PITTSBURGH
GEOLOGICAL SOCIETY

FIELD CONFERENCE

NORTHERN PORTION OF THE APPALACHIAN BASIN

PITTSBURGH GEOLOGICAL SOCIETY
PGS

MIDYEAR MEETING
AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS
PITTSBURGH, PA.

OCTOBER 4-9, 1948

GENERAL INSTRUCTIONS

PLEASE READ CAREFULLY

Delegates to the field conference are asked to observe the instructions given below. Since the trip has been planned as a reconnaissance trip, considerable mileage will be covered each day, and starting times must be strictly observed. Cooperation by each person is essential.

1. **BAGGAGE:** All baggage should be labeled with tags supplied for that purpose at the registration desk. A special committee will handle your baggage, and it will be placed in your hotel room prior to your arrival each night. In order to insure proper handling, please place your baggage each morning as directed below under "Special Instructions For Each Day."

2. **HOTEL RESERVATIONS:** When you register for the field trip, you are automatically registered for overnight accommodations in Harrisburg and Rochester (and Bradford if you attend the Secondary Recovery Conference). When you arrive at the hotel, merely give your name and you will be handed your room key. There will be no individual checking in or checking out, and no individual bills will be rendered. At the time of departure in the morning, return your key to the desk. Please report any special services or telephone calls, as your field trip fee covers only the room charge.

3. **LUNCHES:** Lunches will be provided at the lunch stop each day. They are included in the field trip fee.

4. **BREAKFASTS:** Group breakfasts will be served starting at 6:00 A.M. on Thursday morning at the Penn Harris in Harrisburg, and on Friday morning at the Sheraton in Rochester. On Saturday in Bradford, Breakfast will start at 7:00 A.M.

5. **EXPENSES:** The field trip fee covers all expenses for the trip **EXCEPT** for **dinner on Wednesday night in Harrisburg and dinner on return to Pittsburgh.** The fee includes the following items:

Transportation	Lunches
Hotel Rooms	Breakfasts
Handling of Baggage and Tips	Guidebook

Secondary Recovery Conference, for additional fee, includes also Banquet in Bradford, Transportation charges, Breakfast and Lunch on Saturday.

6. **TRANSPORTATION:** Travel will be by chartered Greyhound Bus. Please remain with the bus in which you start throughout each day in order to facilitate loading and unloading at the stops. Please observe starting times listed below. Boarding your bus a few minutes ahead of time will facilitate prompt departure.

7. **GROUP LEADERS:** A group leader will be in each bus to call out the mileposts along the route, to discuss the geology, and answer questions. An amplifier will be used in each bus.

8. **STOPS:** Because of the distance to be covered each day, the stops are limited in time and number. They will be at localities where the regional geology can best be observed. An amplifier will be used at each stop so that the discussion leader can be heard by the entire group.

SPECIAL INSTRUCTIONS FOR EACH DAY

WEDNESDAY, OCTOBER 6th

Baggage: Leave at 7:15 A.M. in Grant Street Lobby, William Penn Hotel.

Starting Time: 7:30 A.M. Grant Street entrance to hotel.

THURSDAY, OCTOBER 7th

Baggage: Leave at 7:00 A.M. in Lobby of Penn Harris, or Harrisburger.

Starting Time: 7:15 A.M. in front of Capital Building, Third Street, Harrisburg.

FRIDAY, OCTOBER 8th

Baggage: Leave at 7:15 A.M. in Lobby of Sheraton Hotel.

Starting Time: 7:30 A.M. in front of Sheraton Hotel, East Avenue, Rochester.

Baggage for those going to Bradford will remain in the hands of the committee and placed in rooms at Emery Hotel.

Baggage for those returning to Pittsburgh Friday afternoon, or leaving the party at Buffalo will be returned to them by the committee at the Bus Terminal in Buffalo.

Baggage for those returning to Pittsburgh on Saturday afternoon will be returned to them by the committee at the Bus Terminal in Pittsburgh.

Guide Book

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GEOLOGY OF THE NORTHERN PORTION OF THE APPALACHIAN BASIN

Detailed Itinerary of the

FIELD TRIP

Compiled and Edited

by

George C. Grow, Jr.

AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

MIDYEAR MEETING

OCTOBER 4-9, 1948 PITTSBURGH, PA.

Sponsored by

Pittsburgh Geological Society

INTRODUCTION

THIS trip is intended as a reconnaissance trip traversing the northern portion of the Appalachian Basin. It is designed to present a broad, regional picture of the area and to point out the major elements of Appalachian stratigraphy and structure. Road logs have been prepared to point out the geology along the itinerary. Points of historical and economic interest and importance have also been included. In going over the section of rocks exposed in the Appalachian region, and in comparing the stratigraphic, structural, and geomorphic relationships of one part of the area to another, it is hoped that there will be renewed interest in this province. Although it is the world's oldest oil and gas producing area and contains some of the most remarkable fields, only about one-third of its areal extent has been explored, and in places less than one-third of its vertical extent has been tested. Recent trends of exploratory thought lean heavily toward the Appalachian Basin. The regional aspect is, therefore, considered a logical preliminary approach.

PITTSBURGH GEOLOGICAL SOCIETY

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R. C. Stephenson
E. J. Webb, *Route Map and Loud Speakers*
K. W. Wirth, *Baggage and Room Reservations*

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For Index to Maps, Charts, and Sections see page 11

ACKNOWLEDGMENTS

The preparation of this field trip and Guidebook has involved a great deal of work by a large number of individuals. Acknowledgment is hereby given to each one who participated in this effort.

The basic field work for the trip was done as follows:

1. The Pennsylvania Turnpike, by A. B. Cleaves, Head, Department of Geology, Washington University; cooperating geologist, Pennsylvania Topographic and Geologic Survey.

2. From Harrisburg to the New York State line, by Bradford Willard, Head, Department of Geology, Lehigh University; cooperating geologist, Pennsylvania Topographic and Geologic Survey.

3. New York State portions of the trip, by John G. Broughton and staff of the New York State Science Service.

4. Portions of the Pittsburgh-Harrisburg trip not on the Turnpike, by R. E. Bayles, C. R. Fettke, R. E. Sherrill, and R. C. Stephenson.

5. Additional field work along the entire route, to correlate the various segments of the journey together, by C. R. Fettke, G. C. Grow, Jr., C. E. Prouty and F. M. Swartz.

Acknowledgment goes also to the following people who assisted with the drafting of many of the maps, charts, and sections used in the Guidebook: Mr. R. F. Reinhard, Mr. Frank Whalen, Miss D. M. Bye, Mrs. R. J. Christian, Mr. Robert Woods, Mr. A. I. Ingham, Mr. J. L. Scott, and Mr. H. E. Thomas.

The Pittsburgh Geological Society greatly appreciates the cooperation of the Pennsylvania Topographic and Geologic Survey, and of the New York State Science Service. The personnel of both of these organizations have been very helpful in all phases of the work.

Acknowledgement is also due various companies for making available the time of certain employees for planning and carrying out the trip and for planning and editing the Guidebook.

For the Secondary Recovery Conference the work of E. T. Heck, and R. W. Harding is gratefully acknowledged.

The Pennsylvania Topographic and Geologic Survey sponsored the work of F. M. Swartz who contributed much of the descriptive material. The discussions at stop numbers 2, 4, 5, 6, 7, 8, 9, 10, 11, 13, 17, and 18, in the Guidebook are those of Dr. Swartz.

Besides the basic field work, detailed descriptive geology for the Harrisburg-New York State Line sector was submitted by Dr. Willard; Dr. Broughton and staff prepared similar material for the New York State area. These works were combined and consolidated, for the regional purposes of this trip, by Dr. Swartz. With this material at hand, together with considerable work of his own, Dr. Swartz has prepared the section entitled "General Character of the Paleozoic Sediments from Western to Central Pennsylvania and to Western New York," which is included as a part of the Guidebook.

The Pennsylvania Turnpike strip maps, and geologic map and sections for Harrisburg area were supplied by the Pennsylvania Topographic and Geologic Survey.

EXPLANATION OF MAPS AND SECTIONS

In order to provide geological orientation along the route, columnar sections, structure sections, stratigraphic charts, topographic sheets, a structure index map, a relief map, a route map, an oil and gas map, and a geologic map are included in the Guidebook. Stops for geology and important milepost references are indicated on the maps (except oil and gas) and structure sections. By referring to these, one may readily determine, at any place along the trip, the stratigraphic position of the rocks, their structural relationship, and the general regional geology. For various segments of the trip, maps and sections should be used as follows:

Pittsburgh to Allegheny Front (89.55):
Columnar Section A, back pocket
Topographic Sheet 1, page 39
Structure Section 1, page 41

Allegheny Front to Harrisburg (228.70):
Columnar Section B, back pocket
Topographic Sheet 1, page 39
Structure Section 1, page 41

Harrisburg to New York State Line (381.00):
Columnar Section C, back pocket
Topographic Sheets 2, 3 and 4, pages 57, 65, 69
Structure Section 2, page 67

New York State Line to Rochester (490.50):
Columnar Section D, back pocket
Topographic Sheets 4 and 5, pages 69, 77
No structure section for this part of trip.
See structure index map (page 85) for anticlinal trends
Glacial maps..............pages 71, 72, 73, 74

Rochester-Niagara Falls sections:
Columnar Section E, back pocket
No topographic sheets or structure section for this part of trip
Niagara Gorge panorama, back half-pocket

Buffalo to Bradford:
Columnar Sections D and F, back pocket
No topographic sheet or structure section for this trip.

The maps showing the route, geology, relief, and anticlinal trends, cover the entire itinerary, and will aid in the interpretation of the regional features. They are as follows:

Route map ....page 12
Geologic map ....page 17
Structure Index map ....page 85
Relief map ....page 117
The Oil and Gas map ....page 121
(Covers the entire Appalachian Area.)

The stratigraphic charts show the rock system relationships for the area covered by the trip and will aid in interpreting the major facies changes of the northern Appalachian region. They are as follows:

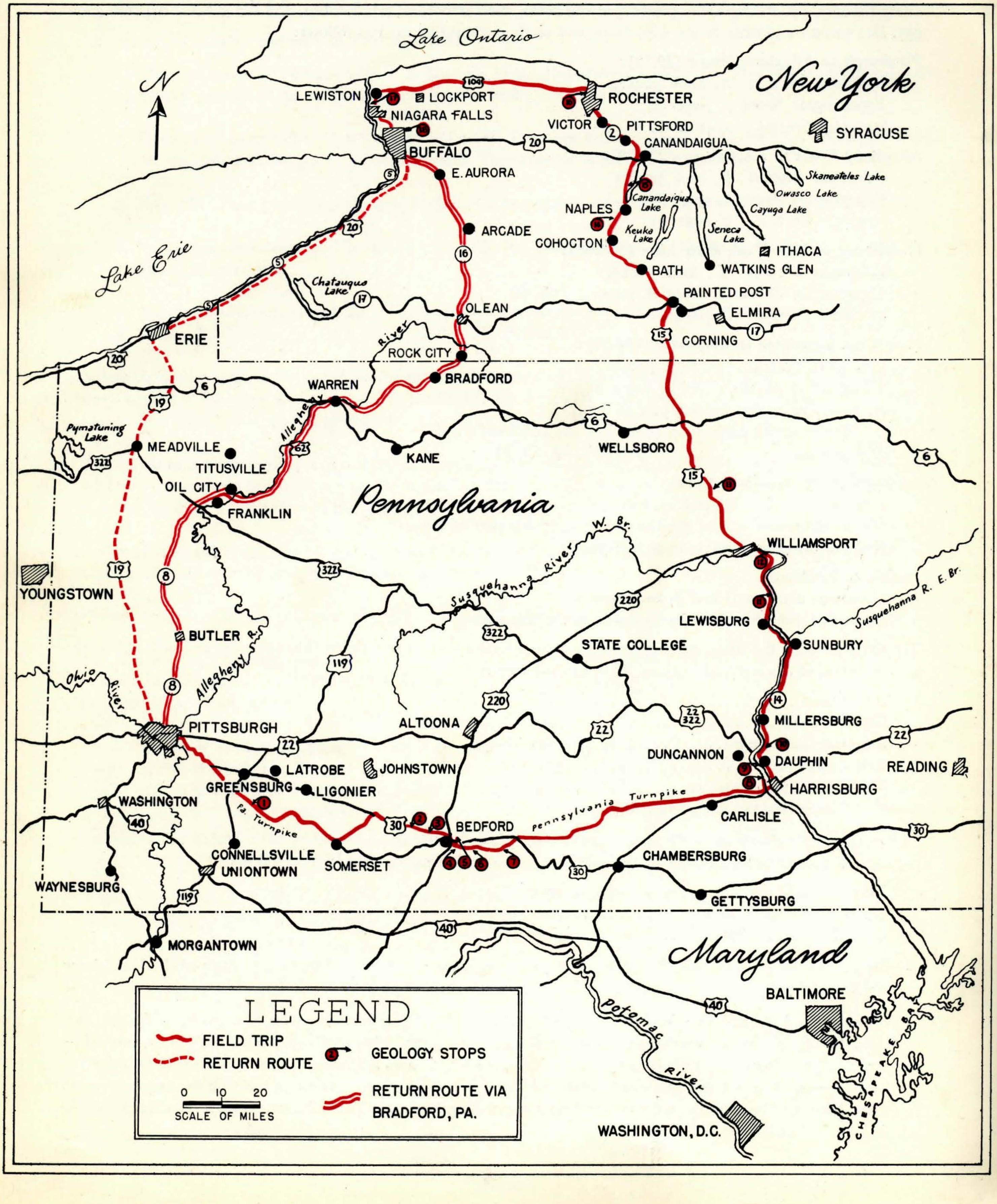
Mississippian-Devonian ....page 101
Silurian and Late Ordovician ....page 107
Ordovician and Cambrian ....page 115

Strip maps for the Pennsylvania Turnpike, and a map showing structure sections and geology of the Harrisburg area (mileposts and geology stops not shown): back half-pocket.

On the maps and structure sections the encircled numbers, (2) etc., refer to stops for geology, other figures, mp. 43.6, mp. 263.9, etc., refer to mileposts in the *total* mileage column. These mileage points have been marked in order to call attention to the features at those localities, since time does not permit stops for discussion of them. In the log of the trip two mileage columns (Total and Trip) are given in order to aid in locating the map references in the road log, and because the milepost markers along the Pennsylvania Turnpike start from its western terminus, which is several miles east of our starting point.

ROUTE MAP OF FIELD TRIP

A·A·P·G Midyear Meeting, Pittsburgh, Pa., October 4 to 9, 1948



THE ITINERARY SUMMARIZED

Leader: FRANK M. SWARTZ

WEDNESDAY, OCTOBER 6, FIRST DAY

Extent of trip: Pittsburgh to the Susquehanna River opposite Harrisburg, north along the west side of the river to Second Mountain north of Marysville; return to Harrisburg for overnight. Mileage: about 229.

Principal features: For the first 90 miles, in the Allegheny Plateau Province of the Appalachian Highlands, the surface is veneered by the gently warped, 1,500-foot sequence of the coal-bearing Pennsylvanian system; a few deeper synclines preserve small thicknesses of Permian strata; Chestnut Ridge and Laurell Hill anticlines bring to the surface Mississippian shales, limestones, and sandstones.

The Allegheny Front marks the striking change to the Ridge and Valley Province, where up-ended sandstones of the strongly folded 25,000 feet of Pennsylvanian, Mississippian, Devonian, Silurian, Ordovician, and Cambrian sediments stand in relief as long narrow ridges above the levels of the less-resistant formations. Large and small anticlines, synclines, and faults will be observed together with significant east-west facies changes and one well-defined disconformity. Axial planes of larger anticlines typically dip southeast, as do the large overthrust faults; axial planes of some small adjustment folds dip northwest.

Leaving Blue Mountain tunnel, there is a fine panorama of the Great Valley, which forms the southeasterly, marginal portion of the Ridge and Valley Province and is floored by folded and faulted Cambro-Ordovician shales and limestones. Along the southeastern margin of the Great Valley the Lower Cambrian quartzites and Pre-Cambrian metavolcanics rise to form the South Mountains region of the Blue Ridge Province, then Triassics are down-faulted in the Piedmont Province.

Blue or Kittatinny Mountain, marking the northern boundary of the Great Valley, again is crossed at Susquehanna Gap. The day's trip ends in the Mississippian Pocono sandstone where it forms Second Mountain north of Marysville. The route along the Susquehanna will be retraced to Harrisburg.

Stops for geology will be as follows:

1. On the approach to Chestnut Ridge anticline to see rocks of the Allegheny formation, and to discuss regional geology.
2. On the Allegheny Front for outlook from the high escarpment of the Mississippian Pocono sandstone. If the day is clear, valleys and ridges formed by rapidly rising, folded Devonian, Silurian and Cambro-Ordovician strata will be observed prior to traversing them.
3. On the Schellsburg anticline to observe the Oriskany sandstone, soon to be penetrated at a depth of about 9,000 feet at the Grove well 13 miles to the west. Drilling is planned to explore the Silurian, Ordovician, and perhaps upper Cambrian in the Schellsburg anticline.
4. At Bedford Gap in Evitts Mountain to see upended basal Silurian and Upper Ordovician sandstones soon to be cut by the drill in Schellsburg anticline. The easterly thinned and coarsened extensions of these strata will be seen at Susquehanna Gap, and the northerly portions are partly exposed at the Niagara Gorge.
5. At quarry 1½ mile northeast of Bedford Gap to see vertically dipping Middle and Lower Ordovician limestones and dolomites that will be drilled in the Schellsburg anticline.
6. In Friends Cove, midway between Evitts and Tussey Mountain to see weathered, sandy Upper Cambrian Gatesburg dolomite and to discuss indications of Friends Cove overthrust. The Gatesburg is the deepest horizon likely to be reached by drilling in the Schellsburg anticline.
7. At Clear Ridge Cut to see interfingering relations of the Catskill red-bed and Chemung marine facies, and to observe from top of cut the regional geology from the Cambrian of Friends Cove to the Carboniferous of the Broad Top Mountain region.
8. At Susquehanna Gap to see thinned and coarsened Late Ordovician resting unconformably on Martinsburg shale and overlain by near-source facies of the Silurian Tuscarora, Clinton, Bloomsburg formations.
9. At Second Mountain to see Mississippian Pocono sandstone, conglomeratic and cross bedded, overturned on south limb of southerly syncline of the "fish-tail" of the southern anthracite coal field. The flat-topped mountain ridges, the level of the hill-tops of the intervening valleys, and the banks neighboring the Susquehanna form three prominent erosional levels.

THURSDAY, OCTOBER 7, SECOND DAY

Extent of trip: Harrisburg, Pennsylvania, to Rochester, New York, about 262 miles.

Principal features: The Allegheny Plateau Province and the Ridge and Valley Province of the Appalachian Highlands, crossed west to east perpendicular to the strike on the first day's trip, are traversed in reversed order and from south to north on the second day. At the northern end of Canandaigua Lake, New York, the route leaves the Highlands, and enters the flatter-surfaced Interior Lowland.

Most of the ridges traversed in the Ridge and Valley Province during the first day are formed by Lower Silurian Tuscarora sandstone. The anticlinoria plunge eastward, so that the route for the second day skirts various anticlinal noses of the Tuscarora ridges that dominate the topography farther west. Four great ridges will be traversed where the Mississippian Pocono sandstone flanks synclines deepening eastward so that they carry Pennsylvanian sediments below surface in the great anthracite fields of eastern Pennsylvania; the route passes close to the nose of another synclinal Pocono ridge.

In contrast to plunge of the Paleozoics to relatively deeper levels in the Ridge and Valley Province where crossed on the second day between Harrisburg and Williamsport, the strata of the Allegheny Plateau Province lie at shallowed depths in northcentral Pennsylvania as compared to the Pittsburgh-Somerset region. Hence belts of Pennsylvanian coal-bearing strata are few and small, and Mississippian and Devonian strata form most of the surficial bedrock. The region is traversed by a number of gentle anticlines and synclines continuous from the southwest.

North of Canandaigua Lake, which is one of the famous "Finger Lakes," the flat-lying surface is underlain by Middle and Lower Devonian and then Upper Silurian shales and some limestones that rise gradually to the north. Bed rock exposures are very limited.

On the northward journey, glacial moraines and kames appear before reaching Sunbury; they become increasingly abundant in northern Pennsylvania, and form striking features of the surface topography along parts of the route in New York.

On the first day's trip, the Mississippian, Devonian, Silurian, and Ordovician sediments undergo important facies changes reflecting eastward approach toward ancient land surfaces from which the clays, sands, and gravels were principally derived. On the second day, the facies changes in considerable part reflect retreat from the region of those land areas.

Stops for geology will be as follows:

10. On Peters Mountain, formed by Pocono sandstone on the northern flank of the Cove Valley Syncline. If the day is clear, there will be a fine panorama across folded Devonian shales and sandstones to Pocono sandstone ridges marking the eastwardly plunging syncline that constitutes the northerly branch of the "fish-tail" of the southern anthracite coal field.
11. South of Allenwood where the McKenzie-Clinton succession is finely exposed and contains sharply marked faunal zones. Sandstones that dominate the Clinton near Harrisburg have changes laterally to shales; the Clinton is more complete and about ten times as thick as at Niagara Gorge.
12. At Bald Eagle Mountain south of Williamsport for view of Susquehanna Valley and approach to the Plateau Province.
13. Steam Valley Summit for lunch and to discuss regional geology of the Plateau Province.
14. South of Naples to observe the glacial kame-moraine topography at the confluence of glacially deepened valleys.
15. Very short stop on bluff along west side of Canandaigua Lake for fine view of this typical Finger Lake, occupying a glacially overdeepened valley.

FRIDAY, OCTOBER 8, THIRD DAY

Extent of trip: Rochester to Niagara Falls and Buffalo, about 118 miles.

Principal features: The first two days furnished observations of the structures and stratigraphy across the northern part of the Appalachian Basin. On the third day the trip skirts the southern shore of Lake Ontario near the escarpment capped by the Middle Silurian Lockport dolomite. The gorges cut in the escarpment by the Genessee River at Rochester and Niagara River at Niagara Falls expose Middle and Lower Silurian and uppermost Ordovician strata of the northern Appalachian Rim. The Silurian sediments are composed of shallow water, largely marine but in part freshened-water sands, clays, and dolomites; they are much thinner than their equivalents in Pennsylvania in part because of less rapid influx of sands and clays, in part because of discontinuities of sedimentation; clastic features are prominent in parts of the dolomites.

At Buffalo, a quarry section exposes Middle Devonian, cherty Onondaga limestone resting with a remarkably regular surface of disconformity upon Upper Silurian limestone. Early Middle Devonian, Oriskany and other Lower Devonian, and some latest Silurian strata are absent.

Marked changes in sequence, facies, and thickness are known to occur in the Ordovician and Cambrian as well as in the Silurian in the Lake Erie as compared to central Pennsylvania region. Except for Queenston beds, the Cambro-Ordovician sediments remain below surface along the south shore of Lake Ontario, and long distances would have to be covered to visit exposures of these older strata. The stratigraphic changes in all these sediments have important bearings on prospects for future production in the deeper geologic horizons of the Appalachian region.

Stops for geology will be as follows:

16. Rochester gorge section of basal Lockport, Rochester-Clinton, Medina, and uppermost Queenston as observed from bridge.

17. Niagara gorge, walking up gorge from quarries at Lewiston in Whirlpool sandstone famous as White Medina gas sand, through the Medina, Clinton, Rochester, and Lockport formations. View of Niagara Falls, after lunch.

18. Devonian-Silurian unconformity at Bennett quarry in Buffalo. Disconformable disappearance of Oriskany and associated strata illustrates the reason for one type of stratigraphic trap, as well as for disappearance of Oriskany sands over large subsurface regions farther south.

Secondary Recovery Conference

Those attending Secondary Recovery Conference will continue to Bradford for evening banquet and talk dealing with geologic aspects of water flooding.

SATURDAY, OCTOBER 9

Field and laboratory inspections of water flooding operations in Bradford Field. Return to Pittsburgh Saturday evening.

LEGEND

TRIASSIC

- Trb — GETTYSBURG SHALE
- Trs — NEW OXFORD FORMATION
- Trd — INTRUSIVE DIABASE

CARBONIFEROUS

- Cd — DUNKARD GROUP
- Cmh — MONONGAHELA FORMATION
- Cc — CONEMAUGH
- Ca — ALLEGHENY
- Cpv — POTTSVILLE FORMATION
- Cm — MISSISSIPPIAN

DEVONIAN

- Du — PORTAGE TO CATSKILL
- Dmu — CHEMUNG TO ONONDAGA
- Dm — HAMILTON TO ONONDAGA
- Dl — ORISKANY AND HELDERBERG

SILURIAN

- Su — CAYUGA
- Sm — UPPER NIAGARA (LOCKPORT)
- Sl — LOWER NIAGARA (CLINTON) AND UPPER MEDINA
- S — SILURIAN

ORDOVICAN

- Ou — UPPER ORDOVICAN
- Olm — LIMESTONES OF TRENTON TO BEEKMANTOWN

CAMBRIAN

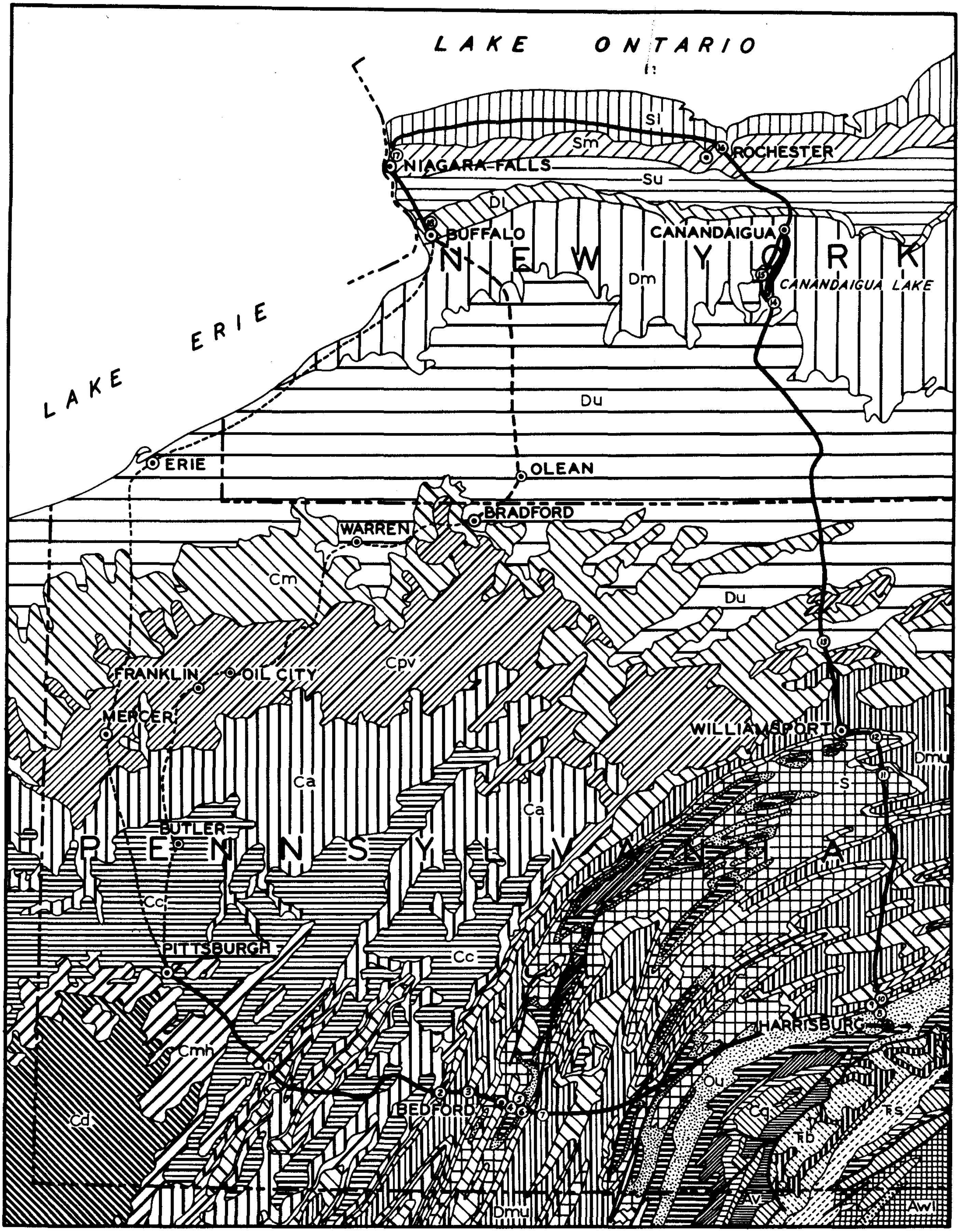
- €u — UPPER CAMBRIAN OR ST. CROIXAN
- €l — LIMESTONE AND SHALE OF LOWER AND MIDDLE CAMBRIAN
- €q — LOWER CAMBRIAN QUARTZITES AND SLATES

PRE-CAMBRIAN

- Awl — ALBITE-CHLORITE SCHIST AND GARNETIFEROUS PHYLLONITE
- Av — VOLCANIC
- Acs — COCKEYSVILLE MARBLE, SETTERS FORMATION AND ASSOCIATED VOLCANIC ROCKS

—②— STOPS FOR GEOLOGY

MAP ADAPTED FROM UNITED STATES GEOLOGICAL MAP
BY J. LEWIS SCOTT & HOWARD E. THOMAS AUGUST 31, 1948



GEOLOGICAL MAP OF THE NORTHERN PORTION OF THE APPALACHIAN REGION

A. A. P. G. FIELD TRIP OCTOBER 6 TO 9, 1948

ITINERARY

FIRST DAY'S TRIP

Pittsburgh to Harrisburg

MILEAGE

Pittsburgh to Harrisburg, up west side of Susquehanna to Second Mountain and return to Harrisburg for overnight.

0.00 — **Leave Grant Street** entrance to the William Penn Hotel, Pittsburgh, Pennsylvania, at **7:30** A.M., E.S.T. Set odometer at 0.00 miles. Proceed southwest on Grant Street, passing city and county government buildings on left. On this site in 1758 Major James Grant, leader of an advance party of English troops, was defeated by the French and their Indian allies from Fort Duquesne. On November 25, 1758, the main English army under General John Forbes occupied the area. The new fort was named Fort Pitt in honor of William Pitt, and letters written by Forbes on this date were headed "Pittsburgh." This was the first use of the name, which has persisted to this day, even to the original spelling.

0.20 — **Turn right** on Third Avenue. Proceed one block, turn left on William Penn Way. Proceed one block, turn left onto the Boulevard of the Allies.

0.60 — Crossing overpass above approach to Liberty Bridge. The hill across the river is composed of UPPER CONEMAUGH and LOWER MONONGAHELA strata lying essentially horizontal. The PITTSBURGH COAL, marking the base of the MONONGAHELA GROUP, crops out on the hillside about 200′ above the level of the Liberty Bridge. This bridge, spanning the Monongahela River, is 2,663 feet long and stands 112 feet above mean low water level. It was completed in 1927 at a cost of $3,380,000.00. It connects, at its southern end, with the Liberty vehicular tunnels, completed in 1924 at a cost of $6,000,000.00. These twin tunnels are driven through the upper part of the CONEMAUGH GROUP in the BIRMINGHAM SHALE approximately 200′ below the base of the PITTSBURGH COAL. The tunnels are 5,889 feet long.

0.60 — Duquesne University on bluff at left. Rocks exposed on left belong to the upper part of the CONEMAUGH GROUP.

1.10 — Mercy Hospital on left. First hospital in Pittsburgh. Established during cholera epidemic in 1847.

1.80 — Jones and Laughlin Steel Corporation plants on both sides of river.

2.50 — Magee Hospital on left.

3.05 — Entrance to Schenley Park over Wilmot Street Bridge. Outcrop of AMES LIMESTONE (at middle of CONEMAUGH GROUP) below bridge at level of Baltimore & Ohio railroad tracks.

3.40 — **Turn right** at clover leaf onto alternate U. S. Route 30.

3.55 — View across PRE-GLACIAL CHANNEL of MONONGAHELA RIVER. Phipps Conservatory, famous for its flower shows, in foreground. Cathedral of Learning, University of Pittsburgh in middle background.

3.75 — **Turn left** at Phipps Conservatory.

3.85 — Buildings of Carnegie Institute of Technology on right.

4.00 — Crossing bridge over POST-WISCONSIN VALLEY in PRE-GLACIAL CHANNEL of MONONGAHELA RIVER. Good view of Carnegie Institute of Technology Buildings on right.

4.10 — Carnegie Institute, on right, includes the Museum, Art Gallery, Music Hall, and Library.

4.20 — **Turn right.** Forbes Field (home field of Pittsburgh Pirates) on left. Cathedral of Learning and Stephen Foster Memorial, University of Pittsburgh, straight ahead.

4.25 — **Turn right** onto Forbes Street. Carnegie Museum on right, Heinz Memorial Chapel and Mellon Institute of Industrial Research (building with columns) on left.

4.60 — Pittsburgh Station, U. S. Bureau of Mines on right.

6.10 — **Straight ahead** on Forbes Street.

MILEAGE	
6.75	Entrance to Frick Park. Homewood Cemetery on left.
7.40	Fern Hollow Bridge over POST-WISCONSIN VALLEY. PRE-GLACIAL CHANNEL of MONONGAHELA RIVER, straight ahead at bridge level.
7.45	Outcrop of MORGANTOWN SANDSTONE (near top of CONEMAUGH GROUP); AMES LIMESTONE (at middle of CONEMAUGH GROUP) crops out at foot of bridge pier.
7.50	**Continue straight ahead** on Forbes Street.
7.60	**Turn left** on East End Avenue leaving street car tracks.
7.80	**Turn right** on Edgerton Street, which becomes Rebecca Avenue on entering Wilkinsburg.
9.15	**Turn right** on Ardmore Boulevard (U. S. Route 30).
9.65	Fine exposures of PITTSBURGH COAL (base of MONONGAHELA GROUP) in excavations for clover leaf interchange. The Pittsburgh Coal seam is the most valuable mineral deposit in the world.
12.35	MORGANTOWN SANDSTONE. (Near top of CONEMAUGH GROUP.)
13.05	Northwest end of George Westinghouse Bridge across Turtle Creek valley. East Pittsburgh plant of Westinghouse Electric may be seen in valley to left.
13.40	Fine section of lower part of MONONGAHELA GROUP in deep cut at southeast end of bridge. PITTSBURGH COAL exposed at level of highway near axis of DUQUESNE SYNCLINE. Note caving of strata above old mine workings exposed in road cut. Excellent section of upper half of CONEMAUGH GROUP exposed on southeast side of Turtle Creek valley below bridge level.
13.95	REDSTONE COAL (lower part of MONONGAHELA GROUP) on both sides of highway.
14.25	BENWOOD LIMESTONE (a fresh water limestone in middle of MONONGAHELA GROUP) in road cut on both sides of highway.
14.85	East McKeesport. Continue straight ahead on Route 30.
15.40	PITTSBURGH COAL stripping operation on left.
15.95	**East McKeesport Gas Storage Area,** 1 mile to right. This pool is operated by The Peoples Natural Gas Company. It covers about 435 acres, and there is now more than 2 billion cubic feet of gas in storage, being held in readiness for peak loads during the coming winter. Gas is stored primarily in the 100′ sand (depth 1800′) at about 500 pounds pressure. This is one of 20 underground gas storage pools in Pennsylvania.
16.35	PITTSBURGH COAL on left. This point also affords a fine view across ALLEGHENY PENEPLAIN
17.30	Cross axis of MURRYSVILLE ANTICLINE. The MURRYSVILLE GAS FIELD, source of first gas piped into Pittsburgh in 1882 is located along this anticline a few miles to the northeast.
17.45	PITTSBURGH LIMESTONE (in uppermost part of CONEMAUGH GROUP) in road cut on left; also in another cut on right a short distance beyond at top of hill.
19.95	Axis of Duquesne Syncline. Fine view across ALLEGHENY PENEPLAIN to left.
21.20	Large gob pile on right near abandoned PITTSBURGH COAL mine.
22.25	BENWOOD LIMESTONE (middle part of MONONGAHELA GROUP).
23.80	BENWOOD LIMESTONE.
24.25	Irwin Ticket Booth. West end of **Pennsylvania Turnpike.** The Pennsylvania Turnpike is one of the most unique highways in the United States. It was completed in 1940 at a cost of more than $70 million. This four lane, 160 mile long highway has no intersections, sharp curves, or steep slopes. Entrance to and exit from Turnpike is by eleven conveniently spaced clover leaf interchanges. Alignment and curvature has been arranged to facilitate movement of vehicles at uniform speed without interruption or delay. Seven tunnels totaling 6.7 miles in length have been

cut through the highest ridges of the Appalachian Mountains, thus saving about 9,000 feet of vertical climb. The highway crosses the entire width of the Ridge and Valley section of the steeply folded Appalachians.

Very extensive geological work was done along the route prior to and during construction. Dr. Arthur B. Cleaves was Turnpike Geologist. A "Guidebook to the Geology of the Pennsylvania Turnpike" has been published by the Pennsylvania Topographic and Geologic Survey (Bulletin G20, 1942, Cleaves and Ashley). A more detailed geological guidebook along the route, prepared by Dr. Cleaves, is now on press.

Nearly all of the material used for the Turnpike portion of this itinerary has been taken directly from Dr. Cleaves' work. Permission has been granted the Pittsburgh Geological Society for the use of this material, and acknowledgment is hereby given.

Note: Re-set odometer to 0.00 miles at this point. For your convenience, note that mile posts are situated in the line of delineators, or reflector markers, on right side of highway. In addition, every 1/10 (one-tenth) mile is stenciled on delineator posts just beneath reflector buttons, e.g., 7.5, 7.6, etc. (Some of these 1/10 mile markers have been removed during repairs on shoulders and by accidents). With these aids, all stations noted in the itinerary should be easily located.

MILEAGES Total	Trip	
24.55	0.30	First cut east of interchange. This outcrop is located structurally on the east flank of the IRWIN-PORT ROYAL SYNCLINE. Dip 2° NW.

Section: Gray shale, arenaceous, 20-24'; upper 10' strongly weathered.
Waynesburg Coal (Upper bench), 11".
Fire Clay, 11".
Waynesburg Coal (Middle bench), 1'10".
Fire Clay, 1'11".
Waynesburg Coal (Bottom bench), 9".
Fire Clay and shale, 11".
Sandstone, platy, micaceous, thin-bedded, 5".

The WAYNESBURG COAL is generally considered as marking the top of the MONOGAHELA GROUP, and therefore, the top of the PENNSYLVANIAN SYSTEM. The top 20-24 feet of arenaceous gray shale would represent the basal part of the PERMIAN SYSTEM as mapped in the Appalachian area. These are the youngest Paleozoic beds to be seen on this trip.

26.45	2.20	REDSTONE LIMESTONE (in lower part of MONONGAHELA GROUP) with overlying sandstone exposed in road cut on right. Channeling at base of sandstone cuts out limestone in places.
26.75	**2.50**	PITTSBURGH COAL, in abandoned openings, right and left of the Turnpike. Extensive stripping operations on north side exposed the coal and the overlying micaceous sandstones and shales. Dip 4° NW on the northwest flank of the GRAPEVILLE ANTICLINE. This coal marks the base of the MONONGAHELA GROUP. Note effect of the acid mine water on the vegetation.

MILEAGES Total	Trip	
27.60	3.35	Bridge over Turnpike. The cut exposes upper Conemaugh as follows: Connellsville Sandstone, 18′ gray, cross-bedded, platy sandstone and interbedded sandy shale. Carbonaceous shale and coal stringers, 2′6″. Little Clarksburg Coal, 8″. Upper Clarksburg Limestone, 2′ gray, brecciated limestone containing secondary nodular siderite.
27.85	3.60	Arona Viaduct over Little Sewickley Creek and the Hempfield branch of the Pennsylvania Railroad.
28.05	3.80	Arona cut. CONEMAUGH GROUP. This high cut is the result of a slump type of slide that occurred during construction. Movement of sandstone block above shale was facilitated by intersecting vertical joints. The strata belong in the Upper Part of CONEMAUGH GROUP, and consist of 20-30′ of sandstone, underlain by soft red shale, interbedded with thin layers of CLARKSBURG LIMESTONE. The area is still part of the northwest flank of the Grapeville Anticline. Dip here is 7° NW.
29.05	4.80	Red beds in Conemaugh Group.
29.15	4.90	GRAPEVILLE ANTICLINE separating the Irwin and Greensburg coal basins. Immediately to the west the dip is 2°. UPPER CONEMAUGH GROUP; 10′ gray micaceous sandstone overlain by 15′ gray shale and clay, some red shale.
31.45	7.20	GREENSBURG SYNCLINE. Occasional exposures of Conemaugh shales.
32.05	7.80	**Rest Stop.** Hempfield Gas Station. Fifteen minute stop.
32.35	8.10	BUFFALO SANDSTONE (lower part of CONEMAUGH GROUP) on left. Yellowish brown, thin-bedded, platy and micaceous. Underlain by BRUSH CREEK SHALE, black, calcareous and fossiliferous; and Brush Creek Coal, 16″, in creek bed to right of road.
32.55	8.30	West end of New Stanton Interchange. BRUSH CREEK coal and shale are again exposed.
32.85	8.60	New Stanton Viaduct and Interchange.
33.15	8.90	MAHONING SANDSTONE and interbedded shales marking base of CONEMAUGH GROUP. The sandstone is a gray, medium-grained rock, predominantly shaly in the upper part. Cross axis of FAYETTE ANTICLINE, separating the GREENSBURG and LATROBE-CONNELLSVILLE synclines or coal basins.
33.35	9.10	Bridge. Note the entry, on left, to the Catherine Coal Company mine in the UPPER FREEPORT COAL. This coal marks the top of the ALLEGHENY GROUP.
33.45	9.20	CONTACT of CONEMAUGH and ALLEGHENY GROUPS. MAHONING SANDSTONE and shale underlain by the UPPER FREEPORT COAL, 4′ thick. It has a 2″ to 3″ binder in the lower portion of the bed.
33.65	9.40	Extensive stripping operations in UPPER FREEPORT COAL (at top of ALLEGHENY GROUP) on right.
34.05	9.80	New Stanton Gas Station. Extensive stripping operation in UPPER FREEPORT COAL left of Turnpike, just east of station. Dip is east.

MILEAGES Total	Trip	
34.45	10.20	BRUSH CREEK SHALE (lower part of CONEMAUGH GROUP). Black, calcareous, fossiliferous. Contains thin limestone member.
34.75	10.50	CHESTNUT RIDGE appears straight ahead in distance.
35.45	11.20	Red, soft shale containing three limestone beds varying from 1′ to 2′ thick, gray, brecciated, thought to be UPPER CLARKSBURG LIMESTONE. These strata are overlain by brown platy sandstone, CONNELLSVILLE (?). Dip 6° E. East flank of Fayette Anticline.
35.65	11.40	Bridge over township road.
36.15	11.90	PITTSBURGH COAL beneath Turnpike immediately west of bridge. Extensive mine subsidence exists at this locality. Consequently, during Turnpike construction the strata were excavated to a level beneath the coal and the area backfilled with suitable material. Note old mine entry in PITTSBURGH COAL south of right-of-way. Also new opening in REDSTONE COAL on hill above. Evidence of subsidence in fields to left of Turnpike.
36.30	12.05	REDSTONE COAL, approximately 44″ thick, underlain by 5′ of REDSTONE LIMESTONE. Dip 2° E.
37.75	13.50	BENWOOD LIMESTONE (middle of MONONGAHELA GROUP) in cut on north side of Turnpike. A fine view of Chestnut Ridge straight ahead from this point. Chestnut Ridge is a topographic feature resulting from the CHESTNUT RIDGE ANTICLINE, the westernmost of the great foreland folds of the Appalachians.
38.25	14.00	PITTSBURGH COAL mine shaft north of Turnpike. Road crosses axis of Connellsville-Latrobe Syncline at this point.
38.55	14.30	BENWOOD LIMESTONE on west flank of CHESTNUT RIDGE ANTICLINE.
39.35	15.10	Mine subsidence area. The Pittsburgh coal underlies this area at a depth of over 150 feet. The strata exposed along the highway and in the railroad cut include the BENWOOD LIMESTONE, the SEWICKLEY SANDSTONE and COAL, and the FISHPOT LIMESTONE. The SEWICKLEY COAL is approximately 4 feet thick and overlies 10 feet of thin-bedded sandstone and arenaceous shale. Beneath this sandstone are 6 feet of black, platy to massive limestone. All of these strata are in the middle of the MONONGAHELA GROUP.
39.60	15.35	REDSTONE COAL and LIMESTONE. This coal shows a thickness of 66″ with binders. It is overlain by about 1′ of shale and thin-bedded, platy sandstone, and underlain by 5′ (plus) of REDSTONE LIMESTONE. Sloughing of the bank partially conceals the section. Also note extensive stripping operations in both REDSTONE and PITTSBURGH COALS on both sides of highway. Slope mine in PITTSBURGH COAL to right of highway. This is the easternmost occurrence of Pittsburgh Coal along the Turnpike. At 15.4 miles the highway crosses the Pittsburgh Coal crop line. The coal averages 8′ 4″ thick in the area and here dips 4° NW.
40.20	15.95	Upper part of CONEMAUGH GROUP. Section: Connellsville Sandstone, 12′ (plus) sandstone and shale. Little Clarksburg Coal, 3″. Sandstone, shaly, 19′. Shale, thin-bedded, black, 1′. Sandstone, shaly, 3′. Clarksburg Limestone, containing siderite concretions, 2′8″. Shale, with siderite concretions, 1′7″. Shale.

MILEAGES Total	Trip	
40.45	16.20	Mt. Joy cut. Middle part of CONEMAUGH GROUP. This cut is 97 feet deep, 1,200 feet long, nearly 300 feet wide at the top, and required 500,000 cubic feet of excavation. The upper 75 feet (plus) of strata exposed is the MORGANTOWN SANDSTONE; massive, medium-grained, cross-bedded, and micaceous. Immediately underlying it is the WELLERSBURG (ELK LICK) COAL. Beneath the coal is the WELLERSBURG CLAY containing limestone nodules. Underlying the clay is a thick section of inter-bedded shale and sandstone with local coal lenses here designated as the BIRMINGHAM SHALE. Note steepening of dip on northwest flank of CHESTNUT RIDGE ANTICLINE.
40.85	16.60	Bridge. SALTSBURG SANDSTONE in middle part of CONEMAUGH GROUP. Platy to medium-bedded sandstone, some interbeds of carbonaceous material high in sulphur.
41.10	16.85	**Stop No. 1.**

Basal CONEMAUGH and upper ALLEGHENY strata rising in western limb of CHESTNUT RIDGE ANTICLINE. Discussion of regional structural, stratigraphic, economic geology and physiography.

The section exposed here may be tentatively divided into cyclothems as follows:

CONEMAUGH GROUP:

BRUSH CREEK CYCLOTHEM:

Marine phase: Brush Creek shale, thin-bedded, carbonaceous, fossiliferous	12	feet
Brush Creek coal	7½	inches
Clay shale, gray	15	feet
Fine grained grayish sandstone	4	feet

MAHONING CYCLOTHEM:

Red and green shale, variegated	10	feet
Shale with limonitic concretions and nodules	4	feet
Mahoning sandstone, fine-grained	0-15	feet

ALLEGHENY GROUP:

UPPER FREEPORT CYCLOTHEM:

(Upper phase missing here)

Upper Freeport coal, deeply channeled by Mahoning sandstone. Typical coal section is in descending order: 22 inches coal, 1 inch binder, 13 inches coal, 1 inch binder, 11 inches coal	4	feet
Shale with limonite nodules	15	feet

Note: South of the Turnpike and below highway grade there are two accessible, abandoned openings into the LOWER FREEPORT COAL.

41.65	17.40	ALLEGHENY GROUP. Dip 10° W. 34" black shale with coal stringers; underlain by platy sandstone, fine-grained; a two-foot bed of limonitic concretions; and a stratum of clay shale. Exact position of the strata is not known. Contact between ALLEGHENY group and underlying POTTSVILLE SERIES is concealed, but the HOMEWOOD SANDSTONE, top member of the POTTSVILLE SERIES is well exposed immediately to the east.
41.85–42.10	17.60–17.85	POTTSVILLE SERIES. A sequence of medium-bedded to platy sandstones, black shales, clay shale, and occasional thin coal seams dipping about 8° W.

MILEAGES Total	Trip	
42.45	18.20	Contact between POTTSVILLE SERIES of the PENNSYLVANIAN SYSTEM and the underlying MAUCH CHUNK GROUP of the MISSISSIPPIAN SYSTEM occurs here but is concealed. Upper portion of the MAUCH CHUNK is exposed on the left side of Turnpike in a 45′ cut. Red shale at top and bottom of cut, separated by gray sandstone and shale. –
42.60	18.35	Top of GREENBRIER LIMESTONE brought to the surface by a local fold on the west flank of CHESTNUT RIDGE ANTICLINE. About 4′ of massive gray limestone exposed. 2° S70°W.
43.35	19.10	GREENBRIER LIMESTONE near crest of CHESTNUT RIDGE ANTICLINE. Massive gray limestone, 14′ thick, underlain by 10′5″ of inter-bedded gray, calcareous shale and thin limestone layers. Fossils very abundant. 5° N 80W.
43.60	19.35	Turnpike crosses axis of CHESTNUT RIDGE ANTICLINE. The Summit gas field is located about 25 miles to the southwest along the axis of this anticline on a very prominent dome. Gas is obtained mostly from the Onondaga Chert and Oriskany Sandstone. Drilling on that dome has revealed a much more complicated faulted structure in depth than was indicated by the surface geology.
	19.6 –	Mauch Chunk
44.00	19.75	Contact between MAUCH CHUNK and overlying POTTSVILLE SERIES.
44.25	20.00	Contact between POTTSVILLE SERIES and overlying ALLEGHENY GROUP. The strata are here dipping about 4° E. The POTTSVILLE sandstones produce considerable float and also account for the rugged topography of Jacobs Creek valley on the east flank of Chestnut Ridge. Jacobs Creek passes under the Turnpike at this point, and the lower part of the ALLEGHENY GROUP with its coals may be seen between the creek crossing and the overhead bridge.
44.55	20.30	Strip operation in one of the coals belonging to the middle part of the ALLEGHENY GROUP may be seen to left of Turnpike.
45.20	20.95	Contact of the ALLEGHENY-CONEMAUGH GROUPS. In this cut, and just east of the bridge over the Turnpike the MAHONING SANDSTONE of the CONEMAUGH GROUP rests on the UPPER FREEPORT COAL of the ALLEGHENY GROUP. The coal varies in thickness from 10″ to 18″. The structure exposed here appears to be a small local anticline imposed on the east limb of the major structure.
46.15– 46.95	21.90– 22.70	BRUSH CREEK fossiliferous shale, dipping 3° E., with the BRUSH CREEK COAL, 6″ thick. The exposures occur both east and west of the bridge over the Turnpike at 21.9.
47.55	23.30	Donegal cut, immediately west of the Donegal interchange. In this deep cut the strata are nearly horizontal and comprise the BUFFALO shales and sandstones (lower part of the CONEMAUGH GROUP). They consist of hard, gray clay shales containing limestone nodules, and coarse, buff, channel sandstone.
47.85	23.60	Donegal Interchange. To left of Turnpike, in cut, the BRUSH CREEK COAL horizon and the BRUSH CREEK SHALE may be seen.
48.30	24.05	BRUSH CREEK COAL and SHALE. This cut, immediately east of the bridge over the Turnpike at the east end of the interchange, exposes a 9″ layer of BRUSH CREEK COAL, 20 feet of overlying fossiliferous BRUSH CREEK SHALE, and a fire clay containing siderite concretions underlying the coal.
48.45	24.20	Rolling hills of Ligonier Valley to left.
48.75	24.50	BRUSH CREEK COAL and SHALE. Coal is 7″ thick.

