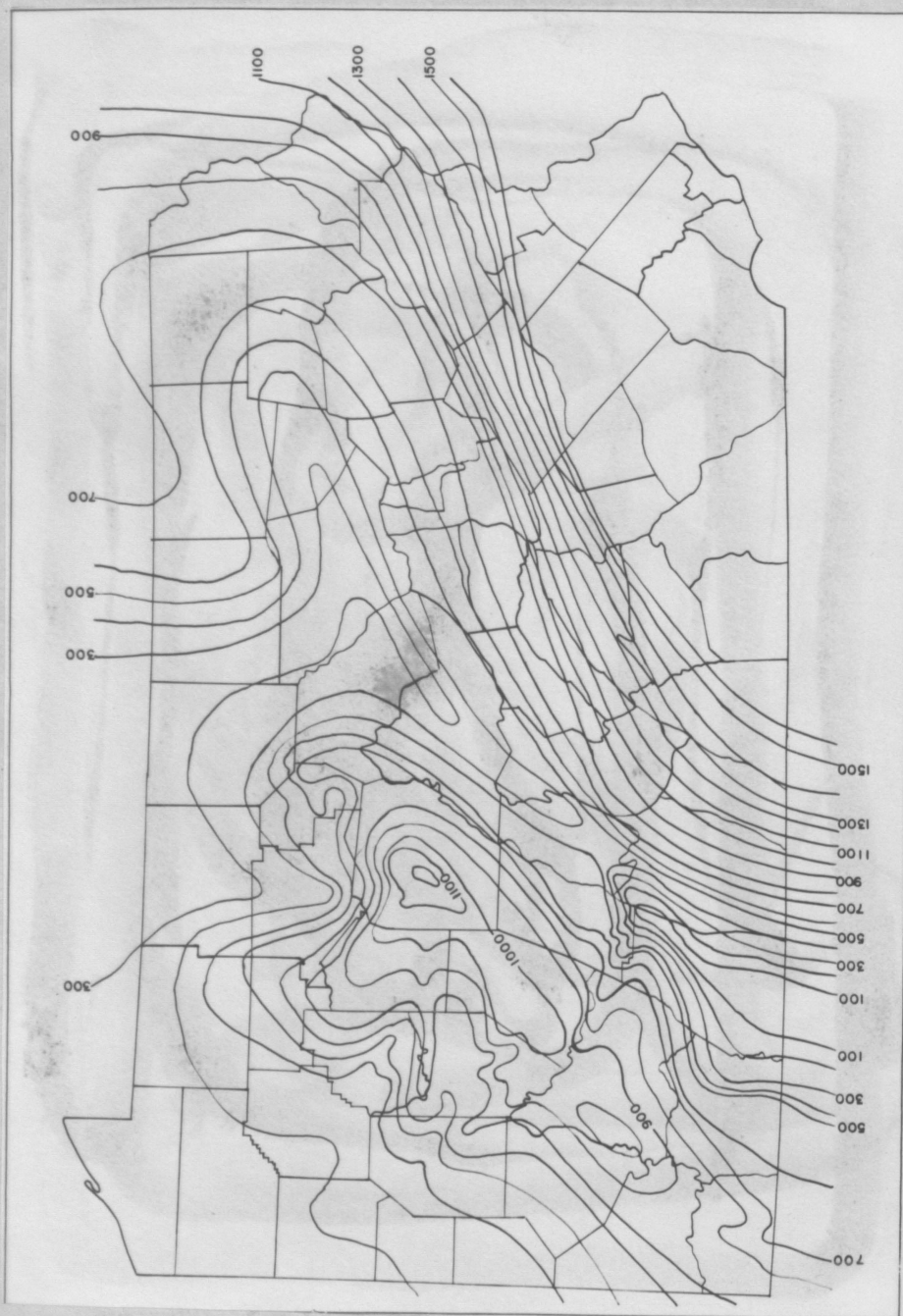


Figure 14. Isopach map of the reported occurrences of the "Pocono".