MILEAGES Total	Trip	
49.05	24.80	WOODS RUN LIMESTONE, (lower part of CONEMAUGH GROUP), nodular, 3′ thick, underlain by variegated red shale. Dips 2° E. and disappears beneath the grade of the road at the bridge.
49.55	25.30	LOWER BAKERSTOWN COAL (lower part of CONEMAUGH GROUP) adjacent to overhead bridge. Here 10 feet of black fissile shale rest on 8½″ of LOWER BAKERSTOWN COAL, which in turn rests on 12 feet of gray fine clay. The average dip is 2° W., although several irregular "rolls" are present. Crossed axis of LIGONIER SYNCLINE between this station and preceding one to the west.
49.95	25.70	View of Laurel Hill, a topographic feature resulting from LAUREL HILL ANTICLINE. Note the dip slopes on the northwest flank.
50.25	26.00	Strata approximately horizontal, belong to the lower part of the CONEMAUGH GROUP. UPPER FREEPORT COAL (top of the ALLEGHENY GROUP) is exposed at highway level at the northeast end of the cut.
53.15	28.90	UPPER KITTANNING COAL exposed in cut east of the bridge over the Turnpike at this point. Dips 5° W. Section: Shale; arenaceous, thin-bedded, 10′. Shale; carbonaceous, fissile, 6′. Upper Kittanning: 1½′ coal. 3″ binder. 4½″ coal. Sandstone; buff, 5″. Johnstown (?). Limestone; dark gray, nodular, 2½′. Fire clay; gray, 8′. Sandstone; fine-grained, medium-bedded. Grades eastward into shale.
54.10	29.85	POTTSVILLE SERIES: The contact with the overlying ALLEGHENY GROUP is concealed, but from this point eastward the series is excellently exposed. Locally, it is conglomeratic and in part iron-stained. Generally, it is a medium-bedded, slabby, and strongly cross-bedded sandstone. The HOMEWOOD SANDSTONE, at the top of the series, is quite massive.
54.55	30.30	CONTACT: POTTSVILLE SERIES of PENNSYLVANIAN and MAUCH CHUNK GROUP of MISSISSIPPIAN. The MAUCH CHUNK beds exposed here on the west flank of the LAUREL HILL ANTICLINE consist of inter-bedded blocky sandstone and soft red shale. Dip 7° W.
54.85	30.60	LOYALHANNA "LIMESTONE" poorly exposed to left of Turnpike. Actually a calcareous sandstone.
55.15	30.90	BURGOON SANDSTONE, top member of the Pocono group, is exposed on north side of highway. The LOYALHANNA "LIMESTONE," together with the BURGOON SANDSTONE, are logged as the BIG INJUN SAND by drillers in the southwestern Pennsylvania oil and gas fields. The BURGOON has been a very prolific producer of natural gas with some oil in Greene and Washington Counties.
56.15	31.90	Crossing axis of LAUREL HILL ANTICLINE.
56.35	32.10	LOYALHANNA "LIMESTONE" quarry to right of Turnpike. This quarry was opened and operated during the construction of the highway. The strata dip 2½° E., and a total thickness of 62.4′ is exposed. The Loyalhanna "limestone" is a massive, calcareous, fine to medium-grained sandstone. On fresh surfaces it is usually bluish to greenish gray in color, thus accounting for the local name "blue stone." Perhaps the most distinctive characteristic of the "limestone" is its cross-bedding. This cross-

MILEAGES Total	Trip	
		bedding, which is of the type generally attributed to a wind blown deposit, is visible even in a small hand specimen and stands out sharply when the surface of the exposure is slightly weathered. The formation is one of the most important key beds in southwestern Pennsylvania, not only in surface mapping, but also in subsurface studies of drill cuttings. The top is a horizon the driller can be depended upon to pick accurately in logging a well. The contact of the calcareous LOYALHANNA with the underlying, non-calcareous BURGOON is sharp.
56.80	32.55	West Portal of Laurel Hill Tunnel. The LOYALHANNA is exposed at the portal, dips 2½° E., and in the tunnel is 62′ thick.
57.65	33.40	East Portal of Laurel Hill Tunnel. The east portal of the tunnel is in the MAUCH CHUNK, which here is a platy, argillaceous sandstone with occasional red shale interbeds. Dip 2° E.
58.25	34.00	MAUCH CHUNK medium to massive-bedded, olive-colored sandstone overlain by red clay. These strata are exposed in a long cut to left of Turnpike.
58.80–59.35	34.55–35.10	MAUCH CHUNK red and green shales with interbedded, cross-bedded, platy sandstone. Dip 2° E.
59.40	35.15	CONTACT: MAUCH CHUNK GROUP of MISSISSIPPIAN SYSTEM and overlying POTTSVILLE SERIES of PENNSYLVANIAN SYSTEM. Red MAUCH CHUNK shales overlain by platy, medium-bedded POTTSVILLE sandstone. Dip 3° E.
59.70	35.45	Contact (?) POTTSVILLE-ALLEGHENY. Dip 6° E. Low cut exposing 12′ arenaceous shale, 2′ carbonaceous shale, 5″ binder slate, 7″ coal (BROOKVILLE ?), and 5′ of platy to medium-bedded, argillaceous sandstone (HOMEWOOD ?).
60.05	35.80	Laurel Hill Gas Station. Opposite the gas station, and in several low cuts toward the west, several beds of coal varying from 14″ to 28″ in thickness may be observed. They dip approximately 4° E., but the fragmentary character of the exposures precludes positive identification of individual beds.
60.35	36.10	UPPER FREEPORT COAL. Contact ALLEGHENY-CONEMAUGH. Pit posts at former entries to the Mary Bell mine may be seen, but slumping of the bank largely conceals the section (north side of road): Shale, thin-bedded carbonaceous, 4′. Upper Freeport coal, 30″. Shale binder, 2″. Coal, 2″. Shale binder, 1″. Coal, 7″. Fire clay. Because of the danger of subsidence of the road into mine workings, the coal in this area was completely removed and the excavation back filled with suitable material.
60.75	36.50	BRUSH CREEK COAL (12 inches) and overlying fossiliferous BRUSH CREEK SHALE. Clay underlies the coal. A fossil starfish was collected at this locality. Dip 4° E.
61.55	37.30	AMES LIMESTONE and HARLEM COAL. In this large cut the best exposures of the AMES LIMESTONE and the HARLEM COAL to be seen on the Turnpike may be observed. They are best seen at the west end of cut north side of the road: Dip 3° E. Sandstone, platy, buff; top of cut. (Berlin Coal Horizon), carbonaceous shale, 6″. Clay, 8″. Shale, gray, concretionary, 40′. Ames, black, calcareous, 9′. Very fossiliferous. Harlem Coal, 16″. Clay-shale, nodular.

MILEAGES Total	Trip	
62.30	38.05	Fresh-water limestone, 7-8 feet thick, weathers buff. Just north of the Turnpike right-of-way there is an old limestone quarry. Dip 1° E.
63.05	38.80	Turnpike crosses axis of JOHNSTOWN SYNCLINE.
63.55	39.30	Quemahoning cut: Old tunnel still open a few feet north of and below Turnpike grade. The rock in this cut consists of 30′ of arenaceous shale and thin-bedded sandstone in the upper part and clay-shales in the lower 45′. The strata are approximately horizontal. This cut has a maximum depth of 85′ and is 1,250′ long. The rock is typical of the upper part of the Conemaugh group. From this cut to the Somerset Interchange, the rocks are all in the CONEMAUGH GROUP or "Lower Barren Coal Measures." Thin coal beds, 12″ or less are present.
64.15– 64.75	39.90– 40.50	Sandstone exposed in cuts along Turnpike, possibly MORGANTOWN SANDSTONE (upper part of CONEMAUGH GROUP).
67.15	42.90	Somerset Interchange. Leave Turnpike and re-set odometer to 0.00 at Ticket Booth.
67.45	0.30	**Turn right** on to Route 219 into Somerset.
67.80	0.65	**Turn left** on to Route 53 in Somerset and continue on Route 53 over rolling upland surface in CONEMAUGH beds. Few outcrops.
73.35	6.20	Cross abandoned railroad grade at Friedens. An abandoned Upper Freeport coal mine (top of Allegheny Group) can be seen on southeast side of highway. Continue on Route 53.
76.80	9.65	Dump of active Upper Freeport coal mine on left side of highway.
77.15	10.00	Cross Beaverdam Creek. Note yellowish brown limonite precipitated from mine waters along stream bed.
77.45	10.30	MAHONING SANDSTONE (base of CONEMAUGH GROUP) on left of highway.
77.50	10.35	**Turn right** at traffic interchange on to Route 30. Fine outcrop of massive MAHONING SANDSTONE at intersection. Continue eastward on Route 30.
77.75	10.60	Cross Stony Creek.
78.05	10.90	Small Upper Kittanning (middle of Allegheny Group) coal mine on left side of highway.
78.55	11.40	Abandoned coal mine in Upper Kittanning coal on right side of highway. Upper Freeport coal being mined in woods in background. Strata ahead are rising on northwest flank of NEGRO MOUNTAIN ANTICLINE.
78.85	11.70	UPPER FREEPORT COAL.
80.30	13.15	MIDDLE KITTANNING COAL to right of highway.
80.45	13.30	Active mine in Lower Kittanning coal on right side of highway.
80.95	13.80	Derrick of Peoples Natural Gas Company's deep test well on R. G. Grove farm can be seen in field on south side of highway. The well is located on the axis of the Negro Mountain anticline. Its objective is the Oriskany sandstone (about 9,300′ deep, or 6,950′ below sea level), which crops out around the Schellsburg dome, 13 miles to the east. There will be a stop at that locality.
81.15	14.00	LOWER KITTANNING COAL on left side of highway. The Grove well starts immediately below the horizon of this coal. Highway crosses axis of NEGRO MOUNTAIN ANTICLINE at this point.

MILEAGES Total	Trip	
82.15	15.00	Long View. A fine view of Allegheny Mountain obtained from this point looking up dip slope. This mountain marks the ALLEGHENY FRONT.
83.80	16.65	Highway crosses axis of the BERLIN SYNCLINE at this point.
85.15	18.00	Reels Corners.
86.35	19.20	Small stripping operation in UPPER FREEPORT COAL on south side of highway.
86.85	19.70	The dip slope on the northwest flank of Allegheny Mountain shows up well in the distance, to left of the highway.
88.10	20.95	Bald Knob Summit of Allegheny Mountains. Elevation 2,906 feet. Large boulders of HOMEWOOD SANDSTONE (Upper Pottsville) can be seen to right of road.
88.15	21.00	POTTSVILLE SANDSTONE quarry on left side of road.
88.45	21.30	POTTSVILLE SANDSTONE and MAUCH CHUNK SHALE in contact exposed to left of highway. The Loyalhanna limestone (Middle Mississippian) near bottom of slope is not exposed at this point. After crossing small creek, road continues up dip slope on Burgoon sandstone (top member of Pocono Group).
89.25	22.10	Grand View Summit. Elevation 2,601 feet. Cross Bedford County line.
89.55	22.40	**Stop 2.**

Grand View Point Hotel. ALLEGHENY FRONT. This marks the boundary between ALLEGHENY PLATEAU PROVINCE with its relatively flat lying carboniferous strata, and the RIDGE AND VALLEY PROVINCE of highly folded paleozoics. Outcrop of BURGOON SANDSTONE (Upper Pocono) on northwest side of highway. This is the Big Injun sand of the western Pennsylvania oil and gas fields.

From Grand View Point is a fine view of the closely folded Appalachians to the east. If the day is clear, Evitts Mountain will be seen 17 miles in the distance, where the early Silurian TUSCARORA sand rises to the surface on the western flank of Nittany Arch. Upper Cambrian GATESBURG rocks form hills 2 miles farther east and may be visible through Bedford Gap in Evitts Mountain. Evitts Mountain is offset on the north to form Dunning Mountain. Nearer and to the southeast, Buffalo and Wills Mountains are also formed by the TUSCARORA along the flanks of Wills Mountain Anticline; the northern tip of Wills Mountain is 11 miles east of Grand View. The prominent water gap west of Cumberland, Maryland, crosses the same anticline to the south. Ten miles to the south, the Carboniferous POTTSVILLE and POCONO form the nose of synclinal Savage Mountain. The Deer Park anticline lies between Grand View and the syncline of Savage Mountain. The axis of the SCHELLSBURG DOME of Deer Park Anticline will be crossed 5½ miles due east of Grand View, almost exactly halfway to the top of Wills Mountain. The ORISKANY SANDSTONE, estimated at 6,950 feet below sea level at the Grove Well on Negro Mountain Anticline 8½ miles to the west, drops to about 7,400 feet below sea level along the Berlin Syncline, then rises rapidly from beneath Grand View to 1,600 feet and more above sea level at the Schellsburg Dome. This is a rise of about 9,000 feet in 11 miles, or an average westward dip of nearly 9°. Latest Silurian and earliest Devonian limestones are exposed in small quarries along this dome, flanked by ORISKANY chert and sandstone. Silty sandstones of Middle Devonian HAMILTON shales form the first escarpment both east and west of the dome. Nearer to Grand View, irregularly knobbed escarpments are formed by sandstone members of the Upper Devonian PORTAGE, CHEMUNG and CATSKILL Groups. The red soil in the fields below the hotel marks the outcrop of the CATSKILL red beds. All of these features can be observed at closer range as the caravan progresses eastward.

90.05	22.90	CATSKILL red beds (Upper Devonian) on north side of highway.
91.55	24.40	Fine view of ALLEGHENY FRONT escarpment looking back, and to the north.
93.15	26.00	CHEMUNG (Upper Devonian) shales below Catskill red beds to right of highway.

MILEAGES Total	Trip	
94.40	27.25	Road left to New Paris. Hill appearing ahead is at axis of SCHELLSBURG DOME of the DEER PARK ANTICLINE. Note southwest plunge of anticlinal axis as indicated by profile of hill.
94.45	27.30	HAMILTON (Middle Devonian) shales and siltstones on left side of highway. Dips are to the northwest.
94.95	27.80	**Stop No. 3.** Lower Devonian ORISKANY SANDSTONE is exposed in ditch and on bank to right of highway. This is highly weathered Oriskany. Fresh exposures in nearby quarries show that it is very calcareous. It is the objective of the Grove Well on Negro Mountain Anticline. The Oriskany projects above the surface at the location of the Schellsburg Dome test about 4 miles northeast of this stop. This is an opportunity to examine the Oriskany sand which is widespread in the Appalachian area. It is an important gas producing formation, has yielded some commercial oil and is now the objective of several wildcat operations.
95.85	28.70	Highway crosses axis of SCHELLSBURG DOME at this point. Cut still in ORISKANY sandstone and chert.
96.45	29.30	Contact of ORISKANY and overlying ONONDAGA (Lower and Middle Devonian) exposed at this point. All but the uppermost five to ten feet of Oriskany sandstone exposed in the cut has weathered to a yellowish brown, fine-grained sand. Quarries in this anticline show that unweathered Oriskany sandstone is highly calcareous. The uppermost part of the Oriskany consists of a medium to coarse-grained, hard, light gray quartzose sandstone. This is overlain by about 100 feet of ONONDAGA shale (Needmore shale facies) with about 10 feet of chert at base and some chert near top. The Onondaga shale is exposed in a small quarry north of the highway at western outskirts of Schellsburg (29.40). The shale is dark when fresh, weathering brownish. The section closely resembles that of the Summit gas field in Fayette County to the west, where production is obtained from both the ONONDAGA CHERT and the ORISKANY SANDSTONE. The Onondaga, however, contains more chert at Summit than at Schellsburg.
97.70	30.55	Entering cut through upper part of HAMILTON SHALE (Middle Devonian).
98.15	31.00	HAMILTON SHALE, dipping eastward.
98.35	31.20	HARRELL SHALE (Upper Devonian), dipping eastward. Top of Tully limestone and bottom of Burket shale are exposed along side road to the north.
98.75	31.60	HARRELL SHALE, dipping eastward.
99.05	31.90	BRALLIER SHALE (Upper Devonian), dipping eastward.
99.55	32.40	BASAL CHEMUNG (Upper Devonian) to left.
99.95	32.80	CHEMUNG. Crossroad—View of Evitts Mountain to east.
100.25	33.10	Axis of Syncline.
100.95	33.80	Note abrupt reversal of dip to the northwest (Dip 70° NW). Reversal occurs between two outcrops.
101.60	34.45	Basal KEYSER LIMESTONE (Upper Silurian) at west end of cut. TONOLOWAY forms most of the outcrop. It is more shaly and laminated. Dip 60° NW. Road cut ahead mostly in TONOLOWAY LIMESTONE (Upper Silurian).
102.19	35.04	WILLS CREEK SHALE (Upper Silurian).
102.20	35.05	BLOOMSBURG red shale (Upper Silurian) in bank on south side of highway. Notice red color of soil in field on north side of highway.
102.25	35.10	BLOOMSBURG red beds. Wills Creek shale can be seen to north along Turnpike.

MILEAGES Total	Trip	
102.30	35.15	Notice water gap ahead on south side of highway where the Raystown Branch of the Juniata River cuts across the northeast end of Wills Mountain. Quarry in TUSCARORA SANDSTONE (Lower Silurian) can be seen in distance.
103.20	36.05	Highway crosses axis of Wills Mountain Anticline. Scattered outcrops of CLINTON SHALE (Middle Silurian).
103.60	36.45	Cross Raystown Branch of Juniata River.
103.95	36.80	Cut in CLINTON SHALE.
104.05	36.90	Evitts Mountain appears ahead on south side of highway. Note water gap east of Bedford where the Raystown Branch of the Juniata River crosses the mountain. Evitts Mountain is held up by the Tuscarora sandstone.
105.50	38.35	Entering Bedford, Pennsylvania, county seat of Bedford County. Bedford Village was settled about 1750. It was originally called Raystown. Fort Bedford (built 1758), important in French and Indian War, was Washington's headquarters during Whiskey Rebellion. The famous Bedford Springs summer resort is 2 miles south of town.
106.55	39.40	Intersection of Routes 30 and 220 in Bedford. Continue on Route 30.
107.70	40.55	Entering Raystown Branch water gap through Evitts Mountain. A fine outcrop of the TUSCARORA SANDSTONE can be seen on the north side of the river at the west end of the water gap. The strata are almost vertical.
108.00	40.85	**Stop No. 4.**

Bedford Narrows where Raystown Branch of Juniata River cuts through Evitts Mountain. View of cut along Turnpike from south side of gap. The highway cut is 2,200 feet long and exposes upended Early Silurian and Late Ordovician sandstones in the western limb of the Friend's Cove anticline or southern component of the great Nittany Valley arch. Stratigraphically, the beds dip to the northwest, but range from vertical to overturned where objectively the dip is as low as 40 degrees southeast. The strata are cut by numerous faults of small throw. Some are subvertical faults with strikes nearly paralleling the Turnpike; the cuts expose large faces of one or two faults of this type. Overthrust faults dipping to the west and thinning the sequence are numerous; the movement on the individual fault is small but the total effect may amount to reduction in apparent thickness of between 50 and 100 feet. At the east end of the cut, fault duplication has placed out of stratigraphic order 60 feet of interbedded red and green shaly sandstones.

The section exposed is as follows in descending order, according to measurements of F. M. Swartz assisted by Doris Bye:

Lower Silurian:

TUSCARORA SANDSTONE: thick bedded, resistant, white silica-cemented quartz sandstone or quartzite, making main ridge of Evitts Mountain. Used as ganister rock for silica brick in central Pennsylvania, the Tuscarora extends westward and northwestward into the gas-producing White Medina ("Clinton" Sand of Ohio), represented by the Whirlpool sandstone in the Niagara Gorge. Total thickness 400+ feet. Exposed in west end of cut .... 165 feet

Upper Ordovician:

JUNIATA RED BEDS:

Upper reddish quartzitic member: dark red quartzitic sandstone, with thin partings of red silty shale increasing below .... 60 feet

Red siltstone member: red siltstone or mudstone and interbedded red sandstone .... 610 feet

Lower sandstone member: thick bedded red medium grained sandstone and some interbedded red mudstone; some minor interbeds of greenish sandstone in lower part .... 380 feet

The Juniata correlates with the Queenston of Rochester and Niagara gorges.

Thickness Juniata red beds .... 1,050 feet

MILEAGES	
Total	Trip

BALD EAGLE SANDSTONE: (intertonguing with Juniata facies)

Ridge making member: thick bedded, cross-bedded, greenish and much interbedded reddish sandstone or graywacke, with a few thin partings of gray or reddish shale; shale chips are common; a few ¼- to ½-inch pebbles of milky quartz occur in three thin lenses. These beds make subsidiary ridge of the mountain.............. 215 feet

Lower shaly member: interbedded greenish and reddish sandstone or graywacke and greenish and reddish silty mudstone that forms about a third of mass.................................... 320 feet

Thickness of Bald Eagle sandstone.......................... 535 feet

Reedsville shale:

Upper sandy member containing *Orthorhyncula stevonsoni* fauna: carbonate-bearing greenish siltstone and some interbedded sandstone.................................... 47 feet

(Bald Eagle red and green shaly sandstone duplicated by faulting at east end of cut; about 60 feet.)

At Aliquippa Gap in Tussey Mountain, 5 miles to the east, the Bald Eagle sandstone formed by the lower shaly member and ridge-making member resting on the *Orthorhyncula* zone of the Reedsville, virtually lacks the red tongues so strikingly developed at Bedford Gap. The facies pattern of these strata is complex and unusual.

108.00–109.35 40.85–42.20 Continue on Route 30 toward Everett, along crop of Ordovician REEDSVILLE SHALE, going through underpass below Turnpike. Some Reedsville shale at 42.1.

Stop No. 5.

109.35 42.20 Turn off Route 30 to quarry on right to see limestone and dolomite formations that probably will be explored by deep drilling in the Schellsburg Dome. Trenton limestones should occur in the concealed interval between the quarry and the road, but may be thinned by faulting. About 400 feet thickness of upended limestones and dolomites are exposed in and near the quarry. Limestones in the near (northwest) part of the main quarry, and in an old adjacent quarry to the southwest, are Middle Ordovician CHAZYAN and BLACK RIVER in age, and contain the small tubular, square-sectioned coral, *Tetradium,* with a single septum projecting inward from each flat wall; other corals are also present, together with gastropods, brachiopods, trilobites, *Eurychilina* and other ostracodes. At base of the Chazyan are limestones with impure silty dolomitic laminae that weather with a peculiar ridge-and-channel surface described by Kay as the "Tiger-striped" member of the Chazyan Loysburg formation; the "Tiger-striped" beds have been included in the top of the Lower Ordovician BEEKMANTOWN by other workers in the region. Below the "tiger-striped" beds are whitish-weathering, dolomitic limestone or dolomites classed by Ulrich and Butts and others as Bellefonte dolomite of the Beekmantown group. According to Butts, the Beekmantown group is 2,500 feet thick in the Hollidaysburg quadrangle to the north.

For a quarter-mile south of the quarry, the BELLEFONTE beds continue to dip northwestward below the quarry; they then reverse dip across an anticlinal axis, and have a gentle dip to the southeast. The southeastern limb of the fold is interrupted by a major fault, where the Upper Cambrian WARRIOR and GATESBURG formations are overthrust upon the much younger BELLEFONTE; the stratigraphic throw is about 4,000 feet, and the actual slip much greater.

Outcrops along the Nittany Arch in central Pennsylvania give evidence of fracture porosity in the BELLEFONTE dolomite, vug-type porosity in the earlier Beekmantown, NITTANY dolomite. Drilling in the Schellsburg well will test these porosity possibilities at depth.

MILEAGES Total	Trip	
109.35– 109.35	42.20– 45.00	Buses will turn and retrace route to Bedford.
112.15	45.00	Turn right on to Route 220, continue north.
112.35	45.20	Quarry on east side of highway exposes lumpy basal KEYSER LIMESTONE and topmost laminated limestone of the TONOLOWAY. The basal Keyser contains *Leperditia scalaris* of the Akron limestone of the Buffalo, New York, region where Middle Devonian Onondaga limestone rests disconformably on Akron.
114.95	47.80 (78.25)	Bedford Interchange Ticket Booth. Enter Turnpike here. Re-set odometer to 78.25 miles to correspond with mile posts on Turnpike. Large cuts in Wills Creek and McKenzie formations in upper Silurian on west side of approach to Turnpike and on north side of Turnpike. Fossiliferous.
115.30	78.60	Underpass for U. S. Route 220 to Bedford.
115.35	78.65	TONOLOWAY LIMESTONE, upper Silurian, east of underpass. Many ostracoda. Strike N 10° E, Dip 23° SE. Wills Mountain, a topographic feature formed by the nearly vertical east flank and rapidly northeast plunging nose of Wills Mountain Anticline, rises to the southwest, culminating in Kenton Knob (Elev. 2,642 feet). Mountain is supported by the Tuscarora quartzite.
115.85	79.15	TONOLOWAY LIMESTONE in 60′ cut on left side of Turnpike. The Keyser limestone overlies the shaly Tonoloway.
116.10	79.40	KEYSER LIMESTONE. Massive, and in part cherty limestone; prominent Stromatoporoid bed. Cherty beds rest on top of the Keyser, but no Coeymans or New Scotland fossils have been reported. Strike N 11° E, Dip 21° SE.
116.30	79.60	Bridge over Turnpike. ORISKANY, decomposed, is exposed.
116.60	79.90	ORISKANY (Ridgeley sandstone), yellowish-brown, strangely weathered, breaks down into a sand. Occasional fossils. This is the west limb of a shallow syncline.
117.00	80.30	**Lunch Stop.** Turnpike Midway. Service stations serve eastbound and westbound traffic. Pedestrian tunnel leads to restaurant for convenience of westbound traffic.
117.30	80.60	ONONDAGA (Needmore shale) ? . Strangely weathered black shale.
117.50	80.80	ORISKANY (Ridgeley sandstone). Yellowish-brown sandstone. *Platyceras* and *Spirifer arenosus* common. This is the east limb of a shallow syncline. Dips to west.
118.20	**81.50**	Viaduct over Dunning Creek at its junction with the Juniata River. Foundations for this structure are placed on Rose Hill (Clinton) strata which are no longer visible.
118.30– 118.65	81.60– 81.95	Bedford Narrows: Passing the exposures of TUSCARORA, JUNIATA, and BALD EAGLE viewed from **Stop 4.**
118.90	82.20	Bridge crossing Juniata River. Contact of the Ordovician REEDSVILLE shale with Middle Ordovician limestone was observed in the coreborings for the foundations of this bridge, but are no longer exposed. Trenton limestone should be in contact with the shale, but judging from position of southeastwardly dipping Beekmantown rocks in next cut to east, part of the Middle Ordovician sequence may be cut out by faulting near the bridge.
119.15– 119.25	82.45– 82.55	Long cut in light-weathering BELLEFONTE dolomite of Lower Ordovician BEEKMANTOWN group. The beds dip about 45° SE and lie in the southeastern limb of the anticlinal fold present near the quarry of **Stop 5.**
119.40	82.70	Scattered crops of Upper Cambrian WARRIOR limestone dipping about 30° SE. Cryptozoon heads provide an interesting means of showing that these beds are not overturned. The Warrior strata by dip appear to overly the Bellefonte (Beekmantown)

Crossing Fault

MILEAGES Total	Trip	
		of the last cut to the west; their trilobites show that they are early Upper Cambrian in age; they belong about 4,000 feet below the Beekmantown, and have been carried to their present position by perhaps the largest of the overthrusts that will be crossed on the entire trip. The thrust plane probably forms a rather low angle to the bedding and if so the actual slip may have been of the order of several miles. It also appears that any structures favorable for oil or gas occurrences in Friends Cove will have to be found in the underthrust block.
119.70–119.80	83.00–83.10	**Stop No. 6.** Beds below middle of the Upper Cambrian GATESBURG sandy dolomite are exposed in a cut on the south side of the highway. The Gatesburg is about 1,600 feet thick; it contains interlayers of sandy dolomite and quartz sandstone, the sand forming about 10% of the mass, and weathers to a thick mantle of loose sandy soil. If parts of this formation were subjected to upwarping and weathering in Late Cambrian or Early Ordovician time, they would tend to provide permeable and promising reservoir horizons. The Middle part of the Gatesburg contains the 50- to 100-foot Ore Hill limestone, characterized by trilobites found near Chambersburg below the middle of the Conococheague limestone. It is reasonably clear that the sandy Gatesburg of central Pennsylvania grades southeastwards into the somewhat silty Conococheague limestone, giving evidence that the Gatesburg sands were transported to central Pennsylvania from the north and northwest. These sands are thus not expected to disappear on the north and northwest by change to finer sediments; it is likely that they extend far to the west, northwest, and north of the Allegheny Front of central Pennsylvania as sandy strata potentially favorable for oil reservoirs. This is probably the formation that was encountered at a depth of 10,069 feet in the Hockenberry well, Butler County, Pa.; at 5,184 feet in the Childs well, Erie County, Pa.; at 6,325 feet in the Arcade well, Wyoming County, N. Y.; and at 3,099 feet in the Rochester well, Monroe County, N. Y. In all of these wells, except the one at Rochester, evidence of porosity was reported in the Upper Cambrian. The stop provides fine views of the ridges formed by TUSCARORA sandstone that bound Friends Cove on the east and west. Evidence for the Friends Cove overthrust will be reviewed.
119.90–120.30	83.20–83.60	Additional cuts exposé Gatesburg sandy dolomite, with Ore Hill limestone member at about 83.2.
120.40	83.70	Fields south (to right) of the Turnpike bear chert fragments with much siliceous oolite of type characteristic of MINES dolomite, 250 feet, at top of Gatesburg formation. The contact between the Mines and Gatesburg occurs about at the woods line at the west edge of the field.
120.75–121.60	84.05–84.90	Lower Ordovician BEEKMANTOWN dolomites, largely whitish weathering and of Bellefonte type. The Axemann limestone, which separates the Bellefonte dolomite above from Nittany dolomite below in the State College region, tends to disappear southward rendering distinction of two dolomites less satisfactory.
121.60	84.90	New Enterprise Limestone Plant on left; quarries are in Middle Ordovician Chazyan-Black River limestones.
122.95–123.30	86.25–86.60	Aliquippa Gap-Tussey Mountain. This gap is cut through the same rock sequence exposed in Bedford Narrows at **Stop 4,** the order reversed, in the eastern as compared to the western limb of the Friends Cove anticline. White TUSCARORA quartzite, 500 feet thick, again makes the main ridge. It is underlain by JUNIATA red siltstones and sandstone then by 500 to 600 feet of BALD EAGLE sandstone, which here lacks the red tongues that constitute half of the formation at **Stop 4,** only 5 miles to the west. The Bald Eagle is underlain by REEDSVILLE shale, with the sandy *Orthorhyncula* zone at its top.

MILEAGES Total	Trip	
		There is marked change in strike of the TUSCARORA and associated rocks on the north versus south side of Aliquippa Gap; projected along its strike, the TUSCARORA would reach the north side of the gap a quarter-mile west of the actual position.
123.25	86.90	Rose Hill (Clinton), covered, but under houses on the south side of the road there exists a filled shaft used in colonial days for mining the Clinton iron ore.
123.55	87.20	Everett Maintenance Building and shops for the Pennsylvania Turnpike. Sight of Everett-Saxton iron works. Note slag piles. Everett was former iron town.
123.75–123.85	87.40–87.50	Warrior Ridge. Lower Devonian strata exposed in deep cut. The sequence of the strata from west to east in this cut is:

Keyser Limestone, 15′, crystalline, very fossiliferous.
New Scotland Chert, 75′, weathered, fragmentary. No fossils found.
Shriver Chert, 76′, weathered, fragmentary.
Oriskany (Ridgeley) sandstone, 114′, fossiliferous.
Onondaga (Needmore) black, fissile shale.

Across the Juniata River, from the town of Everett north, continuous exposures of Oriskany occur. It is extensively quarried at Tatesville, 3 miles north of Everett, by the Pittsburgh Silica Sand Company.

124.15	87.80	HAMILTON GROUP, in a cut 40′ deep, thin-bedded, gray sandstones with massive unit near center of cut. Overlain by Hamilton shales in eastern end of cut. Locally, these beds are very fossiliferous.
124.45	88.10	PORTAGE shales—Brallier. Soft, olive-drab shale. Tully and Harrell beds are concealed in the valley to the west. In this cut a local syncline occurs, the east limb dipping 47° W and its west limb dipping 44° E.
124.75	88.40	CHEMUNG shales, greenish gray, with interbedded grayish red siltstones and shale.
125.45–125.85	89.10–89.50	**Stop No. 7.**

Clear Ridge Cut. Group will leave buses at west end of cut, proceed up the bank to top for view of area and discussion of regional geology. After discussion descend east slope to board buses.

This is the deepest highway cut in the eastern United States, being 143 feet deep and 2,475 feet long. Benches collect rock falls from higher parts of the walls to protect traffic. The strata strike across the Turnpike at this place, and there has been no trouble with slides such as those in the Catskill just east of the Allegheny Front where strata dip toward the Turnpike.

In Clear Ridge Cut the strike is N 32° E, dip 53° SE. The cut continuously exposes 1,800 to 1,900 feet of Upper Devonian CHEMUNG shale and sandstone with some CATSKILL red shaly sandstone at top. The CHEMUNG beds at the Allegheny Front are about 2,000 feet thick, with purplish shales in the higher portion; they are marine and contain the *Spirifer disjunctus* fauna with *Dalmanella tioga* in the lower quarter. At Clear Ridge Cut, the purplish tongues of the higher Chemung becomes more prominent, red, and Catskill-like, and give witness to the eastward change taking place in the Chemung as it transforms into the red continental CATSKILL facies; before reaching Harrisburg, this change from the westerly gray-brown brachiopod-rich Chemung to red continental Catskill is completed, and denotes approach to the old land region from which these sands and clays were worn by Upper Devonian river systems.

From the hilltop there is a fine view of the regional structure. To the west, wooded hills in Friends Cove underlain by the Upper Cambrian GATESBURG formation of **Stop 6** can be seen through Aliquippa Water Gap in Tussey Mountain, where basal Silurian TUSCARORA sandstone plunges below ground to continue beneath our route until we reach Tuscarora Tunnel 30 miles to the east. To the northeast is visible a salient of Rays Hill, at the western "Fish-Tail" prong of the Pocono rim of the BROAD TOP synclinorium. The deeper syncline of the eastern prong, which brings the Pocono below ground along our route, will be crossed 8 to 12 miles east of Clear Ridge between Rays Hill and Sideling Hill tunnels.

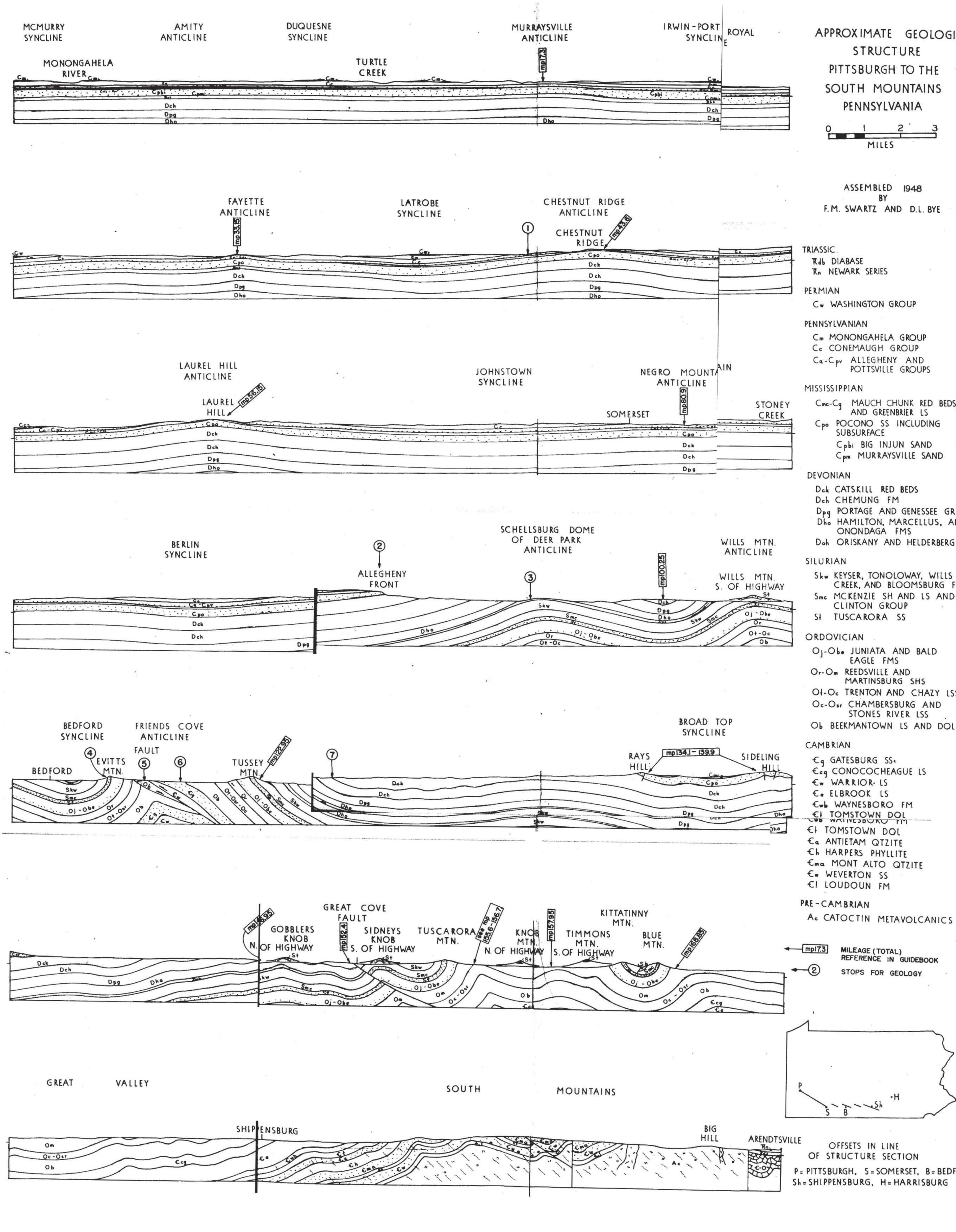
MILEAGES Total	Trip	
126.35–134.10	90.00–97.75	CATSKILL magnafacies. Red sandstones and shales in all cuts from Clear Ridge eastward to Rays Hill. Considerable folding is evident in many of the cuts, hence numerous minor anticlines and synclines can be mapped in this area.
130.95	94.60	View of Rays Hill ahead. This is a topographic feature formed by the POCONO group of Mississippian age.
132.15	95.80	Breezewood Interchange to U. S. Route 30.
132.65	96.30	Note "Fishtail" structure of BROAD TOP Syncline in distance to left.
134.10	97.75	West Portal of Rays Hill tunnel. CATSKILL magnafacies. Soft, earthy, and arenaceous red shale.
		In this tunnel the POCONO sandstones rise sharply to the west. The CATSKILL red beds are exposed at the west portal. The tunnel is driven mostly through POCONO and the overlying MAUCH CHUNK red shales are exposed at the east portal. Leaving tunnel, ridge in near distance is made by POCONO, raised in secondary anticline complicating the BROAD TOP Synclinorium.
		The area between Rays Hill and Sideling Hill to the east is a gentle synclinorium, complicated by a minor anticline that brings the Pocono to the surface approximately midway between the tunnels. To the north, in this basin, progressively younger strata occur so that the productive coal measures of the Allegheny group are found, in this, the Broad Top Coal Field.
134.75	98.40	East Portal of Rays Hill Tunnel. MAUCH CHUNK red shales are exposed at portal.
135.35	99.00	MAUCH CHUNK red shales.
137.05	100.70	POCONO sandstones, brought to the surface in a minor anticline. MAUCH CHUNK red shales crop out both to the east and west.
138.25	101.90	Excellent view of the rim of the Broad Top coal field may be seen in distance to north. The rim is upheld by resistant Pottsville sandstones. Sideling Hill, straight ahead represents the eastern side of the Broad Top synclinorium. Sideling Hill is a topographic feature formed by outcropping Pocono sandstones.
138.65	102.30	West Portal Sideling Hill Tunnel. Approach to cut and tunnel is in the POCONO sandstones and shales. The entire tunnel is driven through the Pocono group. The strata, which dip west at a low angle into the Broad Top synclinorium, are complicated by faulting.
139.90	103.55	East Portal Sideling Hill Tunnel. This is the longest tunnel on the Turnpike (6,632 feet).
140.45	104.10	CATSKILL magnafacies, red shale and sandstone. Contact with overlying Pocono concealed to the west. In this cut the strata are strongly fractured and folded.
140.75	104.40	Fine view of Sidneys Knob. A topographic feature formed by rapidly plunging anticlinal nose. Tuscarora quartzite.
140.85	104.50	Cove Valley Gas Station. Note high terrace gravels on red shales near viaduct.
143.15–143.45	106.80–107.10	CATSKILL magnafacies, soft red, arenaceous shales with interbedded sandstones.
144.65	108.30	Approximate contact of CATSKILL magnafacies with CHEMUNG. Interbedded red and green shales and grayish-green sandstones. A one foot conglomeratic bed is also present.
144.75	108.40	Bridge over the Turnpike. Cut in Chemung, interbedded red sandstone and greenish-gray shale.

MILEAGES Total	Trip	
145.50	109.15	Base of Chemung—ALLEGRIPPIS (?)sandstone. 15′ medium bedded sandstone overlain by 5′ conglomerate.
145.55	109.20	PORTAGE SHALES—Brallier. Olive-drab shale with occasional interbeds of grayish-green sandstone. Much of the shale breaks down into pencil fragments. Fossiliferous.
146.10	109.75	PORTAGE SHALES—Brallier. Interbedded grayish green shales and siltstones.
146.35– 146.75	110.00– 110.40	PORTAGE SHALES—Brallier. A few hundred yards north across the Hustontown road, the Helderberg limestones are quarried and Oriskany beds outcrop. Known faults occur in this area, but locally may decrease in magnitude so that the Portage is scarcely affected at this point on the Turnpike.
146.95	110.60	To north, knob at nose of plunging BLACK LOG ANTICLINE is in Tuscarora Sandstone.
148.05– 148.25	111.70– 111.90	Clay, buff and bluish gray. Section complicated by faulting. A calcareous shale and strongly slickensided limestone (both fossiliferous) are found. This limestone is believed to be Tully, the intervening shale, Upper Hamilton (Moscow), with an underlying slightly conglomeratic Hamilton sandstone.
148.70– 148.95	112.35– 112.60	Fort Littleton Interchange to U. S. Route 522. BURKET and HARRELL shales, dark gray to black, fissile, thin-bedded. Scrub Ridge to the southeast forms west flank of anticlinal mountain which plunges rapidly toward Turnpike, north of Sidney's Knob.
149.45	113.10	Local anticline with residual soil bounding a strongly shattered limestone which is thought to be Tully. Occasional fragmentary fossils are found. The strong fracturing and development of clay suggests that this anticline of Tully (?) may be faulted into position.
149.75	113.40	BURKET, black thin-bedded shale.
150.25	113.90	PORTAGE (Brallier) sandstone, angillaceous, mottled red and green.
150.35	114.00	BRALLIER shale.
150.95	114.60	Gobblers Knob to the north. Point of rising anticline in Tuscarora quartzite.
151.25	114.90	BRALLIER shale with a little interbedded sandstone, grayish green.
151.45	115.10	BRALLIER shale, arenaceous, grayish-green, fossiliferous.
152.35	116.00	GREAT COVE FAULT, sometimes called the Fulton County Fault. There is a concealed interval in this area, but the presence of a fault is inescapable. The first strata west are Upper Devonian, those adjacent to the east are Silurian. The magnitude of this fault increases to the south where Ordovician limestones rest against Upper Devonian shales.
152.95	116.60	BLOOMSBURG red and interbedded greenish gray shale, with ripple-marked surfaces.
153.05	116.70	KEEFER quartzite, cream-colored, and the ROSE HILL shale and sandstone. These strata are complexly folded and faulted.
153.55	117.20	KEEFER quartzite resting on ROSE HILL (Clinton) and underlying the McKENZIE. This exposure is at the eastern end of the structure carrying the Turnpike over the Fannettsburg-Burnt Cabins Road. The Keefer is also exposed at the western end of this structure.
		The Rose Hill is best exposed in the cut beneath and northwest of the bridge, where it is fossiliferous. The weathered shales overlying the Keefer, probably represent the McKenzie; they are in part faulted out. They are fossiliferous. Strike N 55° E, Dip 57° SE.

MILEAGES Total	Trip	
154.35– 153.55	118.00– 117.20	WILLS CREEK interbedded red and greenish-yellow, soft shales.
154.55	118.20	TONOLOWAY (ribbon) limestone, gray, thin-bedded.
155.25	118.90	TONOLOWAY (ribbon) limestone, exposed under the footings of the bridge which carries a township road over the Turnpike.
155.35	119.00	Burnt Cabins Maintenance Building.
155.60	119.25	West Portal Tuscarora Tunnel. WILLS CREEK red and yellowish-green, soft shales crop in the approach cut to the tunnel. Dip 78° W.
156.70	120.35	East Portal Tuscarora Tunnel. Black, siliceous, MARTINSBURG shale, thin-bedded. Strike N 33° E, Dip 64° SE.
157.25	120.90	**Rest Stop.** Path Valley Gas Station. Fifteen minute stop.
157.95	121.60	Willow Hill Interchange. CAMBRO-ORDOVICIAN LIMESTONES. The Turnpike is aligned with the crest and axis of an anticline. At the ticket booth to the southeast, the strata strike N 52° E and dip 27° SE (these beds are replete with "Rosebud" siliceous concretions varying in size from marbles to basket-balls). In the interchange underpass, northwest side of the Turnpike, the strata strike N 45° E, and dip 46° NW.
158.95	122.60	Cambro-Ordovician limestone, light-gray, thick-bedded. Strike N 55° E. Dip 26° SE.
159.25	122.90	"ROSEBUD" CONCRETIONS in open fields and burrow pits, 50 feet north of the Turnpike near the country road underpass. Note large blocks of light-gray, dense, massive limestone weathering almost white.
160.35	124.00	Cambro-Ordovician limestone (Trenton ?), platy, very fossiliferous on the north side of the road at the west end of the cut. On the south side of the road, Martinsburg black shale outcrops. Contact with the Martinsburg. Strike N 37° E, Dip 46° SE. Approximately on the line of strike to the north, one mile south of Spring Run, there is a large quarry opened in these limestones. The strata at the top of the series exposed are very fossiliferous (Trenton ?). Strike N 41° E, Dip 43° SE.
160.95	124.60	MARTINSBURG shale, in cut. Fissile, black, siliceous shale with interbedded sandstone units occurring near the base. The sandstone is cross-bedded. Strike N 25° E, Dip 42° SE.
161.15	124.80	MARTINSBURG shale, as above without sandstone interbeds.
161.45	125.10	Nose of synclinal Knob Mountain on north. The crest of the mountain is Tuscarora Sandstone, the underlying Martinsburg shale forming the lower part of the nose of the syncline.
162.50	126.15	Gravel deposit, stream terrace.
163.15	126.80	Gravel deposit, stream terrace.
164.15	127.80	MARTINSBURG shale, strongly weathered with a veneering of stream gravels, along valley of West Branch of Conococheague Creek.
165.55	129.20	North end of Timmons Mountain, rising syncline, crest of Tuscarora and flanks of Martinsburg.
165.85	129.50	Note cove on south, minor plunging anticline.
166.45	130.10	MARTINSBURG shale on the northeast end of Timmons Mountain, a synclinal spur of Kittatinny Mountain which noses out just south of the Turnpike. The shale is splintery, siliceous, black, and contains hard sandstone interbeds. Strike N 60° E, Dip 42° SE.
166.95	130.60	West Portal Kittatinny Tunnel. MARTINSBURG, black siliceous shale. Strike N 55° E, Dip 68° to 90° SE. Amberson Valley to the north.

MILEAGES Total	Trip	
167.85	131.50	East Portal Kittatinny Tunnel and Gunter Valley. At this portal the BLOOMSBURG red shale is faulted into position against the ROSE HILL formation. The structure through Blue and Kittatinny tunnels being synclinal, the development of the valley may be attributed in part to faulting and to the work of Trout Run parallel to the axis of the syncline.
168.00	131.65	West Portal Blue Mountain Tunnel. ROSE HILL (Clinton) weathered shales, extremely fossiliferous in the cut above the portal building. Strike N 46° E, Dip 55° NW.
168.85	132.50	East Portal Blue Mountain Tunnel. MARTINSBURG, black, siliceous, pencil shale. Strike N 45° E, Dip 38° NW. Great Valley lies ahead, South Mountains in distance to right.
170.65	134.30	Blue Mountain Interchange connects with State Route 944. MARTINSBURG, black shale.
171.85	135.50	Blue Mountain Gas Station.
172.35– 176.55	136.00– 140.20	Throughout these miles numerous low cuts show outcroppings of weathered Martinsburg shale. At 138.2 miles, view to northeast, up Doubling Gap Valley; note winding crest of ridge.
176.70	140.35	MARTINSBURG shale in cut and in the banks of the underpass beneath and north of the Turnpike. Showing numerous minor folds, the shale is fissile and in part arenaceous. Strike N 65° E, Dip 73° NW.
177.95	141.55	MARTINSBURG shale, siliceous with occasional sandy beds. Strike N 56° E, Dip 78° NW.
179.10	142.70	MARTINSBURG shale in long cut, black, siliceous. Strike N 53° E, Dip 70° SE.
180.40	144.00	View of Doubling Gap to north.
181.40	145.00	MARTINSBURG shale in long deep cut. Black siliceous shale, and hard, massive sandstone interbeds. Exposed surfaces on the sandstone show "mud-flows" contemporaneous with deposition, north side of road. Strike N 52° E, Dip 82° SE.
183.60	147.20	Newville Maintenance Building.
184.00	147.60	MARTINSBURG shale, black, siliceous, pencil fragments. Used extensively for shoulder material. Strike N 65° E, Dip 79° NW.
184.55	148.15	Conodoguinet Creek bridge crossing. Martinsburg shale.
184.65	148.25	Bridge over the Turnpike. The Contact between the Martinsburg and the Cambro-Ordovician (Trenton) limestones occurs just west of this bridge.
184.70	148.30	Ordovician (Trenton ?) limestone. Dense, blue, highly fossiliferous. Strike N 60° E, Dip 71° SE.
185.45	149.05	Cambro-Ordovician limestone, weathers light-gray, grainy structure on weathered surface. Strike N 23° W, Dip 21° NE.
185.92	149.52	Cambro-Ordovician limestone, blue-gray, dense, crystalline. Strike N 68° E, Dip 47° NW.
187.15	150.75	Cambro-Ordovician limestone, at bridge over the Turnpike. Impure, blue-gray limestone, some lensing, strongly fractured and cut by calcite veins. Platy limonite developed in residuum. Strike N 61° E, Dip 40° SE.
188.60	152.20	Plainfield Gas Station. J. S. Diller, Geologist of U. S. Geological Survey, 1883-1928, is buried in cemetery to south of highway.
188.82	152.42	Cambro-Ordovician limestone, bluish-black, platy to medium bedded. Strike N 28° E, Dip 18° SE.


MP29.15
MP43.6
MP56.15
MP63.05
MP95.85
MP100.95
MP122.95
MP134
MP138.25
MP168.85


APPROXIMATE GEOLOGIC STRUCTURE
PITTSBURGH TO THE SOUTH MOUNTAINS
PENNSYLVANIA
0 1 2 3
MILES
ASSEMBLED 1948
BY
F.M. SWARTZ AND D.L. BYE
MCMURRY SYNCLINE
AMITY ANTICLINE
DUQUESNE SYNCLINE
MURRAYSVILLE ANTICLINE
IRWIN-PORT ROYAL SYNCLINE
MONONGAHELA RIVER
TURTLE CREEK
mp17.3
FAYETTE ANTICLINE
LATROBE SYNCLINE
CHESTNUT RIDGE ANTICLINE
CHESTNUT RIDGE
mp33.15
mp43.6
LAUREL HILL ANTICLINE
JOHNSTOWN SYNCLINE
NEGRO MOUNTAIN ANTICLINE
LAUREL HILL
mp56.15
SOMERSET
mp80.9
STONEY CREEK
BERLIN SYNCLINE
ALLEGHENY FRONT
SCHELLSBURG DOME OF DEER PARK ANTICLINE
WILLS MTN. ANTICLINE
WILLS MTN. S. OF HIGHWAY
mp100.25
BEDFORD SYNCLINE
FRIENDS COVE ANTICLINE
FAULT
BEDFORD
EVITTS MTN.
TUSSEY MTN.
mp122.95
BROAD TOP SYNCLINE
RAYS HILL
SIDELING HILL
mp134.1 - 139.9
GREAT COVE FAULT
GOBBLERS KNOB N. OF HIGHWAY
SIDNEYS KNOB S. OF HIGHWAY
TUSCARORA MTN.
KNOB MTN. N. OF HIGHWAY
TIMMONS MTN. S. OF HIGHWAY
KITTATINNY MTN.
BLUE MTN.
mp145.95
mp152.4
see mp 155.6 - 156.7
mp157.95
mp168.85
GREAT VALLEY
SOUTH MOUNTAINS
SHIPPENSBURG
BIG HILL
ARENDTSVILLE
TRIASSIC
Rdb DIABASE
Rn NEWARK SERIES
PERMIAN
Cw WASHINGTON GROUP
PENNSYLVANIAN
Cm MONONGAHELA GROUP
Cc CONEMAUGH GROUP
Ca-Cpv ALLEGHENY AND POTTSVILLE GROUPS
MISSISSIPPIAN
Cmc-Cg MAUCH CHUNK RED BEDS AND GREENBRIER LS
Cpo POCONO SS INCLUDING SUBSURFACE
Cpbi BIG INJUN SAND
Cpm MURRAYSVILLE SAND
DEVONIAN
Dck CATSKILL RED BEDS
Dch CHEMUNG FM
Dpg PORTAGE AND GENESSEE GRPS
Dho HAMILTON, MARCELLUS, AND ONONDAGA FMS
Doh ORISKANY AND HELDERBERG
SILURIAN
Skw KEYSER, TONOLOWAY, WILLS CREEK, AND BLOOMSBURG FMS
Smc MCKENZIE SH AND LS AND CLINTON GROUP
St TUSCARORA SS
ORDOVICIAN
Oj-Obe JUNIATA AND BALD EAGLE FMS
Or-Om REEDSVILLE AND MARTINSBURG SHS
Ot-Oc TRENTON AND CHAZY LSS
Oc-Osr CHAMBERSBURG AND STONES RIVER LSS
Ob BEEKMANTOWN LS AND DOL
CAMBRIAN
€g GATESBURG SS
€cg CONOCOCHEAGUE LS
€w WARRIOR LS
€e ELBROOK LS
€wb WAYNESBORO FM
€t TOMSTOWN DOL
€a ANTIETAM QTZITE
€h HARPERS PHYLLITE
€ma MONT ALTO QTZITE
€w WEVERTON SS
€l LOUDOUN FM
PRE-CAMBRIAN
Ac CATOCTIN METAVOLCANICS
mp17.3 MILEAGE (TOTAL) REFERENCE IN GUIDEBOOK
(2) STOPS FOR GEOLOGY
OFFSETS IN LINE OF STRUCTURE SECTION
P = PITTSBURGH, S = SOMERSET, B = BEDFORD, Sh = SHIPPENSBURG, H = HARRISBURG

MILEAGES Total	Trip	
190.95	154.55	Cambro-Ordovician limestone, crystalline, dove-gray, porous, platy. Strike N 43° E, Dip 27° SE.
191.15	154.75	Cambro-Ordovician limestone and an old lime kiln.
193.20– 193.40	156.80– 157.00	Cambro-Ordovician limestone, dark-gray, somewhat argillaceous, solution pits on bedding planes. Exposed in long cut. Strike N 82° W, Dip 62° NE.
193.90	157.50	Carlisle Interchange Ticket Booth. Route 34 passes under the Turnpike. Carlisle, county seat of Cumberland County, is famous in Colonial and Civil War History. It is the home of Dickinson College (founded in 1783), and was the site of "Public Works," a cavalry post for a century (founded in 1777), that later became the Carlisle Indian School, and which has since been enlarged and converted into a U. S. Army Medical Department Field Service School.
195.00	158.60	MARTINSBURG shale, platy, calcareous, grading into black siliceous shale. Approximate contact between the Cambro-Ordovician limestones and the Martinsburg. Turnpike travelling at the level of the Harrisburg peneplane. **From this point is a good view of the South Mountain area.** A few TRIASSIC DIABASE—capped ridges can be seen in distance to the east.
196.00	159.60	Viaduct crossing U. S. Route 11 at Middlesex, eastern terminus of Pennsylvania Turnpike.
196.40	160.00	**Leave Turnpike,** continue east on U. S. Route 11.
196.50	160.10	Cambro-Ordovician (Stones River ?) limestone in field to left of highway; very poor exposure.
196.80	160.40	Cambro-Ordovician (Stones River ?) limestone in low cut to left of highway; poor exposure.
197.00	160.60	Cambro-Ordovician (Stones River ?) limestone in low cut on right. Dark-gray, dense limestone with thin, soft arenaceous partings, giving the crop a nodular appearance. Strike N 80° E. Dip 60° SE.
198.20	161.80	Approaching Stony Ridge—Diabase dike outlined by trees —. This dike extends from the Triassic basin, southeast of South Mountain, across South Mountain and the Cumberland Valley, with a nearly north-south strike, to the Juniata River in Perry County, just west of Amity Hall.
198.35	161.95	Diabase poorly exposed in road cut.
198.50	162.10	Cambro-Ordovician (Chambersburg ls.) exposed to left at eastern end of cut through diabase.
199.30	162.90	Ordovician MARTINSBURG Shale exposed in low cut to left of highway.
199.70	163.30	Passing through New Kingston.
201.30	164.90	Cambro-Ordovician (Stones River ?) limestone exposed in low cut to left of highway. Dark gray, very fine, dense crystalline limestone with conchoidal fracture. Weathers to soft white chalky surface. Many good stylolites. Strike N 75° E. Dip 65° E. Low ridge paralleling road one-fourth of a mile to the north is Martinsburg shale.
201.80	165.40	Cambro-Ordovician (Stones River ?) limestone is well-exposed in cuts on both sides of the highway. Dove-gray with some light to dark-gray (also some reddish) fossiliferous (?) chert. Exposure has interesting system of close-spaced cross joints, filled in part with calcite —could easily be confused with bedding. Bedding plane well-exposed on north side. Strike N 75° E. Dip 43° SE.
202.40	166.00	Passing through Hogestown .
202.60	166.20	Cambro-Ordovician (Stones River ?) limestone exposed in triangular park area to left of highway.

MILEAGES Total	Trip	
		Gray limestone, poorly bedded, dense, with numerous small irregular patches of clear crystalline calcite—gives the light-colored limestone a spotty appearance. Strike N 55° E. Dip 60° SE.
203.70	167.30	Cambro-Ordovician (Stones River ?) limestone well-exposed just east of Green Acres Tourist Hotel. Limestone varies from very fine, dense, dark-gray to blue-gray and black, with thin interbeds of light-gray arenaceous (?) limestone. Strike N 80° E. Dip 80° SE.
204.00	167.60	Cambro-Ordovician (Stones River ?) limestone well-exposed at cross road. A massive light-gray limestone with good bedding. Strike S 85° E, Dip 45° NE. On west flank of north-plunging anticline.
205.10	168.70	Mechanicsburg Naval Depot on right.
205.70	169.30	Ordovician MARTINSBURG SHALE exposed in cut on left.
207.30	170.90	Cambro-Ordovician limestone poorly exposed in field and low cut to left of highway.
207.90	171.50	**Turn left** on U. S. 11, Camp Hill Bypass.
208.10	171.70	Note Triassic diabase-capped hills of Triassic sediments in distance on left.
208.80	172.40	Ordovician MARTINSBURG SHALE in covered cut on left.
209.50	173.10	Susquehanna Gap in distance to left.
210.30	173.90	Ordovician MARTINSBURG SHALE poorly exposed in cut on right approaching railroad underpass.
210.40	174.00	Intersection, Route 11 (bypass) with Route 15. **Turn left** on Route 15. Dredges in Susquehanna River recovering coal brought in from Anthracite washings upstream.
211.70	175.30	Crossing Conodoguinnet Creek. The exposures on the R. R., left, are MARTINSBURG shale.
213.00	176.60	MARTINSBURG shale, highly folded, in cuts to left.
213.30	176.90	R. R. yards ahead occupy abandoned channel of the Susquehanna. The hill to the east is formed of sandstones which overlie the shalier MARTINSBURG and are correlated with the Fairview.
214.00	177.60	MARTINSBURG red beds in cuts.
214.50– 215.10	178.10– 178.70	MARTINSBURG shale.
215.90	179.50	Leaving Great Valley. View of the Susquehanna Water Gap. Kittatinny Mountain is the principal ridge supported chiefly by Lower Silurian sandstone and conglomerate The second ridge, Little Mountain, consists of HAMILTON sandstone of Middle Devonian age. Locally, the Hamilton group is largely coarse, massive sandstone and some conglomerate, the MONTEBELLO. These beds have been worked in large quarries across the river in the end of Little Mountain.
216.30– 216.50	179.90– 180.10	**Stop. No. 8.** Susquehanna Gap in Blue or Kittatinny Mountain. Late Ordovician and Silurian strata are upended in the southern, slightly overturned limb of the major Cove Valley syncline, which within 5 miles north of Harrisburg brings down the Ordovician Martinsburg shale, possibly 2,000 to 3,000 feet thick with its structure complicated by minor folding, and then in the next 4 miles causes the rapid and relatively uncomplicated plunge below ground of the nearly 15,000 feet of strata of the Silurian, Devonian, and Mississippian Systems, until the Pennsylvanian Pottsville conglomerate forms Third Mountain at the synclinal axis. The group will foregather at about the Silurian-Ordovician junction, from which TUSCARORA-ribs can be seen crossing the river channel

to the mountain as it continues east of the river, and views are given of the Harrisburg peneplain and, toward the north, of ridges formed by the Pocono sandstone.

The stop provides a visit to the southeastwardly coarsened, lithologically changed, and in part disconformably telescoped extensions of formations that were seen at Bedford Gap 80 miles to the west, and that will in part, be seen at Rochester and Niagara Gorge, 200 to 225 miles to the northwest.

At the southern end of the gap, the section begins with MARTINSBURG shale containing a *Cryptolithus* fauna of earliest Upper Ordovician Eden age. The highest Martinsburg, represented farther west by 500 feet or more of shales and sandstones carrying the *Orthorhyncula* zone at their summit, was here enough upwarped by Taconic movements so that it was worn away by Late Ordovician erosion. Lapping upon this erosion surface is the thinned, coarsely conglomeratic wedge-edge of the BALD EAGLE-JUNIATA sediments that are here 165 feet thick as compared to 1,500 or 1,600 feet at Bedford Narrows, more than 2,100 feet as close as Shade Mountain 30 miles northwest of Susquehanna Gap. Thus almost a half mile of strata are lost from the succession in a relatively few miles, in part by erosion and in part by lack of deposition. Since the Bald Eagle-Juniata sediments transgress from the west upon the surface of erosion, it is likely that the thinned and coarsened remnant at Susquehanna Gap represents a late rather than early part of the thick Bald Eagle-Juniata deposits farther west.

Northeastward from the Susquehanna to the Schuylkill and Delaware Water Gaps, the unconformity increases in discordance, so that the JUNIATA wholly disappears, and the TUSCARORA lies with marked angular unconformity on Taconic-folded Martinsburg. Still farther to the northeast, lower members of the Silurian progressively lap upon an ancient version of the Adirondack dome, until near Albany a mere 60 feet of Latest Silurian limestones rest directly on the Middle Ordovician.

The lower Juniata beds at Susquehanna Gap contain profuse 2- to 3- and 6-inch, chunky pebbles of milky quartz, vitreous quartzites, chloritic meta-argillites, and cherts, worn from the easterly uplands elevated by Taconic crustal movements.

The Juniata red beds are abruptly superseded by white, clean, TUSCARORA quartz sands, made quartzitic by overgrowths of silica; above the clean lower beds of the formation, the sands are dirty and graywackish, containing considerable amounts of chloritic materials, and colored dark gray, then red, then greenish, then a lighter green as the sands are again quartzose. Shale interlayers increase near the top of the 350 feet of TUSCARORA sandstones, which then are overlain by 650 feet of CLINTON formation here unfossiliferous and composed in half its thickness of dark purplish, iron-rich sandstones, some of which in thin section show crystal blades of hematite transecting silica overgrowths of the quartz sand grains. Above the exposed CLINTON strata 500 feet are concealed; there are then 1,000 to 1,100 feet of red BLOOMSBURG sandstone and shale; upon the Bloomsburg rests a few feet of Middle Devonion MARCELLUS beds, then the heavy-bedded, Middle Devonian, marine MONTEBELLO sandstone.

The Marked contrasts here as compared with Bedford Gap, Allenwood, and Niagara Falls can briefly be summarized as shown on following page: (Dashes indicate absence by unconformity).

It is clear from these comparisons that the Silurian sediments at Susquehanna Gap constitute a relatively near-source mass of land-derived detrital sediments. At their top, the earliest Middle Devonian, Lower Devonian, and highest Upper Silurian sediments are absent by non-deposition on the Auburn Promonotory. Part of the Tonoloway, the Wills Creek, the thin red Bloomsburg tongue, and the higher McKenzie of the Bedford area have changed laterally into the thickening red, continental Bloomsburg shale and sandstone. The Middle and Lower McKenzie shales and limestones and the Clinton clay shales and 10′ Keefer sandstone, are here transformed to somewhat

		Bedford Gap	Susquehanna Gap	Allenwood	Niagara Falls
Middle Devonian	Marcellus	black shale	black shale	black shale	black shale
	Onondaga	125′ sh and ls	— — — —	125′ sh and ls	150′ cherty ls
Lower Devonian	Oriskany	250′ ss and sil. ls.	— — — —	75′ chert and ss	— — — —
	Helderberg	75′ ls and sh	— — — —	75′ ls and sh	— — — —
Upper Silurian		250′ Keyser ls	— — — —	100′ Keyser ls	2′-5′ Akron dol
		600′ Tonoloway ls 500′ Wills Creek sh 20′-50′ reddish Bloomsburg	1000′ to 1500′ red Bloomsburg sh and ss	150′ Tonoloway ls 450′ Wills Creek sh 450′ Bloomsburg red sh and ss	50′ Bertie ls 500′ Camillus sh and dol, some salt 0-50′ Vernon red sh
Middle Silurian		350′ McKenzie sh and ls	(Basal red and uppermost gray ss and sh)	250′ McKenzie sh and ls	150′ Lockport dol
	Clinton Group	40′ Rochester sh 10′ Keefer ss 600′ Rose Hill clayey sh	650-1000′ inter-bedded purplish iron rich ss, some gray ss, gray silty sh	40′ Rochester sh 20′ Keefer ss and ls 1000′ Rose Hill clayey sh 75′ Camillus gray and red ss	10′ Decew ls 44′ Rochester sh 18′ Irondequoit ls 16′ Reynales ls and Neagah sh 8′ Thorold ss
Lower Silurian	Medina	400-500′ White quartzitic ss (Tuscarora)	350′ greenish and red ss and white quartzite in part conglomeratic (Tuscarora)	500′ white quartz-itic ss (Tuscarora)	50′ Grimsby and Cabot Head red and green ss 25′ Manitoulin sh and dol 25′ white ss
Upper Ordovician		1050′ Juniata red siltstone and ss 550′ Bald Eagle red and green ss and some sh	135′ Red ss and cgl, plus 30′ greenish cgl at base	(1200-1400′ Juni-ata red siltstone and ss) (500-600′ gray Bald Eagle ss and cgl)	1000′ Queenston red sh 60′ Oswego gray ss
Middle Ordovician including base of Upper Ordovician		1100′ Reedsville sh 300′ Trenton ls	2000-3000′ Mar-tinsburg sh, in-cluding Tren-ton shales	Not exposed	1000′ gray then black shale (Lorraine-Utica)

MILEAGES Total	Trip	
		hematitic purple sandstones and interbeded shales that locally crest Kittatinny Mountain. The Tuscarora includes some clean, white quartz sandstone or quartz like the characteristic Tuscarora farther west, but in part the formation is graywackish, gray or reddish. The Juniata-Bald Eagle sediments wedge out from 1,500-1,600 near Bedford to 165 feet at Susquehanna Gap and include coarse conglomerates, their lower beds are gone by unconformity, and below them the highest Reedsville-Martinsburg shales were cut away by erosion at the time of their Late Ordovician emergence.
216.60– 216.90	180.20– 180.50	BLOOMSBURG red beds. Unconformity at top of Bloomsburg. Beds between Marcellus and Bloomsburg are missing. See charts of Susquehanna Gap Section.
218.00	181.60	**Crossing end of Little Mountain.** The large cut exposes the MONTEBELLO sandstone, the local name for the massive beds of Hamilton age which represent eastward coarsening of silty sandstone of the Hamilton near Bedford. A large, abandoned quarry, left, is in these beds. Other quarries may be seen across the river beyond the Stone Arch Bridge of the Pennsylvania Railroad.
217.60– 217.80	181.20– 181.40	**Marysville.** To north is the next water gap of the Susquehanna, cut through Second Mountain (east of river) and its continuation, Cove Mountain (west of river).
218.15	181.75	Basal CATSKILL.
218.20	181.80	North from Marysville, CATSKILL red shales appear. Base of Catskill red beds lowered to about level of bottom of Chemung. The basal Mississippian POCONO of Second Mountain across the river shows its trifid character, lower and upper massive units, a platy middle one. Looking to the northeast beyond the village of Dauphin across the river, the end of Third Mountain is capped by Pottsville conglomerate, the extreme western limit of the anthracite fields. The valleys about Third Mountain are cut in MAUCH CHUNK red shales. Still farther to the northeast is Peters Mountain. Peters Mountain and Second Mountain are the limbs of a large syncline whose southern limb (Second Mountain) is overturned slightly north. Third Mountain lies along the axis. The diagonal road up Peters Mountain passes abandoned mines which exploited a four-foot bed of Mississippian coal. Peters and Second Mountain unite to the west of the River as Cove Mountain.
218.80	182.40	**Stop No. 9.**

Second Mountain. Stop 9 is on the west side of the Gap where the Susquehanna River cuts between the structurally continuous Second Mountain, on the east, and the southern limb of Cove Mountain, on the west.

Within the two miles north of Blue or Kittatinny Mountain, 10,000 feet of strata, including the higher Silurian and the whole of the Devonian, plunge almost vertically into the ground, bringing down the resistant Mississippian POCONO sandstone and conglomerate in Second Mountain. North of Second Mountain, 3,000 feet or so of red MAUCH CHUNK shale and sandstone continue to dip below the surface, until at the axis of Cove valley syncline Pennsylvanian POTTSVILLE conglomerate is brought down to form Third Mountain extending eastward from its synclinal nose two miles north of Stop 9. The Mauch Chunk then rises and from beneath it the Pocono re-emerges to form the wall of Peters Mountain.

On the face of Second Mountain directly across the Susquehanna from Stop 9, the Pocono forms great ribs that angle steeply southward; the POCONO, together with the Devonian and Silurian that margin it on the south, is overturned at river level but as it goes to greater depths bends northward beneath the younger strata of the synclinal axis. In the northern limb of the syncline, the dip is truly southward, and the axial plane of the syncline dips southeast in the fashion characteristic of the larger folds of the Ridge and Valley Province.

Cove Valley syncline pitches gently eastward; as the Pottsville at the axis drops to deeper levels, Third Mountain divides to embrace the coal measures of part of the "Fish-Tail" of the southern anthracite field.

The waters of the Susquehanna, half a mile wide where constricted at Second Mountain, surface at 320 feet above tide. Summits of Second Mountain, of Blue Mountain to the south, and of Third and Peters Mountain on the north, rise 1,000 feet higher, undulating for long distances at levels of 1,200 to 1,400 feet, their even silhouettes giving witness to former, nearly complete peneplaination of the region. Hill tops of the intervening valley floors rise somewhat above 500 feet, and represent the Harrisburg erosion surface that planed off the weaker rocks.

The Susquehanna River's course cuts almost straight across Blue, Second, and Peters Mountains; it similarly transects Berry and Mahantango Mountains some miles farther north. It has entrenched into the present surface the course it had created upon the peneplain of the Mountain Summits; some geologists think this superposition reflects the river's course upon Cretaceous-Teritiary sediments supposed to have veneered the ancient peneplain due to its submergence.

About 500 feet of the 1,200 to 1,300 feet of Pocono at Second Mountain are continuously exposed along the highway at Stop 9. Except for the highest of these beds the strata are thick-bedded, strong conglomerates. The pebbles commonly ranging to an inch or inch and a half in greatest diameter. The pebbles consist mostly of milky quartz, with some of chert and quartzites. There are some interlayers of coarse-grained sandstone. Cross-bedding is strikingly developed, and is a serviceable guide to bed-tops, since it tends to merge with the general bedding at the foot of its foresets, is beveled by the bedding at the foreset-tops.

The Pocono at Second Mountain is decidedly more conglomeratic than at the Allgheny Front where seen at Stop 2 at Grand View. Some pebbly zones occur at and to the west of the Allegheny Front, but there is nothing to match the 500 feet and more of nearly solid conglomerates at Second Mountain. It is not necessary to make the 90-mile jump to the Allegheny Front to find marked change in coarseness of the Pocono. In the four miles from Second Mountain to Peters Mountain in clear sight on the north from Stop 9, there is about a 50 per cent reduction in pebbliness of the rock mass. The increase in pebbles in the Pocono as Second Mountain is approached from both north and west shows clearly that the Pocono detritus was, at the time of its deposition, being brought to the Second Mountain region by swiftly moving waters debouching onto a broad delta-coast region from high, rapidly eroding hill-regions to the southeast. Transport had already been long enough continued to destroy fragments of weaker rocks, round the pebbles of milky quartz, cherts, and quartzites, separate them from larger cobbles and limit their sizes to a relatively even maximum of 1 to 2 inches in diameter.

In Peters Mountain, four miles to the north, and probably in Second Mountain as well, pebbly beds are most common in the lower two-thirds of the Pocono. At the Allegheny Front near Stop 2, on the other hand, the coarsest, most continuous sands of the Pocono compose the Burgoon member at the top of the formation. As an early guess needing the test of stratigraphic studies in the intervening occurrences of the Pocono, it seems logical to suppose that the coarsest Pocono of the Allegheny Front is more likely to represent an extension of the coarse, pebbly parts, rather than of the more finely textured parts of the Pocono of Second Mountain.

The Pocono sandstone at Second Mountain is underlain by possibly 4,000 to 5,000 feet of Upper Devonian red CATSKILL sandstones and shales, that contain near their middle 50 to 100 feet of gray Honesdale or Dellville sandstone that makes a hogback along the southern foot of Second Mountain. Topographic effects of this same bed will be seen north of Peters Mountain from Stop 10 on tomorrow's trip. The lateral change of grayish Chemung marine shales and sandstones into the continental red Catskill sediments, represented by interfingering of these two facies at Clear Ridge cut at Stop 7, has progressed eastward so that here on the Susquehanna little if any of the marine Chemung remains. Beneath the continental Catskill reds are, however, nearly 1,500 feet of marine Upper Devonian graywackyish flags and some shale, mostly formed by TRIMMERS ROCK sandstone of the Portage group. Beneath these sediments in turn here are about 1,000 feet of Middle Devonian graywackies, composed of Hamilton-age MONTEBELLO sandstone with a small thickness of upper Hamilton shale at the top, possibly as much as 50 feet of Marcellus (?) shale at the base. The Middle Devonian sediments rest in this vicinity disconformably upon the Upper Silurian Bloomsburg red beds.

As in the Mississippian, the changes taking place in Devonian strata as they are followed eastward from the Allegheny Front, reflect approach to the old, tectonically active hill-lands from which their materials were eroded.

Stratigraphic changes in the early Pennsylvania, Mississippian, and Devonian at and near Second Mountain at Stop 9 as compared to the Allegheny Front region of Stop 2 can be summarized as follows:

Allegheny Front near Stop 2	Second Mountain Area near Stop 9
PENNSYLVANIAN	
Pottsville conglomerate	
250′ sandstone, some cgl and sh	1000′ conglomerate and some ss
MISSISSIPPIAN	
Mauch Chunk	
200′-400′ red and green silty sh, some gray ss	3000′ ± red sh and ss
Loyalhanna	
50′ Cross-bedded sandy ls	? ? ?
Pocono	
1000′ sandstone and shale, with 300′ Burgoon sandstone at top, underlain by ss-sh cyclothems, some with red-bed members.	1200-1300′ sandstone and conglomerate, the pebbly beds most abundant in middle and lower parts.
UPPER DEVONIAN	
Catskill-Chemung	
2000′ Catskill red sh and ss 2000′ gray, brachiopod-rich, marine Chemung shale	4000-4500′ Catskill red sh and ss, 50-100′ Honesdale sandstone about at middle; Chemung has here emerged into the lower portion of the Catskill.
Portage, Genesee and Tully	
1500′ Brallier shale, some flagstones 150′ Harrell gray shale 100′ Burket black shale 10-20′ Tully limestone	1000′ Trimmers Rock sandstone Possibly several hundred feet of early Upper Devonian flaggy sandstone
MIDDLE DEVONIAN	
1200′ gray Hamilton shales, silty to sandy in upper part 200′ black Marcellus shale 125′ Onondaga shale and limestone	100′± late Hamilton shale 1000′ Montebello sandstone 0-50′ Marcellus black and gray shale
LOWER DEVONIAN	
200′ Ridgeley sandstone and Shriver chert of Oriskany Group 60′ Helderberg limestone and shale	....

MILEAGES Total	Trip	
		Turn around and retrace route to Harrisburg.
227.75	17.35	**Turn left** over Walnut Street Bridge. Straight ahead on Walnut Street to Penn-Harris and Harrisburger Hotels.
228.70	18.30	**Over night stop in Harrisburg.**

SECOND DAY'S TRIP

Harrisburg, Pa., to Rochester, N. Y.

228.70	0.00	**Start** in front of State Capitol, proceed north along Third Street. **Starting time: 7:15 a.m.**
230.40	1.70	**North along river front.** Across River the small hill is supported by sandstones of late Ordovician age which overlie the Martinsburg shales. These were seen in yesterday's trip.
232.70	4.00	View of Susquehanna Water Gap ahead with Stone Arch Bridge of the Pennsylvania Railroad. The ledges of rock showing at low water are Ordovician shales and sandy shales.
233.70	5.00	Intersection with Route 39 east (check odometer). Across the river, in Kittatinny Mountain, the large cut exposes the massive TUSCARORA sandstone which supports the ridge. Immediately south of the whitish Tuscarora may be seen the red JUNIATA. Cuts farther south expose the top of the Martinsburg shales of Eden age. The next ridge north is Little Mountain supported by sandstone of Hamilton age and separated from Kittatinny Mountain by a valley underlain by Upper Silurian and Middle Devonian strata in unconformable relationship. Beyond, Cove Mountain forms the skyline. As we continue north, heavy ledges of conglomerate and sandstone in the river are known locally as "Rockville Dam." In passing through the gap, note its unusual width and the shallowness of the river.
234.70	6.00	**Rockville.** Abandoned stone quarries in the end of Little Mountain (right) expose sandstones of the HAMILTON group.
235.10	6.40	**Fort Hunter.** This is the site of one of the forts which defended the gap during the French and Indian wars. The low land on the right and along Fishing Creek is cut in CATSKILL red sandstone and shale.
235.80	7.10	**Heckton.** Across the railroad, right, quarries expose CATSKILL red beds. As the road approaches the next gap, the passage of the red Catskill into the overlying gray Pocono may be observed.
236.30	7.60	Entering the gap of Second Mountain, the ridge is supported by the Pocono formation which here is trifid; upper and lower members are massive sandstone and conglomerate, and middle, a platy unit. The beds are overturned north.
236.90	8.20	**Entering village of Dauphin. Right** on Route 225 upgrade, then **left** across Stony Creek.
237.10	8.40	**Bear right at fork,** upgrade on Route 225. At top of rise, Third Mountain directly ahead is supported by POTTSVILLE conglomerate.
238.00	9.30	**Red Hill,** at the brick school 0.9 mile from Dauphin. The crest of Third Mountain northeast of the school is the western terminus of the basal Pennsylvanian rocks, the

MILEAGES	
Total	Trip

POTTSVILLE conglomerate, of the Southern Anthracite Field. The beds are exposed in an overturned syncline. The white conglomerate overlies the red beds of the MAUCH CHUNK formation. At the contact is a coarse conglomerate presumably composed of re-worked pebbles from the Mauch Chunk.

At this point the physiography is particularly striking. Cove Mountain is observed to swing around to the west, uniting Peters and Second Mountains in a great arc. These even-crested ridges stand out as the trace of an ancient peneplain, while the observer finds himself on a lower level into which Susquehanna River and Clark Creek have entrenched themselves. Water gaps of the river are prominently in view.

The Pottsville conglomerate may be studied by making a short side trip on foot to the crest of Third Mountain. This would be an opportunity to see rocks of Pennsylvanian age in place. The structure of the syncline, and the character of the rock itself (it is fossiliferous with plant stems, and there are a few old coal workings) are apparent. The vertical bedding of the steep, south limb of the syncline forms a small "rock city." From the brick school, our route goes due north along State Highway 225 across Clark Creek and on toward Peters Mountain in the distance.

239.10 10.40 **Crossing Clark Creek;** note that it is entrenched in the surface upon which we started at the brick school, Harrisburg reservoir 14 miles E. Abandoned quarries east of the road expose the MAUCH CHUNK red shale and sandstone. Examination of this sequence reveals several minor details such as cross-bedding in the sandstones, interbedded fine and coarse sediments, differential weathering of hard and soft beds, rain drop imprints in the shale, mud cracks and ripple marks. The Mauch Chunk underlies the valleys about Third Mountain and extends west to floor Cove Valley across the river in Perry County.

239.90 11.20 **The road ascends Peters Mountain.** This ridge is supported by massive, gray POCONO sandstone and pebble beds, great blocks of which have built a talus slope at the foot of the mountain. The beds are exposed in place in cuts higher up.

241.10 12.40 On the north side of the road the rectangle of white fence encloses the mouth of an old mine shaft. At the south side, an abandoned road leads off down the slope toward the east. These are reminders of the days when coal was exploited in the Pocono formation. This Mississippian coal is said to have occurred in several beds, one at least four feet thick, but its quality was too poor to compete with the Pennsylvanian anthracite.

241.30 12.60 **Stop No. 10.**

Summit of Peters Mountain. The highway followed by the trip crosses the summit of Peters Mountain, formed by the Pocono sandstone in the northern limb of Cove Valley syncline, at an altitude of about 1,190 feet. The strike here is N 65° E, dip 65° SE. From this vantage point there is visible on a clear day a picturesque panorama that again lays emphasis on the close relationship in the folded Appalachians of physiography, structure, and stratigraphy.

Eight and a half miles to the north, the Pocono sandstone, vaulting upwards at Peters Mountain, again plunges into the earth's surface forming Berry Mountain. Where Berry is transected by the gap of the Susquehanna, through which our caravan soon will pass, a glimpse is given of Buffalo Mountain, three miles farther distant, where the Pocono once more rises on the far limb of Wiconisco Valley syncline. Buffalo and Berry Mountains converge westwards along the flanks of the syncline, to their synclinal nose 12 miles northwest of Peters Mountain.

Cove Valley syncline, whose northern limb includes Peters Mountain at Stop 10, and that of Berry and Buffalo Mountains on the north, pitch gently eastward; where they bring below erosion the coal-bearing Pennsylvanian strata, they join in the "Fish-Tail" of the Southern Anthracite field.

The major anticline that raises the Pocono out of ground between Berry Mountain in

MILEAGES	
Total	Trip

the distance and Peters Mountain at Stop 10, is complicated by secondary folds. These are reflected by the hogbacks of two moderately resistant formations.

The slope falling away immediately before Stop 10 is floored by basal Pocono, then upper beds of the red Catskill formation. Near the foot of the slope a pronounced bench is held up where the Honesdale or Dellville sandstone member of the Catskill rises from beneath the surface. Below this member, the lower portions of the Catskill floor the nearby anticlinal valley of Powell Creek.

The Catskill crop is then doubled by a westwardly rising syncline, and flanking its axis the Honesdale sandstone marches as Dividing Ridge to a synclinal V-point four miles northeast of Stop 10. The northern portion of the double anticline then rises bringing up the lower part of the Catskill, the Trimmers Rock sandstone and associated strata of the Portage and Genessee groups, and finally at the anticlinal axis the Montebello sandstone of the Mid-Devonian in Half Falls Mountain. The eastwardly plunging nose of this anticlinal ridge nudged against an eastward bend of the Susquehanna six miles north of Stop 10.

The summits of Berry and Buffalo Mountains in the distance undulate gently at elevation of 1,200 to 1,300 feet, dropping at some places to 1,100. They reflect the same high peneplain that levels the top of Peters to east and west of Stop 10. Half Falls Mountain reaches altitudes of about 1,000 feet. It is made irregular by dissection; 4½ miles to west of its nose it is cut through by the Juniata River, and west of that gap divides into Mahonoy and Buffalo Ridges. The highest parts of Dividing Ridge reach levels of about 1,100 feet. Elsewhere within the panorama, the hill tops of the general valley floor lie between 600 and 700 feet, 300 feet or so above the silver path of the waters of the Susquehanna.

Four and a half miles northward from Stop 10, the Susquehanna converges with the trip route at the town of Halifax, and the route then closely follows the Susquehanna, passing opposite the tip of Half Falls Mountain, then through the water gaps in Berry and Buffalo-Mahantango Mountains.

242.10 13.40 **Hairpin turn at bench.** Note the red soil. It indicates that we have passed out of the Pocono into the underlying Catskill red phase of the Devonian. The bench is supported by the HONESDALE gray sandstone and associated beds, a unit interbedded in the red Catskill. As we round the hairpin turn, a large spring on the right is approximately on the lower Honesdale contact.

242.40 13.70 Down grade still, pink conglomerate and red beds show intermittently to the mountain base. Thence northward through the valley of Powell Creek and the village of Powell Valley, the Catskill is omnipresent.

Powell Valley is a broad anticline. Half Falls Mountain is a low ridge to the N.W. and is approximately the axis of the structure. The long ridge of the skyline to the north is composed of Pocono as is Peters Mountain. These two are the outer boundaries of the anticline.

245.20 16.50 **Rest Stop.** 10 minutes.

Intersection of State Route 225 with Route 14. Follow Route 14.

246.80 18.10 **Continuing north** from Halifax, we are still in the red Catskill, but, in the valley of Armstrong Creek one Chemung fossil (*Cyrtospirifer disjunctus*) has been found, indicating the age of the lower part of the red beds here. Half Falls Mountain anticline is responsible for the rise of the older marine beds to the surface here.

246.75 18.05 **Continue north** through Halifax. The region is a lowland cut in the soft CATSKILL red beds. Half Falls Mountain to the northwest is an anticlinal ridge in Middle and Upper Devonian sandstones. The entrenched course of the Susquehanna River skirts the mountain's nose.

247.30 18.60 Marker of Fort Halifax of the French and Indian War is on the west side of the road.

MILEAGES Total	Trip	
248.15	19.45	**Crossing** Armstrong Creek.
249.00	20.30	Small valley about at axis of HALF FALLS MOUNTAIN ANTICLINE.
250.75– 251.35	22.05– 22.65	At end of Berry Mountain the contact between the red CATSKILL and the gray POCONO is uncovered. The dip is about 80° NW. The long cut ahead exposes the POCONO sandstone and pebble beds on the north limb of a broad, complex anticline. These beds are equal to those seen in Peters Mountain at Stop 10, and were once continuous across the interval between the two ridges. We may project them in the imagination as a great arch up into the air and down again.
253.30	24.60	**Crossing** the POCONO-MAUCH CHUNK contact, we are now about to pass north through Millersburg, which is in another great synclinal valley like that at red hill school, but the Coal Measures do not extend so far west here as they do to the south.
253.90– 255.00	25.20– 26.30	**North** of Millersburg cuts and abandoned quarries show the monotonous red sequence of the thick MAUCH CHUNK formation.
254.50	25.80	Cove formed by convergence of Buffalo and Berry Mountains seen to west across Susquehanna River.
255.10	26.40	**Passing** the end of Mahantango Mountain, the Pocono again is exposed. This time it is rising, having passed under the Millersburg syncline to the south, where it forms Berry Mountain. At the mountain end, here, is a cut and abandoned quarry. The structure is quite complicated, and both faulting and folding may be observed by standing back a little way and looking up at the rocks. (Try to trace a single bed across the quarry face and see what happens to it!) North of the quarry in the Pocono is a bed of matted, carbonaceous plant stems.
255.30– 256.30	26.60– 27.60	POCONO with much minor folding and faulting, in general overturned, makes ledges in channel of Susquehanna River. Red CATSKILL fields across river behind Liverpool.
257.30	28.60	Passing beyond the mountain, a large quarry east of the road is mostly in talus from the Pocono, but some red beds in place show that once more we have dropped down into the Catskill facies and are about to cross another Catskill lowland.
259.90	31.20	**Crossing** Mahantango Creek. Dauphin-Northumberland County line.
260.10– 260.20	31.40– 31.50	East of the road, cuts and old quarries expose the fossiliferous, marine TRIMMERS ROCK sandstone of the PORTAGE group. The road now commences to climb over Fisher Ridge, which is supported by the MONTEBELLO sandstone of the HAMILTON group. At 31.9 miles is a secondary road west down a step grade and leading to a large quarry in these beds.
260.80	32.10	Road swings right, away from river to cross Fisher Ridge.
260.90	32.20	PORTAGE (Upper Devonian) flags and shales.
261.30	32.60	**Sharp turn north.** Cuts show the Montebello sandstone, which supports Fisher Ridge.
261.40	32.70	Lower MAHANTANGO (Hamilton group) splintery shales which are non-fissile. These lie between the two crests of Fisher Ridge. Both crests are in the MONTEBELLO sandstone. A fault has caused the repetition. The second ridge is northwest of the road beyond the shales just mentioned. The second occurrence of the Montebello is cut off eastward so that we fail to see it on the highway.
261.60	32.90	MONTEBELLO (Hamilton group) sandstone.
261.90	33.20	Nearly flat, much jointed shale. MONTEBELLO sandstone of Hamilton group makes ridges on left.
262.50	33.80	Cuts expose the black, fissile MARCELLUS shale at the east side of the road.
262.70	34.00	Starting down grade on the north side of Fisher Ridge toward Dalmatia; to the north

MILEAGES Total	Trip	
		the river valley opens before us. The many islands suggest a braided stream. On the west the small subsidiary ridge on the north flank of Fisher Ridge is composed of Oriskany sandstone of the Lower Devonian. Cuts on the right side of the road expose more of the Marcellus black shale, here interrupted by a heavy, brown sandstone. This is a local feature, and is not observed in the Marcellus exposed south of Sunbury.
263.00	34.30	The road dips into a small valley and rises over a little ridge with cuts on both sides. We are on the south limb of the DALMATIA ANTICLINE. Strike S 65° W, dip 40° SE. The sequence here is as follows: At the south end the ONONDAGA limestone and shale appear as olive-drab, punky beds, but fossiliferous. Beneath them (northward) is the ORISKANY sandstone and chert which is fossiliferous, then impure HELDERBERG (Mandata) chert, lumpy KEYSER limestone, and the upper TONOLOWAY or BOSSARDVILLE banded limestone. At the north end of the cut is the Helderberg limestone. This limestone has been quarried and burned a few hundred yards east along the ridge. As the road drops down into Dalmatia, a fine view again opens north up the valley.
263.20	34.50	**Dalmatia.** In the center of the village, on the west side of the road, a small cut exposes greenish shales of Silurian age and thought to represent the Wills Creek formation. This marks the axis of DALMATIA ANTICLINE.
263.90	35.20	At the north edge of Dalmatia, east of the road, an abandoned quarry is in the HELDERBERG limestone. This is the north limb of the DALMATIA ANTICLINE. The Oriskany is hidden.
264.30	35.60	Passing the end of Hooflander Mountain, the MONTEBELLO sandstone appears again in cuts. Strike S 70°W, dip 28° NW. It has passed "up in the air" since we last saw it in Fisher Ridge. It is thinning rapidly north, and will not again be recognized surely beyond this mountain, for the Hamilton group becomes practically all shale.
266.10– 268.40	37.40– 39.70	**Eastward** from the river along the valley parallel to the north slope of Hooflander Mountain, many exposures show the MAHANTANGO shale of the Hamilton group. These particular exposures are among the higher beds of the formation, and are very fossiliferous, but weather to such small pieces that collecting is rather disappointing.
268.40– 268.70	39.70– 40.00	**Hairpin turn** northwestward into the valley of Fidlers Run. At this point a section of unusual interest, particularly for those versed in Middle-Upper Devonian stratigraphic fine points, is exposed. Along the road parallel to Hooflander Mountain the highest Hamilton beds exposed carry *Pustulina pustúlosa,* whose presence marks the uppermost few feet of these beds. On the road, at the inside of the hairpin turn, a tiny exposure of somewhat limy shale carries TULLY fossils and marks the base of the Upper Devonian. (Grading may have concealed this bed.) Swinging around the turn, the secondary road behind the farm house and barn is cut in the BURKET ("Genessee") fissile black shale, carrying a few, minute fossils. Continuing along Fidlers Run in a westerly direction, the BURKET is capped by nonfissile, dark shale with a NAPLES fauna. This is the Harrell shale of the lower Portage group. Above it come greenish, sandy shales correlated with the Brallier of the Allegheny Front far to the west. Among these *Reticularia laevis* marks a key zone. This fossil occurs all through the Susquehanna and Juniata Valleys and marks the position of the Losh Run shale of Perry County. Above this zone the TRIMMERS ROCK sandstone dominates the remainder of the Portage group.
268.70– 269.90	40.00– 41.20	Proceeding down Fidlers Run toward Herndon, the TRIMMERS ROCK sandstone shows in a number of cuts and cliffs along the brookside. Strike S 77° W, dip about 40° NW. As the Montebello sandstone dies out northward, the Trimmers Rock takes its place as the principal ridge-forming element among the Devonian formations. It is

MILEAGES Total	Trip	
		fossiliferous and passes upward by a transition into the Chemung marine beds or the Catskill continental phase.
270.80–271.50	42.10–42.80	Passing through Herndon, cuts north of the town expose unconsolidated sediments, chiefly cross-bedded sands, which probably represent Pleistocene outwash from the ice sheet some miles ahead. North of us looms Line Mountain which, with co-joined Little Mountain beyond, forms another of those great synclines of Pocono sandstone.
271.80	43.10	**Crossing** a single-track railroad, a deep rock cut on the line east of the road exposes a bedding surface of the CATSKILL red rocks.
272.35	43.65	**Crossing** Mahoney Creek.
272.65	43.95	Fine view of Little Mountain and nose of synclinal mountain made by converging Pocono Ridges.
272.80–273.30	44.10–44.60	**Crossing** Little Mountain. The Pocono fails to come down to road level, and the long sequence of cuts exposes only dark red CATSKILL. Strike EW, dip about 35° N. Here we may see interbedded sandstone and shale. Mostly red, there are also brown and green and gray beds. The upturned rocks of the south limb of the syncline show faulting with slickensided surfaces where the adjacent beds have slipped over one another.
		Note the cross-bedded sands, the sheared, weak shale between massive sandstones, and slippage along the bedding surfaces. Where the massive beds are sheared, calcite fills the cracks as gash veins. The massive gray sandstone among the red beds at road level is probably an attenuated remnant of the HONESDALE.
274.50	45.80	Axis of Syncline.
274.70	46.00	The lowest CATSKILL here exposed is passed in toward the north limb of the Line-Little Mountain syncline in a cut to the east of the highway. Strike E-W, dip 35° S. We continue north through Fishers Ferry.
275.60	46.90	At the mouth of Hallowing Run a cut exposes the TRIMMERS ROCK sandstone of the Upper Devonian Portage group. These beds also show in cliffs along the stream to the east. We are passing steadily down in the section as we approach the region of Selinsgrove Junction.
276.20	47.50	Cuts west of the road expose part of the lower Portage shales similar to those seen on Fidlers Run.
276.60	47.90	The road climbs northward from the first fork north of Hallowing Run.
277.20	48.50	Cuts expose shale and thin sandstones of the upper HAMILTON. They are fossiliferous, and the sandy beds may be the "fag end" of the Montebello sandstone we saw in Fisher Ridge. At the top there is a deep cut. The material here is unconsolidated till, the southernmost expression of the Pleistocene glacier in the Susquehanna Valley. It consists of sticky, yellow-brown clay through which are scattered various rough, angular fragments of rock of several kinds. Farther north in this same cut, underneath the till, the black MARCELLUS shale is exhibited.
277.40–277.50	48.70–48.80	Before and after crossing a gully the MARCELLUS black, fissile shale and more till are seen in cuts.
277.70	49.00	The ONONDAGA group which comes up here as the SELINSGROVE limestone (this is the type region for the unit) is exposed in the south limb of the southern of the two SELINSGROVE JUNCTION ANTICLINES. On the south limb the black MARCELLUS shale and gray SELINSGROVE limestone may be seen dipping south. These repeat, north-dipping on the north limb.
277.90	49.20	Opposite the railroad bridge crossing the river to Selinsgrove, cuts along the east side of the road show the sparingly fossiliferous, submassive, light-gray SELINSGROVE limestone overlain by the black MARCELLUS shale. The relations are clear at the river below the bridge, the Oriskany sandstone forms ledges which are to be seen at

MILEAGES Total	Trip	
		comparatively low water. Between it and the Selinsgrove limestone is an interval occupied by ashen gray shale—formerly called Esopus, but now Needmore. This varies greatly in thickness and may be locally absent. Like the Esopus to the east, fossils are few or absent. Looking north from this point, the farthest ridge to be seen in clear weather is Bald Eagle Mountain of the Nittany Arch, and represents the Lower Silurian. The intervening country is floored by Devonian and Middle and Upper Silurian relatively nonresistant formations.
278.90	50.20	MARCELLUS black shale or lower MAHANTANGO dark shale exposed in cuts on the east, as the road turns northeast. As we continue up the road, the cherty Oriskany comes up in the gutters, but it is now float-hidden. Nothing is here seen of the Selinsgrove limestone or the Needmore shale. The presumption is that they have been faulted out. One may leave the road here and walk up the railroad section if he is interested in observing the sequence of Lower Devonian and highest Silurian beds made famous by the researches of I. C. White, J. B. Reeside and F. M. Swartz. The road continues to climb and swings north across the top of a low ridge. This is an anticlinal structure and is, in fact, the northern and geologically more important of the two SELINSGROVE ANTICLINES. The road drops down the north flank toward Sunbury.
281.60– 282.20	52.90– 53.50	Long cuts parallel to the railroad and highway expose the MARCELLUS black shale in what is perhaps the finest showing of this formation in Pennsylvania, at least insofar as completeness is concerned. The lower part only is hidden. The beds contain several zones of large, ellipsoidal concretions. Fossils are very scarce, but a few have been found at the southern end of this cut. Note the absence of any prominent sandstones such as were seen in Fisher Ridge. The rock displays splendid joints and a sub-conchoidal fracture. From the southern end of this cut it is possible to visit the section across the Selinsgrove northern anticline. The published accounts should be consulted for details.
282.20	53.50	Beyond the north end of the cut in the MARCELLUS, the road crosses Shamokin Creek and the railroad. A large abandoned quarry, east at this point, is in the lower part of the MAHANTANGO shales which overlie the Marcellus black shales. Fossils are few. This formation gives rise to steep bluffs east along Shamokin Creek.
283.00	54.30	**Turn left** on first bridge crossing Susquehanna River. Toll 10c. Note long cut in Trimmers Rock sandstone on west side of river.
283.60	54.90	**West End Toll Bridge.** Turn right, then bear left (N.W.) on Route 15 to Lewisburg and Williamsport.
283.70	55.00	Long cut starts in TRIMMERS ROCK SANDSTONE similar to that exposed on railroad to east as seen from the toll bridge. Strike S 75°W, dip 50° NW. A little Chemung is distinguished in this region by its fossils only, since there is no noticeable lithological change. At 57.1 miles the red beds of the Catskill come down in a shallow syncline.
286.60	57.90	**Union County Line.** Down grade, below the Catskill red beds appear olive-gray shales and sandstones of the CHEMUNG with *Cyrtospirifer disjunctus,* in turn underlain by the PORTAGE group now passing rapidly northwestward into the shalier phase.
287.95	59.25	MARCELLUS (?) black shale. Low anticlinal Shamokin Mountain in foreground. White Deer Mountain in distance.
288.10	59.40	Entering Winfield. To the left are quarries and crusher operating in the Helderberg limestone.
288.60	59.90	North edge of Winfield, a small cut, left, exposes red silty mudrock of the BLOOMSBURG continental phase of the Silurian. We are entering a large anticline which brings up the Silurian system.