can be speculated concerning it. There are, however, several possible suggestions which can be presented. It has been suggested by Chadwick (1935, p. 141) that part or perhaps all of this eastern "Pocono" and perhaps even the Mauch Chunk may be uppermost Upper Devonian in age and thus would be one of the easternmost magnafacies of the Upper Devonian. While the writer knows of no paleontological evidence which would disprove this statement it does seem a little too progressive to include the Mauch Chunk in the Upper Devonian. Willard (1939, p. 281) notes the difficulty in applying paleobotanical evidence to the differentiation of the "Pocono" from the Upper Devonian. Thus at present there appears to be little proof one way or the other on this problem. As the "Pocono" of authors in many places in central and eastern Pennsylvania is gradational with the upper part of the Catskill magnafacies, it does not seem impossible that the "Pocono" of these areas might constitute one or more of the eastern magnafacies of the Upper Devonian. In fact it is this apparently gradational contact which has caused much of this difficulty in differentiating these members in central Pennsylvania. Such gradational contacts are noted elsewhere in other parts of Pennsylvania where two known magnafacies are adjacent to one another.

Caster (1934, p. 22) also delimits such a "Pocono" magnafacies as the easternmost of his Upper Devonian magnafacies. If this "Pocono" is such a facies belt, then it would have no relationship at all to the so-called "Pocono" (Chestnut Ridge of this report) of western Pennsylvania which can now be definitely proven to be basal Mississippian in

age. It has already been proven to the satisfaction of most geologists that no "Pocono" of Mississippian age exists on the Pocono Plateau proper. It seems almost as likely that there is no "Pocono" of Mississippian age east of the Allegheny Front with the exception of the Broad Top area.

The other possibility for explaining these zones of thickening and thinning might be that there were two main troughs of deposition during early Mississippian time with "Pocono" sediments being laid down in both troughs simultaneously. The trough in the eastern part of Pennsylvania was receiving its sediments from some source to the east and southeast while the trough in the western part of the State was receiving its sediments from the source to the northwest. These two troughs might have been part of one large trough which was deep on each side and shallower in the middle. If this hypothesis were true it has interesting implications. The shallow zone in the middle of the trough roughly is parallel to the Appalachian structural front which Price (1931, p. 43) says corresponds to the thickest zone of sediments from the early Devonian through the Pottsville and which was also the weakest part of the whole trough. This might suggest that the zone of thinning was due to the beginnings of a fold which culminated in the Appalachian Revolution geologically much later. Krynine (1940, p. 1999) also has suggested that at certain times during the Paleozoic gentle folds arose in the Appalachian geosyncline.

BIBLIOGRAPHY

- Anderson, G.E., Origin of line of color change in red bed deposition:
Geol. Soc. Am. Bull., vol. 52, p. 211-218, 1941.
- Ashburner, C.A., Report of Progress in the Juniata District, Part II:
Pennsylvania 2d Geol. Survey Rept. F, 1878.
- Ashley, G.H., Structure (of southwest Pennsylvania): Report of the
Pennsylvania Topog. and Geol. Survey Comm. (1906-08), p. 205-218,
1908.
- _____, Studies in mechanics of Allegheny structure (Abst.):
Science, new ser., vol. 27, p. 924-925, 1908.
- _____, A stratigraphic time scale: Pennsylvania Geol. Survey
Bull. 19, 10 pp., 1927.
- _____, et. al., Classification and nomenclature of rock
units: Geol. Soc. Am. Bull., vol. 44, p. 423-459, 1933: idem.,
Am. Assoc. Petroleum Geologists Bull., vol. 17, p. 843-863, 1933.
- _____, Willard, Bradford, The use of the term Pocono: Sci-
ence, vol. 81, new ser., p. 615-617, 1935.
- Barrell, Joseph, Origin and significance of the Mauch Chunk shale:
Geol. Soc. Am. Bull., vol. 18, p. 449-476, 1907.
- _____, Criteria for recognition of ancient delta deposits:
Geol. Soc. Am. Bull., vol. 23, p. 377-446, 1912.
- _____, The Upper Devonian delta of the Appalachian geo-
syncline: Am. Jour. Sci., 4th ser., vol. 36, p. 429-472, 1913;
4th ser., vol. 37, p. 87-109, 225-253, 1914.
- Bucher, W.H., Key to papers published by an institute for the study

of modern sediments in shallow seas: Jour. Geol., vol. 46,
p. 726-755, 1938.

Butts, Charles. Fossil faunas of the Olean quadrangle: New York State
Mus. Bull. 69, p. 990-995, 1903.