MP289.2
MP288.6
MP277.7
MP272.8
MP261.4
MP242.7
MP238.0
MP223.7

MILEAGES Total	Trip	
288.70	60.00	Cut in Silurian gray, shaly sandstones and shales which are fossiliferous. Note north dip.
288.85– 289.20	60.15– 60.50	KEEFER sandstone.
289.20– 289.30	60.50– 60.60	Similar to last, anticlinal axis approximately here. The BLOOMSBURG again shows with northern dip. A series of small folds produces alternate exposures of the red beds and the non-red, marine Silurian.
289.30	60.60	CLINTON shale and sandstone in small anticline.
289.40	60.70	KEEFER sandstone.
290.05	61.35	BLOOMSBURG on north limb of anticline.
290.60	61.90	Fine view of south White Deer Mountain made by Tuscarora sandstone.
290.80	62.10	The marine Silurian beds come up briefly, then more Bloomsburg to the north.
291.20– 291.60	62.50– 62.90	Minor folding in BLOOMSBURG and WILLS CREEK.
291.70	63.00	Bucknell University to right as we enter open country west of Lewisburg. Fine view of South White Deer Mountain with eastwardly plunging anticlinal noses of Nittany and Buffalo Mountains to northwest.
292.65	63.95	Cross Route 45 on west outskirts of Lewisburg.
293.50	64.80	Buffalo Creek Alluvial Plain.
295.20	66.50	Small quarry to left exposes the black Marcellus shale in a small syncline along Buffalo Creek.
295.60	66.90	Large cut. The *Stromatopora* beds of the KEYSER limestone are well exposed, the fossils abundant.
296.30	67.60	Passing through West Milton, the Silurian marine greenish-gray shales are exposed. To the north the red BLOOMSBURG reappears.
296.65	67.95	WILLS CREEK greenish and some pink-splotched shale and mudrock. Mudcracks.
297.25	68.55	Cross Route 115 in West Milton. WILLS CREEK at north outskirts of town.
297.65	68.95	BLOOMSBURG red beds with siltstone member.
298.80	70.10	Alluvial plain, with low ridges at left reflecting folded Silurian shales.
301.35	72.65	Crossing White Deer Creek.
301.60	72.90	North of White Deer Village, cuts expose more of the Silurian sandstones and shales.
301.95– 302.20	73.25– 73.50	CLINTON shales southwardly dipping in south limb of SOUTH WHITE DEER RIDGE ANTICLINE. Strike S 80° W, dip 24° SE. In distance North White Deer Ridge and Bald Eagle Mountain form an eastwardly plunging anticlinal nose. The Clinton beds reach their maximum thickness of 1,000 feet in this area.
302.40	73.70	Axis of South White Deer Ridge anticline.
302.60	73.90	Beds begin northward dip on north limb of SOUTH WHITE DEER RIDGE ANTICLINE. Strike N 80° W, dip 3° NE.
302.85– 303.25	74.15– 74.55	**Stop No. 11.** Highway along west side of Susquehanna River one mile south of Allenwood. In the 35 miles from Selinsgrove to Williamsport, seven large anticlines bring westerly crops of the mountain forming TUSCARORA sandstones to within ten miles of the nearly straight, north-south channel of the Susquehanna River. Each time before reaching the river, the Tuscarora plunges underground along an anticlinal nose, in accordance

with the regional pitch that farther east brings in the deep synclinal pockets of the anthracite coal fields.

Among these anticlinal noses of the Tuscarora formation, South White Deer Ridge carries the uppermost Tuscarora to the Susquehanna's bank near Allenwood and on each flank provides good exposures of the Middle-Silurian sediments whose southeastwardly coarsened counterparts were visited at **Stop 8,** near Harrisburg, and whose thinned northwesterly extensions will be seen along the gorge of the Niagara River.

The stop for discussion will be made in beds about 200 feet below the top of the CLINTON, ROSE HILL shale. After brief discussion, the group will walk to the parked buses crossing the upper part of the CLINTON and lower beds of the McKENZIE shale and limestone.

The Clinton and McKenzie strata contain a sequence of exceptionally well-marked faunal zones, characterized by distinctive brachiopods, trilobites, and especially by ostracodes. Two of the zones, traceable from locality to locality southwestwards to Warm Springs, Virginia, commonly occur in beds two to five feet thick and at no place are known to be more than ten feet. These zones at the base of the McKenzie are distinguished by *Schuchertella elegans* and by coquinites of *Whitfieldella marylandica.*

The Rose Hill reaches, near Allenwood, its maximum known shale thickness of 1,000 feet. Equivalent strata eastward on the Lehigh River are roughly equal in thickness but are increasingly sandy in their transitional phases where they are joining with Tuscarora sandstone to form the Shawangunk conglomerate. Northwestward at Niagara Falls, the Rose Hill-age sediments are less than 50 feet in thickness, reduced below a twentieth of their thickness at the present stop.

The Rose Hill shales near Allenwood contain only rare, 1- or 2-inch interlayers of fine grained sandstone. In the upper hundred feet, 2- to 6-inch coquinites are numerous. The coquinite-rich portion is left untouched where the Rose Hill is worked for ceramic clays across the river from Allenwood and near Lock Haven west of Williamsport.

The Rose Hill at Stop 11 contrasts markedly here and at Susquehanna Gap near Harrisburg. There its beds are unfossiliferous and are about half composed of iron-rich sandstones. Tongues of iron sandstone can be traced northwards into fossiliferous Rose Hill shale, and iron oxides produce rosy and purplish tones in some shales of the formation. The Rose Hill shale received its name from a knoll near Cumberland, Maryland, itself named for these rose-tints. The Rose Hill shale is one of the outcropping formations at the Rose Hill oil field of southwestern Virginia.

The discussion point at the stop is made on the *Bonnemaia rudis* zone, traced northeastwards from eastern Tennessee. The *Mastigobolbina typus* zone occurs in higher strata; *typus* is abundant on slabs that were submitted from the Rose Hill field in Virginia; in New York, it has been found near Rochester in the Irondequoit limestone. Four additional ostracod zones are represented in local collections from underlying parts of the Rose Hill formation. These ostracod zones contrast with one another as well distinguished zones of evolution of the distinctive species, not as zones reflecting changes in environment; hence they are excellent for close age correlations.

The Rose Hill shale is overlain at Allenwood by KEEFER sandstone, 40 feet thick, including at its base a member formed by 15 feet of crystalline, crinoidal, grayish limestone, with some thin shaly partings. The contact of the limestones with the Rose Hill is lithologically troublesome, but faunally is sharply marked by a regionally persistent change in species.

Both the limestone member of the Keefer, and limy layers containing highest occurrences of the Rose Hill faunas, have hematitic lenses, and there is one 3- to 6-inch layer of almost solid oolitic hematite. Many such oolites when sectioned have as nuclei fragments of crinoid plates, brachiopods, bryozoa, and other fossils. In some hematitic layers elsewhere associated with the Keefer, certain brachiopod shells tend to be replaced by specularite.

Hematite zones are persistently associated with the Keefer sandstone through central Pennsylvania, and at some places are rich enough so that they were extensively prospected and locally worked for iron ore from the time of the Revolutionary War until after the Civil War. Fossil ores also occur locally at other levels of the Rose Hill.

The Keefer sandstone is a thin tongue from the Shawangunk conglomerate and conglomeratic sandstone of easternmost Pennsylvania, New Jersey, and southeastern New York, and from similar beds in the easternmost Silurian belts of Virginia. For so thin a lithologic unit, the Keefer is remarkably widespread, being traceable with minor changes in its limits over some 25,000 square miles in Pennsylvania, Maryland, and the Virginias. It represents a sedimentary response to a gentle but geographically extensive upwarp of the eroding sediments to the east; and probably more especially to lift of the platform of deposition, at least in terms of level of the sea, with consequent shallowing of the waters and strengthening of the currents that distributed the sands.

Above the Keefer are 40' of ROCHESTER shale, with thin 2- to 4-inch interlayers of gray, medium crystalline, highly fossiliferous limestone. Fossils distinctive of the Rochester shale of New York are profuse; but with them is the ostracod, *Drepanellina clarkei,* and some other fossils unknown in the type of Rochester. *D. clarkei* is abundant and persists southwestwards to Warm Springs, Virginia; its absence in New York may signify a slight difference in age of the Rochester shales of the two regions; the type Rochester may really be equal to shales that replace the Keefer sandstone in the vicinity of Williamsport.

At the top of the *Drepanellina clarkei* beds is a knife-edge, plausibly disconformable faunal change in the lithologically similar *Schuchertella elegans* zone; about six feet higher is another change to the *Whitfieldella marylandica* zone. The latter zonal change in part reflects facies differences; there is marked reduction in diversity of megafossils in the *W. marylandica* coquinities, although distinctive ostracod species are plentiful.

Within the *W. marylandica* zone the limestones change in character becoming aphanitic, dark. Edgewise conglomerates appear in local lenses. Fossils are rare in the next 30 feet, until ostracods and a few brachiopod species again are common. West of Williamsport, a coralline tongue intrudes these strata from the north. Its two coral species are found in Lockport beds in New York, and combine with stratigraphic position, direction of invasion of the coralline wedge, and presence of several Lockport brachiopods, to suggest that the McKenzie probably is a facies equivalent to the Lockport, deposited in shallower reaches of the sea where the floor recurrently received some clay, and where the water chemistry was not favorable to either Lockport lithology or in general to the Lockport faunas.

The Middle and upper parts of the McKenzie, together with higher parts of the Silurian, are concealed as the highway continues northward.

The Lower Devonian-Silurian succession near Allenwood can be summarized as follows:

Middle Devonian

Onondaga shale and argillaceous limestone

Lower Devonian

Oriskany cherts, 50'±, with about five feet of sandstone at the top. Helderberg shales and shaly limestone, 60', with about ten feet of New Scotland and 5' of Coeymans limestone at the base.

Upper Silurian

Keyser limestone, 100' nodular below; *Chonetes jerseyensis* fauna in lower half, and at base *Leperditia scalaris* of the Akron dolomite of western New York.

Tonoloway limestone, laminated, 200′; only the upper part of the type Tonoloway is here represented by limestone, so that the formational name Bossardville from eastern Pennsylvania, could well be used.

Wills Creek shale, 500′; near middle in this region are *Kyammodes swartzi* and *Dizygopleura longipunctata* found below the middle of the Tonoloway in Maryland and Virginia; much of this "Wills Creek" is Tonoloway in age though not in facies.

Bloomsburg red shale and sandstone, 450′; a persistent, thin sandstone member may represent sandstone beds found in the Bloomsburg 50 miles to the southwest near Mifflinburg, Mount Union, Neffs Mills, and Altoona. In the Neffs Mills area especially, the sandstone detail shows a real persistence giving evidence of distribution on the floor of extensive, shallow waters.

Middle Silurian

McKenzie shale and limestone, 250′. Equivalents of the highest McKenzie of Maryland here are incorporated in the basal Bloomsburg; the remaining McKenzie strata are distinguished by zones of *Kloedenella nitidia, Beyrichia moodeyi, Whitfieldella marylandica* with *Kloedenia ventralis, Schuchertella elegans.*

Clinton Group

Rochester shale with thin interlayers of limestone, 40 feet. *Dalmanites limulurins, Drepanellina clarkei.*

Keefer sandstone, 40′; medium bedded sandstone above, thick-bedded crystalline, locally hematitic limestone below. *Schuchertella subplana.*

Rose Hill shale, 100′. Clay shale, with thin coquinites near top where there are several hematitic layers. *Liocalymene clintoni, Coelospira hemispherica, Chonetes aff. novascotieus* fauna, with zones of *Mastigo bolbina typus, Bonnemaia rudis, Mastigobolbina modestus, M. lata, Zygobolba bimuralis, Zygobolba anticostiensis.*

Castanea sandstone, 75′, consisting except at the top of red and some greenish sandstones, many layers transected by *Scolithus* worm tubes and having profuse worm-castings on their bedding surfaces. Suggestive of and perhaps in part an extension of the red Grimsby sandstone of New York.

Lower Silurian

Tuscarora sandstone or quartzite, 500′; cleanly washed quartz sand cemented by overgrowths of silica; 10 to 20 per cent of the rock probably consists of silty shales. Exposed on mountain as it rises west of the highway.

Ordovician

Juniata red sandstone and shale.

Total	Trip	
303.45	74.75	Crossing White Deer Hole Creek.
307.20	78.50	Southwest of Montgomery, the Devonian marine beds form the hill crossed by the highway.
309.10	80.40	Ascending the south slope of Bald Eagle Mountain. This is an anticlinal ridge with its nose pointing eastward and encircled by the great bend of the Susquehanna River between Williamsport and Milton. Along the road the slopes are strewn with whitish talus blocks from the TUSCARORA, basal Silurian formation.
310.80	82.10	Here the whitish talus changes to red indicating that the road has passed through the Tuscarora and is now entering the red JUNIATA of late Ordovician age. The still older Bald Eagle gray conglomerate and the Reedsville (or Martinsburg) shale are not exposed along the crest of the ridge.
312.20	83.50	Cut. This is an excellent exposure of the contact between the red JUNIATA SANDSTONE and the overlying gray to whitish TUSCARORA. The absence of conglomerate from the Juniata is in marked contrast with its pebbly nature north of Harrisburg. Here too, the transition between the red and white is brief. As the dip is north, we are now on the north limb of the anticline.

MILEAGES Total	Trip	
313.10	84.40	**Stop No. 12.**
		Cut exposes Silurian sandstones, approximately on the north flank of the mountain. Susquehanna Valley opens below us to the north.
		From this point is a fine view of the ALLEGHENY PLATEAU region to the north, which we are about to recross. Some of the folds which were crossed in yesterday's journey before reaching Grand View, will again be crossed as we travel northward. It will be observed, however, that these folds do not create the pronounced topographic features that they form further southwest.
		After leaving this point and going through Williamsport we will leave the RIDGE AND VALLEY section of the highly folded Appalachians through which the caravan has traveled since **Stop 2** at Grand View. From Grand View part of the Ridge and Valley section could be seen before crossing it. From this stop, part of the Allegheny Plateau can be observed before re-entering it.
315.80	87.10	Crossing the west branch of the Susquehanna River. Note flood control levee. Follow Route 15 through Williamsport. The city overlies beds of late Silurian and early Devonian ages.
318.60	89.90	Leaving Williamsport, cut right exposes the greenish BRALLIER shale, here somewhat sandy, of Portage age. The beds dip northward as we are now leaving the Appalachian folded mountain structures to enter the relatively flat-lying strata of the Allegheny Plateau.
318.90	90.20	At Lycoming Creek, two large quarries right expose the BRALLIER shale and slabby sandstone. This is a good exposure of these beds and illustrates well the development of joints therein.
		Continuing up the valley of Lycoming Creek, we enter the Allegheny Plateau. From the valley the topography appears rugged. However, it will be observed that the strata lie nearly flat, and the flat tops of the hills are apparent. Occasional openings show rocks of Chemung and Portage ages, chiefly gray shale and sandstone.
320.25	91.55	Cross meander of Lycoming Creek, Allegheny Front Escarpment ahead. Road on floodplain of Lycoming Creek; Hepburn Hills made by Upper Devonian Portage and Chemung.
322.25	93.55	Lycoming meander on right.
322.90	94.20	Cross Lycoming Creek with red soil on right.
323.00	94.30	North of Hepburnville, cuts expose terrace gravels.
324.20	95.50	This point is approximately at the base of the Catskill continental beds. In this vicinity coal beds, at most a few centimeters thick, have been found in the Catskill.
325.50	96.80	The valley narrows with steep walls cut in the CATSKILL sandstones. The Catskill is quite uniformly red sandstone and shale with very little non-red material, unlike its counterpart farther northeast where thick, non-red units are interspersed with the red (*Cf.* Honesdale ss). Note again the flat topped "hills" of the plateau country.
326.75	98.05	Fine view of Allegheny Front escarpment.
327.10	98.40	Crossing Lycoming Creek.
329.00	100.30	Good exposure of Catskill red beds.
329.50	100.80	Crossing Wolf Run.
330.50	101.80	**Trout Run.** Bear left on Route 15. At the right a small cut shows OSWAYO or ELK MOUNTAIN SANDSTONE float. The Oswayo is a persistent non-red unit of cross-bedded, greenish sandstone which occurs near the top of the Catskill, widely in north-central Pennsylvania. It is the correlative of the Elk Mountain sandstone in the northeast.

MILEAGES Total	Trip	
332.00	103.30	CATSKILL red beds.
336.50	107.80	CATSKILL.
336.90	108.20	CATSKILL.
337.10	108.40	**Stop No. 13.**

Steam Valley Summit. After leaving Williamsport, near the margin of the Ridge and Valley Province, the trip route followed for twelve miles the flood-plain of Lycoming Creek, rising in altitude from 550 to about 680 feet. Turning up the tributary valley of Trout Run, the route then in seven miles lifted a thousand feet to Steam Valley Summit, a topographic saddle at about 1,700 feet above tide.

In the first seven miles from Williamsport, the route traversed a region of low hills, their tops at elevations of 1,100 to 1,200 feet. Here most of the Devonian sequence, though disturbed by secondary folding, dips gradually underground. The Lycoming Valley then narrowed between higher crowding hills, their summits flattening at altitudes of 1,800 to 2,100 feet. Entering this higher land, the route returned to the Allegheny Plateau Province, left at **Stop 2** after the first 90 miles of the trip. Near Williamsport, the Front is breached by Lycoming and other creeks, so that it is perhaps less striking as a topographic feature than farther south where for many miles its rampart is unbroken.

From Pittsburgh eastwards to the Allegheny Front at **Stop 2,** the Allegheny Plateau region is almost continuously veneered by coal-bearing Pennsylvanian strata. Here in its northeastern part, the great, broad synclinorium of the Plateau region is shallower, so that its surface is floored by Upper Devonian and some Mississippian strata, with coal-bearing sediments of the Pennsylvanian preserved only as small outliers capping a few of the higher hills along parts of the deeper synclines.

In the 100 miles across the Plateau Province along our route, there are synclines and anticlines low in amplitude when contrasted with the folds of the Ridge and Valley region; some, however, can be traced to a hundred miles or more along the Appalachian strike, and some folds arch 2,000 feet or more from trough to crest.

Near Steam Valley Summit the stratigraphic sequence can be summarized as follows:

Pennsylvanian

Allegheny formation: 250′ shale and sandstone with four good 3-foot coals and some thinner coal beds; preserved on hills near Blossburg.

Pottsville formation: 100′ ± of coarse white sandstone and some conglomerate.

Mississippian

Mauch Chunk formation: 250′ of red and greenish shale and sandstone thinning northwards.

Pocono sandstone: 300′ (?). Higher parts of the next succeeding 500 to 600 feet of greenish, strongly cross-bedded sandstones may include equivalents of the Pocono formation seen elsewhere on the trip.

Devonian

Oswayo or Elk Mountain sandstone: 200′ (?). Lower parts of the 600′ ± sequence of greenish, strongly cross-bedded, slabby sandstones are thought to pass northwestwards into the fossiliferous Oswayo shales and sandstones characterized by *Camarotoechia allegania.*

The type Oswayo currently is included in the latest Devonian Conewango group.
Catskill red sandstone and shale: thickness unknown, probably between 500 and 1,000 feet.

Chemung shale: at top, about 400 feet of interbedded grayish and purplish to reddish, fossiliferous shale and some sandstone; total thickness of Chemung may be 1,500 feet.

Bedrock at Steam Valley Summit is upper Catskill, here at high levels along Coogan House anticline. Surrounding hills both north and south are capped along the adjoining synclines by Oswayo-Pocono sandstones, with Pottsville on one summit five miles to the east, and on another five miles to the south. The neighboring synclines combine with their dividing anticline to make a double synclinal belt that preserved the Oswayo-Pocono sandstones along the mountain summits along a belt ten miles in width.

Though secondary at this place, the Cogan House anticline is essentially continuous with LAUREL HILL ANTICLINE extending southward past Somerset into West Virginia.

Northward from the double syncline of the Steam Valley Summit area, two synclines are deep enough to preserve Oswayo-Pocono and younger strata. Along the Blossburg syncline at Blossburg, fourteen miles north of Steam Valley Summit, post-Pottsville beds cap the hill summits and active coal mines can be seen above the town. Seventeen miles still farther north, Oswayo and perhaps some Pocono-age strata summit hills along the Pine Creek syncline. From Pine Creek syncline north, no remnants of the Mississippian are preserved.

Anticlines, of course, alternate with the synclinal belts. Northward from Steam Valley, the route will cross the Towanda anticline before reaching Blossburg, the Wellsboro anticline north of the Blossburg syncline, and the Sabinsville anticline north of the Pine Creek syncline. The Tioga gas field is located along the Sabinsville anticline, producing from the Oriskany sandstone at depths of about 4,000 feet.

Northward from the Sabinsville anticline the amplitude of folding decreases and little evidence of the folding can be observed from the bus windows.

338.80 110.10 Descending northward past a large spring, right, the CATSKILL is again visible.

339.80 111.10 Cuts expose beds assigned to the OSWAYO or ELK MOUNTAIN.

343.10 114.40 Crossing TOWANDA ANTICLINE.

345.00 116.30 Liberty. For several miles the road has been following closely the Oswayo cross-bedded sandstone, sometimes dropping below it into the red beds, then rising again into the greenish strata.

346.60 117.90 North from Liberty, the fields are strewn with gray boulders of sandstone and conglomerate which indicate that we are passing above the Catskill into the Pocono.

350.00 121.30 Bloss Mountain, elevation 2,140 feet. The Pocono is poorly exposed in cuts on the south slope.

353.90 125.20 A long cut exposes the upper part of the CATSKILL near the "Coal Discovery" historic marker. A little whitish Pottsville float indicates nearness to the base of the Coal Measures, and a small coal mine is being operated on the hillside to the north beyond Blossburg. Small coal basins lie two to three miles east and west of Blossburg. "Coal was found at present Blossburg by Robert and Benjamin Paterson, 1792, while acting as scouts for the Williamson road party. David Clemons about 1815 opened the first drift mine in it on Bear Creek." "One of the earliest railroads in U. S. was completed from Corning, N. Y., to Blossburg in September, 1840. Built to connect the Erie Railroad and canal with the local coal fields." (From historic markers.)

355.60 126.90 Entering Blossburg. Route 15 keeps west of the town.

356.50 127.80 Leaving Blossburg, northward. The cliff which borders the road, left, is POCONO with a few feet of red MAUCH CHUNK shale at the top.

357.85 129.15 Rising gray sandstone, some red shale at road level.

358.70 130.00 Cross Tioga River into Covington. The valley opens as a wide, flat expanse near the

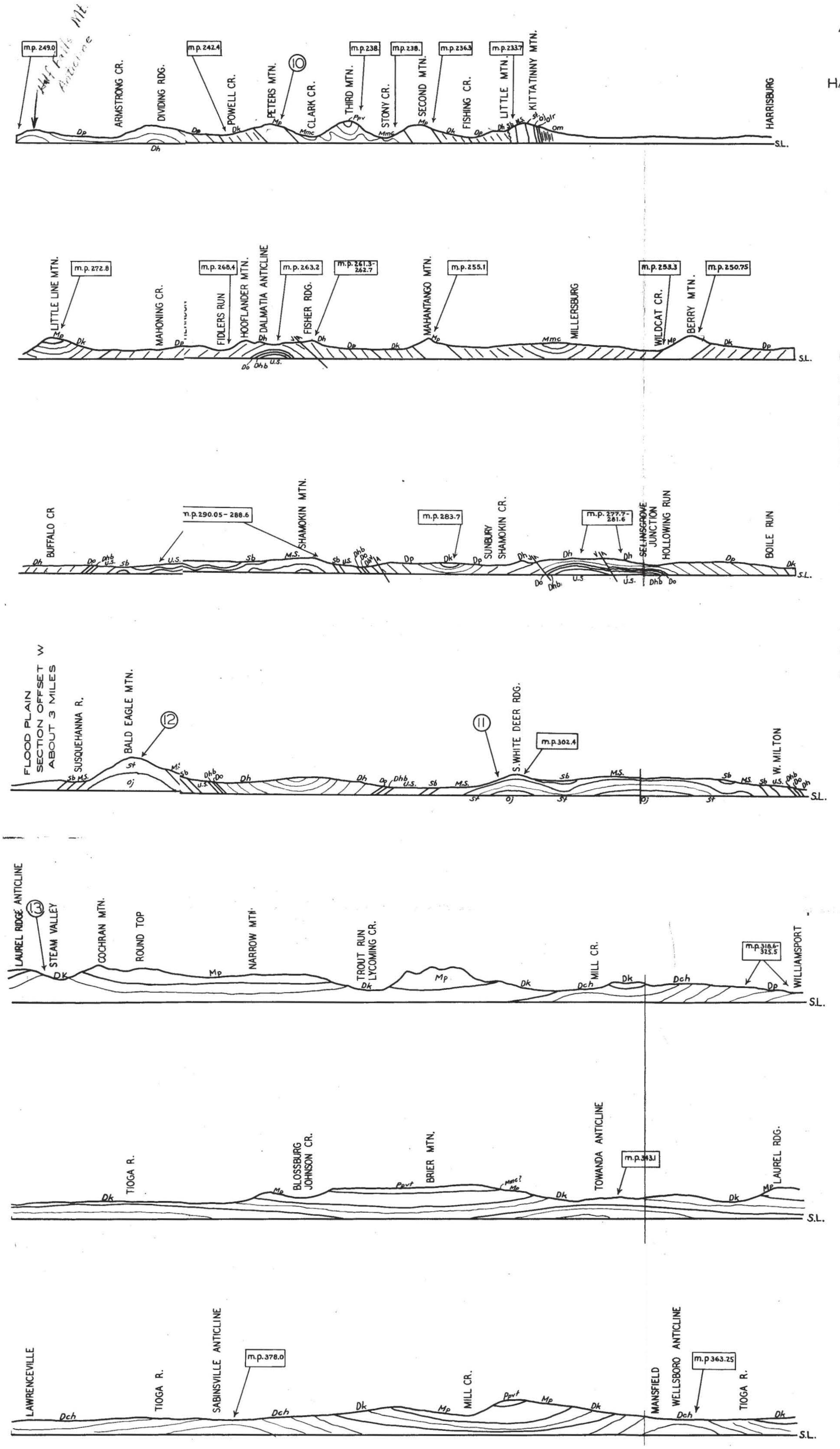

MP 343.1
13
MP 330.5
MP318.90
12
11
MP302.4

MILEAGES Total	Trip	
		road. Pocono and Catskill beds underlie the hills. Dip slopes on hill tops to west show northward rise of strata toward crest of Wellsboro Anticline.
360.50	131.80	Cross roads in Covington.
363.25	134.55	Canoe Camp—near axis of WELLSBORO ANTICLINE. This structure may be regionally a continuation of the CHESTNUT RIDGE ANTICLINE of Western Pennsylvania and West Virginia.
364.60	135.90	Mansfield. Northward from the village, no bedrock exposures are available. The region has been heavily glaciated and glacial and fluvio-glacial deposits abound, particularly south of Lawrenceville.
365.00	136.30	Cross U. S. Route 6.
372.90	144.20	Crossing Tioga River and entering Tioga.
374.00	145.30	CHEMUNG (?) dipping south, outcrop well to right of road and river.
378.00	149.30	Eastern limit of Tioga Gas Field. Now used as underground storage reservoirs. Reservoir formation: Oriskany sandstone. Structure: Sabinsville Anticline, complexly faulted.
380.10	151.40	Entering Lawrenceville.
380.30	151.60	Kame like deposits along flood plan to right indicate little post-glacial changes of Alluvial plain.
380.80	152.10	**Rest stop.** Lawrenceville. 10-minute stop. Join New York State Police escort.
381.00	152.30	**State Line.** Enter New York State at Lawrenceville village limits. The bedrock in this vicinity is Devonian; Catskill in the hills, marine Chemung or later under the valleys.
381.10	152.40	Cross Cowanesque River, tributary to Tioga River. Route continues north along west bank of Tioga River. This valley was not one of the main glacial lake outlet channels tributary to the Susquehanna.
383.80– **384.50**	155.10– 155.80	Roadside outcrop of gray sandy shales and graywacke with micaceous partings—also arenaceous coquinites. Formation not definitely dated, but probably in Gardeau (West Hill flags and shales).
389.00	160.30	Cross Canisteo River.
389.40	160.70	Turn right on New York Route 17 and continue down Tioga River.
390.40	161.70	Note glacial valley fill deposited by glacial outlet streams flowing down Tertiary drainage ways from the ice front to the north.
393.60	164.90	Cross Cohocton River north of its confluence with the Tioga River and enter Painted Post. On bed of glacial Lake Elmira into which aggraded glacial outlet streams flowed from north.
394.00	165.30	Left on U. S. Route 15. Fairchild calls this valley perhaps the finest in the State as an exhibit of glacial overdrift or "valley train."
395.00	166.30	Cross approximate trace of VAN ETTEN (HARRISON) ANTICLINE. Oriskany sandstone at 2,200 feet. The Woodhull field with Oriskany production is along this anticline, approximately 15 miles to the southwest.
396.00	167.30	Cross Meads Creek.
397.00– **397.90**	168.30– 169.20	Outcrop of West Hill flags and shales of the Chemung group (Portage). Thin bedded shales and massive sandstone layers. Here is crossed the approximate trace of the ALPINE ANTICLINE.
401.80	173.10	Route continues along east bank of Cohocton River. Valley has been filled by glacial outwash from lakes in the Finger Lakes basins which overflowed the divide at the Valley Heads moraine. Note glacial oversteepened valley walls.

APPROXIMATE GEOLOGIC STRUCTURE HARRISBURG - LAWRENCEVILLE PENNSYLVANIA

MILES

AFTER BRADFORD WILLARD



LEGEND

Ppv POTTSVILLE AND COAL MEASURES

Mmc MAUCH CHUNK

Mp POCONO

Dk CATSKILL

Dch, Dp, Dh CHEMUNG - PORTAGE - HAMILTON PLUS OR MINUS

Do ORISKANY

Dhb HELDERBERG

U.S. UPPER SILURIAN UNDIFFERENTIATED

Sb BLOOMSBURG

M.S. MIDDLE SILURIAN UNDIFFERENTIATED

St TUSCARORA

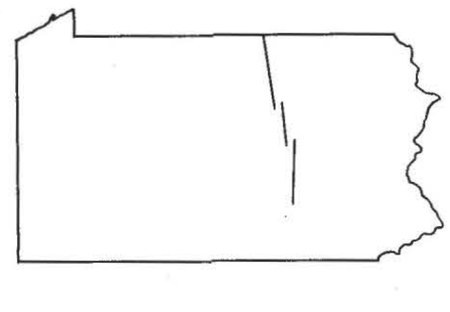
Oj JUNIATA

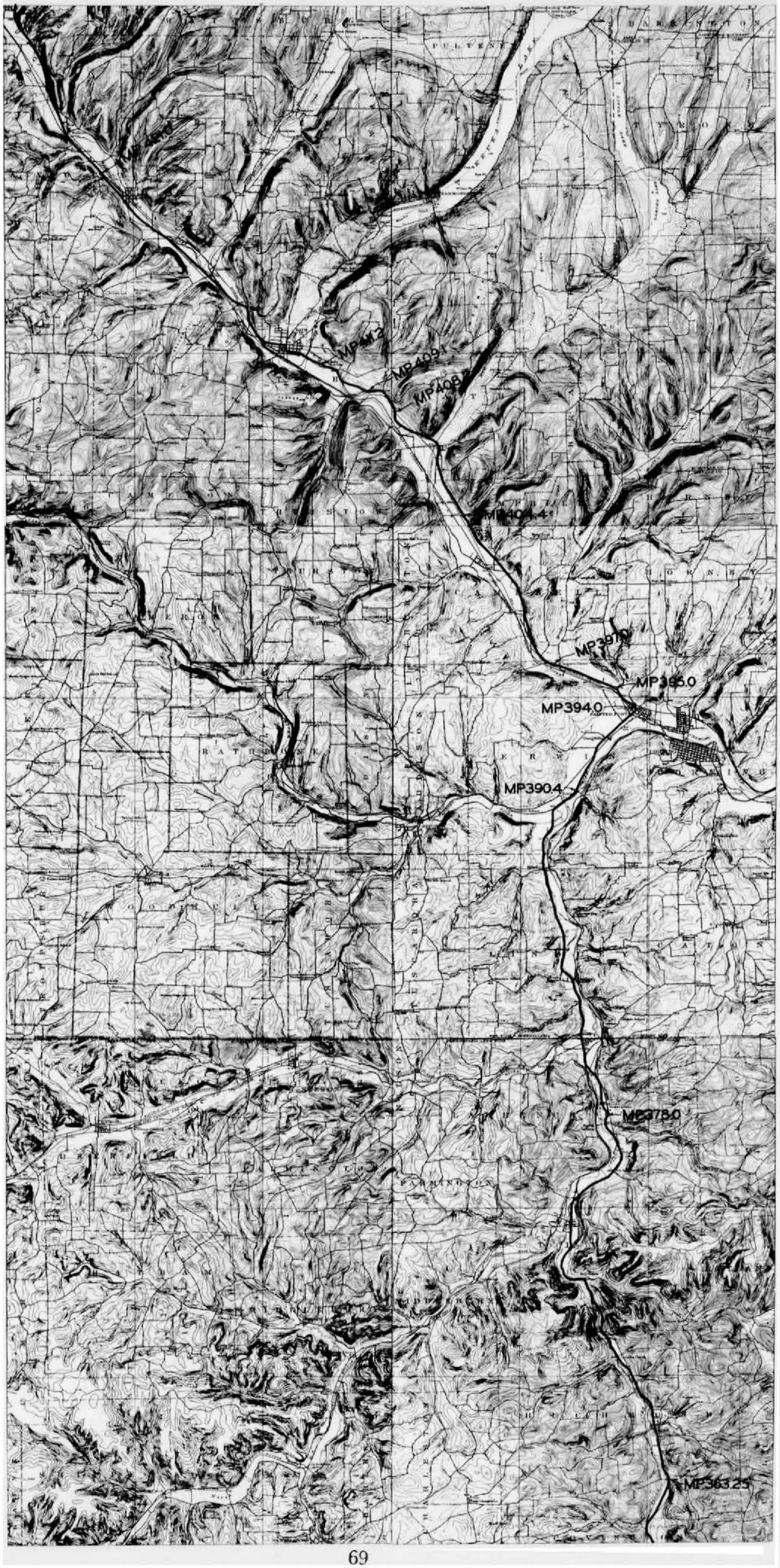
Obe BALD EAGLE

Om MARTINSBURG

(7) STOPS FOR GEOLOGY

m.p. 23.7 MILEAGE (TOTAL) REFERENCE IN GUIDEBOOK

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MP394.0
MP390.4
MP363.25

MILEAGES Total	Trip	
404.40	175.70	Kame terrace built up at mouth of tributary stream entering Cohocton valley. Crossing approximate trace of WATKINS ANTICLINE. On the westward extension of this anticline are several Oriskany fields, including the State Line Field.
406.20	177.50	Savona, N. Y. Junction with New York Route 226. Continue on Route 15.
408.20	179.50	Crossing edge of recently discovered stratigraphic trap type gas pool in Oriskany sandstone. Although the limits of the pool have not yet been defined, it is probably rather small. Seven test wells were drilled in this locality before the pool was found.
409.10	180.40	Across glacial delta, somewhat dissected.
410.40	181.70	Note glacially oversteepened valley walls.
411.20	182.50	**Lake Salubria** on right. This is exceptionally deep, often referred to as "Bottom less Lake." It is considered an excellent example of a pit lake. There are other pits near the lake that do not contain water. On left near Bath NUNDA sandstone caps the steep cliffs.
412.50	183.80	Center of Bath, N. Y. Continue on Route 15.
414.40	185.70	Glacial kame on right.
415.90	187.20	Fragment of kame terrace on right.
421.00	192.30	Crossing approximate trace of FIRTREE ANTICLINE. Oriskany sandstone (if present) at elevation of —1,400 feet.
421.70	193.00	Pit in kame terrace on left.
427.00	198.30	Thin bedded siltstones of Chemung (Portage) age.
427.80	199.10	"High level" delta on left (west side of Cohocton Valley).
428.70	200.00	Village of Cohocton—leave U. S. Route 15, continue straight ahead on New York Route 371.
430.00	201.30	Kame terrace on left with valley fill from outwash of Valley Heads moraine.
430.90	202.20	Kame terrace with ice contact slope and associated delta.
433.70	205.00	North Cohocton—New York State Routes 245 and 21 join 371. Route climbs up on VALLEY HEADS MORAINE—terminal moraine of the Cary substage. From this point for four miles to the north, the route will traverse this well developed kame moraine. This is the drainage divide between the Susquehanna and the St. Lawrence Rivers systems.
434.20	205.50	Glacial kettle hole on right.
436.00	207.30	**Stop No. 14.**

Short stop for discussion of glacial and physiographic history. Middlesex valley ahead and to the right, Canandaigua Lake valley near center, Bristol Hills and Honeoye valley to the left. Flat topped Bristol Hills capped with PRATTSBURG sands and flags. Top of cliff—NUNDA sandstone (100 feet thick) of Chemung group. WEST HILL sands and flags in hillsides and valleys. Kame moraine topography—part of Valley Heads moraine at confluence of valleys. Talk on glacial geology by Dr. Earl T. Apfel, Syracuse University.

The Bristol Hills are well known for the "Burning Spring" visited by LaSalle in 1669 —a gaseous spring fed by methane from the black shales of the Naples and Genesee groups. Gas in commercial quantity was found in the Medina sandstone in wells first drilled in 1869. The Medina is at a depth of 2,500 feet. The first pipe line on this continent was constructed to carry natural gas from the Bloomfield district (just to the north) to Rochester. It was made entirely of wood and was soon abandoned.

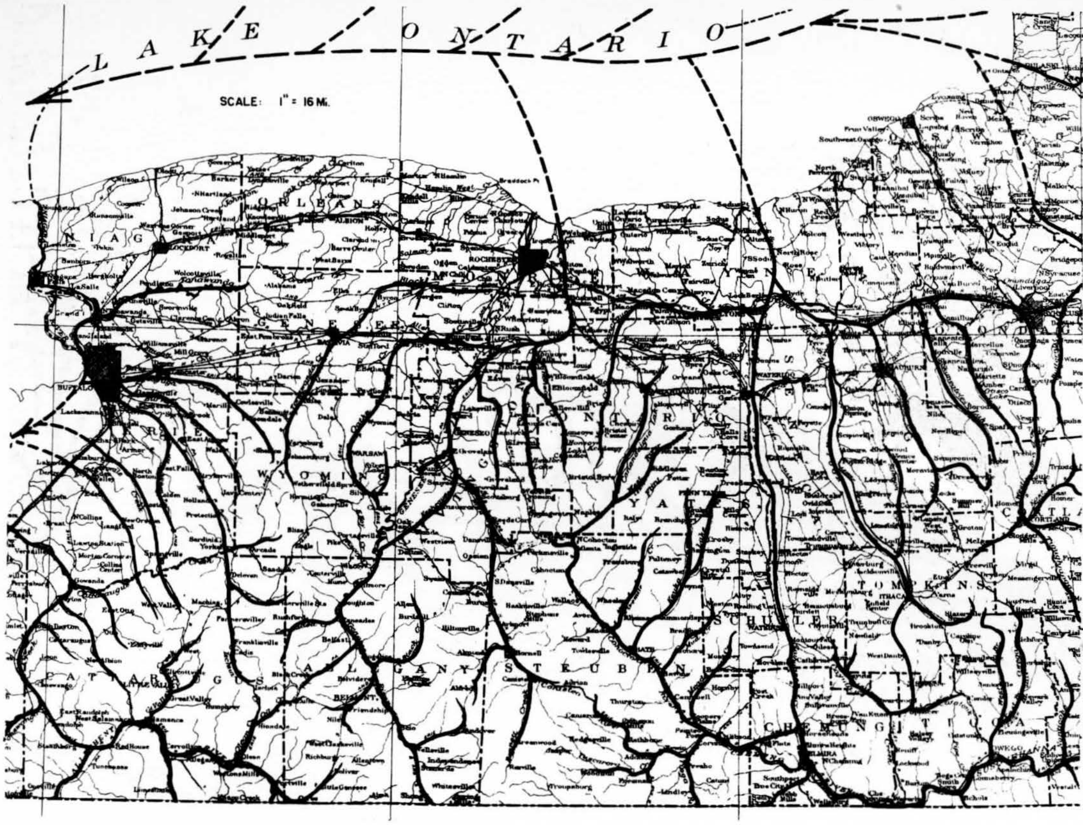


Fig. 1. Preglacial, late Tertiary, drainage in New York. Glaciation has obscured the minor stream courses in the belt bordering Lake Ontario (after Fairchild).

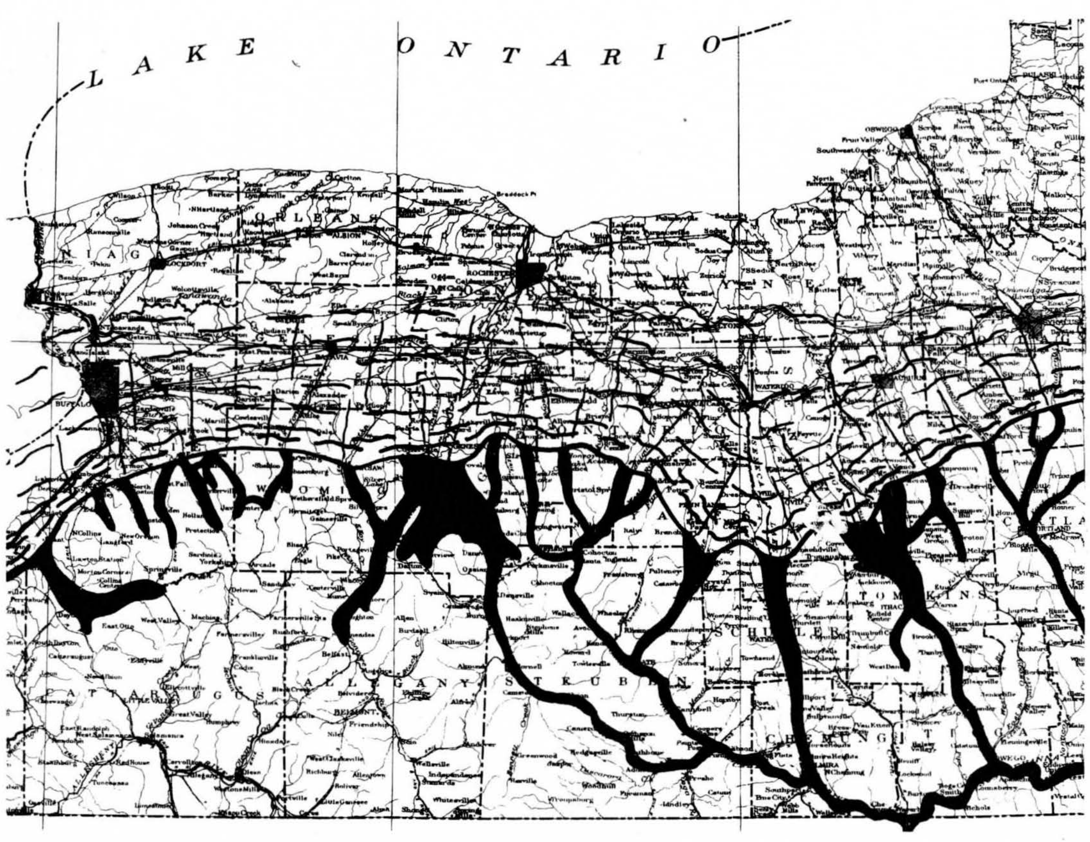


Fig. 2. Local glacial lakes were dammed between the ice front and the Valley Heads moraine. Outlets flowed south into Susquehanna drainage system, depositing vast quantities of outwash in tributary valleys. Lake Whittlesey was invading the eastern part of the Erie Basin (after Fairchild).

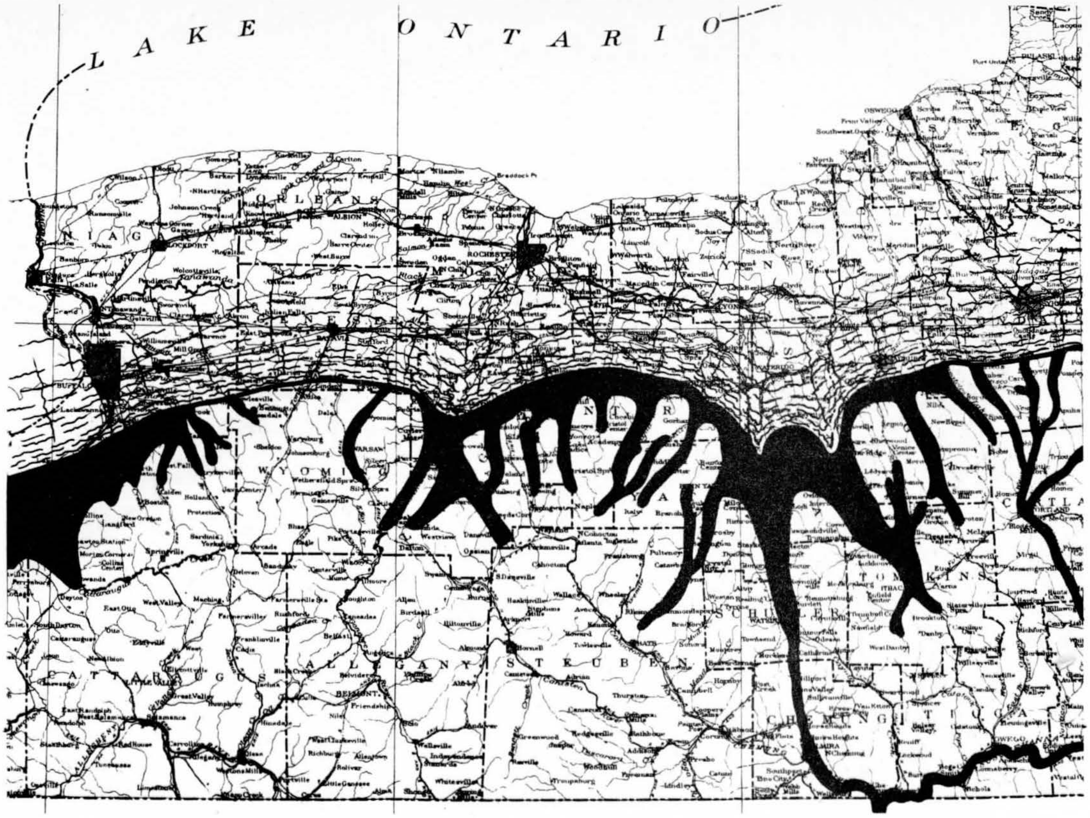


Fig. 3. Glacial Lake Newberry, coexistent in Finger Lakes valleys with Glacial Lake Whittlesey in Erie Basin. The outlet southward into the Susquehanna drainage system is the lowest pass leading out of the Ontario Basin to southern drainage (after Fairchild).

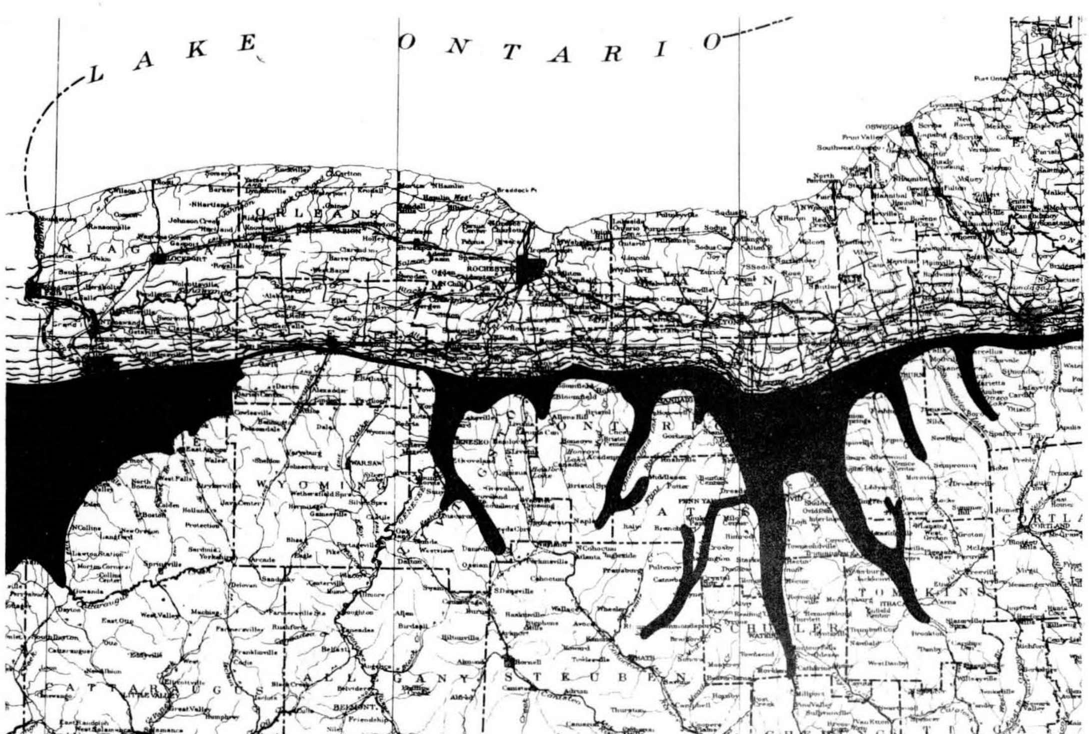


Fig. 4. Glacial Lake Vanuxem drained eastward into Mohawk-Hudson system. Lake Warren still confined to Erie Basin (after Fairchild). (Lake Vanuxem was preceded by Glacial Lake Hall which drained westward into Lake Warren.)

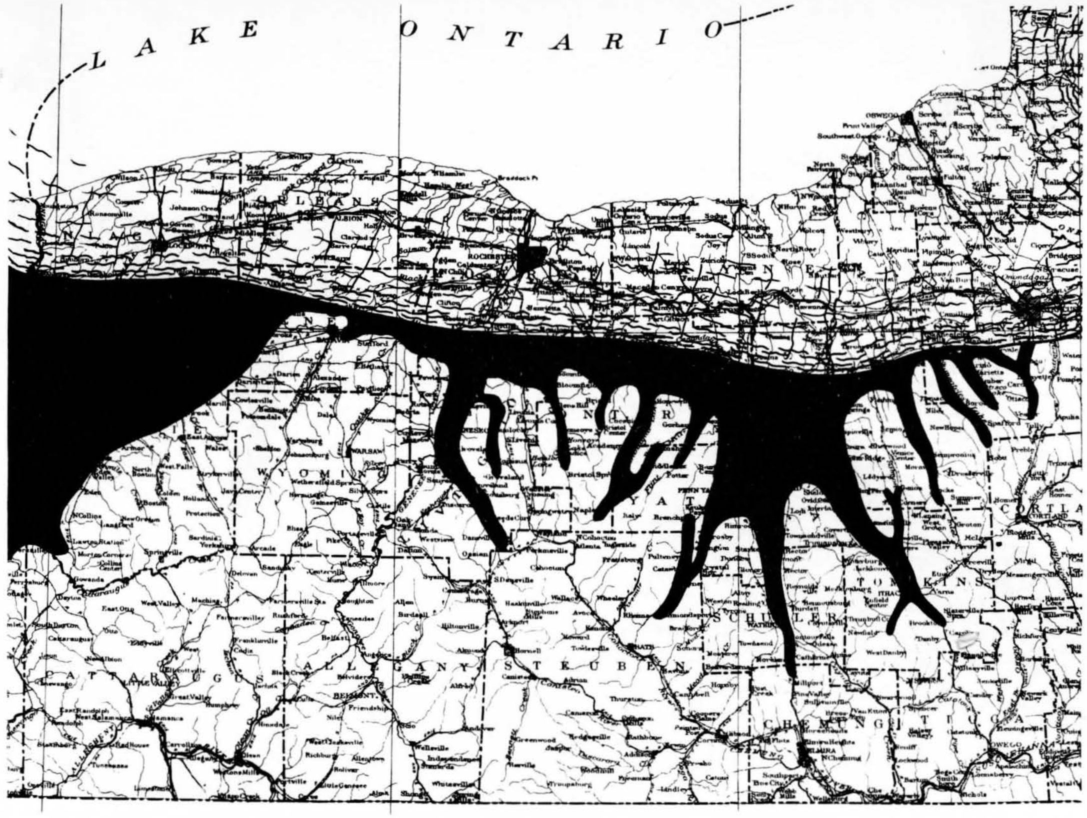


Fig. 5. Glacial Lake Warren—draining westward to the Mississippi drainage system. Fig. 4 was followed by a readvance of the ice front in the Syracuse area which halted eastward drainage. Recession of the ice front in the Batavia area permitted Lake Warren to occupy Vanuxem territory as represented by Fig. 5 (after Fairchild.)