_____, U. S. Geol. Survey Geol. Atlas, Kittanning folio (no.
115), 15 pp., 1904.

_____, U. S. Geol. Survey Geol. Atlas, Ebensburg folio, (no.
133), 1905.

_____, U.S. Geol. Survey Geol. Atlas, Rural Valley folio (no.
125), 11 pp., 1905.

_____, Kittanning and Rural Valley quadrangles, Pennsylvania:
U.S. Geol. Survey Bull. 279, 198 pp., 1906.

_____, The Devonian section near Altoona, Pennsylvania: Jour.
Geol. vol. 14, p. 618-630, 1906.

_____, Pre-Pennsylvania stratigraphy: Rept. of the Pennsyl-
vania Topog. and Geol. Survey Comm. (1906-1908), p. 190-204, 1908.

_____, U. S. Geol. Survey Geol. Atlas, Warren folio (no. 172),
11 pp., 1910.

_____, Geologic section of Blair and Huntingdon counties,
central Pennsylvania: Am. Jour. Sci., 4th ser., vol. 46, p. 523-
537, 1918.

_____, The Loyalhanna limestone of southwestern Pennsylvania
especially with regard to its age and correlation: Am. Jour. Sci.,
5th ser., vol. 8, p. 249-257, 1924.

_____, Oil and gas possibilities at Early Grove, Scott
county, Virginia: Virginia Geol. Survey Bull. 27, 18 pp., 1927.

- _____, Geologic map of the Appalachian valley of Virginia with explanatory text: Virginia Geol. Survey Bull. 42, 56 pp., 1933.
- Campbell, M. R., U. S. Geol. Survey Geol. Atlas, Pocahontas folio (no. 26), 5 pp., 1896.
- _____, U. S. Geol. Survey Geol. Atlas, Masontown-Uniontown folio (no. 82), 21 pp., 1902.
- _____, and others, The Valley coal fields of Virginia: Virginia Geol. Survey Bull. 25, 300 pp., 1925
- Carll, J. F., The geology of the Oil Regions of Warren, Venango, Clarion, conglomerates in Warren and Crawford and in Chautauqua County, New York, descriptions of oil well rig and tools, and a discussion of the preglacial and postglacial drainage of the Lake Erie country: Pennsylvania 2d Geol. Survey Rept. 13, 482 pp., 1880.
- _____, Geological Report on Warren County: Pennsylvania 2d Geol. Survey Rept. 14, 1883.
- Caster, K.E., Higher fossil faunas of the upper Allegheny: Bull. Am. Paleontology, vol. 15, p. 1-174, 1930.
- _____, The stratigraphy and paleontology of northwestern Pennsylvania, Part I, Stratigraphy: Bull. Am. Paleontology, vol. 21, p. 1-185, 1934.
- _____, Marine fauna in the seaward phase of the Catskill magnafacies: Geol. Soc. America Proc. 1934, p. 363, 1935.
- _____, A restudy of the tracks of Paramphibius: Jour. Paleontology, vol. 12, p. 3-60, 1938.

- _____, Comparison of the siliceous sponges *Armstrongia* Clarke, 1920, and *Titusvillia* Caster, 1939; *Jour. Paleontology*, vol. 13, p. 531-532, 1939.
- _____, Review: The Devonian of Pennsylvania (Willard, Swartz and Cleaves); *Jour. Paleontology*, vol. 14, p. 605-610, 1940.
- _____, The *Titusvilliidae*; Paleozoic and Recent branching Hexactinellida; *Paleontographica Americana*, vol. 2, p. 5-41, 1941.
- _____, Torrey, P. D., and Chadwick, G. H., Discussion: Demise of the "Bradfordian Series"; *Am. Assoc. Petroleum Geologists Bull.*, vol. 19, p. 912-915, 1935.
- Cathcart, S. H., Geologic structure of northwest Pennsylvania has deep sand possibilities of gas and oil: *The Oil and Gas Jour.*, p. 58, Dec. 20, 1934.
- _____, Gas and oil in Potter Co., Pennsylvania, Pennsylvania Geol. Survey Bull. 106, 31 pp., 1934.
- _____, Geologic structure in the plateaus region of northern Pennsylvania and its relation to the occurrence of gas in the Oriskany sand: *Pennsylvania Geol. Survey Bull.* 108, 24 pp., 1934.
- _____, The possibility of finding gas in Cameron County, Pennsylvania: *Pennsylvania Geol. Survey Bull.* 109, 16 pp., 1934.
- _____, The possible occurrence of gas in the Oriskany sand of Elk County: *Pennsylvania Geol. Survey Bull.* 110, 21 pp., 1934.
- _____, Myers, T. H., Gas in Tioga County, Pennsylvania: *Pennsylvania Geol. Survey Bull.* 107, 42 pp., 1934.
- _____, Sherrill, R. E., and Matteson, L. S., Geology of the