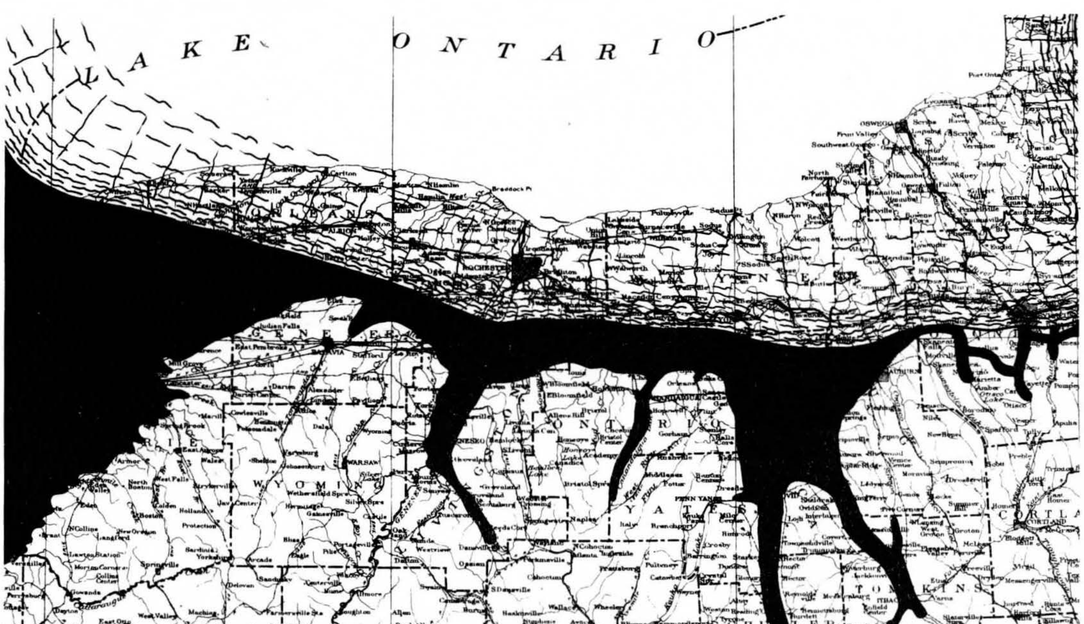


Fig. 6. Glacial Lake Dana. At this stage, the ice front retreated so that Glacial Lake Warren could drain eastward into Mohawk-Hudson system (after Fairchild).

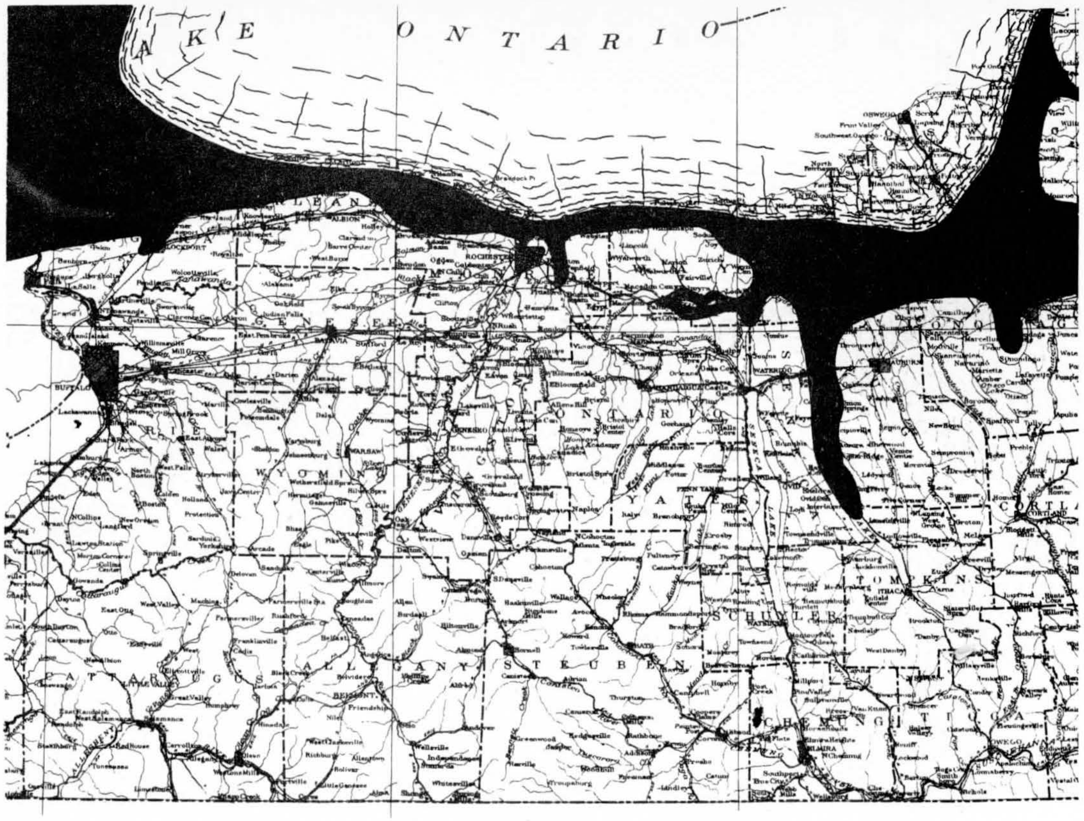


Fig. 7. Lake Iroquois—Final non-marine submergence. Iroquois beach (Ridge Road) formed at this stage. Drainage eastward into Mohawk-Hudson drainage system (after Fairchild).

Fig. 8. Glacial Terminal Moraines and the Iroquois Beach. (Illinoian and Wisconsin, except Mankato substage, based on MacClintock and Apfel, 1944. Iroquois Beach after Leverett, 1902.)

Iroquois Beach ....
Wisconsin:
Hamburg and Marilla (Mankato substage) ......
Valley Heads (Cary substage) ....
Binghamton
Olean
Binghamton
Correlation uncertain
Illinoian ....

MILEAGES Total	Trip	
437.70	209.00	Naples, N. Y., center of New York State Wine Industry.
438.40	209.70	Vineyards on right.
440.20	211.50	Bear left on New York State Route 21. At intersection, CASHAQUA gray shale with occasional flags and lumpy siltstone beds. Close to horizon of PARRISH limestone member—a bed used as a key horizon for mapping.
441.00	212.30	Post-glacial alluvium at head of Canandaigua Lake.
443.50	214.80	Canandaigua Lake on right, westernmost of the Finger Lakes. WEST RIVER grayish-black shale (Genesee group) on left.
444.00	215.30	Typical concretionary layers in WEST RIVER shale.
444.30	215.60	WEST RIVER shales overlain by STANDISH flags.
444.70	216.00	**Stop No. 15.** Vantage point for view of Canandaigua Lake. Note small post-glacial alluvial fans at foot of tributary ravines. The depth of the lake ranges up to about 800 feet.
446.10	217.40	Junction Routes 61 and 21—keep right on 21.
447.60	218.90	Outcrop of CASHAQUA olive shales.
451.60	222.90	Right on Housel road.
452.10	223.40	Right on Seneca Point road.
452.20	223.50	Left on West Lake road.
452.60	223.90	Geneseo shale and underlying Hamilton shales on east shore of lake.
455.50	226.80	**Menteth Ravine.** Type locality—Menteth limestone member. "Tully pyrite" exposed far up the gorge. Its fauna is Hamilton and is composed of small individuals, brought together by sorting. This is underlain by the following section: *Windom shale*—Calcareous shale with abundant *Spirifer granulosus, S. marcyi.* *Kashong shale*—Blacker, more fissile shale with *Tropidoleptus carinatus* and *Grammysia bisulcata.* *Menteth limestone*—1-2 foot limestone, not obviously fossiliferous. It has yielded 123 species, however. Some parts have the fossils well silicified and can be etched. *Deep Run shale*—15′ of shale with a fauna similar to that of the Kashong.
456.90	228.20	**Tichenor Ravine.** Type locality—Tichenor limestone member. Thousands of ravines—some deep gorges, some small gullies—occur in the Finger Lakes Region. In this heavily glaciated area, most of the bedrock exposures for surface geologic mapping are found in these ravines. The route continues along the west shore of Canandaigua Lake. Summer cottages with their private beaches and docks predominate.
461.60	232.90	Junction of West Lake road with U. S. Route 20 and New York State Route 5 in Canandaigua. Continue north through Canandaigua along New York State Route 332.
465.90	237.20	Outlet channel of Glacial Lake Warren.
466.30	237.60	Note that the hills of the plateau region have disappeared. We have crossed the ALLEGHENY CUESTA on to the Lake Plains, essentially the INTERIOR LOWLAND Province.
469.50	240.80	Junction New York State Route 96—bear left on this route.
470.80	242.10	On left—drainage channel for lower level of Glacial Lake Warren.

MILEAGES Total	Trip	
471.10	242.40	BERTIE waterlime—top of Salina group.
472.20	243.50	Poorly formed drumlins.
473.60	244.90	North bank of glacial drainage channel on right. Cut in glacial material.
475.00	246.30	Radio tower of Station WHAM located on Victor kame moraine.
476.60	247.90	On left—wave cut terraces of Glacial Lake Dana.
477.00	248.30	On right—wave cut terraces of Glacial Lake Dana.
478.30	249.60	Gravel pit in typical kame.
478.90–480.30	250.20–251.60	Northwest across glacial lake (Iroquois) sand fill of pre-glacial river channel of Genesee River. Surface deposits include kames, kettle holes and eskers. New York State Barge Canal on right.
480.50	251.80	Sand bank in glacial sand fill deposited in Lake Iroquois.
483.30	254.60	Cross Barge Canal in Pittsford. Type locality of black PITTSFORD shale at base of VERNON shale (base of Salina)—famous eurypterid locality.
484.10	255.40	Nazareth College on left.
485.10	256.40	Left on Routes 96, 31 and 33B. East Avenue, leading into City of Rochester.
486.00	257.30	LOCKPORT dolomite in Allen's Creek on left.
489.30	260.60	On right—George Eastman's home—now official residence of President of University of Rochester. Soon to be converted into historical museum of photography.
489.70	261.00	Rochester Museum of Arts and Sciences, on left.
490.50	261.80	**Sheraton Hotel—overnight stop.**

Evening in Rochester

7:00 p.m. The group will be guests of the Bauch & Lomb Optical Company for a buffet supper at the Rochester Museum of Arts and Science. After the supper, the Museum will be open especially for members of this field party. Exhibits of interest have been arranged.

THIRD DAY'S TRIP

Rochester to Niagara Falls and Buffalo

490.50	0.00	**Leave Sheraton Hotel, 7:30 A.M.** Proceed west on Route 21.
490.70	0.20	Cross Main Street East and bear right on Franklin Street (Route 31).
491.10	0.60	Bear right on to St. Paul Street (Route 31).
491.60	1.10	Bausch & Lomb Optical Co. on left, continue on Route 31.
492.10	1.60	On left—Gorge of Genesee River—Rochester shale in valley wall.
492.80	2.30	Turn left on Avenue E (Driving Park Avenue). Hawkeye Plant Eastman Kodak Co.
492.90	2.40	Cross Driving Park Avenue bridge over Genesee Gorge.
493.05	2.55	Turn right into Maplewood Park.
493.15	2.65	**Stop No. 16.**

Park in parking space. Leave buses and view Rochester Gorge section from bridge and from Maplewood Park Section: Queenston shale through Rochester shale.

Talk on local geology by Dr. Harold L. Alling, University of Rochester.

ROCHESTER GORGE

Clinton group—The Clinton varies widely in its extent of outcrop east and west in New York. At Rochester the section contains the following members:

A. **Thorold sandstone,** thickness this locality .... 5′
An essentially barren gray sandstone.


16
MP470.8
MP466.3
MP465.9
EAST BLOOMFIELD
MP456.9
MP455.5
15
MP444.0
MP440.2
14
MP430.9

MILEAGES Total	Trip	

B. **Maplewood shale** .... 20′
A slightly calcareous green platy shale, essentially barren. Local; not continuous with the Neahga shale in a similar position at Niagara.

C. **Reynales limestone** .... 10′
Here contains a basal 3′ light crystalline limestone, the Brewer Dock member, capped by 8″-14″ of Furnaceville iron ore and followed by 6′ of typical Reynales. Several of the layers immediately above the ore are filled with *Pentamerus oblongus.*

D. **Lower Sodus shale** .... 16′
Greenish gray shale with thin limestone layers. Sparse fauna.

E. **Williamson shale** .... 5½′
Gray fissile shale, the lower part with black layers filled with *Monograptus.*

F. **Irondequoit limestone** .... 18′
Lower part shaly, middle massive, upper part with bioherms. In many places a crinoidal limestone. Contains an abundant fauna with many species in common with the Rochester shale above.

G. **Rochester shale** .... 13′ or more
Limey gray shale with intercalated thin limestones. Highly fossiliferous particularly in lower layers. *Spirifer niagarensis, S. radiatus, Calymene niagarense, Trimerus delphinocephalus, Dawsonoceras americanum, Arctinurus boltoni, Camarotoechia neglecta,* and many others.

H. **Decew waterlime**
Formerly classed with the Lockport, the break appears to come at its top rather than the base.

Lockport Dolomite. At Rochester this is a barren dolomite without clear differentiation of members. The formation is mainly barren. In the upper part some fossils are found, on the basis of which a lower Shelby and an upper Shelby horizon were recognized. The Lower Shelby horizon is properly retained in the Lockport, its fauna being Racine; the upper Shelby is probably of Guelph age, though the Guelph cannot here be well distinguished from the Lockport.

After discussion, return to buses in park. Trip continues along Maplewood Avenue.

Total	Trip	
493.60	3.10	Turn right on Seneca Parkway.
494.10	3.60	Turn left on Ridge Road (Route U. S. 104).
494.40	3.90	Cross Lake Avenue—Kodak Park—Eastman Kodak Company on right.
497.10	6.60	Ridge Road—built on offshore bar of Glacial Lake Iroquois.
506.00	15.50	Lake Iroquois lake bed on right.
508.55	18.05	**Rest Stop.** Garland crossroads. 10-minute stop.
509.70	19.20	Outcrop of QUEENSTON shale (red siltstone) at left in creek.
519.20	28.70	Much land developed in lagoon back of Ridge Road bar.
522.65	32.15	QUEENSTON shale in creek at left.
528.60	38.10	QUEENSTON shale outcrop on left.
552.90	62.40	Junction Route 78—follow left on Routes 78 and 104.
553.30	62.80	Turn right on U. S. 104—off 78—over delta materials of outlet Lake Tonowanda—early stage in history of Niagara Falls.
557.40	66.90	Junction Route 93—stay on U. S. 104.
561.40	70.90	Junction Route 425—stay on U. S. 104.
563.70	73.20	Lockport dolomite escarpment rising sharply to south.
567.30	76.80	Outcrop WHIRLPOOL sandstone (White Medina) in field right of road.

MILEAGES Total	Trip	
570.00	79.50	Irondequoit limestone (Clinton) escarpment on left.
571.80	81.30	Cross Route 18—stay on U. S. 104.
572.80	82.30	Leave U. S. 104—continue straight on Route 18 E.
573.30	82.80	Turn left in Lewiston on 18 E.
573.75	83.25	**Stop No .17.**

At water pumping station buses stop and discharge passengers for walk up railroad along east bank Niagara Gorge—section WHIRLPOOL sandstone through LOCKPORT dolomite. Buses turn around and retrace route to Lewiston and proceed to Niagara University.

Gorge of the Niagara River. The falls and gorge of the Niagara, famous for their beauty and valuable for their water energy, are also accepted by geologists as their own especial gift in their example of the might of running water and their exceptional display of the rock sequence.

The Niagara escarpment, where breached by the Niagara River, rises to an altitude of about 620 feet, 225 feet above foot on the Ontario Plain, 375 feet above the waters of Lake Ontario. Powered by the discharge from Lake Erie, the river since withdrawal of the Wisconsin ice has carved its way headward for seven miles. Recent rates of retreat are about 3.8 feet per year, faster than in earlier stages when much water from the upper lakes crossed southern Canada to reach the sea.

Halfway up its present course, the river intersects the moraine-choked gorge of old St. David River. Here is the dog-leg of the Whirlpool.

At the falls, Niagara's waters plunge 160 feet from 517 feet at the fall's brink to 357 feet at the foot; the waters drop another 110 feet on their way to Lewiston, with rapids especially virulent in the mile above the Whirlpool.

Four major rock divisions will be visited in the gorge, and are as follows in descending order:

Middle Silurian

Lockport group

Ermosa dolomite, cherty	15'+
Suspension Bridge dolomite, geodiferous	80'
Gasport limestone, crystalline, crinoidal, clastic structures	5'-6'
Thickness Lockport beds exposed in cliffs	100'

Clinton group

Decew waterlime, siliceous, includes beds with slumped, clastic laminae conspicuous on the weathered surface	10'
Rochester shale, calcareous bands, highly fossiliferous, *Dalmanites limulurus* fauna	44'
Irondequoit limestone, projecting somewhat on the cliffs; crystalline, crinoidal, with lime sands. Bioherms near top. Base disconformable	18'
Reynales limestone, thin-bedded below, phosphate pellets near base	12'
Neagah shale, green	4'
Thorold sandstone, whitish, quartzose	8'
Thickness Clinton group	96'

Lower Silurian

Medina group

Grimsby red sandstone interfingering with Cabot Head red shale: *Lingula cuneata* abundant on some surfaces. Some pelecypods	50'
Manitoulin shale and dolomite; some gastropods	25'
Whirlpool sandstone, white quartz sand. Cross-bedding; ripple marks	25'
Thickness Medina group	100'

Upper Ordovician

Queenston shale, red, uppermost beds exposed in gorge	1,000'-1,100'

The gorge will be entered at its northern end near Lewiston, the group gathering for discussion at quarries in the Whirlpool sandstone, then walking the upper railroad cut of the east wall for a mile and a half, where an easily traversed foot path leads to the highway where the buses will be parked.

The oldest formation of the gorge, the Queenston shale, remains below the level of the trip, but its upper hundred feet are visible in the lower cliffs. The Queenston for many years was included in the Medina, since the Medina at Medina, N. Y., is red Grimsby, the white Whirlpool lacking at its base as at Rochester, so that red Grimsby and red Queenston seem to merge as one formation. Many years ago, however, it was discovered that the Queenston as it traces to Lake Huron develops fossiliferous, calcareous interlayers bearing Richmond fossils. Following the probably prevailing view that the Richmond is Latest Ordovician, the Queenston likewise belongs below the Silurian. The white Whirlpool sandstone of the Medina group is, in its subsurface areas, the White Medina, important as a gas horizon in western New York. The Whirlpool disappears at the crop before reaching Rochester, but extends below ground eastward to Canandaigua Lake. It thickens southwards in deep wells and appears to be continuous with the white, much more tightly cemented Tuscarora quartzitic sandstone of Stops 4 and 8 in Pennsylvania. The Whirlpool sands are rather cleanly washed quartz sands with minor proportions of feldspars and argillaceous materials; some layers contain enough green tourmaline to be apparent to the eye. Cross-bedding is common and there are ripple marks on some surfaces. Cleansing probably was aided by working and reworking where waves and currents were active in shallow waters. The quartz grains have silica overgrowths, but these do not produce the tight cementation of the Tuscarora of central Pennsylvania.

Medina beds above the Whirlpool here represent the intergradation of the continental red Grimsby sandstone facies on the east with marine shales, limestone, and dolomites on the west across the Ontario peninsula. Resting on the Whirlpool is a shaly, sparingly fossiliferous tongue of the Manitoulin dolomite. Above this are red, red and greenish splotched, and some greenish sandstones and some shales, and can be classed as Grimsby red sandstone with tongues of Cabot Head shale. Some bedding surfaces are crowded with shells of *Lingula cuneata,* and there are rare pelecypods. *Arthrophycus* trails are found near the summit. Channel cut and fill structures can be found.

The 8-foot Thorold sandstone, basing the Clinton group, is whitish, finer grained than the Whirlpool beds. Alling reports 6% feldspars, 20% argillaceous materials, the sand grains having little enlargement by silica. *Arthrophycus* trails are rare; *Scolithus* tubes are present. The overlying, 4-foot Neagah shale is greenish, gritty below, platy above. The Reynales limestone, 12 feet thick is siliceous, with phosphate nodules in its lower part. The characteristic Clinton *Coelospira hemispherica,* elsewhere contains ostracodes of the *Zygobolba excavata* zone.

The Reynales limestone is directly overlain by Irondequoit limestone, 18 feet in thickness. The intervening boundary is sharp and is shown by stratigraphic evidence to be a marked disconformity. The *Zygobolba excavata* fauna of the Reynales is represented at the very base of the thousand feet of Rose Hill shale at Allenwood at Stop 11 in Pennsylvania; the Irondequoit contains *Mastigobolbina typus* restricted at Allenwood to less than the uppermost 100 feet of Rose Hill beds. Equivalents of about 900 feet of shale at Allenwood are missing at the Reynales-Irondequoit break at the Niagara River; the missing beds are about 40 feet near Rochester, and reach combined totals of 250 feet farther east toward Clinton, N. Y.

The Irondequoit is thick bedded, resistant, projecting on the cliffs beyond the Reynales. Clastic limestone grains are dominant. Some shaly parts of the limestone are abundantly fossiliferous, containing especially *Whitfieldella intermedia.*

MILEAGES		
Total	Trip	

The Irondequoit contains bioherms or reef structures; a small one at its top is well shown along the course of the trip. Elsewhere they range to 35 feet across, 10 feet in height. The reef masses are made of very finely crystalline limestone, tougher than adjoining rocks. The reefs were primarily built by bryozoa, which built mounds above the surrounding areas off the sea floor. The mounds seemingly were favored feeding grounds; brachiopods, trilobites, some cephalopods flourished in association with them, their shells sometimes abundant on flanks and in pockets of the mounds.

The Rochester shale, next above the Irondequoit, is calcareous and has thin limestone interlayers. It furnishes by far the finest hunting ground for fossils among the strata of the gorge. Bryozoa are profuse and varied. Brachiopods are numerous, including *Eospirifer radiatus* and *niagarensis, Atrypa reticularis, Schuchertella subplana, Strophonella striata.* Trilobites are reasonably common, and include especially *Dalmanites limulurus, Trimerus delphinocephalus, Bumastus ioxus, Arctinurus boltoni.* Ostracodes are represented by horned *Paraechminas,* double-yoke-ribbed *Dizygopleura.*

At top of the Clinton group is ten feet of Decew limestone, formerly included with the Lockport. The Decew is rather fine grained siliceous limestone, the limestone clastic, with strikingly slumped and contorted laminae, that weather in relief. Fossils are rare. The Lockport group has at its base 5 to 6 feet of coarsely crystalline, crinoidal limestone. Laminae of the clastic limestone fragments, many grains probably crinoidal, weather in relief, but are less striking than those of the Decew, and rarely are slumped. Stylobites are conspicuous at some bedding surfaces in the Gasport and other limestones. The overlying Suspension Bridge dolomite limewise is crystalline, is somewhat geodiferous, has few recoverable fossils. The Ermosa cherty dolomite at the top of the bluff is not well exposed near the footpath by which the group will leave the gorge.

The Lockport of the region has three faunal groups. Corals were associated with some bioherms, and on the flanks and pockets of such mounds some brachiopods, pelecypods, and gastropods flourished in considerable abundance. Cephalopods of the Guelph limestone faunas of Ontario penetrated to the western New York areas as a pelagic group.

The Lockport is the reservoir horizon for a gas field near Geneva, New York. The gas was yielded too readily and the field was in production for only three years. Commonly the Lockport yields "black water."

574.15	83.65	**Right** in Lewiston on 18 E.
574.65	84.15	**Right** on U. S. Route 104 (south).
575.45	84.95	Outcrop of Irondequoit on left.
575.55	85.05	Outcrop of Lockport.
575.55	85.05	**Buses wait for party just south of Niagara University campus.**
577.85	87.35	Leave U. S. Route 104 and follow Niagara Falls scenic route.
579.05	88.55	**Right** into Whirlpool State Park entrance.
579.15	88.65	LUNCH STOP. Park in parking lot and unload for lunch and view of Whirlpool and rapids. After lunch—turn right out of park and continue on scenic route (Whirlpool Street).
579.95	89.45	Under Whirlpool Rapids bridge. Follow Whirlpool Street which becomes First Street.
581.25	90.75	**Right** at Junction with U. S. Route 104.
581.55	91.05	**Turn right.**
581.65	91.15	Under new Rainbow Bridge.

MILEAGES Total	Trip	
581.95	91.45	**Right** into American Falls Park and park.
		Short stop for view of Falls.
582.05	91.55	**Left** out of parking lot.
582.15	91.65	**Right** in park along river.
582.75	92.25	**Right** out of park on to Buffalo Avenue.
582.85	92.35	Power Diversion canal and plant.
582.95	92.45	**Bear right** on N. Y. S. Routes 324 and 384.
583.55	93.05	Plant of Carborundum Company of America.
584.05	93.55	Stay on 384. (324 turns right across Grand Island bridge.)
585.65	95.15	**Left** on to 265. Cross railroad tracks.
586.25	95.75	**Left** on to Military Road (still 265).
586.65	96.15	**Right** on Routes 18 and 62.
588.05	97.55	Niagara Falls Airport and Bell Aircraft Corporation Plant. Built on lake bed of glacial Lake Tonowanda.
590.60	100.10	Cross Ward Road (Route 429).
594.80	104.30	Cross Tonowanda Creek.
596.70	106.20	Cross Elliott Creek.
599.80	109.30	Cross Sheridan Drive.
599.90	109.40	Leave Routes 18 and 62, continue straight on Niagara Falls Boulevard.
601.40	110.90	Buffalo City limits—Kenmore Avenue.
601.70	111.20	**Right** on N. Y. S. Route 5. University of Buffalo ahead and to left.
602.30	111.80	**Left** on LaSalle Avenue just east of Delaware, Lackawanna & Western Railroad underpass.
602.70	112.20	**Right** on Range Avenue.
602.75	112.25	**Left** on Shirley Street.
602.80	112.30	**Right** on Park Ridge Street.
603.20	112.70	**Right** on Amhurst to quarry.

Stop No. 18.

Buses discharge passengers at quarry and turn around.

Bennett quarry in northeastern section of Buffalo. The last planned geological stop of the itinerary exposes strata at the Silurian-Devonian junction. The sequence is as follows:

Middle Devonian

Onondaga limestone, black chert abundant. Only lower beds exposed. Total thickness in region .... 150′

(Unconformity)

Upper Silurian

Akron dolomite, crystalline, rich in corals .... 3′

Bertie waterlime. The upper 5 to 10 feet are a natural cement rock. These beds are famous for their fossil eurypterids .... 30′

The first striking feature of this quarry section is absence at the base of the Onondaga of all the Lower Devonian, together with some earliest Middle Devonian and some latest Silurian.

The sections here and in the region of Stop 3 near Schellsburg, Pennsylvania, can be compared with each other as well as with sections in eastern New York, as follows: Dashes indicate absence by unconformity.

		Schellsburg	East-central New York	Buffalo
Middle Devonian	Onondaga	125′ Needmore sh and ls	100′ cherty ls	150′ cherty ls
Middle Devonian	Schoharie	— — — — —	10′-100′ silty sh and ls	— — — — —
Middle Devonian	Esopus	— — — — —	100′-300′ silty sh	— — — — —
Lower Devonian	Oriskany Group	100′ sandstone 120′ siliceous limestone	0′-10′ sandstone — — — — — —	— — — — — — — — — —
Lower Devonian	Helderberg Group	— — — — — — — — — — 40′ Mandata sh 25′ New Scotland ls 10′ Coeymans ls	0′-50′ Port Ewen ls 50′-100′ Becraft is 125′ New Scotland sh 25′ Kalkberg ls 50′ Coeymans ls	— —
Upper Silurian	Keyser	— — — — — 200′ Keyser ls	50′ Manlius ls 0′-25′ Rondout ls 0′-10′ Cobleskill ls	— — — — — — — — — — 3′-5′ Akron dol
Upper Silurian	Pre-Cobleskill	Tonoloway ls	— — — — — —	30′ Bertie waterlime

The totalled thicknesses of rock formations missing at the Onondaga-Akron boundary is thus at least 1,000 feet.

Despite the marked difference in age of the Akron-Onondaga beds, the strata above and below the junction are markedly parallel, as well as nearly flat-lying. The disconformity is however, evidenced by sharpness of the contact plane, small irregularities of the surface, presence of some glauconitic grains and some sand grains in the basal inch or so of the Onondaga beds. It was in this region that Clarke many years ago described the caverns of the Akron and Berite, dissolved during the pre-Onondaga emergence, then filled with quartz sands possibly of Oriskany age that were almost wholly removed from the Akron before the Onondaga was deposited.

The disconformity associated with the Oriskany horizon has significance associated with Oriskany gas in the subsurface areas to the south and southeast.

The same earth movements active in the Buffalo region in Early Devonian times also cause absence of the Oriskany sands in extensive subsurface areas. Elsewhere, emergence may have caused leaching of cements from calcareous Oriskany sands, improving their porosity and permeability and thus their reservoir capacity.

Where disconformable subsurface disappearance of the Oriskany occurs updip, conditions are developed favorable for one type of stratigraphic trap.

Examination of the cherts of the Onondaga gives ready explanation for rapid wear of bits in final stages of drilling to the Oriskany.

The Bertie limestone of the quarry floor is underlain by 400 to 500 feet of Camillus shale in dolomite; where more deeply buried these beds preserve the valuable Upper Silurian salt beds of the region. Red Vernon shale occurs locally at the base of the Camillus, thickening eastwards, as well as southeastwards when it becomes the Bloomsburg beds of Pennsylvania. The Vernon, or where that formation is absent the Camillus, rests on the Lockport dolomite of the Niagara escarpment. Fifteen feet of eurypterid-rich shale at the Lockport-Vernon contact at Pittsford, New York, have been termed Pittsford shale.

603.30 112.80 **Left** on Park Ridge Street.

603.70 113.20 **Left** on Shirley Street.

603.90 113.40 **Left** on LaSalle Avenue

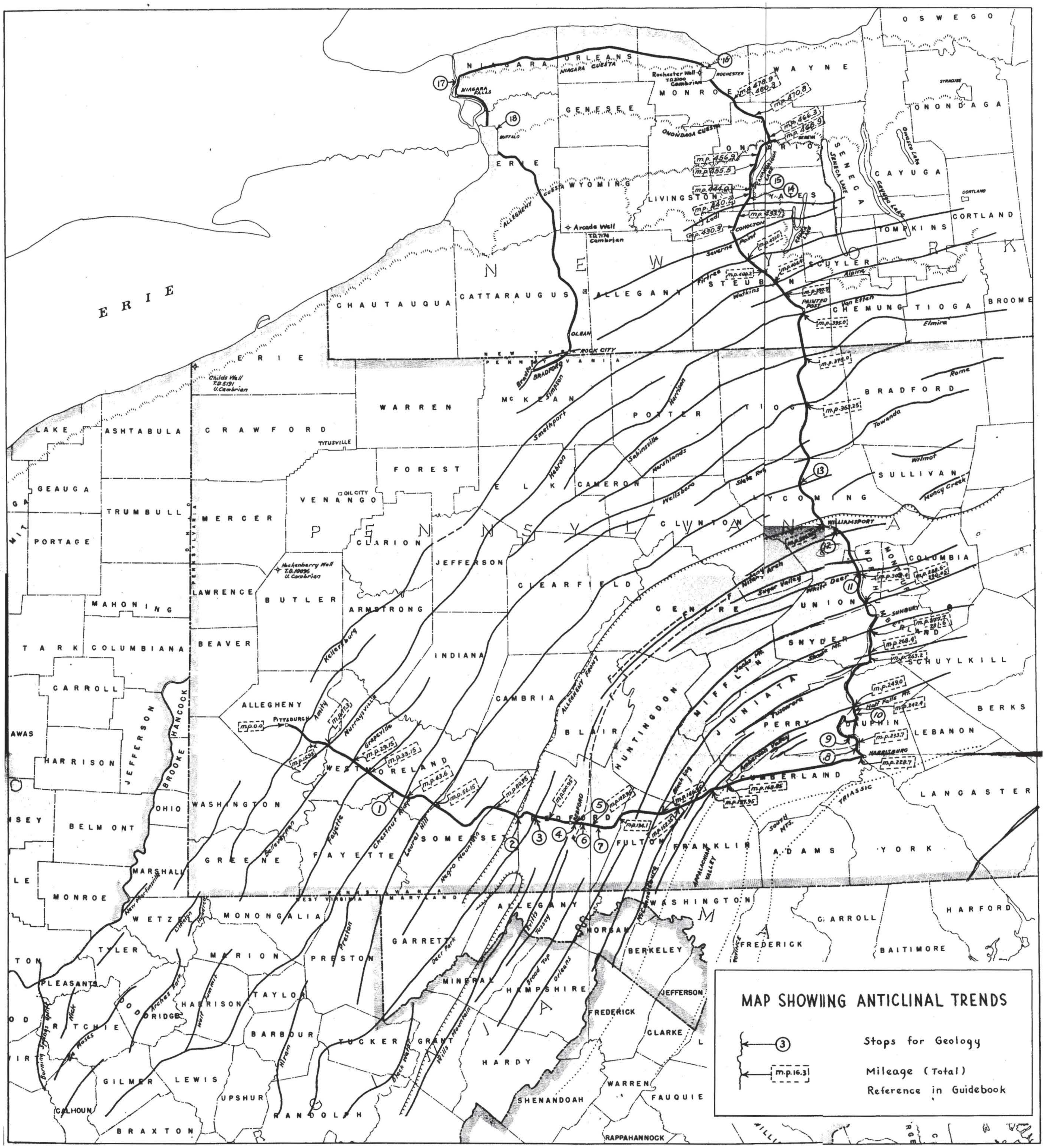
604.20 113.70 **Left** on to Route 5—Main Street.

606.00 115.50 Cross Humboldt Parkway.

608.80 118.30 **Greyhound Bus Terminal. Rest Stop. 15 minutes.**

This is the end of the field trip. At this point the field party will divide into three groups as follows:

1. Those going to Bradford for Secondary Recovery Conference. (Board Bradford-bound buses.)
2. Those returning directly to Pittsburgh. (Board Pittsburgh-bound buses.)
3. Those leaving party to make transportation connections for home destinations.


MAP SHOWIING ANTICLINAL TRENDS
Stops for Geology
Mileage (Total)
Reference in Guidebook
m.p.16.3
ERIE
NIAGARA
ORLEANS
NIAGARA CUESTA
NIAGARA FALLS
BUFFALO
Rochester Well
Cambrian
ROCHESTER
MONROE
WAYNE
OSWEGO
SYRACUSE
ONONDAGA
GENESEE
ONONDAGA CUESTA
ONTARIO
SENECA
SENECA LAKE
CAYUGA
Cayuga Lake
CORTLAND
WYOMING
LIVINGSTON
YATES
ALLEGHENY CUESTA
Arcade Well
Cambrian
TOMPKINS
SCHUYLER
STEUBEN
Watkins
PAINTED POST
Van Etten
CHEMUNG
TIOGA
BROOME
Elmira
CHAUTAUQUA
CATTARAUGUS
ALLEGANY
OLEAN
ROCK CITY
BRADFORD
Childs Well
U. Cambrian
McKEAN
WARREN
POTTER
LAKE
ASHTABULA
CRAWFORD
TITUSVILLE
FOREST
ELK
CAMERON
SULLIVAN
LYCOMING
WILLIAMSPORT
Muncy Creek
Wilmot
Towanda
Rome
GEAUGA
TRUMBULL
MERCER
VENANGO
OIL CITY
CLARION
PORTAGE
JEFFERSON
CLINTON
CLEARFIELD
Hackenberry Well
U. Cambrian
LAWRENCE
BUTLER
ARMSTRONG
MAHONING
CENTRE
Nittany Arch
Sugar Valley
White Deer
UNION
COLUMBIA
NORTHUMBERLAND
SUNBURY
SNYDER
Shade Mt.
SCHUYLKILL
BEAVER
INDIANA
COLUMBIANA
CARROLL
ALLEGHENY
PITTSBURGH
m.p.0.0
Amity
Murraysville
Grapeville
Kellersburg
CAMBRIA
ALLEGHENY FRONT
BLAIR
HUNTINGDON
MIFFLIN
JUNIATA
Jacks Mt.
Tuscarora
PERRY
DAUPHIN
Half Falls Mt.
LEBANON
BERKS
HARRISBURG
CUMBERLAND
LANCASTER
TRIASSIC
HARRISON
JEFFERSON
BROOKE
HANCOCK
WESTMORELAND
WASHINGTON
Chestnut Ridge
Laurel Hill
Negro Mountain
SOMERSET
BEDFORD
FULTON
FRANKLIN
ADAMS
YORK
APPALACHIAN VALLEY
OHIO
BELMONT
GREENE
FAYETTE
Fayette
Belle Vernon
MARSHALL
MONROE
WETZEL
MONONGALIA
Preston
GARRETT
ALLEGANY
Deer Park
WASHINGTON
CARROLL
HARFORD
FREDERICK
BALTIMORE
MORGAN
BERKELEY
JEFFERSON
TYLER
MARION
PRESTON
MINERAL
HAMPSHIRE
Broad Top
Orleans
PLEASANTS
TAYLOR
HARRISON
DODDRIDGE
RITCHIE
BARBOUR
TUCKER
GRANT
HARDY
FREDERICK
CLARKE
Burning Springs
GILMER
LEWIS
UPSHUR
RANDOLPH
Wills Mountain
SHENANDOAH
WARREN
FAUQUIE
CALHOUN
BRAXTON
RAPPAHANNOCK

SECONDARY RECOVERY CONFERENCE

Those attending the Secondary Recovery Conference will board Bradford bound buses in Greyhound Terminal, Buffalo, at conclusion of regular field trip.

Bradford to Buffalo—about 92 miles.

Rocks exposed—Devonian to Pennsylvanian.

LOG OF TRIP

MILEAGE	
0.00	Greyhound Bus Terminal—Main Street, Buffalo, N. Y.
0.90	Turn right on Upper Terrace Street.
1.00	Turn right on Pearl Street.
1.10	Turn right on West Seneca Street (Route 16).
4.30	Cross Buffalo Creek.
7.20	Floor of Glacial Lake Warren.
10.90	Gorge of Cazenovia Creek on right (Wanakah, Tichenor and Moscow of Hamilton group).
11.70	Cross U. S. Route 20.
11.90	Deltas of glacial Lake Warren on right.
12.60	Cross shoreline of glacial Lake Warren.
14.10	Cross shoreline of glacial Lake Whittlesey.
16.40	Kame moraine (Wisconsin).
17.40	Left around traffic circle and into East Aurora.
18.50	Outcrop of Wiscoy shales in East Branch of Cazenovia Creek on right.
29.00	Morainal topography.
31.50	Kame topography.
34.70	Kettle on right.
37.60	Crossing Cattaraugus Creek.
37.90	Yorkshire. About three miles east of here in the Village of Arcade, one of the deepest tests in this part of the state was completed in August, 1946. Total Depth 7,144. The lower portion of the well cuttings are described by Fettke in the August, 1948, A. A. P. G. Bulletin (Vol. 32, No. 8), page 1468. Indications of porosity were found in the Middle and Lower Ordovician Limestones, and Upper Cambrian Sandstones. Outcrops of beds that may correlate with these were seen at stops 5 and 6 of the field trip.
46.10	Machias—Route 16 bears left.
49.60	Kame terrace left side of valley.
50.70	Junction with Route 98—bear right on Route 16.
53.90	98 turns right—continue left on Route 16.
58.70	Kame moraine cut by stream.
66.00	Nearest point to Cuba Oil Spring (about three miles to east).
72.30	Entering Olean.
73.10	Turn left at north end of bridge.
74.00	Turn right on Route 17.
74.50	Turn left on Route 16 A—Center of Olean.

75.00	Cross Allegheny River—Kame of Olean terminal Moraine right on south side of river.
77.80	Bear right on 16 A.
78.40	Outcrop of OSWAYO (Upper Devonian) in road cut.
78.50	OLEAN conglomerate (basal Pennsylvanian). Loose blocks on left.
79.10	Olean conglomerate. Note rod-lines from central pumping powers to oil wells—New York State portion of Bradford Oil Field.
79.60	Entrance to Rock City Park. (If time permits there will be a short stop here. Turn right into park—about ½ mile—to rock ledge).
	This is the type locality for the Olean conglomerate where weathering along joint planes has formed a "rock city." The thickness of the Olean is 64 feet here, and it is predominantly conglomeratic. Cross-bedding is a prominent feature. The pebbles consist mostly of vein quartz and, for the most part, are well rounded. In shape they are ovoid or ellipsoidal.
84.40	Pennsylvania-New York State line. Continue on Route 646.
86.40	Turn right to Derrick City.
89.20	Turn left at Foster Brook. Proceed southward on Route 219 to Bradford.
91.70	**Emery Hotel, Bradford.**

Evening Session

Banquet: 6:30 P.M.—Emery Hotel.

Speaker: Maynard M. Stephens.

Topic: Geological Factors Involved in Secondary Recovery.

Saturday, October 9: Field inspections of Bradford area, and visit to research laboratories.
There will be visits to the research laboratories of the Penn Grade Crude Oil Association, and the laboratories of a commercial core analysis company. In the Penn Grade Laboratories the group will see equipment used in flooding long cores of sandstone and also equipment used in flooding small sections of diamond cores taken from various oil sands. The commercial laboratory specializes in analyzing chip samples, and the methods used in this type of analysis will be described.

Since these laboratories will not accommodate a large group at one time the party will be divided, so that while one group is visiting the labs, the other group will be in the field.

ITINERARY OF BRADFORD FIELD TRIP

Starting point, Hotel Emery.

Proceed east on Main Street five blocks to traffic light at intersection of East Main Street and High Street extension.

Turn right on High Street extension.

At .8 miles, just off to right of road will be seen the United Refining Company's pressure plant (formerly Healy pressure plant).

At approximately this point, to left of road, is an old quarry in which there is exposed about 100′ of CHEMUNG interbedded sands and shales. The total thickness of the Chemung in the Bradford area is about 2,100′. The THIRD BRADFORD OIL SAND occurs at the lower part of the Chemung.

Continue southward on High Street extension, .7 miles, to Rutherford Run where the Drake lease of the Quaker State Oil Refining Corporation, pumping wells, intake wells, and powers can be seen. The Drake Lease has produced, through secondary recovery water-flooding methods and interdrilling, more than 7,000 barrels of oil per acre.

Continue south on High Street extension about .6 miles. A power, rod-lines, and a standard rig can be seen on west side of valley.

Continue south, cross Route 59 on to Helenbrook Road (Route 336), 1.4 miles.
Turn right at Custer City—Helenbrook Road intersection, .3 miles due west to Stop 1.

Stop No. 1.

Minard Run Oil Company Pressure Plant.

Here is a modern secondary recovery pressure plant in operation. The processes may be followed from the water supply wells located on the valley floor, producing water from gravel and drift deposited during the Pleistocene period and presently covered by 50′ to 100′ of mantle. The water treating processes may be followed through the filters to the high pressure pumps, and into the intake wells for repressuring the oil sands.

Retrace route to intersection of Routes 336 and 59. Proceed east on 59 past Penn Hills Club, 5.1 miles. Here pulling poles can be seen standing at most of the oil wells on either side of the road. Properties at this locality now belong to South Penn Oil Company, but in recent past belonged to Hugh Grant of Bradford. The pulling poles are left standing in this locality because the wells are at higher elevations, hence their depths are greater. Many individual electric pumping units may also be seen in this area.

Continue east along Route 59, 1.5 miles to Stop 2.

Stop No 2.

Cyclone Pressure Plant of South Penn Oil Company. Park buses in front of Cyclone station.

This pressure plant is the second largest of its kind in the world. It handles 28,000 barrels of water daily for pressure injection. The largest plant of this type in the world is located at Wolf Run about three miles to the northeast. It also is owned by South Penn. At the Cyclone Plant there are sixteen high pressure pumps, all powered by electric motors. In contrast to this, the Wolf Run Plant handles 30,000 barrels of water daily, and its pumps are driven by gas engines. Water treating systems may also be seen at this stop.

After investigating the pressure plant, the party will walk directly across the highway, about 800 feet, to a large 24′ bandwheel power of the South Penn Oil Company. Here may be seen, not only the bandwheel power, but also the rod-lines, and a complete five spot flood recovery program.

The Cyclone plant and its surroundings rest on top of the peneplain at about the Olean or Knapp formations of Pennsylvanian and Mississippian age. The red shales and interbedded sandstones noted along Route 59 belong to the Cattaraugus (Upper Devonian) formation.

From Stop No. 2 retrace route along highway 59 to Penn Hills Club for lunch.

RETURN ROUTES TO PITTSBURGH

1. Buffalo to Pittsburgh on Friday afternoon.

   Distance: about 220 miles.

   The route follows the shores of Lake Erie (via Route 5 to Silver Creek and Route 20 through Erie, Penna., to Fairview) in the Interior Lowlands (Lake Plains), just off the Allegheny Cuesta. The lake is usually visible to the right, and the escarpment formed by Devonian shales and siltstones nearly parallels the highway on the left. The area from Buffalo to the vicinity of Fredonia is underlain by Middle Devonian strata. Upper Devonian strata underlie the region from Fredonia through Fairview and southward to approximately the Crawford County line. The approach to the Allegheny Plateau will be observed traveling south from Fairview. Rocks of the Mississippian and Pennsylvanian underly the route from the Crawford County line to Pittsburgh. (Route 98 from Fairview to west of Meadville, Route 19 into Pittsburgh.) Coal stripping operations will be observed from the vicinity of Mercer to Pittsburgh. The terminal moraine of the Wisconsin ice sheet is crossed about ten miles east of New Castle. A glance at the Oil and Gas map will show the productive areas along this trip.

2. Bradford to Pittsburgh, Saturday afternoon.

   Distance: about 176 miles.

   Route 219 to Custer City, four miles south of Bradford, Route 59 to Warren, Route 62 to Oil City, and Route 8 to Pittsburgh. Except for Upper Devonian (Catskill facies) in the vicinity of Bradford, Kinzua, and Warren, the routes are underlain by Mississippian and Pennsylvanian rocks. The Music Mountain Oil Pool will be crossed a few miles west of Custer City along Route 59. Scattered oil and gas operations will be observed all along the return route to Pittsburgh. In northwestern Butler County the route passes within a few miles of the Hockenberry well, the deepest cable tool well in the world, total depth 10,096. The heart of the "Middle District" oil and gas fields will be crossed in the vicinity of Oil City and Franklin. Production in this area comes primarily from the Venango (Upper Devonian-Conewango) group of sands. Titusville, the birthplace of the oil industry, is about 15 miles north of Oil City. The route from Warren along the Allegheny River to Tidioute lies at the southwestern edge of glaciation. From Franklin to Slippery Rock (about 16 miles north of Butler) the route nearly parallels the Illinoian terminal moraine. Many coal operations will be observed from the area just north of Butler in to Pittsburgh.

General Characters of the

PALEOZOIC SEDIMENTS

from

Western to Central Pennsylvania and to Western New York*

By FRANK M. SWARTZ **

* By permission of the Pennsylvania State Geologist and the Dean, School of Mineral Industries of the Pennsylvania State College.

** Head, Department of Geology, Pennsylvania State College.

SUMMATION OF PALEOZOIC SEDIMENTS OF THE REGION OF THE TRIP

The Paleozoic sediments of the regions in Pennsylvania and New York crossed by the route of the 1948 field trip, total somewhere in the neighborhood of 25,000 feet in maximum thickness.

At their base in south-central Pennsylvania are several thousand feet of Lower Cambrian sands and clays that during the Appalachian deformation were metamorphosed to low-rank metaquartzites and phyllites. Higher Cambrian sediments, and Lower and Middle Ordovician deposits predominantly are limestones and dolomites. Sands intercalated in the Upper Cambrian of central Pennsylvania came from the north and northwest, and in their subsurface areas give promise for gas and oil. By Middle Ordovician time, lands bordering the eastern margin of the Appalachian region were enlarging and rising, shedding detritus to the Appalachian platform of deposition. Throughout the remainder of the Paleozoic Era, these easterly lands underwent recurrent uplift, each reinvigoration of their erosion reflected by a complex of detritals spreading westward across the Appalachian area. Carbonates accordingly decrease in proportion to clays and sands in the post-Middle Ordovician sediments. Shifting loci of the crustal movements of the easterly land areas probably from time to time brought differing regions into the belts of uplift and erosional attack.

Oftimes, the sedimentary rate of supply was rapid, and even in shallow reaches of the sea the detrital materials were poorly winnowed and graywackyish. During other intervals, clean quartz sands spread widely over the basin floor, the separation of sedimentary fractions probably aided by reworking of sedimentary detritus already partly sorted, by character of weathering in the regions of erosion, as well as by repeated shifting and reshifting of the land-derived debris in broad shallow regions of the sea, where cleansing was vigorous in ratio to influx.

The more significant upwarpings of the source-lands on the east slowed subsidence of nearer parts of the platform of deposition so that sedimentation or in some instances actual uplift raised the surface of accumulation, caused westward retreat of marine waters, and led to westward spreading of continental, poorly washed sands and clays, laid down across wide delta-coasts by sluggish river and lagoonal waters.

The keynote of this Appalachian Paleozoic deposition is flatness of the platform of deposition and wide spreading of the detrital sediments laid upon it. There is marked contrast, for example, with the narrow, rapidly sinking straits that set the scene for the Cretaceous and Tertiary sedimentation of California.

The platform was of course unstable. There was progressive though irregularly discontinuous subsidence that eventually carried the earliest Paleozoic surfaces as much as four to five miles below the level of the sea. Gentle warping ever shifted the details of the paleogeographic patterns. The Adirondack region of northeastern New York especially was a positive area, at least in terms of the earlier Paleozoic sediments that flank it and give some evidence of its history. Some of the large fold axes emphasized by Appalachian folding may have been gently active during Paleozoic sedimentation, but in general the effects are obscure and difficult to detect.

Aquatic plants and animals flourished through long periods and over wide areas of the marine and estuarine waters. The ratios of growth of organic debris, its oxidation and trend toward destruction, its entombment in the accumulating sediments, must have fluctuated widely both from place to place and from time to time. To the extent that the balances were favorable, organic substances became part of the sedimentary accumulations and thus potentially were the raw materials for oil and gas that then required proper reservoirs for preservation for human use.