oil and gas fields of the Tidioute quadrangle, Pennsylvania
(Advance Report): Pennsylvania Geol. Survey Bull. 118, 14 pp.,
1938.

Chadwick, G. H., The stratigraphy of the Chemung group in western New
York: New York State Mus. Bull. 251, p. 149-157, 1924.

_____, Chagrin formation of Ohio: Geol. Soc. America Bull.,
vol. 36, p. 455-464, 1925.

_____, Storm rollers (Abst.): Geol. Soc. Am. Bull., vol.
42, p. 242, 1931.

_____, Catskill as a geologic name: Am. Jour. Sci., 5th
ser., vol. 26, p. 479-484, 1933.

_____, The Great Catskill delta and revision of Late De-
vonian Succession: Pan-Am. Geol., vol. 60, p. 91-107, 189-204,
275-286, 348-360, 1933A.

_____, Faunal differentiation in the Upper Devonian: Geol.
Soc. Am. Bull., vol. 46, p. 305-342, 1935.

_____, Chemung is Portage: Geol. Soc. Am. Bull., vol. 46,
p. 343-354, 1935A.

_____, Summary of Upper Devonian stratigraphy: Am. Midland
Naturalist, vol. 16, p. 857-862, 1935B.

_____, What is "Pocono"?: Am. Jour. Sci., 5th ser., vol. 29,
p. 133-143, 1935C.

_____, History and value of the name "Catskill" in geology:
New York State Mus. Bull. 307, 116 pp., 1936.

Chance, M. M., Geology of Clinton County: Pennsylvania 2d Geol.

Survey Rept. G4, Part II, 1880.

Clarke, J. M., and Schuchert, C., The nomenclature of the New York series of geological formations: Science n.s. vol. 10, pp. 874-878, 1899.

Cooper, G. A., Stratigraphy of the Hamilton group in eastern New York: Am. Jour. Sci., 5th ser., vol. 26, p. 537-551, 1933: idem. (Abst.): Geol. Soc. Am. Bull., vol. 44, p. 200-201, 1933.

Dickey, P.A., Oil geology of the Titusville quadrangle: Pennsylvania Geol. Survey Bull. M22, 87 pp., 1941.

_____, Review: Petroleum and Genesis of the Third Bradford Sand, by Paul D. Krynine: Am. Assoc. Petroleum Geologists Bull., vol. 25, p. 1413-1415, 1941.

Dunbar, C. O., Permian faunas: a study in facies: Geol. Soc. Am. Bull., vol. 52, p. 313-332, 1941

Fettke, C. R., Physical characteristics of Bradford sand and relation to the production of oil: Am. Assoc. Petroleum Geologists Bull., vol. 18, p. 191-211, 1934.

_____, Subsurface stratigraphy of northwestern Pennsylvania and a resume of gas and oil possibilities of deeper sands: Pennsylvania Geol. Survey Bull. 114, 23 pp., 1935.

_____, Bradford Oil Field (Preliminary report): Pennsylvania Geol. Survey Bull. 116, 13 pp., 1937.

_____, Bradford oil field, Pennsylvania and New York: Pennsylvania Geol. Survey, 4th ser., Bull. M21, 454 pp., 1938.

_____, Summit gas pool, Fayette county, Pennsylvania: Pennsylv-

vania Geol. Survey Progress Rept. 124, 21 pp., 1940.

Flower, R. H., and Caster, K.E., The Stratigraphy and paleontology of northwestern Pennsylvania, Part II, Paleontology, Section A; The Cephalopod fauna of the Conewango series of the upper Devonian in New York and Pennsylvania: Bull. Am. Paleontology, vol. 22, p. 1-74, 1935.

Girty, G. H., "Discussion" (untitled abstracted statement); Report of the meeting of the Geological Society of Washington, D. C.: Science, vol. 19, new ser., p. 24-25, 1904.

_____, The Pocono fauna of the Broad Top coal field: U. S. Geol. Survey Prof. Paper 150E, p. 111-127, 1927.

Glenn, L. C., Devonian and Carboniferous formations of southwestern New York (with stratigraphic map of the Olean quadrangle): New York State Mus. Bull. 69, p. 966-990, 1903.

Grabau, A. W., Principles of stratigraphy, 2nd ed.: 1185 pp., New York, A. G. Seiler, 1924.

Grimsley, G. P., Jefferson, Berkley and Morgan Counties: West Virginia Geol. Survey County Reports, 644 pp., 1916.

Hall, James, Geology of New York, Part IV, comprising the survey of the fourth geological district: Nat. Hist. New York, Part IV, 683 pp., 1843.

Hennen, R. V., and Reger, D. B., Preston County: West Virginia Geol. Survey County Reports, 566 pp., 1914.

Herrick, C. L., The Cuyahoga shale and the problem of the Ohio Waverly:

- Geol. Soc. Am. Bull., vol. 2, p. 31-48, 1891.
- Hickok, W. O., and Moyer, F. T., Geology and mineral resources of Fayette County, Pennsylvania; Pennsylvania Geol. Survey, 4th ser., Bull. G26, 530 pp., 1940.
- Hyde, J. E., The ripples of the Bedford and Berea formations of central and southern Ohio with notes on the paleogeography of that epoch: Jour. Geol. vol. 19, p. 257-269, 1911.
- _____, Stratigraphy of the Waverly formations of central and southern Ohio: Jour. Geol. vol. 23, p. 655-682, 757-779, 1915.
- Kay, G. M., Allegheny synclorium and Appalachian geosynclines: Geol. Soc. America Bull., vol. 52, no. 12, pt. 2, p. 1912, 1941.
- Kindle, E. M., Faunas of the Devonian section near Altoona, Pa.: Jour. Geol., vol. 14, p. 631-635, 1906.
- Krynine, P. D., Appalachian orogeny and sedimentation: Geol. Soc. Am. Bull., vol. 51, p. 1999, 1940.
- _____, Petrology and genesis of the Third Bradford sand: Pennsylvania State College Min. Ind. Exper. Sta. Bull. 29, 134 pp., 1940.
- _____, Graywackes and the petrology of the Bradford oil field, Pennsylvania: Am. Assoc. Petroleum Geologists Bull., vol. 25, p. 2071-2074, 1941.
- Lahee, F. H., Field geology, 3d ed.: 789 pp., New York, McGraw-Hill Book Co., Inc., 1931.
- Laird, W. M., Devonian and Mississippian relations in southwestern

Pennsylvania (Abst.): Geol. Soc. Am. Bull., vol. 50, p. 1983, 1939.

_____, Devonian and Mississippian inliers of southwestern Pennsylvania: Am. Assoc. Petroleum Geologists Bull., vol. 25, p. 161-164, 1941.

_____, The Upper Devonian and Lower Mississippian of southwestern Pennsylvania: Pennsylvania Geol. Survey Progress Rept. 126, 23 pp., 1941.

Lesley, J. P., Upper Silurian and Devonian formations, Summary Final Report: Pennsylvania 2d Geol. Survey, vol. 2, 1892.

Martin, G. C., U. S. Geol. Survey Geol. Atlas, Accident-Grantsville folio (no. 160), 14 pp., 1908.

Melton, F. A., Easton, J. E., Discussion: Time-equivalent versus lithologic extension of formations: Am. Assoc. Petroleum Geologists Bull., vol. 16, p. 1039-1044, 1932.

Mencher, Ely, Catskill facies of New York State: Geol. Soc. Am. Bull., vol. 50, p. 1761-1794, 1939.

Middle and Upper Devonian: Maryland Geol. Survey, 720 pp., 1913.

Moore, R. C., Historical Geology: 673 pp., New York, McGraw-Hill Book Co., Inc., 1933.

Morse, W. C., and Foerste, A. F., The Waverly formations of east central Kentucky: Jour. Geol., vol. 17, p. 164-177, 1909.