The Pennsylvanian and Permian sediments of the closing phases of Appalachian Paleozoic sedimentation were laid down over wide regions on surfaces exceptionally adjusted to the curvature of sea level. Slight fluctuating movements, with irregularities of subsidence and sedimentary fill, gave rise to cycles of sedimentation that began with low emergence and shallow fluviatile sculpturing, and then continued successively through alluvial aggradation, the spreading of ill-drained swamps nearly free of detrital influx, and the transgression of clay-depositing shallow estuarine-marine waters, until new shallowing or emergence began a new cycle. The swamp deposits of these cyclothems form the coal layers basic with man's ingenuity for industrialization of the Commonwealth of Pennsylvania.

PERMIAN AND PENNSYLVANIAN

Permian strata virtually are confined in Pennsylvania to a structuarlly deepened basin extending southwest of Pittsburgh. Pennsylvanian strata are preserved below present levels of erosion over a far larger region, the total area of outcrop forming a fourth or more of the surface of the state.

The trip route begins in upper parts of the Pennsylvanian; for the first 90 miles eastward to the Allegheny Front the surface is almost continuously veneered with the 1,400 or 1,500 feet thickness of the Pennsylvanian strata, that rise and fall in gentle anticlinal arches and synclinal troughs. East of the Allegheny Front the trip will skirt the southern margin of the Broad Top coal field, where Pennsylvanian strata are preserved in the deeper, gently flexed axial part of the Broad Top Synclinorium. North of Harrisburg on the second day, synclines deepen eastward from the route to form the major anthracite coal fields of the world. At Blossburg in northern Pennsylvania the trip will give a view of one of the small hilltop outliers of the Pennsylvanian preserved along axes of several synclines.

The older generation of geologists and miners realistically divided the Permian and Pennsylvanian or Coal Measures strata of western Pennsylvania into Upper Barren Measures, Upper Productive Measures, Lower Barren Measures, and Lower Productive Measures, based by the sandstones and conglomeratic sandstones now named Pottsville formation.

The Upper Barren Measures represent the Permian System. They reach thicknesses of 1,100 to 1,200 feet near the southwestern angle of Pennsylvania, where they are termed the Dunkard group or series. The sediments dominantly are shale with some thin interbeds of sandstone and limestones, and include several thin coals of which only one has much commercial value. The lower portion contains more limestone interbeds and is named Washington formation; higher beds are classed as Greene formation.

The Upper Productive Measures, 350 feet thick near Pittsburgh, are now termed Monongahela, and like the next lower Conemaugh and Allegheny were named from rivers that reach confluence in the Pittsburgh region and give rise to the Ohio. The Monongahela, Conemaugh, and Allegheny have been classed as formations since they commonly are mapping units; all are complex, and have variously been ranked as groups or series.

At the top and in the middle parts of the Monongahela are the Waynesburg, Uniontown, Sewickley, and Redstone coals. These are outweighed by the basal Pittsburgh coal, probably continuous in its original extent across at least 12,000 to 15,000 square miles. It is more than 13 feet thick near Pittsburgh, averages 7 feet through 2,000 square miles, and is workable in some 6,000 square miles. It has already yielded nearly 4,000,000,000 tons of coal. It has been said to be the most valuable continuous mineral deposit of the world.

Like the Monongahela, the Allegheny group contains coals of great value, including in descending order Upper and Lower Freeport, Upper, Middle and Lower Kittanning, and Brookville coals. Because of greater areal extent, the Allegheny coals probably total more in value in Pennsylvania than do those of the Monongahela. The Allegheny group is about 250 feet thick in western Pennsylvania. Between the Monongahela and Allegheny, the Conemaugh is 600 to 900 feet, its coals few and thin. Below the Allegheny, the Pottsville west of the Allegheny Front commonly measures about 200 feet; it has persistent upper and lower sandstone members, with the discontinuous, thin Mercer coal associated with the intervening shales.

The coals of The Pennsylvanian System constitute the greatest mineral resource of Pennsylvania. They furnish the major source of energy for transport and industrialization, and their byproducts are invaluable for chemicals and plastics. They draw to the State iron ores from Lake Superior and other regions of the world, and have led to growth of metallurgical and fabricating industries of first magnitude.

Sedimentation of the coal and associated strata of the Pennsylvanian presents features of much geologic interest. The continental surface stretched from Pennsylvania to and beyond Illinois as a platform of remarkable flatness. At times the platform stood high enough so that larger traversing streams sculptured valleys 20, 50, and less commonly 80 or 100 feet in depth, some of them nearly flat-floored for a mile or two in width. Side-walls slumped into deeper channels. With gradual subsidence of the platform, sluggish streams clogged the channels with sands, silts, and clays swept in from hill-lands on the east, and in some degree eventually spread their debris over the flat-surfaced interfluves. Subsequently, perhaps by lateral shifts of the scenes of sedimentation, the influx of silt and clay was lessened, and widespread swamp lands were clothed by spreading growths of ancient, spore-reproducing ferns, giant horse-tails and scale-bark trees. Leaves, spores, branches, and tree-trunks fell into the swamp muck, were protected from complete oxidation, and grew into thick layers of peat that after burial were destined to become our present coals. Beneath the coals are underclays of disputed origin; some of these are fire-clays valuable for fire brick manufacture; some have been investigated as future ores of aluminum.

Upon this continental sequence, incoming seas and their marginal lagoonal-estuarine waters slowly deposited clays; where and when the waters cleared, marine limestones accumulated on the sea floor. The platform then again began to rise and the receding waters left behind them upper clayey and silty muck.

Continued rise carried the continental platform high enough so that it was again sculptured by its streams, which might locally cut to or through the buried, underlying layer of peat. After the interval of platform uplift, the cycle of movement would again revert to the predominant, progressive subsidence, and the scene again was set so that if the balance needed for swamp growth was long and delicately maintained, another sheet of peat would be formed and another bed of potential coal would be created.

The cyclic deposits or cyclothems produced by this combination of astounding flatness of platform, favorable relation to level of the sea, and tectonic fluctuation, were repeatedly spread upon areas stretching from eastern to central states, though the individual lithologic members had lesser geographic persistence. For some combination of reasons, fundamentally tectonic, swamps were most widespread and longest maintained during two stages of still larger rhythms, and the Allegheny and Monongahela productive measures were accumulated.

The coal measures of Pennsylvania reflect the closing stages of Appalachian Paleozoic sedimentation, just as the Late Cretaceous-Early Cenozoic coals of the western states were formed during the end period of the Rocky Mountain trough. Flatness of platform in part at least resulted from the grading effects of long continued sedimentation. Resurgent upward movements that time and again interrupted the progressive though slow subsidence may bear witness to activity of those earth movements that soon were to culminate in strong Appalachian folding; it might more properly be supposed that they reflect early stages of the Appalachian orogeny that were more strongly at work at or beyond the present eastern margin of the Appalachian Highlands.

Although the cyclothems have remarkable geographical extent, lateral changes within them are to be expected as in all sediments. Marine parts of the cyclothems, and limestone members of these marine portions, tend to be better developed toward the west, in the direction from which the marine invasions were derived. Relations to the geography of marine and fresh waters may have effected peat-swamp waters themselves and may be related to some of the variations in pyrite content of the coals. Some eastward coarsening of the clastic sediments can be expected. The sandstone and siltstones have of course intricate variations and patterns of thickness related to the sculpturing of the surface on which they were spread and the intricacies of the streams that deposited them. The upper marine hemicycle likewise is intricately transected by erosion that resulted from the post-cyclothem uplift.

The Pottsville in eastern Pennsylvania reaches thicknesses of 1,200 and 1,300 feet as compared to the 200 feet at the Allegheny Front. Many beds are conglomerates crowded with well worn pebbles of milky quartz and other rocks commonly an inch or so in diameter but ranging to six inches or even more. Neighboring lands on the east were active tectonically, undergoing rapid wear. At other times, however, little sediment reached the eastern Pennsylvania coal-field regions; the mammoth coal seam, 30 to as much as 50 feet and more in the anthracite fields, represents such a period of freedom from influx of clastic detritus.

Superimposed upon all these other geologic features of the Pennsylvanian is a change in character of the coals so that near the Ohio line the fixed-carbon content on the ash-free basis is about 55 to 57 per cent; compositions change progressively eastward so that at the Allegheny Front the fixed carbon has increased to 75 or 80 per cent; in the Broad Top field it is 80 to 85 per cent; in the eastern anthracite fields it rises from 90 per cent at the tip of the "Fish-Tail" north of Harrisburg to 97 per cent and more in some interior parts of the fields. At Blossburg in north-central Pennsylvania it is about 75 per cent.

The overall rise in percentage of fixed carbon toward the east is complicated by various secondary modifications or anomalies of the general pattern.

General geologic opinion has long attributed the overall eastward increase in proportion of fixed carbon to physico-chemical alterations associated with the Appalachian deformation. Attention has also been called to secondary anomalies not immediately explained by relation to the region of deformation. Influence of varying thicknesses of overburden has been emphasized through its influence on building up of temperatures and pressures. One view has held that bacterial activities in the ancient swamps, continuing anaerobically under an accumulating overburden of sediments, has been an important factor affecting coal rank. Character of roof would affect rate of loss of gaseous hydrocarbons, and might modify the physico-chemistry of change of peat to coal. Time is of course a kind of super-factor modifying the work of all of the above conditions and processes.

In the writer's opinion, all of these factors have played their parts in the history of changes of the coals. Differing types of layers within one coal seam, and cannel coals as compared to others, have slight variations in fixed carbon content, that are in part due to differences in type of original vegetable tissues, in part perhaps to differing bacterial action. In general, however, all of the successive coals undergo much the same geographic variations in rank, and it is unlikely that this would be a response to patterns of bacterial activity. Deeper coals in any region tend with minor exceptions, to be slightly higher in rank, and this plausibly reflects some response to the overburden. Many of the secondary geographic variations in rank may likewise have resulted from variations in the overburden; there may have been effects of east-west regional changes in thickness of overburden. After attempting to make allowance for effects of all of those other factors, however, the writer feels that the geography of variation in rank in the Pennsylvanian coals in Pennsylvania and elsewhere in the Appalachians, and likewise the variations in rank of the much younger coals of the Rocky Mountains region, give strong evidence that the regional deformation played a major role in coal modifications. This would not require that stress alone was the important control; indeed the belts of deformation in the Appalachians may be less reflective of distribution of stress than they are of temperature patterns that favored deformation where the basement was weakened through increased warmth.

The problem of cause of change in coal rank has immediate interest to the petroleum geologist in view of the controversies that have continued to rage about the carbon-ratio theory of David White.

MISSISSIPPIAN SYSTEM

The Mississippian rocks of southwestern and central Pennsylvania consist of two major divisions: an upper body of red shale and sandstone, and a lower mass of graywackyish sandstone. The red shale is named Mauch Chunk from a town in eastern Pennsylvania, and the sandstone Pocono from a mountain area of the same general region. Thin sandy Loyalhanna limestone is widespread at the top of the Pocono west of the Allegheny Front in southwestern Pennsylvania, and thin Greenbrier limestone locally interfingers with the Mauch Chunk red beds.

As known in wells near and for some distance to the east of Pittsburgh, the Mauch Chunk red shale varies from zero to about 150 feet in thickness. Where it rises to the surface at the Chestnut Ridge and Laurel Hill anticlines along the course of the trip, it is about 150 feet thick and contains in its lower part thin tongues or lentils of highly fossiliferous, marine Greenbrier limestone, containing brachiopods and other fossils indicative of equivalence to the Maxville limestone of Ohio; the Greenbrier limestone thickens rapidly southwestwards across western Maryland to east-central West Virginia. Continuing eastward in Pennsylvania to the Allegheny Front, the Mauch Chunk red beds are 200 to 300 feet thick, and the Greenbrier limestone facies disappears, possibly replaced in part by greenish sandstones.

Eastward from the Allegheny Front, the Mauch Chunk shales thicken further in the Broad Top synclinorium, and still farther east in Cove Valley north of Harrisburg reach totals of 2,500 or possibly 3,000 and more feet, consisting of repetitions of red shale and weak red sandstone. Thicknesses of several thousands of feet are maintained along much of the margins of the southerly anthracite fields, giving rise to wide-floored valleys between the high ribs made of the Pocono and Pottsville conglomerates. Amphibian tracks have been reported in the Mauch Chunk of these easterly regions.

The Mauch Chunk sediments are deposits of a broad delta-coast region, the climate warm and humid. Much of the material probably was spread directly by sluggish rivers whose active upper waters were eroding hill lands on the east. Parts of the sediment probably spread, still red, into freshened waters of lagoons and estuaries. Shallow seas entering across western Maryland brought with them, when currents maintained normal saltiness, a profusion of brachiopods, together with bryozoa, mollusks, crinoids and blastoides, and rare trilobites.

The Pocono sandstone likewise was formed by a vast supply of detritus worn from easterly lands. Near Harrisburg the formation is about 1,200 to 1,500 feet in thickness, its middle and lower parts dominated by cross-bedded, thick-bedded and resistant conglomerates in which the rounded pebbles consist of milky quartz, some cherts and quartzites, and commonly are an inch or so in diameter. Conglomerates are rarer in the upper parts, where some shale interbeds made their appearance, and the boundary with the overlying Mauch Chunk red shales appears to be transitional. Beneath the Pocono near Harrisburg are several hundred feet of red shaly Catskill sandstones, then the greenish Honesdale sandstones, then the bulk of the Catskill red beds.

In successive ridges north of Harrisburg, the Pocono undergoes marked diminuition in numbers of the pebbles that are so prominent in Second Mountain. Similar diminuition in numbers though not disappearance of pebbly beds occurs westward toward the Allegheny Front; minor pebbly members persist to the Laurel Hill and Chestnut Ridge anticlines.

At the Allegheny Front, the Pocono formation is about 1,000 feet thick. Here the coarser sandstones constitute the upper third or somewhat more of the formation and form the Burgoon sandstone member, in which shale interbeds are few. The lower two-thirds of the Pocono consist of interbedded greenish sandstone and shale, with some purplish to reddish shale interlayers; farther northwest, one of the shale interlayers has been named the Patton member of the Pocono.

Actually, the lower sandstone and shale member is composed of repetitive cyclothems, simpler than those of the Pennsylvanian. Where described by the writer near the Horseshoe Curve, a characteristic cyclothem of the lower or Middle Pocono rests upon an erosion surface, in some instances clearly channelled even in a limited exposure; graywackyish sands were spread irregularly upon the eroded surface, tending to thicken in the channel depressions; the sands were followed by clays or silty clays; emergence was then sufficient to cause shallow erosion features. With renewal of sedimentation, another cyclothem was inaugurated.

Plant fossils are moderately common in many of the sandstone and shale members of these Pocono cyclothems; in the shales some of the preserved plant structures are very delicate and could not have survived other than quiet transport. The shale member of one of the cyclothems near the Horseshoe Curve contains thin-shelled pelecypods and fish plates; this may represent a shale member that farther south contains brachiopods and fossils of other definitely marine creatures.

Red deposits occur in several of the cyclothems. Most characteristically, it is the upper part of the sandstone member and more especially the lower part of the shale member that becomes red-colored.

In the Broad Top region, several thin streaks of coal have been reported in the Pocono. Relations to cyclothems are not known.

Westward from the Allegheny Front, the Pocono sandstones become sparingly calcareous, and marine fossils become more numerous. Pebbly lenses persist as a minor feature of the mass.

It is anomalous that at the Susquehanna north of Harrisburg it is the middle to lower part of the Pocono that is coarsest grained with few interbeds of shale, whereas at the Allegheny Front the upper beds of the formation as now understood form the thick and solid mass classed as Burgoon. It is possible that the main pebbly mass of the Pocono near Harrisburg will prove to be the equivalent of the Burgoon, and it may be that the strata at the Susquehanna now classed as highest Catskill, possibly including the Honesdale, will be found to represent the lower portion of the Pocono of the Allegheny Front. Further studies of the facies problems of these formational boundaries are much needed.

The Pocono relations in the region north of Williamsport where the formation is crossed by our route, are not well understood, and again the problems of correlation with members of the Pocono of the Allegheny Front near Bedford require much further study.

In general it appears that during Pocono time the eastern hill lands were elevated and were being actively carved by swift running streams that transported vast quantities of detritus to broad lowlands. In eastern Pennsylvania a delta coast with associated estuaries, lagoons, and beaches subsided below accumulating gravelly sands. Farther west the pebbles lessened in numbers; but sands and clays were carried onto floors of shallow marine waters. In parts of the region and for a time, at least, the progressive subsidence was recurrently interrupted; repeatedly, elevation with gentle erosion was followed by renewed sedimentation beginning with sands, that were followed by clays spread over the floors of shallow estuarine and lagoonal waters locally varying to more normal marine. Red sediments, that were to dominate the region in Mauch Chunk time, were formed from time to time, increased somewhat in quantity toward the east, and may be represented near Harrisburg by some of the red beds now classed as highest Catskill.

At the top of the Pocono sandstone along and to the west of the Allegheny Front, there is a well defined and widespread calcareous sandstone or sandy limestone termed Loyalhanna limestone. This formation is persistently characterized by strong cross-bedding suggestive of aeolian type. The sand grains are mostly quartz. More calcareous laminae in part are oolitic. Butts believes these strata are traceable southwestwards into the Fredonia-St. Genevive division of the Mississippian. The rock has been quarried extensively for railroad ballast. For subsurface geology, it makes a sharply marked and excellently recognizable horizon. The Loyalhanna appears to be associated with renewal of sedimentary accumulation upon a widespread surface of emergence; the Burgoon sandstone beneath it is believed to trace into the Logan-Black Hand sandstone of Ohio, and if the Loyalhanna is St. Genevive then the Meramec of the Mississippi Valley region is unrepresented in this region.

The Mississippian strata are well known to the well driller of western and southwestern Pennsylvania. The thin red Mauch Chunk shales are a marker at the summit of the persistent Big Injun sand or Burgoon sandstone. Lower beds of the subsurface Pocono include the important Murraysville sand.

The Mississippian sediments change character in northwestern Pennsylvania. There they are limited to a generally marine, early Mississippian sequence of sands and gravels, about 250 feet thick, truncated disconformably by the Pottsville-age sandstones and conglomerates, and include the Shenango sandstone, Meadville shale and sandstone, Berea-Corry sandstone, and Knapp conglomerate.

DEVONIAN SYSTEM

The Devonian strata of Pennsylvania and New York are composed of a great volume of sands and clays that were eroded from hill lands on the east and spread out upon the broad platform of the Appalachian trough, in part on delta-plains of rivers and in part on the floors of shallow estuarine and marine waters.

Eastwards from Pittsburgh to Harrisburg the Devonian sediments increase in thickness, coarseness of texture, and in proportion of continental red clay and sand rocks; toward the north from Harrisburg into western New York as westward from Harrisburg toward Pittsburgh they gradually thin, tend to become more largely marine, and contain increasing proportions of clay versus sand.

Throughout the region, limestones are thin and minor in proportion to the mass. There are, however, three limestone members that are widespread and important in correlation; these are the Tully limestone at the base of the Upper Devonian, the Onondaga limestone at the base of the Middle Devonian, and the Helderberg limestone at the base of the Lower Devonian. Several additional thin limestone layers occur more locally in the offshore phases of the Middle Devonian. Black shales tend to thicken somewhat westwards above the Tully and Onondaga limestones.

In tectonics of the time of deposition, the Devonian sediments of the region principally reflect resurgent uplifts of the Taconic disturbance.

In Early Devonian time, the hill lands of the east were relatively quiescent. Thin Helderberg lime deposits and some clays accumulated in seas that stretched southwestwards from western New York toward western Tennessee. The waters teemed with brachiopods and other marine life, and seem to have been connected with the oceans both to the northeast and southwest. On the southeastern margin of these shallow straits the Harrisburg region was emergent as was the Buffalo area to the northwest. Minor tongues of cleanly washed quartz sands were deposited locally along margins of the trough during Helderberg time, and later during the Oriskanian such sands spread far more widely over the sea floor to form the Oriskany sandstone beds.

Like the Helderberg strata, Oriskany deposits are missing both near Harrisburg and near Buffalo. In the latter area, however, sands of Oriskany type though not of proven strict Oriskany age occur as sandstone dikes in solution cavities of the Late Silurian limestones.

The Lower Devonian Helderberg and Oriskany sediments rarely are as much as 300 feet thick along the course of the trip. The Oriskany sands nevertheless are significant where below ground for their pools of natural gas. In some regions of exposure they are valuable as a source of quartz sand pure enough to use in manufacturing glass. Over wide areas, the Oriskany sands contain considerable proportions of lime both as shells of the locally profuse brachiopods of the *Spirifer arenosus* fauna, and also as cement in interstices between the grains of quartz sand. Where the Oriskany sands are used for glass manufacture, the lime is low in percentage, perhaps in part due to leaching of the modern weathering cycle. In central Pennsylvania, and also probably in the subsurface areas of western and northern Pennsylvania and western New York, there is a surface of disconformity at the top of the Oriskany sands; lime-leaching at the time of post-Oriskany emergence may be significant in origin of porosity in at least some of the Oriskany reservoir areas, and may also have affected the Oriskany where most valuable for glass sand.

The Oriskany deposits are widely overlain by Onondaga sediments that inaugurate the Middle Devonian. In central Pennsylvania the Onondaga beds consist of limy clays and clayey limestones; but northeastward, northward, and westward, the limestones are less argillaceous but contain nodules of dark chert abrasive for drilling tools.

Following Onondaga time, upward surge of the hill-lands to the east led to rapid erosion, so that poorly washed graywackyish sands were carried to the Harrisburg region and there accumulated to form the thousand feet or more of Hamilton-age marine Montebello sandstone; clays swept farther west and north in the shallow marine waters to form the black Marcellus shales and the brachiopod-bearing, gray Hamilton or Manantango shales with some thin, very subordinate limestone members such as the Menteth limestone of the shore of Lake Canandaigua in New York.

Following Hamilton sedimentation, the easterly hill-lands for a time were low; the seas of the Appalachian trough may have deepened somewhat; they at least cleared enough for widespread accumulation of the thin Tully limestone, highly valuable as a marker in subsurface studies. The Tully is characterized by *Hypothyridina venustula* that for a half-century was identified as *Hypothyris cuboides* and considered an intercontinental marker for the base of the Upper Devonian.

Renewed Acadian activity in the easterly lands again strengthened the forces of erosion and transportation, so that sands and clays again flooded westwards into the Appalachian basin. In some parts of northern New Jersey and eastern New York and Pennsylvania, the earliest of the Upper Devonian deposits and indeed at some places the later Middle Devonian as well, consist of continental red beds. At Harrisburg, however, the basal one to two thousand feet of the Upper Devonian consist of rapidly deposited, poorly cleansed, graywackyish marine or estuarine Trimmers Rock sands and some clays, that to the west and north become increasingly argillaceous and form the Naples or "Portage" shales and silty shales with decreasing sandstone interlayers. Black shales interfinger at the base of these deposits. The black shales in part contain a pelecypod fauna with distinctive *Buchiola retrostriata.* In the gray shales brachiopods rarely are abundant, perhaps due to unfavorably low salinity of the waters.

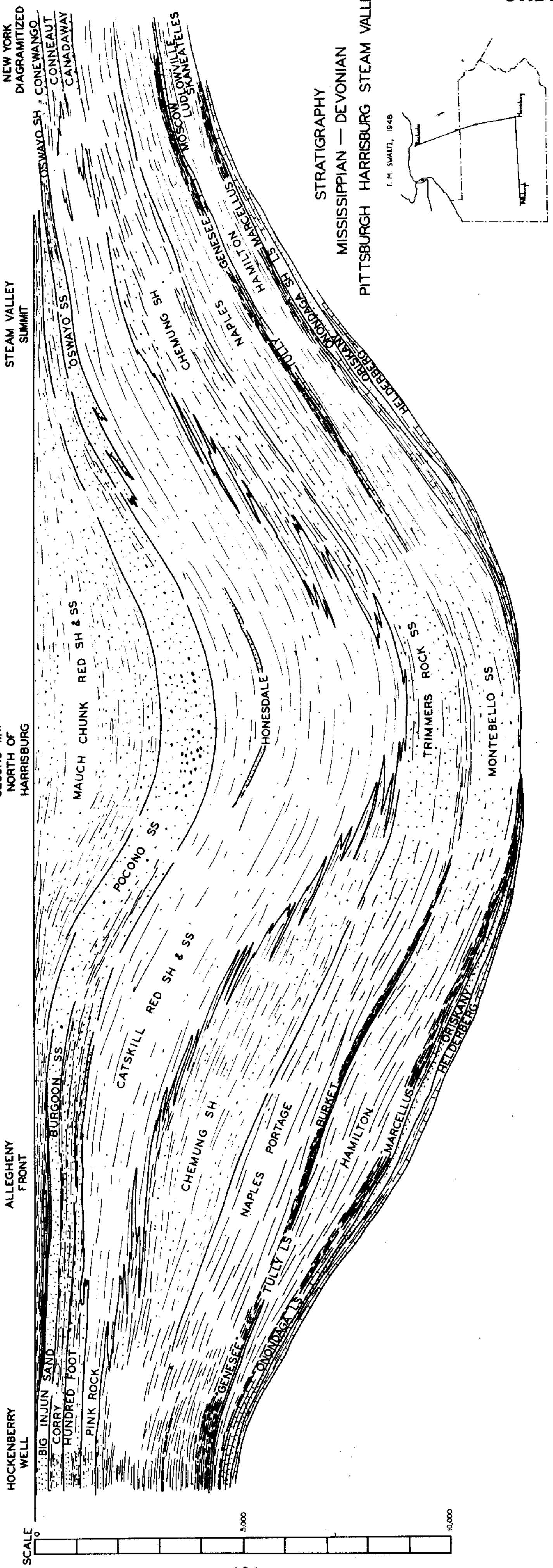
Progression of the Acadian diastrophism caused continued erosion of the hill lands on the east, westward retreat of the seas and westward advance of continental red bed sedimentation. Thus near Harrisburg the earlier Upper Devonian Trimmers Rock sandstone is overlain by 4,000 to 5,000 feet of red sandstone and shales of Catskill facies. Some interbeds near the base contain *Spirifer disjunctus* of the Chemung. High in the Catskill, there are about a hundred feet of hogback-forming gray Honesdale sandstone, thought to belong in the Devonian though relations to the Catskill-Pocono boundary farther west near the Allegheny Front are not well assured. The Catskill red beds consist in general of poorly washed, micaceous and graywackyish sand and clay strata, in which are found rare plates of bony-skinned Devonian fishes. Where the red beds interfinger westward into grayish sediments, they may contain brachiopods and other marine fossils, but such shells are lacking in the main parts of the red mass. The red sediments bear witness to the warm moist climates of their day and region.

Westward from Harrisburg to the Allegheny Front near Bedford, as well as northward to the Allegheny Front near Williamsport, the lower half of the red Catskill beds near Harrisburg grade laterally into grayish shales and sandstones that are characterized by *Spirifer disjunctus* and associated fossil species, and are classed as Chemung shale. The boundary between the Chemung and subjacent Naples is primarily faunal and based on the lowest appearances of *disjunctus* and certain other fossils; the junction of the Chemung and overlying Catskill is drawn where there is the major change from grayish Chemung with *disjunctus* faunas into red shales and sandstones in which marine shells are wanting. The Chemung-Catskill boundary clearly is transitional and is variable in time and stratigraphic level; the Chemung-Naples boundary as drawn may likewise shift somewhat in age. The Chemung-Catskill intergradation is accompanied by marked interfingering of red and grayish sediments, so that over wide areas a third or more of the Chemung deposits contain reddish and purplish interlayers, the purplish facies continuing farther into the marine masses of the rock.

At the Allegheny Front near Bedford, the Chemung beds are about 2,000 to 2,500 feet thick, the overlying Catskill facies having concomitantly thinned to about 2,000 feet from the approximately 4,500 feet near Harrisburg. The mass consists of numerous cyclothemic repetitions of shale with little sandstone and sandstone with little shale, the sandstones forming a fifth to a fourth or so of the mass. The sandstones in general are flaggy, poorly winnowed, graywackyish. Influx of the sediment evidently was relatively rapid. Marine shelly fossils are abundant at many horizons, so that the waters must have been salty and well oxygenated. Faunal changes are not very well marked from level to level, though the lower fourth is distinguished by *Dalmanella tioga.* Slump structures of "storm roller" type occur locally at some levels. There are several thin conglomeratic layers; an upper conglomeratic layer or series of lenses in southcentral Pennsylvania has been termed Saxton conglomerate, and lower lenses have been named Allegrippus sandstone and conglomerate.

Westward from the Allegheny Front there is thinning both of the Catskill red bed facies in proportion to total thickness of the Devonian, and also thinning of the Devonian sediments as a whole. In the Hockenberry well north of Pittsburgh the total thickness of the Devonian is only about 4,000 feet as compared to 7,000 to 8,000 feet in the region from the Allegheny Front to Harrisburg. "Pink rock" beds representing westerly tongues of the Catskill, but perhaps largely marine, are about 400 feet thick. The highest Catskill beds of the Front as well as the lower portions, have changed to non-red marine strata. The highest marine strata contain the Hundred Foot oil-gas sand. The Speechley and Bradford oil sands of western and northern Pennsylvania, and various other lenticular oil-gas sands as well, are believed to occur at stratigraphic levels represented at the Allegheny Front within the Catskill red bed facies.

In regions of outcrop in northwestern Pennsylvania and southwestern New York, marine sediments that replace post-Chemung parts of the Catskill red bed facies are divided into the Conewango, Conneaut, and Canadaway groups, given in descending order. These rock divisions essentially consist of marine shales with sandy interbeds or lenses. It is these rocks that have been the main oil-gas producers of northwestern Pennsylvania and southwestern New York. It may be that they represent a region that in latest Devonian time was discontinuously covered by shallow marine waters. Sands and clays seem to have come principally from the southeast and east, but probably were subject to local reworking that shifted directions of transport. Sedimentation was favorably adjusted to rate of development of organic matter, and waves and currents constructed bar and beach deposits suitable to become reservoirs after proper burial. Subsequent sedimentary loading and tectonic activities shifted but did not disburse the petroliferous accumulations of the sandstone lenses, so that they remained available for human use.


STRATIGRAPHY
MISSISSIPPIAN — DEVONIAN
PITTSBURGH HARRISBURG STEAM VALLEY
F. M. SWARTZ, 1948
HOCKENBERRY WELL
ALLEGHENY FRONT
SECOND MT. NORTH OF HARRISBURG
STEAM VALLEY SUMMIT
SOUTHWESTERN NEW YORK DIAGRAMITIZED
BIG INJUN SAND
CORRY
HUNDRED FOOT
PINK ROCK
BURGOON SS
MAUCH CHUNK RED SH & SS
POCONO SS
CATSKILL RED SH & SS
HONESDALE
CHEMUNG SH
NAPLES
PORTAGE
BURKET
HAMILTON
MARCELLUS
ORISKANY
HELDERBERG
GENESEE
TULLY LS
ONONDAGA LS
TRIMMERS ROCK SS
MONTEBELLO SS
OSWAYO SS
OSWAYO SH
CONEWANGO
CONNEAUT
CANADAWAY
GENESEE
MOSCOW
LUDLOWVILLE
SKANEATELES
HAMILTON
MARCELLUS
TULLY LS
ONONDAGA SH
ORISKANY
HELDERBERG
SCALE
0
5,000
10,000

SILURIAN SYSTEM

The Silurian sediments of Pennsylvania and New York predominantly are formed of sands and clays, largely carried westwards from eroding, easterly hill-lands of Appalachia.

Reflecting tectonic movements and paleogeographic changes, the sediments form two great, subequal complexes. In each complex, the detritals coarsen eastwards; the detritals are coarser in the earlier, lower members, tend to become finer above, and tend to pass upward into carbonates that are better developed towards the west.

In contrast to these similarities, the complexes differ in that the lower, Early-Middle Silurian mass transforms eastwards into grayish sands and gravels, whereas the upper, Late Silurian complex grades eastwards into thickening red clays and sands. Interbedded toward the northwest in the upper complex are commercially important salt deposits that persist westward into the Michigan basin.

At the base of the lower complex in western New York is the important Medina gas sand; at its top in the same area some gas has been produced from the Lockport dolomites, which more commonly yield "black waters" where penetrated in wells.

The lower complex where first encountered along the trip route near Bedford, includes at its base about 500 feet of Tuscarora quartz sandstone, the grains strongly cemented by silica overgrowths. Shaly interlayers form 10 to 15 per cent of the formation. The Tuscarora sandstones represent the Medina group of western New York. Their excellently winnowed character over large regions, the rather low amplitude of cross-bedding in most parts and presence in other parts of wave-rippled laminae paralleling the general bedding, suggest deposition in broad reaches of shallow water. The Tuscarora facies nowhere preserve shelly fossil faunas; it does contain *Arthrophycus* and *Scolithus* worm trails and burrows, and some of the shale interlayers bear eurypterid fragments. The faunas suggest that the shallow Tuscarora seas were relatively freshened, not salty enough to favor the shell-fish that might otherwise have flourished in them.

The Tuscarora sediments are overlain by 600 feet of Clinton clay shales, containing near the top numerous 2- to 4-inch interbeds of limestone, as well as the 10-foot tongue of Keefer sandstone with which are associated thin Clinton iron ores. Above the Clinton strata are 300 feet of McKenzie interbedded shales and limestones. Both Clinton and McKenzie strata abound in marine fossil faunas, principally brachiopods and ostracodes; trilobites are common in the Clinton but not the McKenzie; the minute ostracodes are especially valuable as zonal markers traceable over wide regions.

The upper 40 feet of the Clinton sediments contain numerous fossil species of the Rochester shale of western New York, and are classed as Rochester shale.

Above the McKenzie strata near Bedford are 1,300 to 1,400 feet of Upper Silurian sediments. These begin with about 40 feet of red, calcareous Bloomsburg shales, then 450 feet of calcareous, greenish-weathering Wills Creek shale, the latter overlain in turn by 600 feet of laminated Tonoloway limestone, then by 250 feet of thicker-bedded Keyser limestone that marks the top of the Silurian system.

Among these Late Silurian strata, the Keyser limestone contains shells of a profusion of marine brachiopods, bryozoa, and ostracodes, with some corals and trilobites. Fossils are rarer in the other formations, but ostracodes are found in parts of the Wills Creek and Tonoloway and brachiopods occur in some Tonoloway strata.

Traced eastward toward Harrisburg, profound changes occur in the lithologies and succession of the Silurian strata, and shelly faunas virtually are absent.

At Harrisburg the Tuscarora contains a hundred-foot tongue of graywackyish, in part reddish sandstones and conglomerates, and some other layers are less perfectly winnowed than the typical white Tuscarora sandstone beds. The Clinton strata are half sandstone, half silty shale; most of the Clinton sandstones are purplish, and contain possibly five per cent of iron oxide so that they have long been named "iron sandstones." In some layers, thin sections show blades of hematite enclosed in overgrowths of the quartz sand grains. The McKenzie has disappeared as a distinguishable formation, though its lower part is represented in the highest Clinton beds.

Except for *Arthrophycus* and *Scolithus* worm burrows, no fossils have been recognized in the Tuscarora and Clinton strata where exposed along the Susquehanna River near Marysville, north of Harrisburg, although fossils are profuse in the Clinton and McKenzie within 20 miles to the northwest and several brachiopods and ostracodes have been discovered 25 miles to the northeast. Tuscarora sandstones become increasingly conglomeratic with some dirty, graywackyish layers as they are traced across eastern Pennsylvania along their one narrow belt of outcrop; the Clinton beds become more sandy, but the iron sandstones so abundant near Harrisburg disappear; where the Tuscarora-Clinton strata cross into New Jersey they have as a result of these changes combined to form the Shawangunk conglomerate and sandstone, suggesting the essential paleogeographic-tectonic unity of the Tuscarora-Clinton deposits.

The higher Silurian, Bloomsburg-Wills Creek-Tonoloway-Keyser formations of the Bedford region are represented near Harrisburg only by Bloomsburg red shales and sandstones, thickened to at least 1,000 and possibly 1,200 or 1,300 feet. This change has largely occurred because of geographic variations in composition of the ancient sediments. At intervening localities, red-bed tongues appear in the Wills Creek and basal parts of the Tonoloway, as well as in the upper McKenzie strata below the main western Bloomsburg tongue. Not only the thin Bloomsburg formation near Bedford, but also the higher part of the marine McKenzie shale and limestone, the marine-estuarine Wills Creek shale, and the lower part of the marine Tonoloway limestone have all passed laterally, near Harrisburg, into the thickened, continental red Bloomsburg rocks.

There are good reasons to believe that the Keyser and the higher Tonoloway as well, are absent near Harrisburg by the same disconformity that there causes absence of the overlying Lower Devonian sediments.

The base of the Tuscarora sandstone, or base of the Silurian as here understood, is not marked by conspicuous disconformity near Harrisburg. There is on the other hand a well defined disconformity 165 feet lower in the section, where basal conglomerates of the Juniata rest with sharp contact on the eroded surface of the Ordovician Martinsburg shale. Tectonically, this disconformity might be regarded as the Ordovician-Silurian boundary; but fossiliferous equivalents of the Juniata have been regarded as Late Ordovician in age by the majority of the men working with them.

Northward from Harrisburg along the route to Rochester, the stratigraphic toward-source changes that take place eastwardly from Bedford to Harrisburg are reversed and give witness to recession from the old source-land. The Tuscarora sandstone again is well-winnowed, silica-cemented quartz sandstone or ortho-quartzite; the iron sandstones of the Clinton tongue out and disappear, and at Allenwood the eleven hundred-foot Clinton sequence is mostly shale, with thin interlayers of limestone in the upper 150 feet, and near the top with 40 feet of Keefer sandstone, limestone and thin iron ore. A thin red and greenish sandstone at the base of the Clinton is distinguished as Castanea sandstone. Above the Clinton, the McKenzie formation is again well characterized, and consists of shales with numerous limestone interbeds.

As near Bedford, the Clinton and McKenzie sediments contain profuse fossils shells, the ostracodes especially being distinctive and giving rise to a dozen successive faunal zones. The highest Clinton beds carry fossil faunas of the Rochester shale. The most distinctive McKenzie fossil species are unknown in New York. A few Lockport brachiopods, however, occur in the McKenzie, and near Williamsport are joined by several Lockport corals, so that the McKenzie may well be a facies of Lockport age.

In the Upper Silurian, the continental Bloomsburg red shale and sandstone thins northward, its upper part giving way to Wills Creek-type shales that in part contain ostracodes showing equivalence to Tonoloway limestone of southwesterly sections. Only the higher Tonoloway is represented by limestones. The Keyser limestone reappears with distinctive, profuse marine faunas. Near Allenwood, and farther north near Williamsport, deep weathering of the Wills Creek facies suggests original presence of salt interlayers such as occur in these strata in subsurface areas in northern Pennsylvania and western New York.

Northwards from central Pennsylvania to the Rochester-Niagara Falls region of New York, the Silurian sediments undergo marked, progressive thinning, coupled with increase in proportion of carbonate members. The Lower-Middle Silurian beds thin from 1,800 feet near Allenwood to 350 feet at the Niagara Gorge, where they comprise in ascending order the Medina, Clinton, and Lockport groups. Late Silurian strata similarly are reduced from 1,200 or 1,300 feet to about 450 feet.

The Medina sediments, 100 feet thick at Niagara Falls, lie at the threshold of change from the continental red Grimsby sandstone facies present at Rochester, into the equivalent marine dolomites and greenish shales that increase across the Ontario peninsula to the shores of Lake Huron.

At the base of the Medina at the gorge are 25 feet of Whirlpool white quartz sandstone, characterized by its well-cleansed character, water-laid cross-beds of moderate amplitude, and some wave and current ripple marks. Fossils are rare; a single specimen of *Lingula cuneata* has been reported. Rounded shell-fragments are moderately common among the dark sand grains of the rock. The sands are well winnowed and well sorted, more than 95 per cent composed of quartz. They evidently were shifted back and forth repeatedly in shallow reaches of the sea. The sand grains are somewhat modified by silica overgrowths and the rock can be crumpled to sand without much difficulty, especially as compared to the Early Silurian white Tuscarora sandstone or orthoquartzite that is so resistant a ridge maker in Pennsylvania.

The Whirlpool white sandstone beds crop out for some distance from Niagara Gorge along the foot of the Niagara escarpment, but at the outcrop reach neither to Rochester on the east nor to the shores of Lake Huron on the northwest. It is not now clear to what extent the member lenses out in these directions by the unconformity basing the Medina strata, or whether it instead changes laterally toward Rochester into the lower Grimsby or toward Lake Huron into the basal part of the Manitoulin dolomite.

Downdip toward the south and southeast from Niagara Falls, the white sandstones are widely persistent, and constitute the White Medina sands that furnish most of the natural gas of western New York. The porosity evident in the Whirlpool at its outcrop has been increased by modern weathering, but nevertheless is in accord with the character of the rock as a reservoir horizon.

So far as can now be determined, the white sandstones extend continuously from the Niagara Falls region into northern Pennsylvania, where they progressively thicken and become the White Tuscarora sandstone, 500 feet instead of 25 feet, and tightly cemented by silica overgrowths where it rises to the surface along the flanks of the Nittany Arch near Williamsport. Details of change in age of the limits of the sand as it thickens southward are not thoroughly understood. The Tuscarora and overlying Castanea sandstone contain *Arthrophycus,* which is known only in the higher part of the Medina at Niagara Gorge; but the evidence of these worm burrows should not be overemphasized.

Above the Whirlpool sandstone at Niagara Gorge are about 25 feet of greenish shales, containing in five feet of the upper beds thin interlayers of sandstone and dolomitic limestone, with some additional dolomitic layers at lower levels. The dolomites are sparingly fossiliferous. These shales and dolomite interlayers are believed by Williams and others to represent the eastwardly changing continuation of the biohermal Manitoulin dolomite that is the basal member of the Medinan or Manitoulin Island in Lake Huron. Faunal evidence is scanty and does not permit clear identification with the Manitoulin dolomite as compared to the Cabot Head shale above it.

The fifty feet of Medinan rocks above the shaly "Manitoulin" at Niagara Gorge, are formed of reddish and some green and gray sandstones and sandy shales. Cross-bedding, and shallow channels with channel-fill sandstone lenses, are fairly common. Bedding surfaces of many of the sandstone layers are covered by small pellets. Some bedding surfaces bear numerous shells of the phosphatic brachiopod, *Lingula cuneata;* in many instances the shells predominantly are oriented by action of the ancient sea currents, and may have associated, leeward sand ridges. Some of the sandstones contain a few pelecypods, especially *Modiolopsis primigenius. Arthrophycus alleghaniensis* has been reported near the top.

The reddish strata form a westerly extension of the Grimsby red sandstone facies as developed at the Rochester Gorge. They are in progress of westward change into the Cabot Head shale and perhaps the associated Dyer Bay dolomite and Wingfield shale of the Medina group of Lake Huron. The red Medina rocks at Niagara Gorge probably are best termed Grimsby, since the type Cabot Head shale is mostly green and contains little sand. The Grimsby beds are lithologically suggestive of the Castanea sandstone where it occurs at the base of the Clinton group near Williamsport and Allenwood in central Pennsylvania; the two formations may prove to be mutually continuous.

The Clinton group at Niagara Gorge begins with five to eight feet of whitish Thorold sandstone; the quartz grains are finer than those of the Whirlpool and tend to bear thin clayey coatings. This is the "gray band" of earlier geologists, and formerly was classed as highest Medinan. Fossils are very rare in the Thorold beds.

Above the Thorold "gray band," the Clinton group at Niagara Gorge includes in succession four feet of Neagah shale; 12 feet of Reynales limestone; 18 feet of Irondequoit limestone; 45 feet of Rochester shale; 10 feet of Decew limestone.

The Reynales limestone is fine-grained; fossils are poorly preserved but include *Coelospira hemispherica* and *C. plicatula* of the lower Clinton. The overlying Irondequoit limestone is crystalline, crinoidal, at many places built of lime sands. It is thicker bedded and more resistant than the Reynales, and tends to project beyond it along the gorge wall. Shaly partings yield the best fossils. Conspicuous bioherms, formed especially by bryozoa, occur in the Irondequoit, some of them projecting upwards into the basal Rochester shale.

The Irondequoit limestone has furnished abundant upper Clinton fossils, including some specimens of the ostracode, *Mastigobolgina typus,* which characterizes the uppermost part of the Rose Hill shale of central Pennsylvania. The contact with the underlying Reynales limestone is a disconformity that cuts out middle Clinton strata that are around 150 feet thick in New York east of Rochester, 500 or more feet in thickness at Allenwood in Pennsylvania. The Rochester shale consists of gray calcareous shale with thin limestone interlayers that are more numerous in the upper half. The Rochester strata are the best collecting ground for fossils in the gorge; bryozoa, cystoides and crinoides, brachiopods, trilobites, and ostracodes are abundant. Among distinctive species are *Schuchertella subplana, Stropheodonta striata, Eospirifer radiatus* and *niagarensis, Dalmanites limulurus, Trimerus delphinocephalus, Paraechimina spinosa.*

Above the Rochester shale, the 10-foot Decew limestone is unfossiliferous, thick-bedded, somewhat silty, and questionably is referred to the Clinton rather than to the Lockport group. Weathering brings into relief laminae of clastic carbonate grains, the laminae strangely contorted by slump movements, possibly initiated by wave trenching.

Dolomites of the later Middle Silurian Lockport group cap the Niagara plain near the Niagara escarpment, and provide the resistant strata that crest Niagara Falls. The Lockport beds are 125 to 150 feet thick near the Falls, and consist in ascending order of Gasport limestone, five to ten feet; Suspension Bridge dolomite, 80 feet; cherty Ermosa dolomite, 15 feet; questionable Guelph dolomite beds along the river south of the Falls.

The basal Gasport limestone is thick-bedded, crystalline, crinoidal; much of the rock is a lime sand, with rather regular laminae showing in relief on weathered surfaces. Stylolites are conspicuous along some bedding surfaces. Many of the clastic lime grains are formed of fossil fragments; more complete fossils can be found in some parts of the rock.

The term, Suspension Bridge dolomite, has been applied in a rather general way to the beds between the Gasport limestone and cherty Ermosa dolomite. The rock is gray to brownish, geodiferous, highly dolomitic, its fossils rare and poorly preserved. The geodiferous openings may provide much of the storage space for the "black waters" commonly encountered where the Lockport is penetrated in wells in western New York.

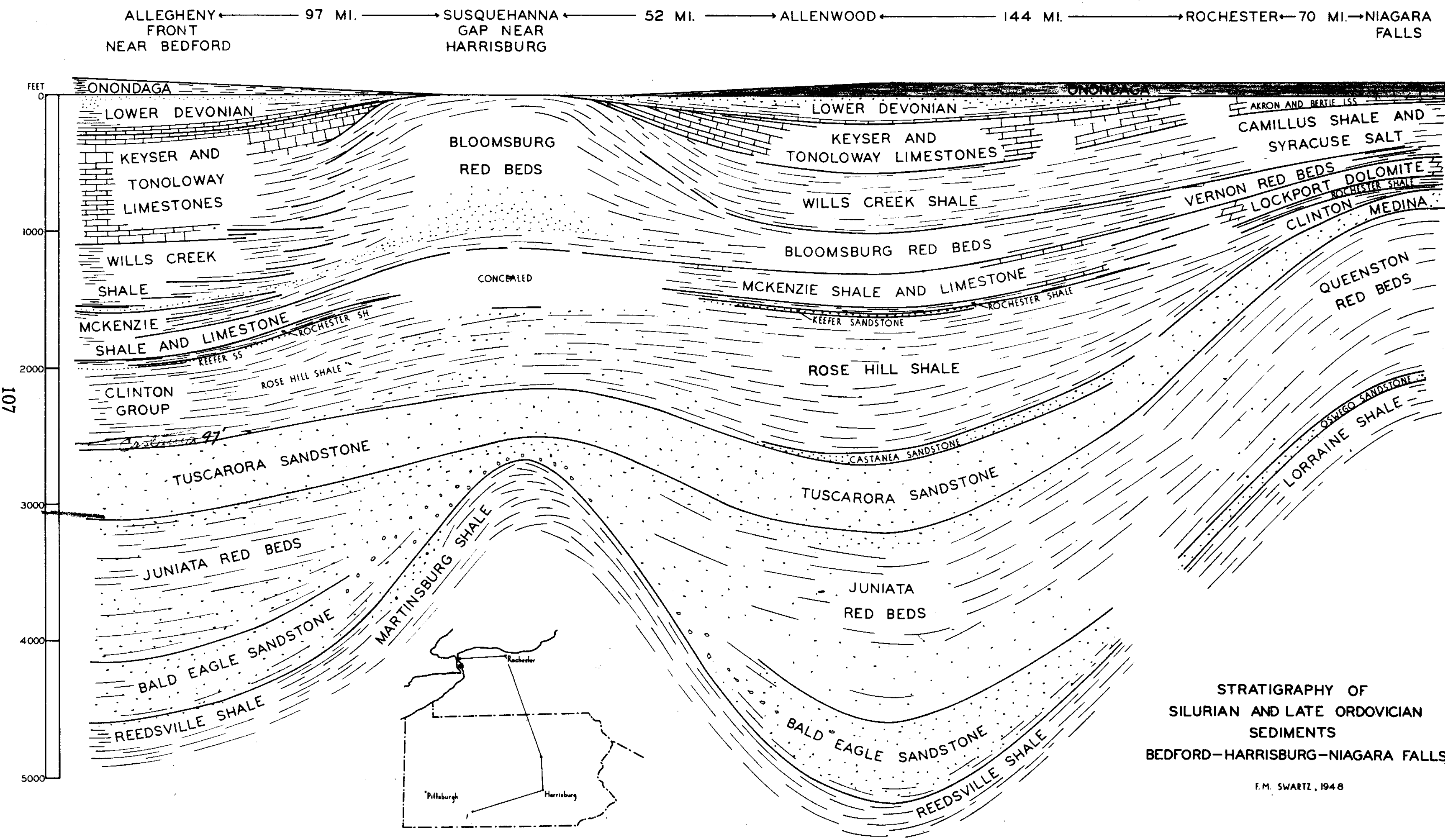
The Lockport dolomites and limestones extend westward from Niagara Falls into Ontario, Ohio, Indiana, and Illinois, and there are joined by limestone and dolomite formations of Clinton and Medina age. These are the strata famous for the large-scale bioherms described by Cummings and Ehlers, in which massive, dolomitic core rocks, that formed mounds rising from the sea floor, are flanked by initially dipping, thin-bedded limestones that grade into the inter-reef sediments. Bioherms are less conspicuous in the Lockport group of New York, but Clarke many years ago speculated about the paleoecologic relations of coral and other reef making organisms, the dwellers of the exposed and more protected parts of the reef surfaces, and the cephalopods and other groups that lived chiefly in the inter-reef areas.

In central Pennsylvania the McKenzie formation may represent the sediments of more clayey, perhaps somewhat brackish extensions of the Lockport seas.