Moyer, F. T., Structure and stratigraphy of Fayette County (Preliminary Report): Pennsylvania Geol. Survey Bull. 115, 20 pp., 1937.

Munn, M. A., and Shaw, E. W., U. S. Geol. Survey Geol. Atlas, Foxburg-

Clarion folio (no. 178), 17 pp., 1911.

Platt, Franklin, Report of Progress in Cambria County: Pennsylvania
2d Geol. Survey Rept. HH, 1875.

Price, Paul, Pocohantas County: West Virginia Geol. Survey County Re-
ports, 531 pp., 1929.

_____, The Appalachian structural front: Jour. Geol., vol. 39,
p. 24-44, 1931.

Prosser, C. S., The Devonian and Mississippian formations of north-
eastern Ohio: Ohio Geol. Survey, 4th ser., Bull. 15, 574 pp., 1912.

Raymond, P. E., The significance of red color in sediments: Am. Jour.
Sci., 5th ser., vol. 13, p. 234-251, 1927.

Reger, D. B., Mineral and Grant Counties: West Virginia Geol. Survey
County Reports, 866 pp., 1924.

_____, Review of "The Valley Coal Fields of Virginia", by
M. R. Campbell and others; Virginia Geol. Survey Bull., vol. 25,
Econ. Geol. Vol. 20, pp. 778, 1925.

_____, Mercer, Monroe and Summers Counties: West Virginia
Geol. Survey County Reports, 963 pp., 1926.

_____, Pocono stratigraphy in the Broadtop basin of Pennsyl-
vania (Abst.): Geol. Soc. Am. Bull., vol. 38, p. 156-157, 1927.

_____, Pocono stratigraphy in the Broadtop basin of Pennsyl-
vania: Geol. Soc. Am. Bull., vol. 38, p. 397-410, 1927A.

_____, Randolph County: West Virginia Geol. Survey County
Reports, 989 pp., 1931.

Report of the committee on "Nomenclature and classification for the geologic atlas of the United States": Twenty-Fourth Ann. Rept. of the U. S. Geol. Survey for 1902 and 1903, p. 21-27, 1903.

Schenck, H. G., et. al., Hedberg, H. D., Tomlinson, C. W., Eaton, J. E., White, R. T., Discussion: Stratigraphic nomenclature: Am. Assoc. Petroleum Geologists Bull., vol. 25, p. 2195-2211, 1941.

Schuchert, Charles and Dunbar, C. O., A Textbook of Geology, Part II, Historical Geology, 4th ed.: 544 pp., New York, John Wiley & Sons, Inc., 1941.

Sherrill, R. E., Symmetry of northern Appalachian foreland folds: Jour. Geol., vol. 42, p. 225-247, 1934.

_____, Some problems of Appalachian structure: Am. Assoc. Petroleum Geologists Bull., vol. 25, p. 416-423, 1941.

Stevenson, J. J., Report of progress in the Fayette and Westmoreland district of the bituminous coal fields of western Pennsylvania, Part I, East Allegheny county and Fayette and Westmoreland Counties west from Chestnut ridge: 436 pp., 1877; idem. Part II, The Ligonier valley, 331 pp., 1878: Pennsylvania 2d Geol. Survey Reports K3 and K2, 1877 and 1878.

_____, The Upper Devonian rocks of southwestern Pennsylvania: Am. Jour. Sci., 3rd ser., vol. 15, p. 423-430, 1878.

_____, The Geology of Bedford and Fulton counties: Pennsylvania 2d Geol. Survey Rept. T2, 382 pp., 1882.

_____, Lower Carboniferous of the Appalachian basin: Geol.

Soc. Am. Bull., vol. 14, p. 15-96, 1903.

Stone, R. W., U. S. Geol. Survey Geol. Atlas, Elders Ridge folio (no. 123), 10 pp., 1905.

_____, Geologic section in southern Somerset county, Pennsylvania: Proc. Pennsylvania Acad. Sci., vol. 11, p. 78-81, 1937.

Stose, G. W., Geology of the salt and gypsum deposits of southwestern Virginia in Biennial report of the mineral production of Virginia during the calendar years 1911-1912 by T. L. Watson: Virginia Geol. Survey Bull. 8, p. 51-73, 1913.

_____, Pre-Pennsylvanian rocks; in the geology and mineral resources of Wise County and the coal-bearing portion of Scott County, Virginia, by J. Brian Eby: Virginia Geol. Survey Bull. 24, p. 22-62, 1923.

_____, The black shale of southwestern Virginia: Jour. Geol. vol. 32, p. 311-315, 1924.

Tilton, J. L., Prouty, W. F., Price, P.H., Pendleton County: West Virginia Geol. Survey County Reports, 384 pp., 1927.

Tucker, Rietz, Deep-well records: West Virginia Geol. Survey, 560 pp., 1936.

Ver Wiebe, W. A., The Berea formation of Ohio and Pennsylvania: Am. Jour. Sci., 4th ser., vol. 42, p. 43-58, 1916.

_____, Correlation of the Mississippian of Ohio and Pennsylvania: Am. Jour. Sci., 4th ser., vol. 43, p. 301-318, 1917.

_____, Correlation of the Devonian shales of Ohio and Pennsylvania: Am. Jour. Sci., 4th ser., vol. 44, p. 33-47, 1917.

- Wagner, N. S., Terreplain geology of the Pocono plateau: Pan-Am. Geol., vol. 63, p. 241-247, 1935.
- Weller, J. M., and Wanless, H. R., Correlation and extent of Pennsylvanian cyclothems: Geol. Soc. Am. Bull., vol. 43, p. 1003-1016, 1932.
- White, David, The age of the Pocono: Am. Jour. Sci., 5th ser., vol. 27, p. 265-272, 1934.
- White, I. C., The Geology of Erie and Crawford counties: Pennsylvania 2d Geol. Survey Rept. Q4, 355 pp., 1881.
- _____, The geology of Huntingdon county: Pennsylvania 2d Geol. Survey Rept. T3, 471 pp., 1885.
- Willard, Bradford, "Catskill" sedimentation in Pennsylvania: Geol. Soc. Am. Bull., vol. 44, p. 495-515, 1933.
- _____, Chemung of southwestern Pennsylvania: Proc. Pennsylvania Acad. Sci., vol. 7, p. 1-12, 1933.
- _____, Early Chemung choreline in Pennsylvania: Geol. Soc. Am. Bull., p. 897-908, 1934.
- _____, Portage group in Pennsylvania: Geol. Soc. Am. Bull., vol. 46, p. 1195-1218, 1935.
- _____, Hamilton group along the Allegheny Front, Pennsylvania: Geol. Soc. Am. Bull., vol. 46, p. 1275-1290, 1935.
- _____, Middle-Upper Devonian contact in Pennsylvania: Proc. Pennsylvania Acad. Sci., vol. 9, p. 39-44, 1935.
- _____, Continental Upper Devonian of northeastern Pennsyl-

vania: Geol. Soc. Am. Bull., vol. 47, p. 565-608, 1936.

_____, Devonian nomenclature in Pennsylvania: Proc.
Pennsylvania Acad. Sci., vol. 11, p. 26-35, 1937.

_____, Middle and Upper Devonian: The Devonian of Pennsylv-
vania: Pennsylvania Geol. Survey, 4th ser., Bull. G19, 481 pp.,
1939.

_____, and Caster, K. E., Age of Devonian of southwestern
Pennsylvania: Am. Assoc. Petroleum Geologists Bull., vol. 19,
p. 1546-1550, 1935.

Williams, H. S., Recurrent Tropidoleptus zones of the Upper Devonian
in New York: U. S. Geol. Survey Prof. Paper 79, 84 pp., 1913.

Willis, Bailey, Index to North American stratigraphy: U. S. Geol.
Survey Prof. Paper 71, 894 pp., 1912.

Wilmarth, M. Grace, The Geologic time classification of the U. S.
Geol. Survey compared with other classifications accompanied by
the original definitions of era, period and epoch terms, A com-
pilation: U. S. Geol. Survey Bull. 769, 138 pp., 1925.

_____, Lexicon of geologic names of the United States
(including Alaska): U. S. Geol. Survey Bull. 896, 2396 pp., 1938.
Woolsey, L. H., U. S. Geol. Survey Geol. Atlas, Beaver folio (no. 134),
15 pp., 1905.