Southwards from Niagara Falls, the Lockport strata dip gently below ground, so that at Buffalo they are overlain by 450 feet of Upper Silurian sediments. The bulk of these higher strata are grayish Camillus shales with interbedded, thin-bedded dolomitic limestones, and interlayers variably rich in gypsum and salt. Reddish tongues from the red Vernon shales that underly the Camillus facies farther east, are inconspicuous and the Vernon probably should not be recognized as a distinct formation in the Buffalo area. The Camillus beds are overlain by 30 to 35 feet of thin-bedded Bertie limestone, extensively quarried in the eastern outskirts of Buffalo where it is famous for its fossil eurypterids. Disconformably above the Bertie are in turn three to five feet of crystalline "Bullhead" or Akron dolomite, fossiliferous, with numerous corals, and correlated with the Cobleskill limestone of central New York, and with early Keyser beds of Pennsylvania.

The Upper Silurian salt beds associated with the Camillus occur extensively across western New York, where the rocks are deep enough to be free of meteoric circulation, and persist southward in the Upper Silurian of Pennsylvania, westward into Michigan. The salt beds are worked extensively, and at Syracuse and elsewhere support large industries. The salt evaporites persistently are associated with the Camillus facies, not with the Upper Silurian Vernon red shale of New York which is an extension of the Bloomsburg red beds of Pennsylvania. The red beds essentially are freshwater sediments; the Camillus facies accumulated in shallow saline waters where from time to time and place to place circulation was impeded and evaporation precipitated some of the dissolved salts.

Middle Devonian Onondaga cherty limestone rests directly on the Akron at Buffalo. The whole Lower Devonian Oriskany-Helderberg sequence is missing here by disconformity, together with equivalents of higher parts of the Late Silurian Keyser limestone of Pennsylvania, and possibly of the early Middle Devonian Esopus shales of eastern New York. Some solution cavities, developed in the Akron and Bertie at the time of their emergence, are filled with sandstone dikes, and sand grains occur in the basal inch or so of the Onondaga at its contact with the Akron. After emergence of the Akron-Bertie and the leaching of their solution cavities, sands were moved across their surface and sifted into the openings, most of the sand being then removed before the Onondaga sediments were laid down. Whether the sands are truly Oriskany in age, or whether they entered the region at a slightly later or earlier time, remains uncertain.



STRATIGRAPHY OF
SILURIAN AND LATE ORDOVICIAN
SEDIMENTS
BEDFORD–HARRISBURG–NIAGARA FALLS

F.M. SWARTZ, 1948

STRATIGRAPHIC CHART 2

ORDOVICIAN SYSTEM

The Ordovician sediments of Pennsylvania and New York reach their maximum thickness of about one and a half miles in central Pennsylvania, and are at least a half mile in thickness through most other parts of the two states. The Lower Ordovician strata consist predominantly of limestones and dolomites over most of the region, as does the earlier part of the Middle Ordovician. Beginning by Middle Ordovician time, however, Taconic activities were elevating easterly land areas so that great volumes of clay and attendant silts and sands spread farther and farther west over the sea floor, until they blanketed virtually the entire region. During the Late Ordovician, the Ordovician seas retreated westwards. In eastern Pennsylvania and easternmost New York, the Taconic movements culminated with folding and faulting; the disturbed region emerged and was planed by erosion. Several hundred feet of non-fossiliferous gravels and sands in central Pennsylvania reflect a stage during which the easterly lands were high, and the westwardly moving streams especially active. The gravel-rich beds were buried beneath as much as 1,500 feet of Latest Ordovician red beds, mostly sands below and giving place to silts and clays above; the sediments choked the delta-fluviatile plains and perhaps the freshened estuaries of a warm and humid region, and were supplied so rapidly in proportion to the rate of subsidence that marine waters were not able to invade the region. The red beds and the deposits at their base become finer textured toward the west, and grade laterally into fossiliferous marine sediments of Ohio and southwestern Ontario. In eastcentral Pennsylvania, on the other hand they transgress upon the surface of erosion produced by the Taconic movements, so that their thin, gravelly wedge-edge can be seen near Harrisburg.

Turning to the more factual characters of the Ordovician sediments of the area, the Lower Ordovician or Canadian strata reach their reported maximum of 4,000 feet in Nittany Valley near State College in central Pennsylvania, and there are about three-quarters dolomite, with 500-foot bodies of limestone at the base and near the middle of the mass. Where visited at Stop 5 in Friend's Cove east of Bedford, Pennsylvania, the Beekmantown group is probably 2,000 to 2,500 feet thick, mostly dolomite. The upper beds have the dense, dove-weathering character of the Bellefonte dolomite division of the Beekmantown of Nittany Valley, where as lower beds in part at least have the darker color and somewhat coarser texture of the Nittany dolomite. If the test wells on the Schellsburg dome west of Bedford are dry at higher levels, they probably will continue downward through the Beekmantown group, with possibilities of fracture-porosities in the Bellefonte and of vug-porosity in the Nittany.

Eastward from Friend's Cove, the Beekmantown is about 2,000 feet thick where exposed along the Great Valley from Chambersburg to Harrisburg and eastwards toward New Jersey. Limestone tends to predominate over dolomite, instead of being subordinate as in Nittany Valley and Friend's Cove. Edgewise conglomerates are common in the lower limestones as in Nittany Valley, and are also present in higher beds. A few thin, very minor arenaceous zones suggest gentle tectonic movements.

The most southeasterly, definitely identified Beekmantown strata of Pennsylvania are argillaceous, moderately metamorphosed limestones, and more argillaceous Beekmantown sediments may be incorporated in the Wissahickon schists of disputed age. Beekmantown graptolites have been identified from some shales near Harrisburg that present a perplexing paleogeographic and structural problem.

In New York, the Beekmantown horizon is exposed only in the Hudson Valley and flanks of the Adirondacks. Beekmantown sediments are absent apparently by non-deposition along the western margin of the Adirondacks, but lap upon the southern margin as a thin sandy, dolomitic limestone wedge-edge from the thicker Beekmantown toward Pennsylvania to the south. Beekmantown sediments extend along the Hudson Valley and eastern flank of the Adirondacks as the limestones and dolomites deposited along the Beekmantown seaway east of the Adirondack dome; except that near Albany shales deposited farther to the east have been overthrust upon the autochthonous strata.

In subsurface areas, Beekmantown limestones and dolomites extend westward, northwestward, and northward from their areas of thick development in central Pennsylvania. To the west, in the Hockenberry well north of Pittsburgh about 200 feet of dolomite have been assigned to the Beekmantown by Fettke. To the north, the Beekmantown may be represented by 50 to 100 feet of silty dolomite in wells at Arcade and Rochester. In western, northwestern, and northern Pennsylvania there are thus at depth considerable thicknesses of Beekmantown limestones and dolomites, thinning out from their area of maximum thickness in central Pennsylvania, and extending as a thinning wedge up the regional dip into southern New York. These sediments may in some yet unknown areas have favorable reservoir porosities derived from fractures and vug-cavities; their up-dip thinning in part at least must involve unconformities with which solution porosities may be associated.

The Middle Ordovician sediments are represented in Nittany Valley, central Pennsylvania, by about 1,000 feet of limestone plus several hundred feet of the overlying 1,100 feet of Reedsville shale. The limestone sequence includes in ascending order Chazyan, Black River or Bolarian, and Trenton deposits; the Black River beds include several high quality chemical limestone beds, including near Bellefonte a member that is worked in deep mines where the produced rock analyzes around 98 per cent calcium carbonate. The Trenton limestone is impure; many layers are dark, dense-textured though others are gray, crystalline, fossiliferous; shale interlayers appear on the higher part of the formation.

Well defined regional unconformities bound several members of the Middle Ordovician limestones.

Traced from central Pennsylvania to the Harrisburg region, the greater part of the Trenton limestone passes laterally into shales, that unite with the continuation of the overlying Reedsville shale to form the thick Martinsburg shale formation, sandy in its upper part. Chazy and Black River beds persist as limestones in the Harrisburg region, and are somewhat thicker than in Nittany Valley. East of Harrisburg these strata, and some thin limestones of early Trenton age, provide certain pure lentils workable for chemical lime, and other argillaceous limestones used for cement manufacture.

In New York, the Middle Ordovician like the lower portion crops out along the flanks of the Adirondacks and in the Hudson Valley. The type Black River limestone occurs along the western margin, the type Trenton a little farther south where its major portion originally was termed the "Blue Foetid limestone of Trenton Falls." For a considerable distance at the outcrop the Black River sediments rest directly on the eroded surface of a Pre-Cambrian granite-gneiss complex, with all the earlier Paleozoic sediments absent by unconformity. Minor unconformities occur within the limestone sequence.

The Black River-Trenton limestones are about 500 to 600 feet thick along the western flank of the Adirondacks, and with them several hundred feet of the overlying shales are Middle Ordovician in age. The shales immediately upon the limestones are very fine textured, black, "Utica" in facies, and pass upwards into gray shales.

Traced southeastwards along the flanks of the Adirondacks, the Black River-Trenton sediments first thin somewhat, then thicken, with much of the Trenton limestone first becoming shaly, then being transformed to black shale, the black shale in turn grading eastward into grayish shales that tend to become silty and then somewhat sandy. Traced to the eastern margin of the Adirondacks, there are still a few feet of early Trenton limestone; Black River sediments are generally absent; the Chazy group missing along the western and southern margins, is represented by about 900 feet of limestone. Near Albany, Normanskill shale of Chazy-Black River age has been thrust westward from their more easterly locale of original deposition.

In their subsurface regions in western and northern Pennsylvania and western New York, there are relatively minor changes in the overall characters of the Middle Ordovician sediments as compared to their equivalents along the outcrop belts in Nittany Valley in central Pennsylvania and along the western margin of the Adirondacks. So far as known, Middle Ordovician limestones are persistent with thicknesses of 500 to 1,000 feet. They are overlain by fine-textured dark shales, the boundary between the Middle and Upper Ordovician as currently defined being obscure.

East of a line extending from the southwestern Adirondacks into eastcentral Pennsylvania much of the Trenton limestone probably grades laterally into shales.

It is improbable that any significant sandstones are interbedded in the subsurface portions of the Middle Ordovician shales in New York and Pennsylvania west of the Catskill and Pocono Mountain regions.

Sandstones at the bottom of the Childs well in northwesternmost Pennsylvania were at one time tentatively correlated with the Chazyan St. Peter sandstone of the northern Mississippi Valley region. More recently it has been thought that the sandy beds in the Childs well are Upper Cambrian.

Trenton limestones have been a source of gas for many years in westcentral New York as well as in Ohio and Indiana. In the latter area, the occurrences are according to some geologists thought to be related to areas of dolomitization, though others have thought that the reservoirs primarily are associated with surfaces of unconformity. In New York, shale breaks commonly act as caps to gas occurrences in the limestone, and additional quantities of gas are obtained by deepening wells to cut through the successive shale layers. Some reservoirs have been explained as representing dolomitized shelly masses in the limestone.

Through the subsurface areas in general in western and northern Pennsylvania and western New York, it is unlikely that extensive dolomitized lenses will be found in the Middle Ordovician limestones. Shale breaks that may trap gas in any available openings of the subjacent limestones can be expected, even though the boundary between the limestones and overlying shales probably undergoes some regional changes in age. The dark dense limestones of the Trenton of central Pennsylvania like the "Blue Foetid limestones of Trenton Falls," appear to have accumulated under conditions that did not favor as extensive a degree of oxidation and destruction of organic matter as may have occurred in the sedimentation of some other limestones. Judging from conditions both in central Pennsylvania and along the western Adirondack margin, the Middle Ordovician limestones of the subsurface areas farther west probably are interrupted by several surfaces of unconformity, and these may at places be associated with solution phenomena favorable for potential reservoir porosities.

The base of the Upper Ordovician of North America commonly is drawn at horizons correlated with the base of the Eden shale of the Cincinnatian of Ohio. This horizon is represented in Pennsylvania and New York within the body of grayish shale that overlies Trenton limestones in the westerly two-thirds or so of the two states, and so has little objective meaning within the area.

In Friend's Cove near Bedford, Pennsylvania, where the Middle and Upper Ordovician sediments are first encountered along the route of the trip, and elsewhere along the Nittany Arch upon which the Cove is located, the Middle-Upper Ordovician boundary occurs near the middle of the 1,100-foot Reedsville shale. The higher, Upper Ordovician portion of the Reedsville consists of brownish-weathering clay shales, with thin calcareous silty and finely arenaceous and some limestone interlayers appearing near the top.

Fossils are common at many horizons, and include strophomenid and other brachiopods, bryozoa, crinoid fragments, some trilobites. In the uppermost 50 feet of the Reedsville are calcareous siltstones and some shale and sandstone, characterized by the stout, coarse-ribbed brachiopod, *Orthorhyncula stevensoni,* lingulas, gastropods and pelecypods, with few of the strophomenids and bryozoa of the subjacent strata. The *Orthorhyncula* fauna persistently in central Pennsylvania marks the latest fossiliferous marine sediments of the Ordovician; to some degree it is a facies fauna, and yet it continues eastwards into medium to thick-bedded graywackyish sandstones, and appears from all evidence so far available to persistently mark a horizon of relatively constant age. The fauna is found southwards from Pennsylvania along the Ridge and Valley region of the Virginias. The *Orthorhyncula* in the past has been widely identified with *Orthorhyncula linneyi* of Fairview beds of the Maysville group of Ohio but this identification is not satisfactory.

The Reedsville shale as a whole gives witness to the Taconic tectonic activities that were raising easterly lands so that their clays spread farther and farther westwards across the Appalachian platform. Progress of these crustal activites is further evidenced along the Nittany arch by the increase of silt and sand in the upper Reedsville, and then by the influx of Bald Eagle or Oswego sands that blanketed the Reedsville along the Friend's Cove-Nittany Valley region.

In its crops along the Nittany Arch the Bald Eagle deposits commonly are 600 to 700 feet thick, consist of graywackyish sandstone, and subdivide into lower sandstone with shale interbeds, middle resistant sandstones that crest subsidiary hogbacks of the double, Tuscarora-Bald Eagle ridges, and upper weak graywackyish sands. Eastward from the more northerly part of the Nittany Arch, the middle, resistant member becomes conglomeratic and transforms into the Lost Run conglomerate, which attains thicknesses of more than 350 feet, and contains a profusion of pebbles, commonly ranging to two and three inches and consisting of milky quartz, quartz-veined vitreous metaquartzites, whitish cherts, reddish jaspers, and some quartz veined, chloritic metaquartzites. These pebbles derived from parent rocks of the easterly, eroding source lands must not be confused with the 2- to 6-inch shale chips that tend to be common throughout the extent of the Bald Eagle sediments and that evidently were formed by fragmentation of clay layers deposited on the platform of Bald Eagle sedimentation.

The Bald Eagle-Lost Run sandstones and conglomerates are overlain in the region of the Nittany Arch by 1,000 to 1,500 feet of Juniata red sediments, sandy below, silty above, with the thin, more quartzitic red Run Gap member at the very summit. The silty member passes eastward into sandstones.

The Bald Eagle-Lost Run sediments present a peculiar color pattern in the Nittany Arch region. Commonly they are grayish beds, and tend to be so distinguished from the overlying Juniata red beds. Toward the east and northeast, the Lost Run conglomerates tend largely to become red and Juniata-like, a change not unexpected in the nearer-source portion of these sediments. A special change takes place, however, in Friend's Cove in the southern part of the Nittany Arch. Here the Bald Eagle deposits consist of 500 to 600 feet of gray graywacke at Aliquippa Gap on the eastern flank of the Cove; but five miles to the west at Bedford Gap on the west flank of the Cove the Bald Eagle sediments contain numerous red tongues that form nearly 50 per cent of the rock so that the Bald Eagle is a hybrid of Bald Eagle and Juniata facies. Still farther southwest in Wills Mountain the green tongues of Bald Eagle facies virtually have disappeared. The paleogeographic causes of this southwesterly change of gray beds to red beds are not yet well understood.

Marked changes in the Upper Ordovician sediments occur from the Nittany Arch to Susquehanna Gap north of Harrisburg that will be visited at Stop No. 8. The Juniata-Bald Eagle sediments that are about 1,600 feet thick at Friend's Cove and 2,200 feet farther northeast near Lewistown and Mifflintown, have here thinned down to 165 feet and rest disconformably upon the eroded surface of Martinsburg shale beds that correspond to middle if not earlier parts of the Reedsville shale. The lower half of the 165 feet consists of coarse puddingstone conglomerates, 2- and 3-inch pebbles numerous, some reaching six inches and more. The basal 30 feet of the conglomerates are gray; most of the higher beds are red. Half or more of the pebbles are chlorite-splotched quartz; but other rock types are numerous, and include vitreous, quartz-veined metaquartzites; many pebbles of quartz-veined chloritic metaquartzites or meta-argillites; gray and red jaspers, dark slaty-appearing highly siliceous rocks.

The 165 feet of red and grayish conglomeratic sandstones and conglomerates at Susquehanna Gap represent the thinned wedge-edge of Bald Eagle-Lost Run-Juniata sediments that are about 2,200 feet thick near Mifflinsburg and Lewistown 30 to 50 miles toward the northwest, and that rapidly disappear along their belt of outcrop east of the Susquehanna River. They are transgressive upon the eroded surface of the Martinsburg shale and hence are younger than the main emergence caused by the Taconic crustal movements. In view of these transgressive relationships, and lack of well marked evidence of disconformity within and at the top of the Juniata deposits, it appears likely that the 165-foot wedge-remnant at Susquehanna Gap represents the eastwardly coarsened later rather than earlier portion of the Bald Eagle-Lost Run-Juniata sediments of the Mifflintown-Lewistown-Nittany Arch region.

Northward in western New York, the Bald Eagle-Lost Run-Juniata deposits are represented by the Queenston red shale, about 1,100 feet thick where named from Queenston at the north end of Niagara Gorge, and the subjacent, graywackyish Oswego sandstone, possibly 150 feet thick near Oswego on the shores of Lake Ontario east of Rochester. All evidence supports the conclusion that the Queenston is, without much change in limits, the northerly, less sandy extension of the Juniata red beds of central Pennsylvania. The Oswego sandstone is comparable in facies to the Bald Eagle sandstone and lies at essentially the same stratigraphic horizon; it is thinner than the type Bald Eagle and does not certainly fall within the actual time limits of that formation; it is not itself fossiliferous and is not underlain by beds carrying the *Orthorhyncula* fauna that is so helpful in Pennsylvania. The areal, surface geologist thus is attracted by use in their respective areas of the terms Bald Eagle and Oswego; the subsurface geologist who almost certainly will find the gray sandstones continuous below-surface probably will throughout these sediments prefer the name, Oswego sandstone, that has precedence in time.

No shelly fossils have ever been discovered in the Juniata-Queenston red bed sediments of Pennsylvania and New York, nor in the Bald Eagle sandstone and Lost Run conglomerate of Pennsylvania; fossiliferous sandstones and shales have been incorporated in the lower part of the Oswego sandstone in New York but do not show at the surface at Oswego. In general, the Juniata-Queenston-Bald Eagle-Lost Run-Oswego are continental and may in part be alluvial, in part the sediments of shallow sheets of water too freshened for the shelly faunas of the age. Westward from Niagara Falls in southwestern Quebec, however, the Queenston red beds develop grayish bands with fossils of the marine Richmond group, and Richmond fossils likewise appear in tongues within Juniata sediments of southwestern Virginia.

In the subsurface regions of western and northern Pennsylvania and western New York, the Oswego can be expected through wide areas even though it has given way to shales and so is absent in deep wells that have penetrated its horizon near Lake Erie and toward Ohio. Lying at the summit of the thick marine shales of general Reedsville age, it should if porosities are favorable have promise as a potential reservoir horizon for oil or gas.

CAMBRIAN SYSTEM

Crops of Cambrian sediments will be crossed along the trip route only in Friends Cove in the vicinity of Stop No. 6 although if the day is clear glimpses may be had from the Great Valley before reaching Harrisburg of South Mountains ridges crested by Lower Cambrian quartzites.

The Cambrian sediments surfacing in Friends Cove are Upper Cambrian in age and are as follows in descending order:

	Feet
Mines dolomite with nodular layers of siliceous oolite	250-300
Gatesburg dolomite with interlayers of dolomitic quartz sandstone; Ore Hill limestone 50-100 feet thick near middle	1,600
Warrior limestone	1,200

The Mines dolomite is overlain by Lower Ordovician Beekmantown strata. In Morrison Cove north of Friends Cove, the Warrior limestone is underlain by Middle Cambrian Pleasant Hill limestone, 600 feet; below this the oldest strata exposed in the two coves are 200 feet of Waynesboro shales and sandstone containing the Lower Cambrian *Olenellus* fauna.

The Gatesburg dolomite crops out extensively in Friends Cove, and with weathering of its carbonates mantles the surface with sandy soil, so that at first sight it appears that the bulk of the formation is sandstone. Actually the sandstones form only 10 to 15 per cent of the mass of the formation, and are interbedded in cyclical fashion with dolomite layers, that include some cryptozoon beds; there are several thin limestones in addition to the Ore Hill limestone member. The Mines dolomite above the Gatesburg contains little sand, and much oolitic chert that is rare in the Gatesburg. The Warrior limestone below the Gatesburg includes dark, medium textured, in part oolitic limestones bearing diagnostic Upper Cambrian trilobites. Thin cryptozoon reef beds and argillaceous limestones also are present.

The Gatesburg sandy dolomites of central Pennsylvania are lithologically comparable to the Upper Cambrian Theresa sandy dolomites of the northwestern and southern margins of the Adirondacks, and apparently are essentially continuous with the Theresa and Potsdam sediments of those regions. Sandy Gatesburg-Theresa-Potsdam sediments are represented at the bottom of the Hockenberry well north of Pittsburgh; the bottom of the Childs well in northwesternmost Pennsylvania; the Wilson well at Arcade in Wyoming County, New York. In the Wilson well about 950 feet of dolomites, sandy dolomites, and sandstones have been classed as Upper Cambrian Little Falls, Theresa, and Potsdam formations by Fettke; the rocks upon which they rest unknown. In a well 50 miles farther northwest at Rochester, however, there reportedly are not more than a few feet of Upper Cambrian sediments resting directly on the Pre-Cambrian complex. The reported Pre-Cambrian materials penetrated in the bottom three feet of the well, are said to consist of powdered quartz and quartzite, so that their Pre-Cambrian age is not wholly assured.

So far as can be judged from the data now available, sandy dolomites of Gatesburg type can be expected throughout subsurface regions in western, northwestern, and northcentral Pennsylvania, and likewise in western New York where they may thin decidedly as they approach the shore regions of Lake Ontario and Lake Erie. Salt waters have been reported at a number of places in these sandy rocks so that porosity conditions are reasonably promising; locally, porosities may have been further improved wherever any Late Cambrian or Early Ordovician weathering was associated with surfaces of unconformity and produced sandy soil like that mantling the Gatesburg crop in Friends Cove. Where the Gatesburg-Theresa-Potsdam sediments are thick and underlain by earlier Cambrian marine sediments such as the Warrior, Pleasant Hill, and Waynesboro of central Pennsylvania, relations to possible source horizons are further improved and oil and gas possibilities tend to be enhanced.

Westward, northwestward, and northward from the Allegheny Front region of central Pennsylvania, the Gatesburg strata rise in accordance with regional convergence of the overlying Paleozoic sediments. This regional condition must have developed by Middle Paleozoic time, and may have significantly affected the history of the Early Paleozoic oil and gas of the region.

The Gatesburg sands, unlike the clays and sands of most other parts of the Paleozoic detrital sediments of the Appalachians, evidently were carried in from regions on the northwest or west, rather than from the Appalachia oldlands on the east. The trilobites of the Ore Hill member of the Gatesburg occur in the Great Valley on the east in the middle part of the somewhat silty Conococheague limestone, and some Warrior trilobites are found in the basal Conococheague. The stratigraphic-paleontologic evidence thus shows with considerable clarity that the Gatesburg of the Nittany Arch grades laterally southeastward into the Conococheague both with loss of its sandy interlayers and change from dolomite to limestone with some dolomite. Contrariwise, the expected persistence of sands and dolomites in the Gatesburg northwestward from the Nittany Arch favor Gatesburg oil and gas possibilities in its regions of subsurface occurrence.

The fullest development of Cambrian strata in Pennsylvania occurs 50 miles east of Friends Cove along the Great Valley-South Mountains region southwest of Harrisburg near Shippensburg and Chambersburg. In this area the Conococheague limestone of Gatesburg and late Warrior age is underlain successively by 3,000 feet of Elbrook argillaceous limestone and calcareous shales; 1,000 feet of Waynesboro limestone and shaly sandstone; 1,000 feet of Tomstown dolomite; 3,000 to 4,000 feet of Antietam quartzite, Harpers phyllite, Weverton quartzite, and Loudoun conglomerate and slate. The Elbrook probably is Upper Cambrian above; Middle Cambrian below. The Waynesboro beds have not yielded fossils in the Chambersburg region, but probably are late Lower Cambrian. The Lower Cambrian *Olenellus* fauna has been discovered in the Tomstown dolomite and upper part of the Antietam. The Harpers, Weverton, and Loudoun strata represent the beginning phases of a stage of sedimentation that continued through Antietam and Tomstown time, and their depositional history favors their classification as Lower Cambrian along with the Antietam and Tomstown formations.

Thus in the Chambersburg-Harrisburg region the Conococheague limestone of Gatesburg age is underlain by 8,000 to 9,000 feet of Upper, Middle, and Lower Cambrian sediments that include thick sandy formations in their lower half and that have been subjected to appreciable metamorphism.

Available data are too scanty to furnish much insight into features of the earlier Cambrian sediments in their regions of subsurface occurrence in western, northwestern and northern Pennsylvania and in western New York.

The 3,000 feet of Elbrook shaly limestones and calcareous shales of the Chambersburg region are represented in central Pennsylvania along the Nittany Arch by the 600 feet of Pleasant Hill limestone plus part of the 1,200 feet of Warrior limestone. The thickness of these strata accordingly is reduced northwestward. The Warrior limestone contains silty and shaly layers, together with two local, thin layers of quartz sandstone; the lower part of the Pleasant Hill limestone is shaly. The direction from which these detritals were derived remains uncertain; the quartz sand lenses of the Warrior could have been reworked from uparched, emergent portions of the Lower Cambrian sandstones.

The stratigraphically deepest wells of western and northwestern Pennsylvania bottom in the Upper Cambrian, and so give no guidance about the progressive changes of the Middle and Lower Cambrian sediments. Toward northwestern Ohio, deep wells show about 1,000 feet of Upper Cambrian sandstones and dolomites resting on the Pre-Cambrian. The Wilson test well at Arcade, western New York, likewise bottoms in sandy dolomites thought to be Upper Cambrian in age. Late Cambrian strata have been reported resting directly on the Pre-Cambrian in wells near Buffalo and Rochester, New York; taken at face value these reports suggest marked thinning of the Upper Cambrian as compared to its development at the Wilson well, and likewise total absence of Middle and Lower Cambrian sediments. The evidence from these wells however, is not wholly satisfactory, and must have further substantiation.

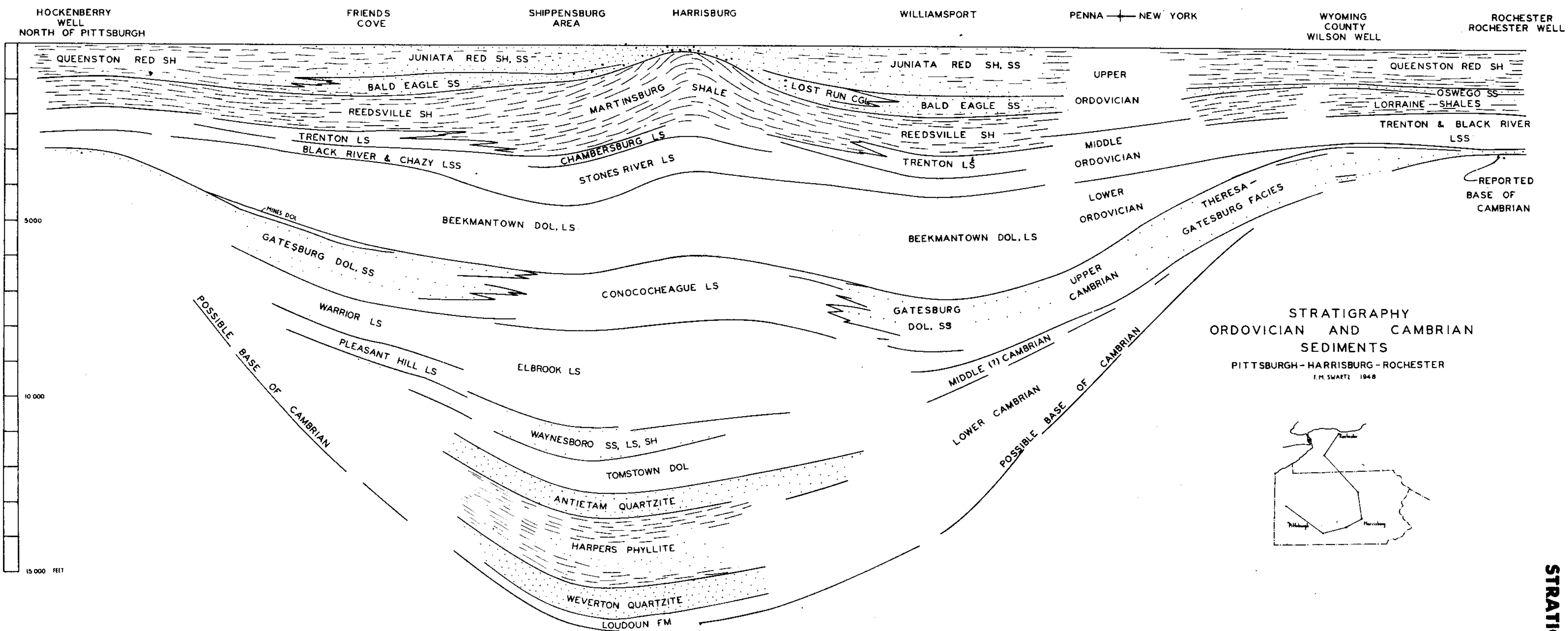
Cambrian sediments extend onto the southern flank of the Adirondacks as a 300- to 400-foot wedge-edge that rests directly on the Pre-Cambrian granite-gneiss complex. Not only are Middle and Lower Cambrian strata absent along the belt, but even the Upper Cambrian sediments fail along the western border of the Adirondack area. Farther west, however, Upper Cambrian sandy dolomites reappear down the dip of the Paleozoic, Pre-Cambrian boundary, and have thicknesses of 50 to 100 feet in wells east of Syracuse.

The Lower and Middle Cambrian sediments thickly developed southwest of Harrisburg in Pennsylvania, thus disappear northeastwards toward the Adirondacks and westwards toward northwestern Ohio. The rate of thinning and locale of disappearance remain unknown.

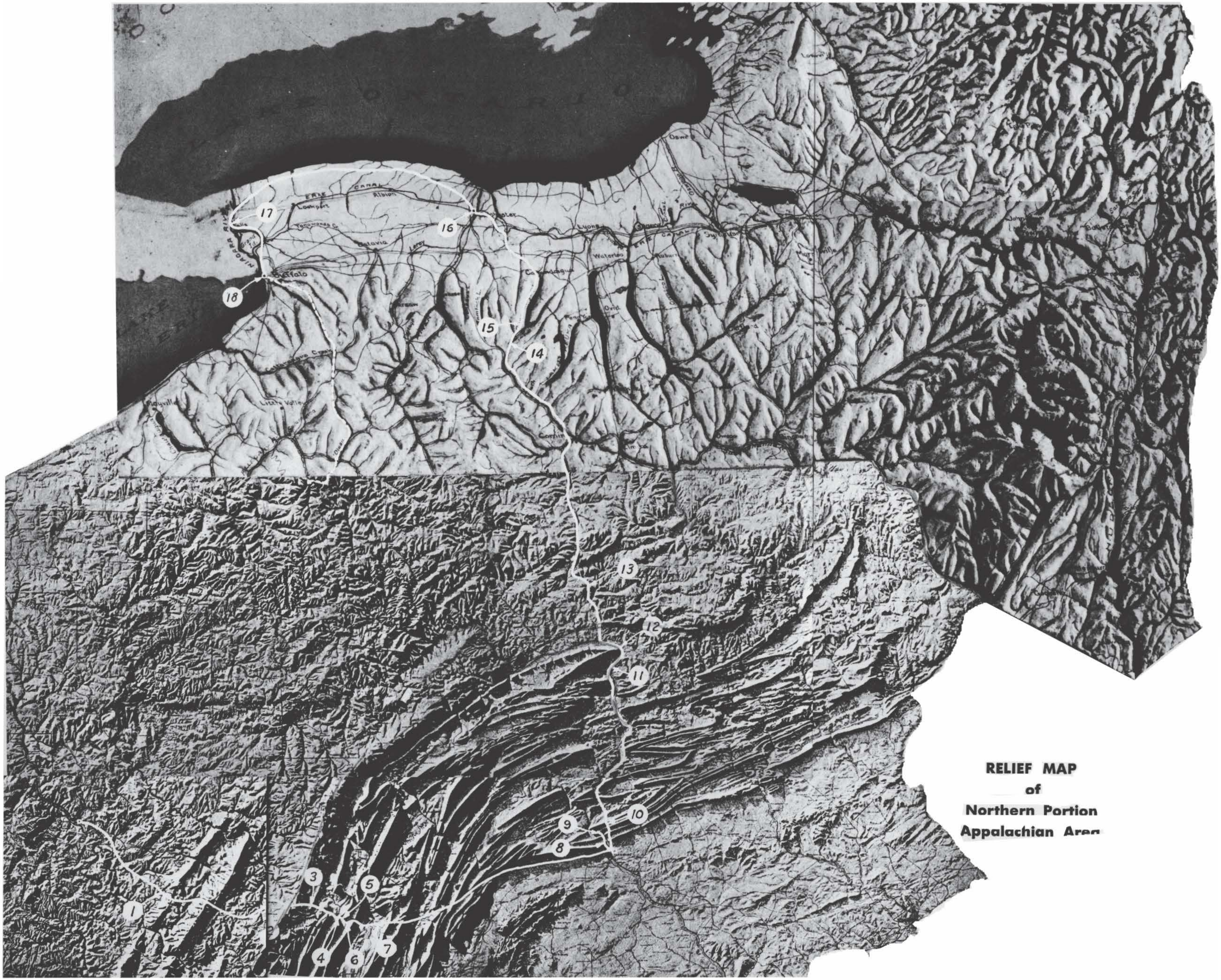
Improved grounds for speculation about changes of the Lower Cambrian sediments in the subsurface areas would be obtained if better information were available about source and direction of transport of the exposed detrital sands and clays. There is some evidence in the Chambersburg region that the Lower Cambrian sands and clays came from the east. The geographic pattern of textural changes, however, is too imperfect to allow confident use of this supposition. If the sands were derived chiefly from easterly source-areas they probably thin out westward and northward from their thick development in the South Mountain area.

Whatever the exact distribution, the Middle and Lower Cambrian sediments must in some fashion thin across western and northern Pennsylvania, and must rise in accordance with the convergence of overlying strata as well as with the regional rise of surface formations from northern Pennsylvania into New York. Such conditions are favorable for stratigraphic traps; the beds are, however, very deep and any exploration would be very costly.

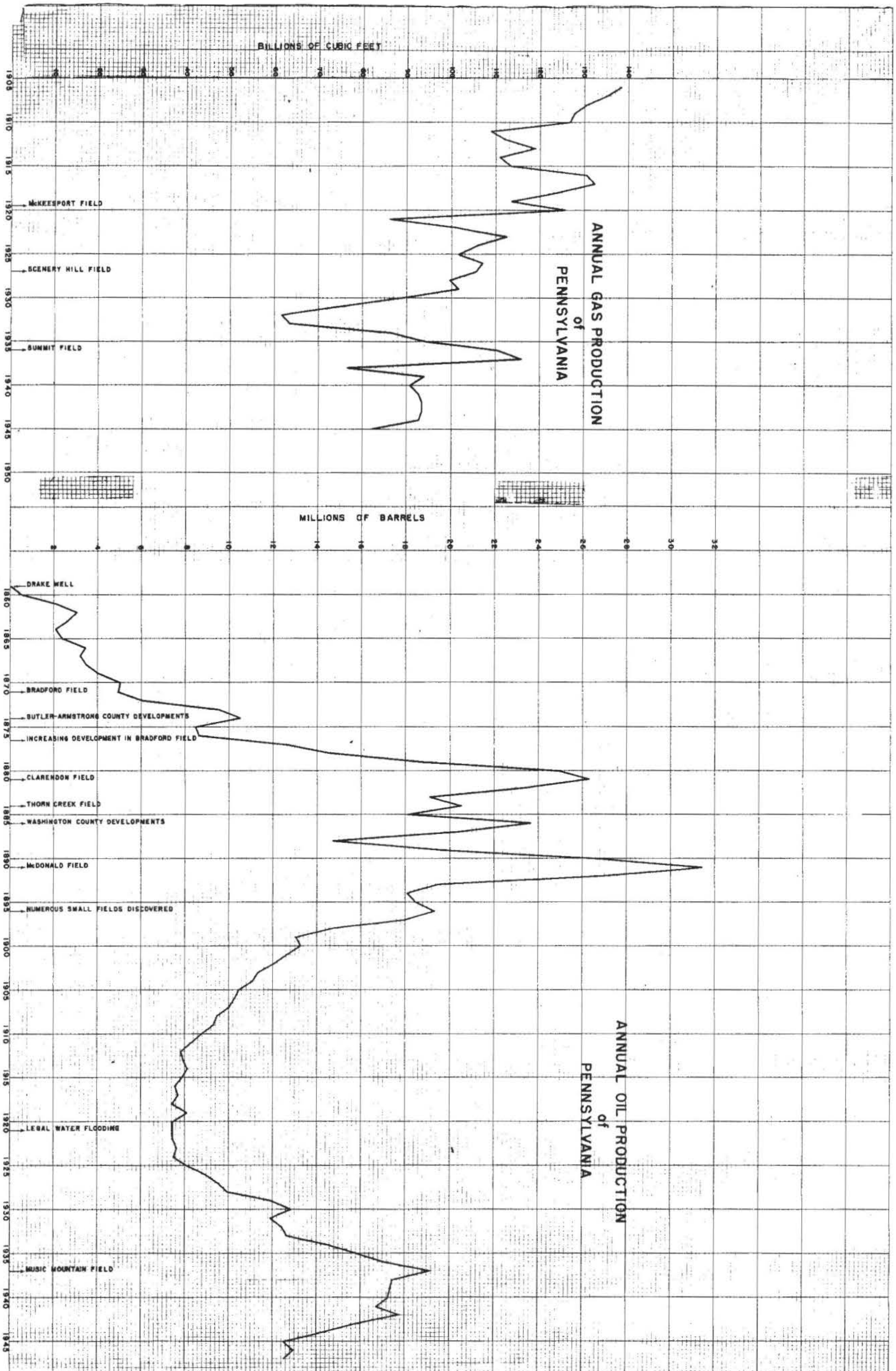
In the area of the folded Appalachians of central Pennsylvania, Lower Cambrian sandstones should everywhere be present, and should be thrown into great folds related to structures transected by the present surface of erosion. Possibilities for oil and gas will be conditioned by rate of waning of the metamorphism exhibited in the South Mountains.

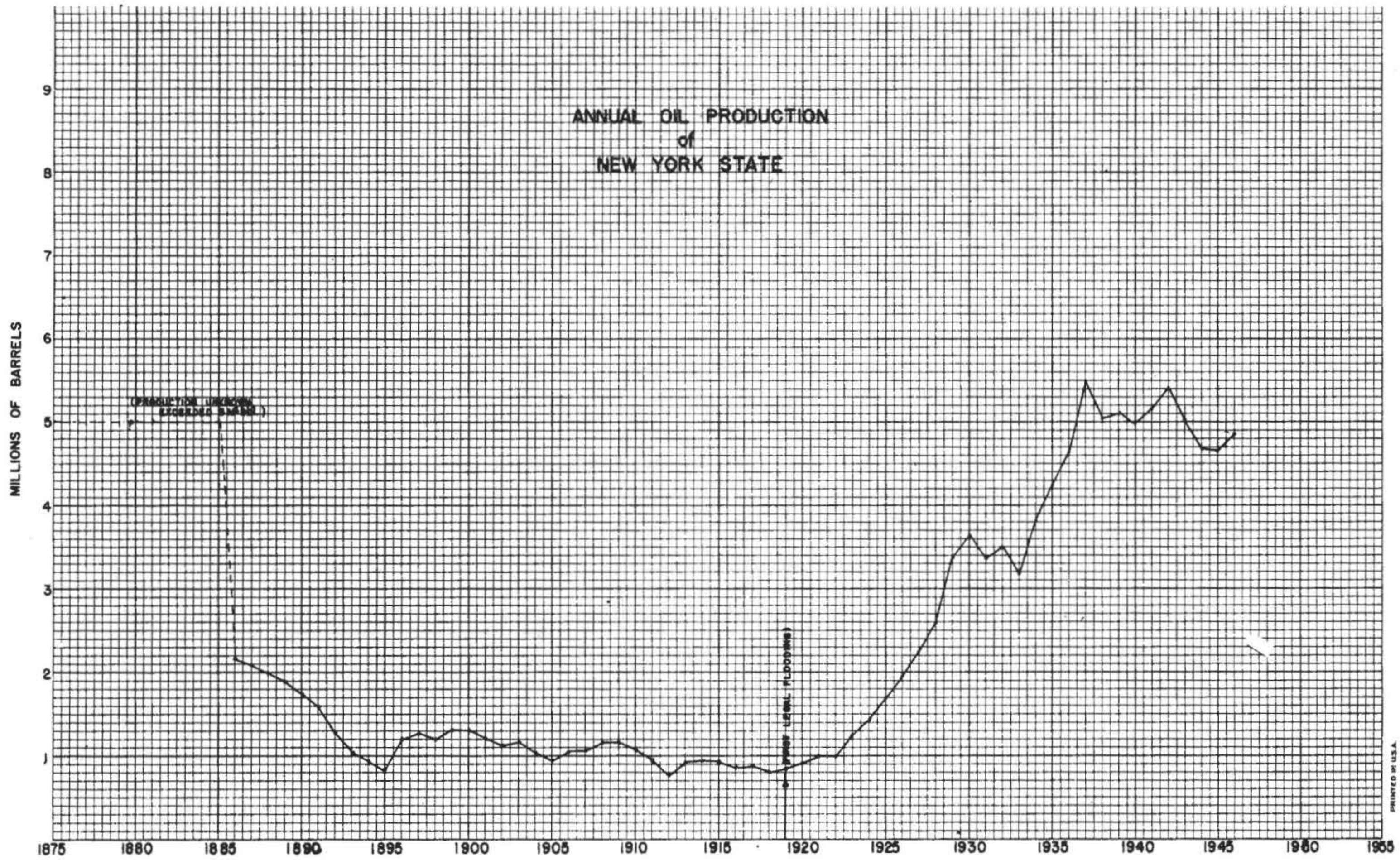


STRATIGRAPHIC CHART 3



RELIEF MAP
of
Northern Portion
Appalachian Area


ANNUAL GAS PRODUCTION of PENNSYLVANIA
BILLIONS OF CUBIC FEET
McKEESPORT FIELD
SCENERY HILL FIELD
SUMMIT FIELD
ANNUAL OIL PRODUCTION of PENNSYLVANIA
MILLIONS OF BARRELS
DRAKE WELL
BRADFORD FIELD
BUTLER-ARMSTRONG COUNTY DEVELOPMENTS
INCREASING DEVELOPMENT IN BRADFORD FIELD
CLARENDON FIELD
THORN CREEK FIELD
WASHINGTON COUNTY DEVELOPMENTS
McDONALD FIELD
NUMEROUS SMALL FIELDS DISCOVERED
LEGAL WATER FLOODING
MUSIC MOUNTAIN FIELD


ANNUAL OIL PRODUCTION
of
NEW YORK STATE
MILLIONS OF BARRELS
(PRODUCTION UNKNOWN
FIRST LEGAL FLOODING
1875
1880
1885
1890
1895
1900
1905
1910
1915
1920
1925
1930
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1945
1950
1955
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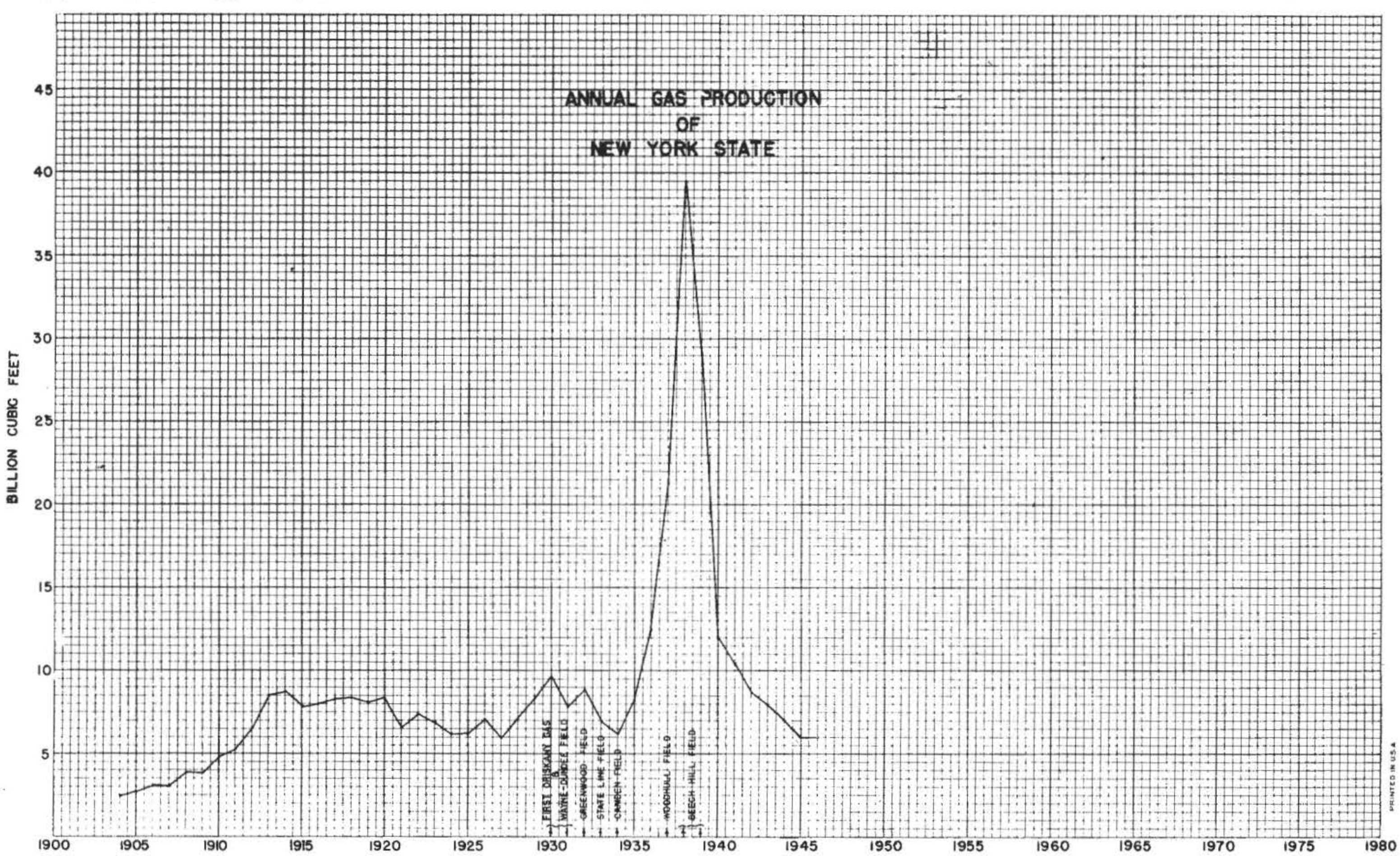
ANNUAL GAS PRODUCTION
OF
NEW YORK STATE
BILLION CUBIC FEET
FIRST ORISKANY GAS
&
WAYNE-DUNDEE FIELD
GREENWOOD FIELD
STATE LINE FIELD
CAMDEN FIELD
WOODHULL FIELD
BEECH HILL FIELD
1900
1905
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1940
1945
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1955
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1965
1970
1975
1980
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45

NOTES

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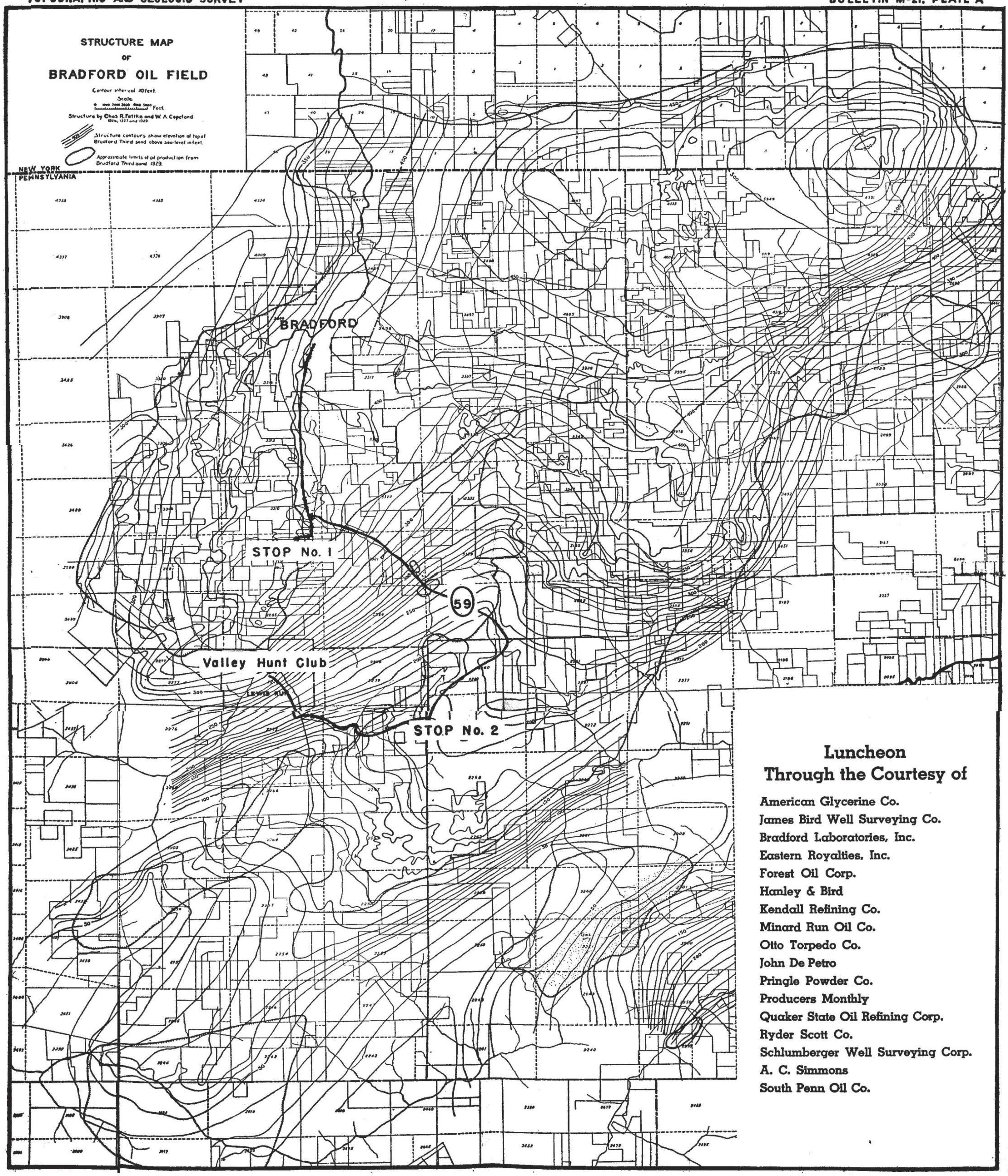
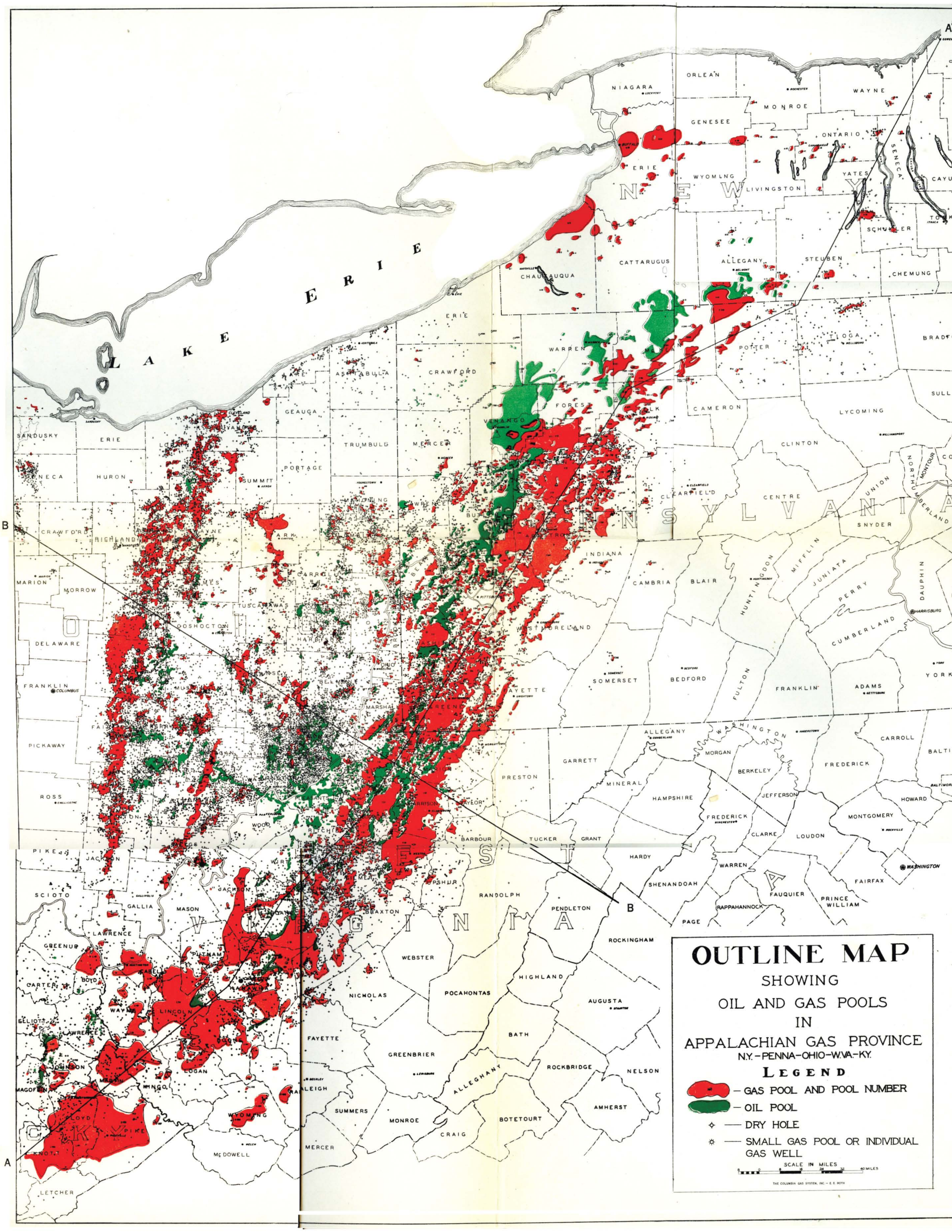
PENNSYLVANIA
TOPOGRAPHIC AND GEOLOGIC SURVEY

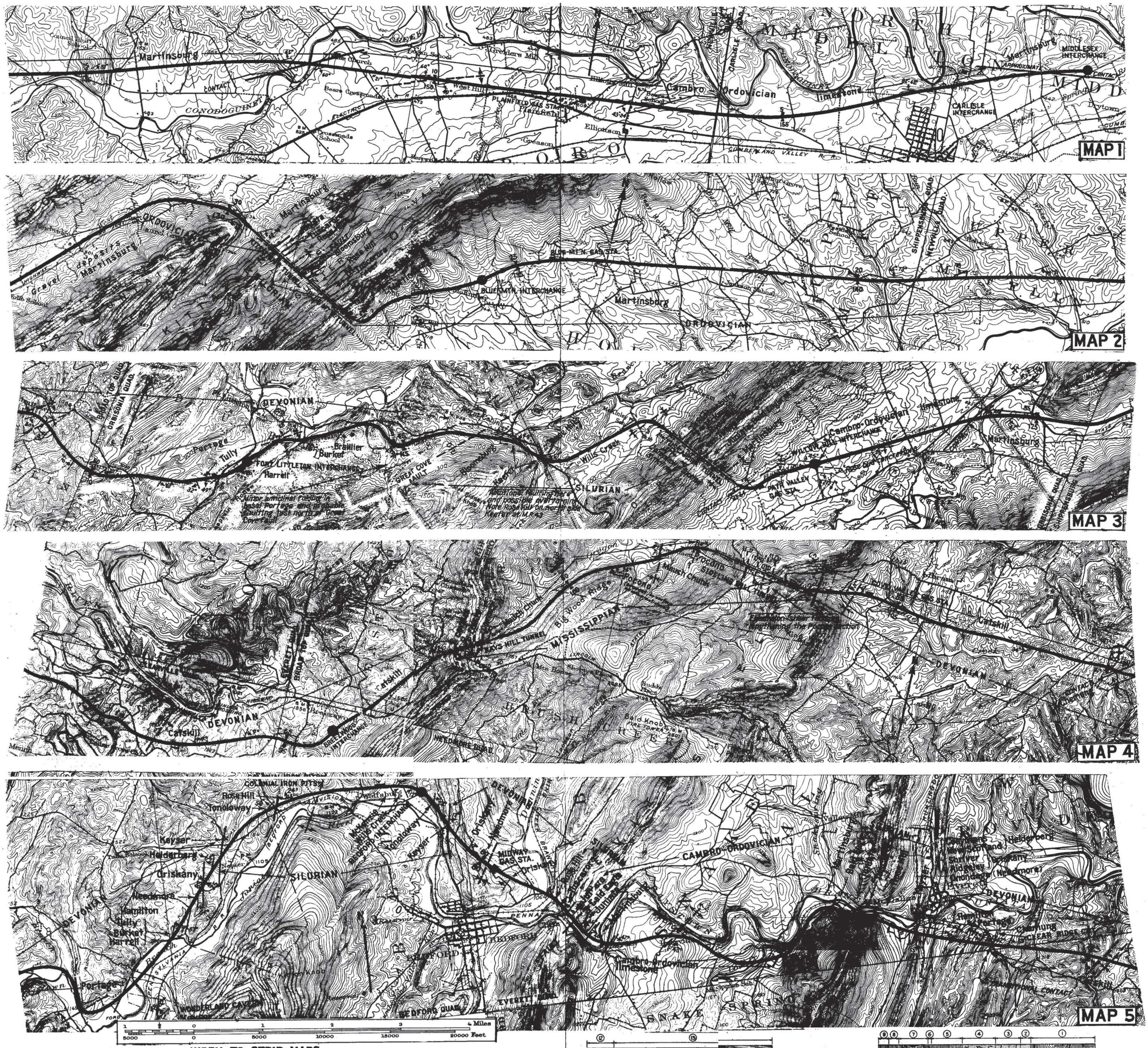
BULLETIN M-21, PLATE A



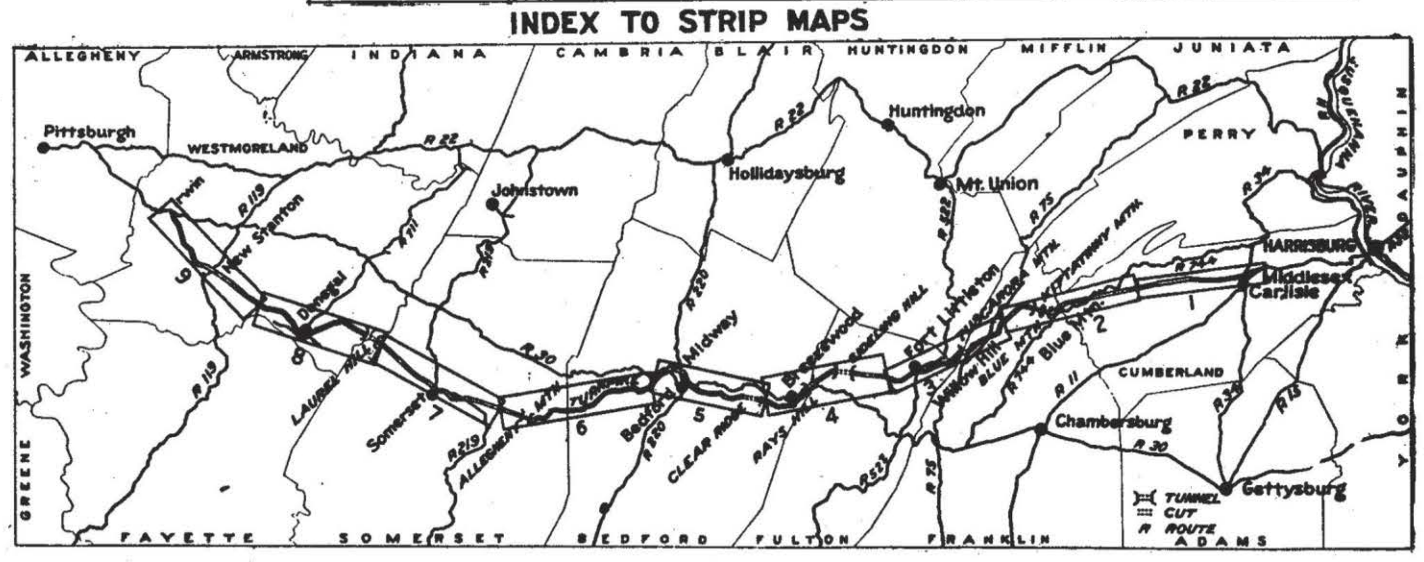
Luncheon Through the Courtesy of

American Glycerine Co.
James Bird Well Surveying Co.
Bradford Laboratories, Inc.
Eastern Royalties, Inc.
Forest Oil Corp.
Hanley & Bird
Kendall Refining Co.
Minard Run Oil Co.
Otto Torpedo Co.
John De Petro
Pringle Powder Co.
Producers Monthly
Quaker State Oil Refining Corp.
Ryder Scott Co.
Schlumberger Well Surveying Corp.
A. C. Simmons
South Penn Oil Co.


OUTLINE MAP
SHOWING
OIL AND GAS POOLS
IN
APPALACHIAN GAS PROVINCE
N.Y.-PENNA-OHIO-W.VA.-KY.
LEGEND
— GAS POOL AND POOL NUMBER
— OIL POOL
— DRY HOLE
— SMALL GAS POOL OR INDIVIDUAL GAS WELL
SCALE IN MILES
8 0 8 16 24 32 40 MILES
THE COLUMBIA GAS SYSTEM, INC. – E. E. ROTH
LAKE ERIE
A
A'
B
B
NIAGARA
ORLEAN
WAYNE
MONROE
GENESEE
ONTARIO
ERIE
WYOMING
LIVINGSTON
YATES
SENECA
SCHUYLER
CATTARAUGUS
CHAUTAUQUA
ALLEGANY
STEUBEN
CHEMUNG
WARREN
POTTER
TIOGA
CRAWFORD
ASHTABULA
FOREST
VENANGO
CAMERON
LYCOMING
GEAUGA
TRUMBULL
MERCER
PORTAGE
SUMMIT
SANDUSKY
HURON
CLINTON
CENTRE
UNION
SNYDER
CLEARFIELD
INDIANA
CAMBRIA
BLAIR
HUNTINGDON
MIFFLIN
JUNIATA
PERRY
DAUPHIN
CUMBERLAND
WESTMORELAND
SOMERSET
BEDFORD
FULTON
FRANKLIN
ADAMS
YORK
FAYETTE
MARION
MORROW
DELAWARE
COSHOCTON
TUSCARAWAS
FRANKLIN
PICKAWAY
ROSS
PIKE
SCIOTO
GALLIA
LAWRENCE
MASON
JACKSON
WOOD
GREENUP
BOYD
CARTER
WAYNE
LINCOLN
LOGAN
MINGO
WYOMING
McDOWELL
MERCER
LETCHER
GARRETT
ALLEGANY
WASHINGTON
CARROLL
FREDERICK
MORGAN
BERKELEY
PRESTON
MINERAL
HAMPSHIRE
JEFFERSON
HOWARD
MONTGOMERY
FREDERICK
CLARKE
LOUDON
BARBOUR
TUCKER
GRANT
HARDY
WARREN
SHENANDOAH
FAUQUIER
PRINCE WILLIAM
FAIRFAX
RAPPAHANNOCK
PAGE
WASHINGTON
RANDOLPH
PENDLETON
ROCKINGHAM
BRAXTON
WEBSTER
NICHOLAS
HIGHLAND
POCAHONTAS
AUGUSTA
BATH
FAYETTE
GREENBRIER
ALLEGHANY
ROCKBRIDGE
NELSON
SUMMERS
MONROE
CRAIG
BOTETOURT
AMHERST
PENNSYLVANIA
VIRGINIA
WEST



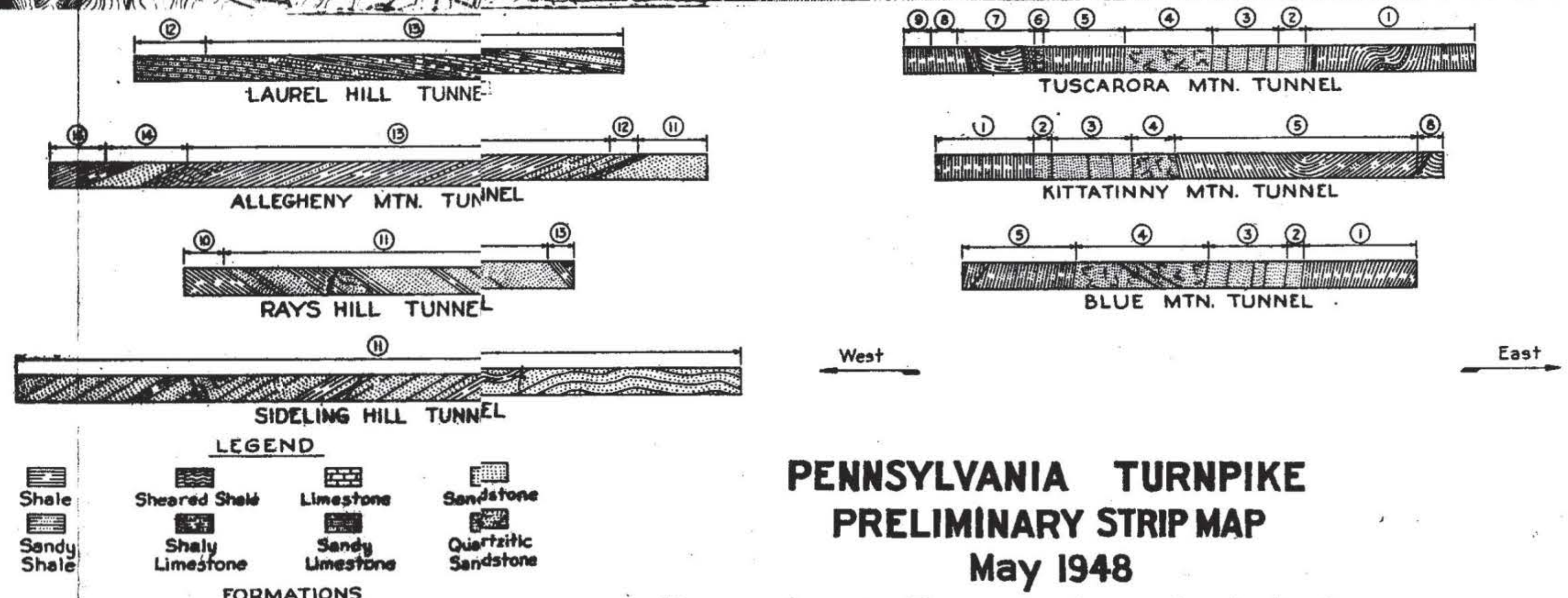
INDEX TO STRIP MAPS



LEGEND

● Interchange ▬ Gas station Tunnel

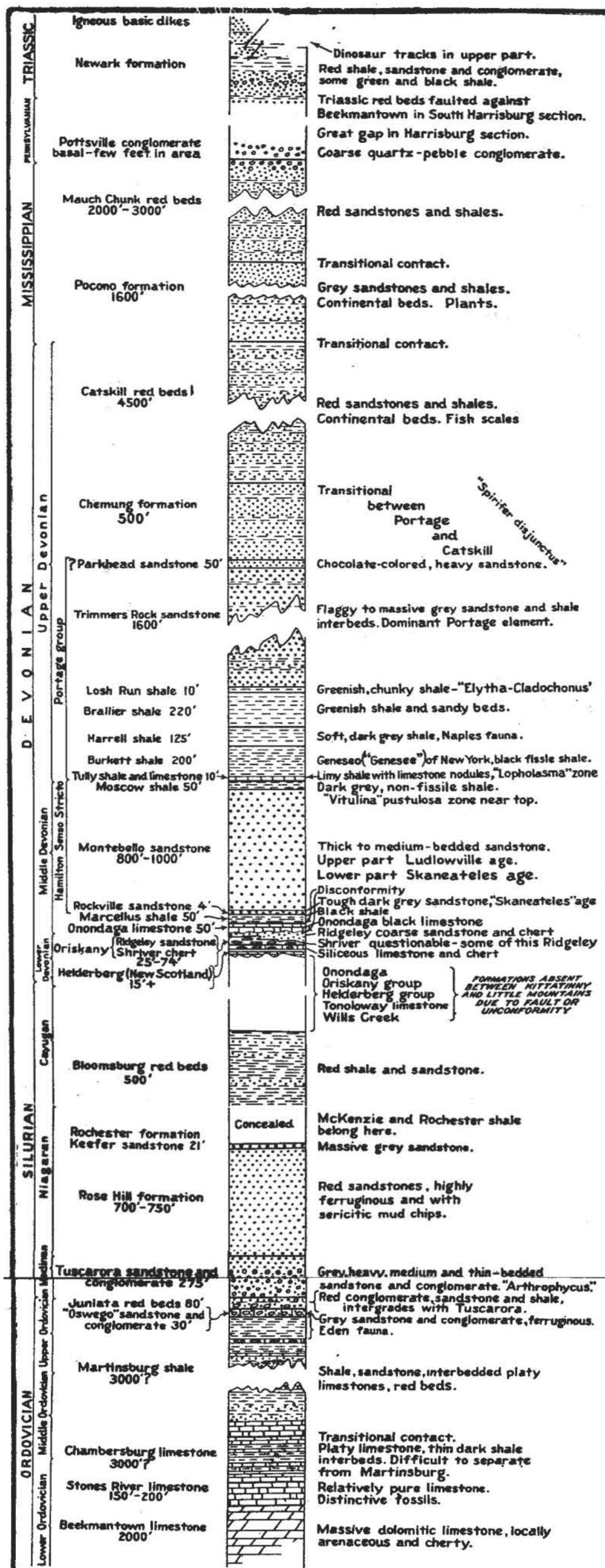
West-bound / Mile posts / East-bound



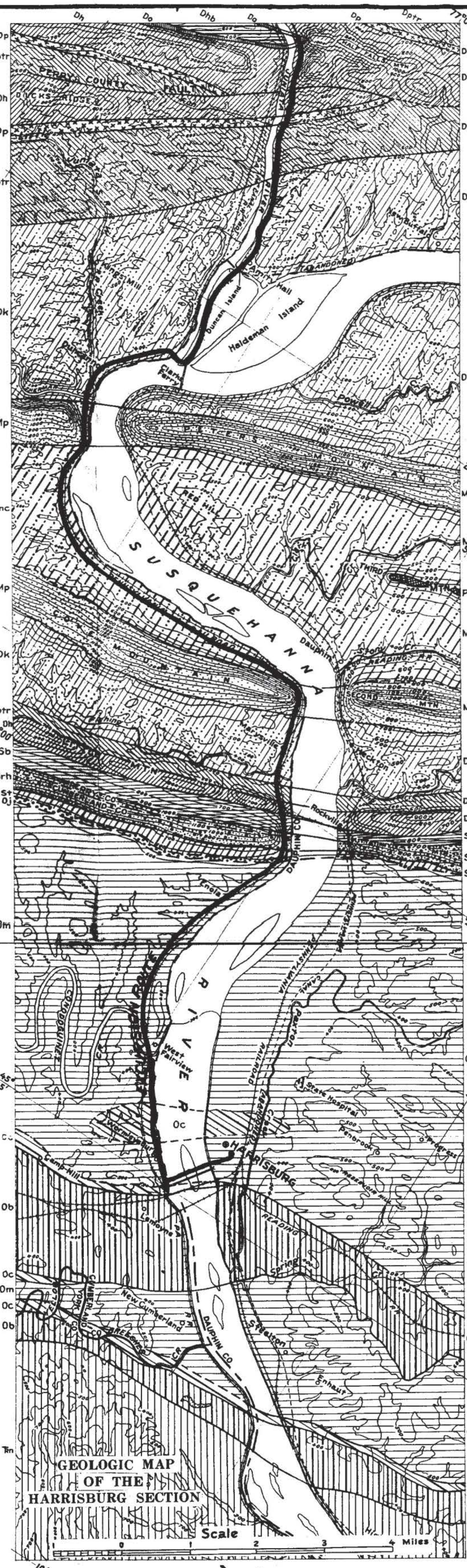
FORMATIONS

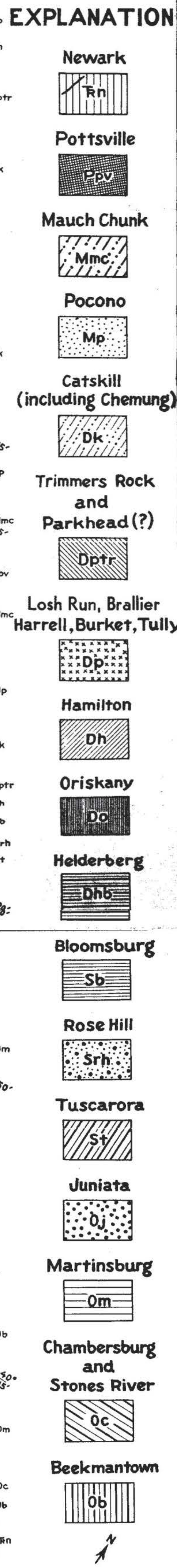
1. MARTINSBURG
2. BALD EAGLE
3. JUNIATA
4. TUSCARORA
5. ROSE HILL
6. KEEFER
7. McKENZIE
8. BLOOMSBURG
9. WILLS CREEK
10. CATSKILL
11. POCONO
12. LOYALHANNA
13. MAUCH CHUNK
14. POTTSVILLE
15. ALLEGHENY

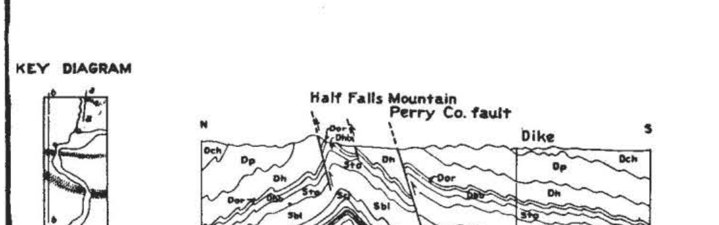
PENNSYLVANIA TURNPIKE
PRELIMINARY STRIP MAP
May 1948
Pennsylvania Topographic & Geologic Survey
Geology by A. B. Cleaves



COLUMNAR SECTION ON SUSQUEHANNA-JUNIATA RIVERS BETWEEN HALF FALLS MOUNTAIN AND HIGHSPIRE

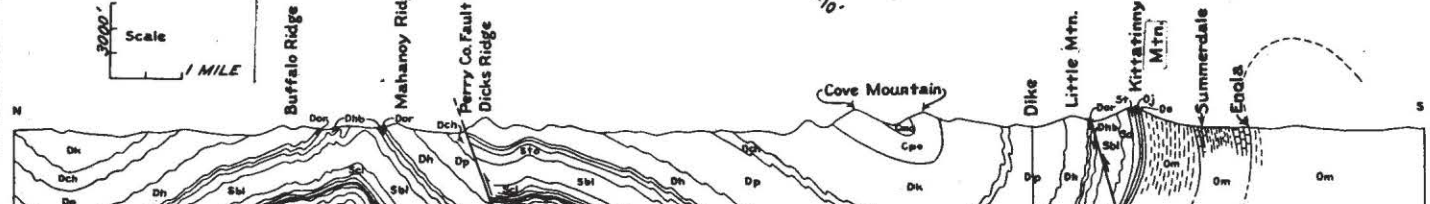






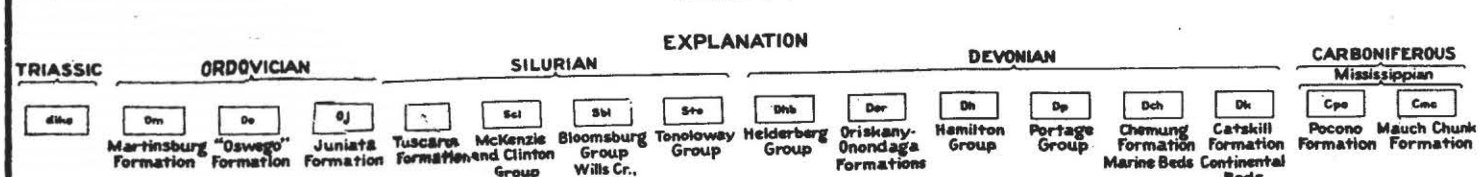
NORTH-SOUTH SECTION THROUGH HALF FALLS MOUNTAIN ANTICLINE

Section a-a



NORTH-SOUTH SECTION THROUGH THE CENTRAL PART OF THE NEW BLOOMFIELD AREA

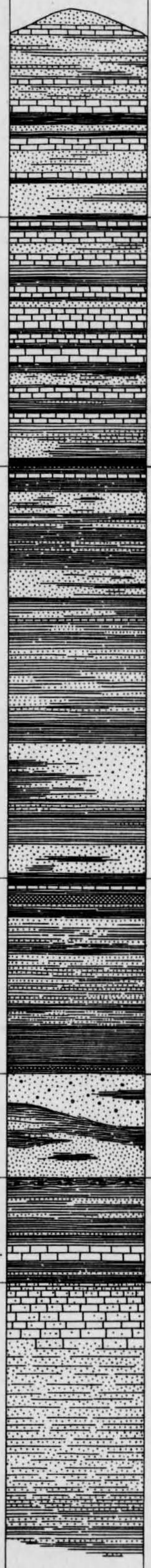
Section b-b



STRUCTURE SECTIONS

A

GENERALIZED COLUMNAR SECTION—PITTSBURGH TO ALLEGHENY FRONT

Period.		Group or Formation Name	Symbol.	Columnar Section	Thickness in Feet.	Name of Members	General Character
CARBONIFEROUS	PERMIAN?	Dunkard	Cd		300+	Washington coal Waynesburg "A" coal Waynesburg sandstone	Coarse, friable sandstone and sandy shale; many thin beds of blue or buff limestone; and several beds of coal, mostly thin and only locally workable. The formation is 1,000 feet thick in Greene County, but only the lower 25 feet are seen on this trip.
	PENNSYLVANIAN	Monongahela	Cm		310-400	Waynesburg coal Uniontown coal Benwood limestone Sewickley coal Redstone coal Pittsburgh coal	Prevailing calcareous. Massive limestone 140 to 160 feet thick near middle of formation and thin beds of limestone both above and below. Considerable shale interbedded with the limestones. Occasionally coarse sandstone near the top and bottom of the formation. Waynesburg coal at the top and Pittsburgh coal at the base.
		Conemaugh	Ccm (Css)		600	Connellsville sandstone Morgantown sandstone Ames (crinoidal) limestone Saltsburg sandstone Mahoning sandstone	Shale and coarse sandstone with occasionally thin beds of limestone and coal. Most of the shale is sandy, but there are some prominent beds of green and red, fine-grained clay shale which give a distinct color to the soil on their outcrop. The lower half of the formation is prevailingly sandy, carrying several beds of coarse sandstone or conglomerate.
		Allegheny	Ca		280	Upper Freeport coal Bolivar fire clay Lower Freeport coal Upper Kittanning coal Middle Kittanning coal Lower Kittanning coal Brookville-Clarion coal	Shale, sandstone, fire clay, and coal beds. Shale predominates. Sandstone is generally thin bedded and shaly, but in places is coarse and massive. Fire clay is generally present and of great value. Coal beds are actively operated in various parts of the area.
		Pottsville	Cpv		150	Homewood sandstone Mercer coal group Conoquenessing sandstone	Coarse, quartzose sandstone or conglomerate, sometimes massive, with intermediate shale carrying coal beds locally.
	MISSISSIPPIAN	Mauch Chunk	Cmc (Cgr)		150	Greenbrier limestone	Red and green shale with green, flaggy sandstone. Blue, fossiliferous limestone near the base.
		Loyalhanna			40-70	Loyalhanna limestone	Blue sandy limestone.
		Pocono Pocono	Cpo		400+	Burgoon sandstone (Big Injun Sand)	Coarse gray sandstone, at the base interbedded with sandy shale.

Adapted from U.S.G.S. folio 94

GENERALIZED COLUMNAR SECTION—ALLEGHENY FRONT TO HARRISBURG

SYSTEM	SERIES	GROUP	FORMATION	SYMBOL	SECTION	THICKNESS IN FEET	MINOR DIVISIONS	GENERAL CHARACTER
CARBONIFEROUS	PENNSYLVANIAN		Allegheny formation.	Ca		50	Brookville coal member.	Shale and sandstone with workable coal beds.
			Pottsville formation.	Cpv		130-300	Homewood sandstone member Mercer shale member Connoquenessing sandstone member.	Mainly coarse sandstone with shale, coal, and clay in middle.
			UNCONFORMITY					
	MISSISSIPPIAN		Mauch Chunk formation.	Cmc		180-1000		
			Loyalhanna limestone.	Cl		40		Siliceous cross-bedded limestone.
			Pocono formation.	(Cb) Cpo		(300-500) 990	Burgoon sandstone member Patton shale member.	
DEVONIAN	UPPER DEVONIAN		Hampshire formation. "Catskill"	Dck		2000-2500		About 80 percent bright red shale, alternating with layers of reddish or brown sandstone, which is generally thick-bedded and medium-grained. Some laminated layers. The red shale is in places mottled with bright green, and there are many thin layers of bright green in the red shale. Beds of gray shale and sandstone occur throughout the formation; in these is a sparse marine fauna. No fossils have been found in the red parts. This interval contains many oil and gas producing zones to the west.
			Chemung formation.	Dch		2400-3350		Shale and sandstone. Upper 1,000 feet largely chocolate-colored clay shale and fine-grained, thin-bedded chocolate-colored sandstone. Lower part gray and green shale, mostly gray clay shale, with sandstone. Sandstones from 1-inch layers of argillaceous sandstone to 50-foot beds of quartzose, medium-grained, moderately thick-bedded sandstone. Some of the sandstone and conglomerate beds are rather persistent, some are only local. There are sands in this interval that are highly productive of gas farther west. Fossils moderately plentiful throughout
		Portage	Brallier shale.	Db		1350-1800		Very fine-grained, sandy and micaceous stiff greenish-gray shale. Much of it thinly laminated, even-surfaced, with lamination cleavage dividing rock into large slaty plates, with weathered surfaces stained black with manganese oxide. Thin fine-grained greenish sandstone layers near top. Small fossils throughout but very scarce. Characteristic Portage (Naples) fauna.
			Harrell shale.	Dhr (Dbk)		250 (80)	Burket black shale member. Tully Limestone at base.	Interbedded black and gray soft, very fissile (paper) clay shale. Soft brownish-gray shale above. Burket black shale member below. Small fossils throughout (Naples-fauna).
	MIDDLE DEVONIAN		Hamilton formation.	Dh		750-1200		Nearly all shale and siltstone in western area. Layers of very fine-grained sandstone up to 1-foot thick in middle part, characteristically jointed into straight-edged, smooth cuboidal or rhomboidal blocks; partly olive-green shale in upper part; finely laminated, dark shale below. A few feet of gray shale with thin layers of limestone at top crowded with fossils.
			Marcellus shale.	Dm		150		Black fissile shale. Sparsely fossiliferous (*Leiorhynchus limitaris*).
			Onondaga formation.	Don		50		Dark and drab shale, thin limestone at top. Fossiliferous. (Needmore facies).
	LOWER DEVON.	Oriskany	Ridgeley sandstone.	Dr		100		Calcareous sandstone, coarse siliceous sandstone, and fine conglomerate. Highly fossiliferous.
			Shriver limestone.	Ds		200		Thin-bedded siliceous limestone; black calcareous, fossiliferous shale in bottom. 10 feet (Oriskany fauna).
			Helderberg limestone.	Dhb		150±	New Scotland limestone member Coeymans limestone member Keyser limestone member.	Thick- and thin-bedded, coarsely crystalline, fine-grained, bluish-gray limestone. Characteristic nodular argillaceous layers everywhere in Keyser limestone member. Locally cherty layers near bottom of Keyser (Calico rock). Main quarry bed at bottom.
SILURIAN		Cayuga	Tonoloway limestone.	Stw		450		Thick-bedded, dark to black limestone at top, mostly thin-bedded and laminated, dark, fine-grained. A few fossils, mainly *Leperditia*.
			Wills Creek shale.	Swc		400±		Mostly drab fissile clay shale. Some green and dark shale. Probably calcareous. Thin limestone, especially near bottom. Fossils very scarce, mostly small *Leperditia*, a few brachiopods.
			Bloomsburg redbeds.	Sb		50±		Red shale and sandstone east of Tussey Mountain. Red shales thicken eastward.
			McKenzie formation.	Smk		400		Thin-bedded blue limestone. Highly fossiliferous; small ostracodes, mostly *Kloedinella*, very plentiful.
		Niagara	Clinton formation.	Sc		(10) 775±	Keefer sandstone member. Marklesburg ore. Frankstown ore. Block or Levant ore and "Iron sandstone	Predominantly shale; chocolate at top, greenish and gray in middle, with red layers in lower part; pink, fissile shale at very bottom. Thin limestone at top; rather thick limestone at bottom, interbedded with red shale. Thin impure, limy ore beds near top, and a workable bed in places near middle. Generally fossiliferous especially so in upper part.
			Tuscarora quartzite.	St		400-600		Gray quartzitic sandstone and quartzite. Supplies the ganister of the region, which is extensively used for refractory brick and furnace linings.
ORDOVICIAN	UPPER ORDOVICIAN		Juniata formation.	Oj		850		Predominantly red shale sandstone, sandstone medium-grained and much of it finely cross-laminated.
			Oswego sandstone.	Oo		800		Almost all gray, brown-speckled medium-grained, thick-bedded sandstone; a few layers of red, gray, or green sandy shale.
			Reedsville shale.	Orv		1000	Black shale (Utica?).	Olive-green clay shale in lower part, except about 20 feet at bottom, which is generally black. Upper part dark clay shale with many thin shell-limestone bands. Top 20 feet heavy calcareous sandstone with fossils in upper part. Fossils plentiful in the limestone bands in the upper part and in the black shale at the bottom; scarce in the olive-green shale of the lower part.
	MIDDLE ORDOVICIAN		Trenton limestone.	Ot		850		Thin-bedded dark-gray to black fine-grained or nongranular limestone. Sparingly fossiliferous.
		Black River	Rodman limestone.	Or		30		Gray granular limestone. Fossiliferous.
			Lowville limestone.	Ol		180		Thick-bedded dark fine-grained to nongranular pure limestone. Moderately fossiliferous. Best quarry rock.
			UNCONFORMITY					
			Carlim limestone.	Oc		180	Lemont argillaceous limestone member.	Thick-bedded dark limestone, mostly finely crystalline. Moderately fossiliferous. Quarry rock.
			UNCONFORMITY					
	LOWER ORDOVICIAN	Beekmantown	Bellefonte dolomite.	Ob		1000		Thick-bedded crystalline dolomite, mostly gray; more or less chert throughout, but especially in middle and lower parts. A few fossils in the chert.
			Axemann limestone.	Oa		150		Thin-bedded blue limestone fossils rather plentiful.
			Nittany dolomite.	On		1000		Thick-bedded gray crystalline dolomite. Much dense chert in middle part and some chert throughout. Fossils in chert; *Lecanospira* zone.
			Larke dolomite.	Ol		250		Thick-bedded dolomite, without sandstone, and in most of its area without notable development of chert. Locally, yields abundant heavy chert, which is sparingly fossiliferous.
			Mines dolomite.	Om		250		Thick-bedded dolomite like that of the Gatesburg. No sandstone. Abundant development of platy scoriaceous oolitic chert with Cryptozoa, but without other fossils. Basal layer of dolomite locally full of gastropods (*Sinuopea*).
CAMBRIAN	UPPER CAMBRIAN		Gatesburg formation.	(Єo) Єg (Єs)		(100) 1750 (800)	Ore Hill limestone member. Stacy dolomite member.	Thick-bedded bluish coarsely crystalline dolomite and fine-grained dolomite with argillaceous bandings giving striped appearance to weathered surfaces. Many interbedded layers of quartzite from a few inches up to 10 feet thick. Makes ridges which are covered with quartz boulders and sand, suggesting only sandstone beneath. Sand in places 40 feet deep, utilized to a considerable extent.
			Warrior limestone.	Єw		1250		Generally thin- to thick-bedded, blue to dark bluish-gray, mostly fine-grained limestone, much of which is probably magnesian. Fossils, mainly small trilobites, sparingly distributed at several horizons. A few thin quartzite bands and thicker layers of perfectly rounded grains of quartz, generally 5 millimeters or less in diameter.
	MIDDLE CAMBRIAN		Pleasant Hill limestone.	Єph		(200±) 600		Upper 200± feet thick-bedded dark gray pure limestone, with oolitic and conglomeratic layers containing trilobites and other fossils; lower 400 feet thin-bedded and argillaceous, yielding shaly debris on weathered outcrop.
	LOWER CAMBRIAN		Waynesboro formation.	Єwb		250+		Green and red shale above, sandstone, quartzite, and conglomerate below. Not all exposed, and thickness unknown.

Adapted from U. S. G. S. Folio 227.

Knox

B

GENERALIZED COLUMNAR SECTION — HARRISBURG TO STATE LINE

(NOT TO SCALE)

System	Series	Formation	Section	Thickness (feet)	Minor Divisions	General Character
Pennsyl-vanian	Pottsville	POTTSVILLE		50		White coarse quartz pebble conglomerate with land plants and coaly layers in Third Mountain.
MISSISSIPPIAN	Chester	MAUCH CHUNK		0-3000		Red sandstones and shales.
						TRANSITIONAL CONTACT
	Mermac / Waverly	POCONO		100-2500		Gray sandstone and conglomerate, carrying remains of land plants. These hard beds are the chief ridge forming rocks in this area.
						TRANSITIONAL CONTACT
DEVONIAN	UPPER DEVONIAN	CATSKILL		1100 to 4500	Elk Mountain (Oswayo) Honesdale	Red sandstone and shale with occasional greenish or gray green sandstones. These beds interfinger with the underlying Chemung or Portage groups, but are themselves non-marine (fresh water formed). In northeastern Pennsylvania, the succession of red beds is interrupted by green, cross-bedded sandstone members. The most prominent are the Elk Mountain near the top and the Honesdale lower in the sequence. The Honesdale extends into the lower Susquehanna Valley. The Elk Mountain becomes the Oswayo westward and is encountered in the Allegheny Plateau at or near the top of the red beds.
		CHEMUNG		0-2000		Gray to greenish-gray marine sandstones and shales, probably absent in the lower Susquehanna Valley, but expanding to about 2,000' in the Allegheny Plateau. "Spirifer Disjunctus."
		PORTAGE		50	Parkhead	Chocolate-covered, heavy sandstone.
				1500 to 1800	Trimmer's Rock	Gray, hard, fossiliferous sandstone.
				10	Losh Run	Greenish, chunky shale. "Elytha Cladochonus."
				300 to 1200	Brallier and Harrell	Greenish and gray sandy shales; fossiliferous in the lower part.
				50-200	Burkett	Black shale, fissile sparingly fossiliferous.
				1-200	Tully	Limey shale with limestone nodules. "Lopholasma" zone.
	MIDDLE DEVONIAN	HAMILTON		50	Moscow	Dark gray, non-fissile shale.
				800 to 1000	Montebello	Thick to medium-bedded sandstones. Upper part Ludlowville age. Lower part Skaneateles age.
				4	Rockville	Tough, dark gray sandstone.
				50 to 500	Marcellus	Black shale, locally with large concretions, occasional sandstone members; fossils scarce.
		ONONDAGA		0-75	Selinsgrove	(a) Limestone, gray, massive to platy; sparingly fossiliferous.
				0-60	Needmore	(b) Shale, ashen-gray; unfossiliferous.
	LOWER DEVONIAN	ORISKANY		25-74	Ridgeley Shriver	(c) Coarse sandstone above. (d) Chert below, fossiliferous.
		HELDERBERG		60	New Scotland	(e) Limestone and limy shale, local black shale at top; quite fossiliferous.
				3-4	Coeyman's	(f) Limestone, light gray, fossiliferous.
SILURIAN	SALINA	SALINA		200	Keyser	(g) Limestone and some shale. Limestone is lumpy and fossiliferous.
				148	Tonoloway	(h) Very thin-bedded limestone dominant; fossils scarce save for swarms of ostracoda.
				Trace	Wills Creek	(i) Greenish to Reddish shale. Divisions a-i are absent between Kittatinny and Little Mountains due to fault or unconformity.
				500	Bloomsburg	Red shale and sandstone.
	Niagaran	NIAGARA		20-40	Keefer Rochester	Shale. Massive gray sandstone.
	Medinan	MEDINA		300 to 750	Rose Hill	Red sandstones; highly ferruginous and with sericitic mud chips.
				275 to 750	Tuscarora	Gray, heavy, medium and thin-bedded sandstone and conglomerate. "Arthrophycus."
ORDOVICIAN	UPPER ORDOVICIAN	Juniata		80 to 1000	Juniata	Red conglomerate sandstone and shale.
		Bald Eagle "Oswego"		30 to 800	Bald Eagle "Oswego"	Gray sandstone and conglomerate, ferruginous.
		MARTINSBURG		200	Fairview	Sandstone.
				2000	Dauphin	Shale.

ORDOVICIAN SYSTEM

Cambrian rocks are not exposed in the region north from Harrisburg. The oldest system to be seen on the excursion is the Ordovician. The lower portion is chiefly thick dolomitic limestones and lies south of Harrisburg. The higher, clastic units are well exposed in the vicinity of Harrisburg and northward to the Susquehanna Gap. The Ordovician sequence in its entirety is as follows:

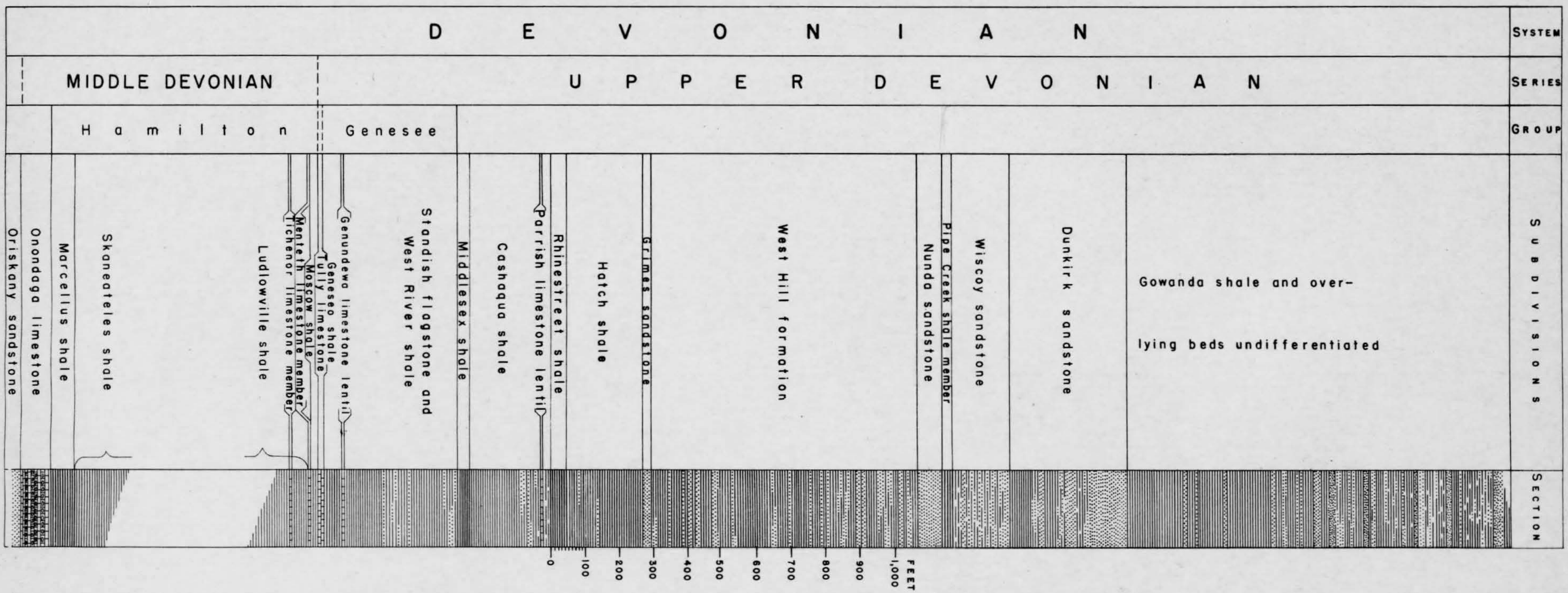
Juniata Red Beds
Bald Eagle conglomerate and sandstone
Martinsburg Group
Chambersburg Limestone
Stones River Limestone
Beekmantown Limestone

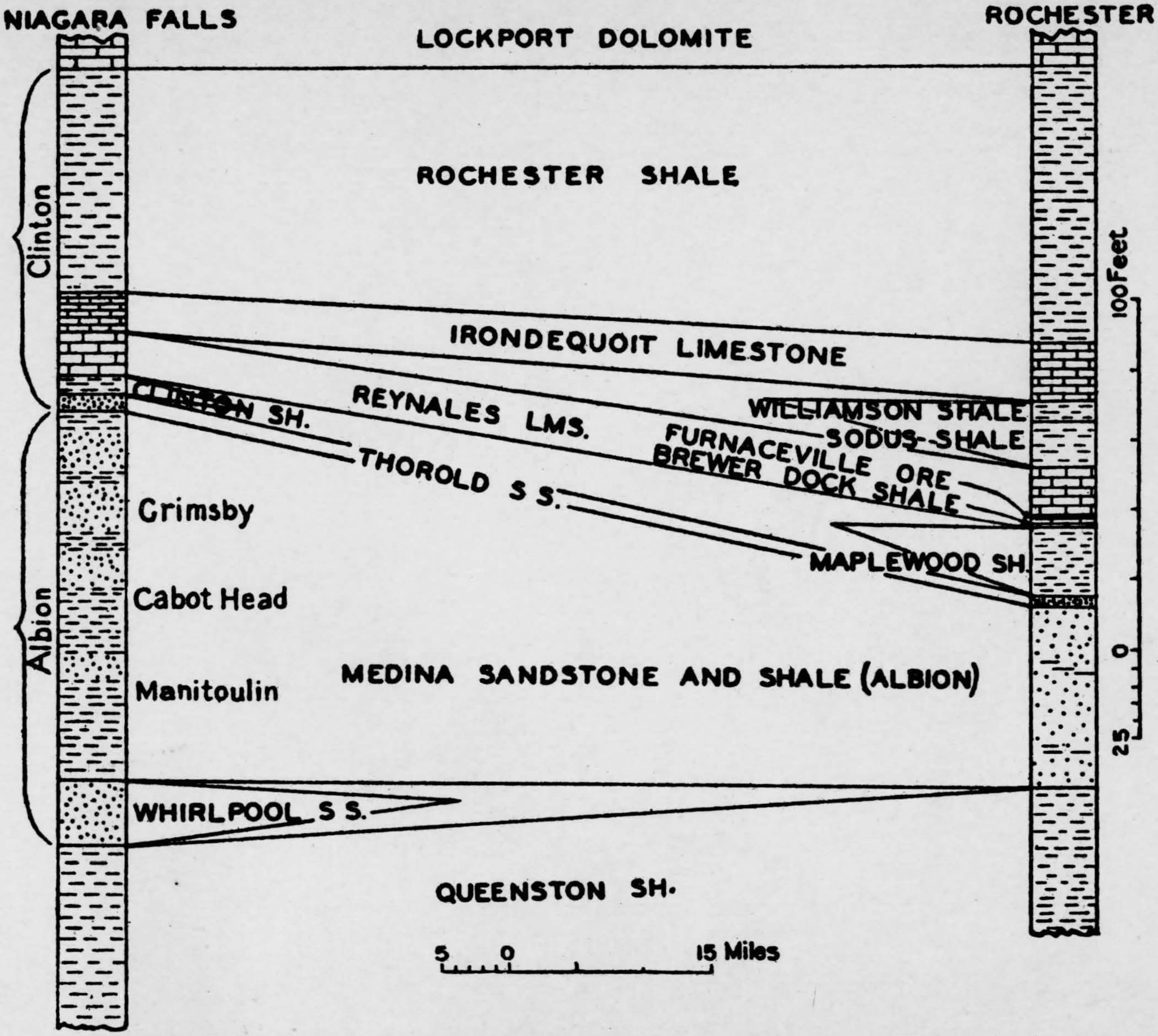
Adapted from Williard, Pennsylvania Topographic and Geologic Survey, Bulletin G8.

C

COLUMNAR SECTION—SOUTHWESTERN NEW YORK

MODIFIED AFTER U. S. G. S. BULLETIN 899A





Stratigraphic section of the Niagara Falls-Rochester area

Adapted from XVI International Geological Congress Guidebook 4.

COLUMNAR SECTIONS SHOWING STRATIGRAPHIC POSITIONS OF OIL AND GAS SANDS OF WESTERN PENNSYLVANIA

CHAS. R. FETTKE 1948