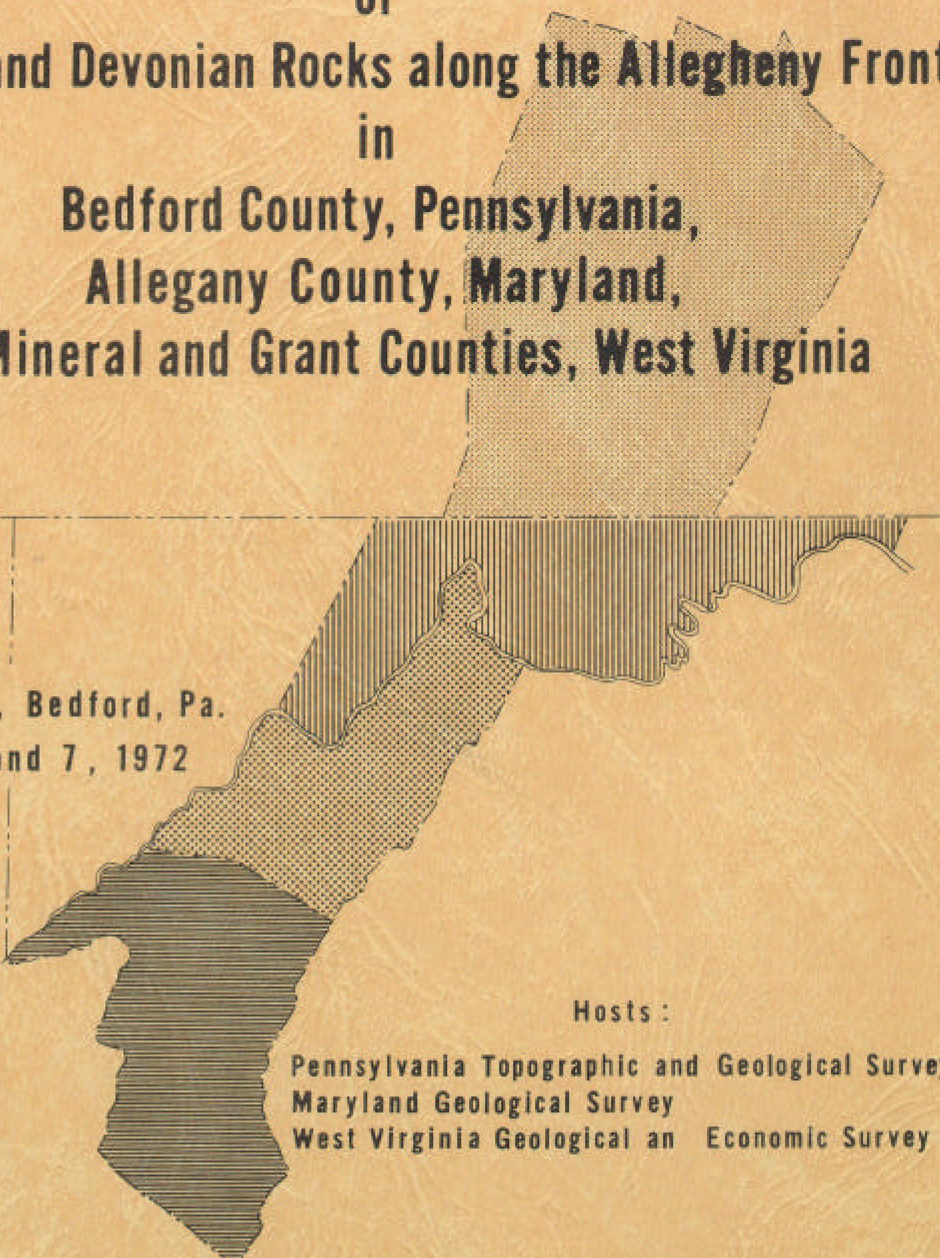
GUIDEBOOK

37th. Annual Field Conference Of Pennsylvania Geologists

Stratigraphy, Sedimentology, and Structure of Silurian and Devonian Rocks along the Allegheny Front in Bedford County, Pennsylvania, Allegany County, Maryland, and Mineral and Grant Counties, West Virginia



Holiday Inn, Bedford, Pa.
October 6 and 7, 1972

Hosts:

Pennsylvania Topographic and Geological Survey
Maryland Geological Survey
West Virginia Geological an Economic Survey

Guidebook for the 37th Annual Field Conference of Pennsylvania Geologists

October 6-7, 1972

STRATIGRAPHY, SEDIMENTOLOGY, AND STRUCTURE OF SILURIAN AND DEVONIAN ROCKS ALONG THE ALLEGHENY FRONT IN BEDFORD COUNTY, PENNSYLVANIA, ALLEGHENY COUNTY, MARYLAND, AND MINERAL AND GRANT COUNTIES, WEST VIRGINIA

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TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

Page

Page

INTRODUCTION

The upturned strata along the Allegheny Front have yielded some of the longest measured sections of Silurian through Pennsylvanian strata in the central Appalachians. The cause of this prominent linear topographic boundary between the Valley and Ridge and the Appalachian Plateau Provinces has been the topic of much geologic writing. In the past 20 years many workers have provided a much better understanding of outcrop and surface structural patterns and stratigraphic sections. The deep-seated cause for the structural and topographic front now seems related to a jumping upward to the northwest of the Appalachian décollement from Cambrian Waynesboro Formation under the Valley and Ridge Province to the Martinsburg-Reedsville Formation under the Plateau. Subsurface work by drilling and seismic investigation seems to verify the essential truth of such an hypothesis.

The purpose of this guidebook and field conference is to bring together those who have worked to solve the structural and stratigraphic problems of the Allegheny Front and to show the varied types of research done in recent years. We are especially grateful for the cooperative efforts of various funding agencies which have allowed us to examine the rocks over the years and to lead this field trip tracing the Allegheny Front geology from Pennsylvania southward across Maryland to West Virginia. This is the only way to demonstrate the regional continuity of certain stratigraphic and structural trends we wish to emphasize.

One additional worker should have contributed to our field trip, except for his untimely death doing geologic field work in Louisiana in 1968. Vinton Gwinn was especially fascinated by the Allegheny Front structure, and many of us writing in this guidebook have shared the stimulus of field examination of these rocks with Vint. He could not write specifically for this guidebook, but certainly his geologic contribution permeates the ideas here presented and the field discussion we hope to promote.

John M. Dennison
Guidebook Editor 1972

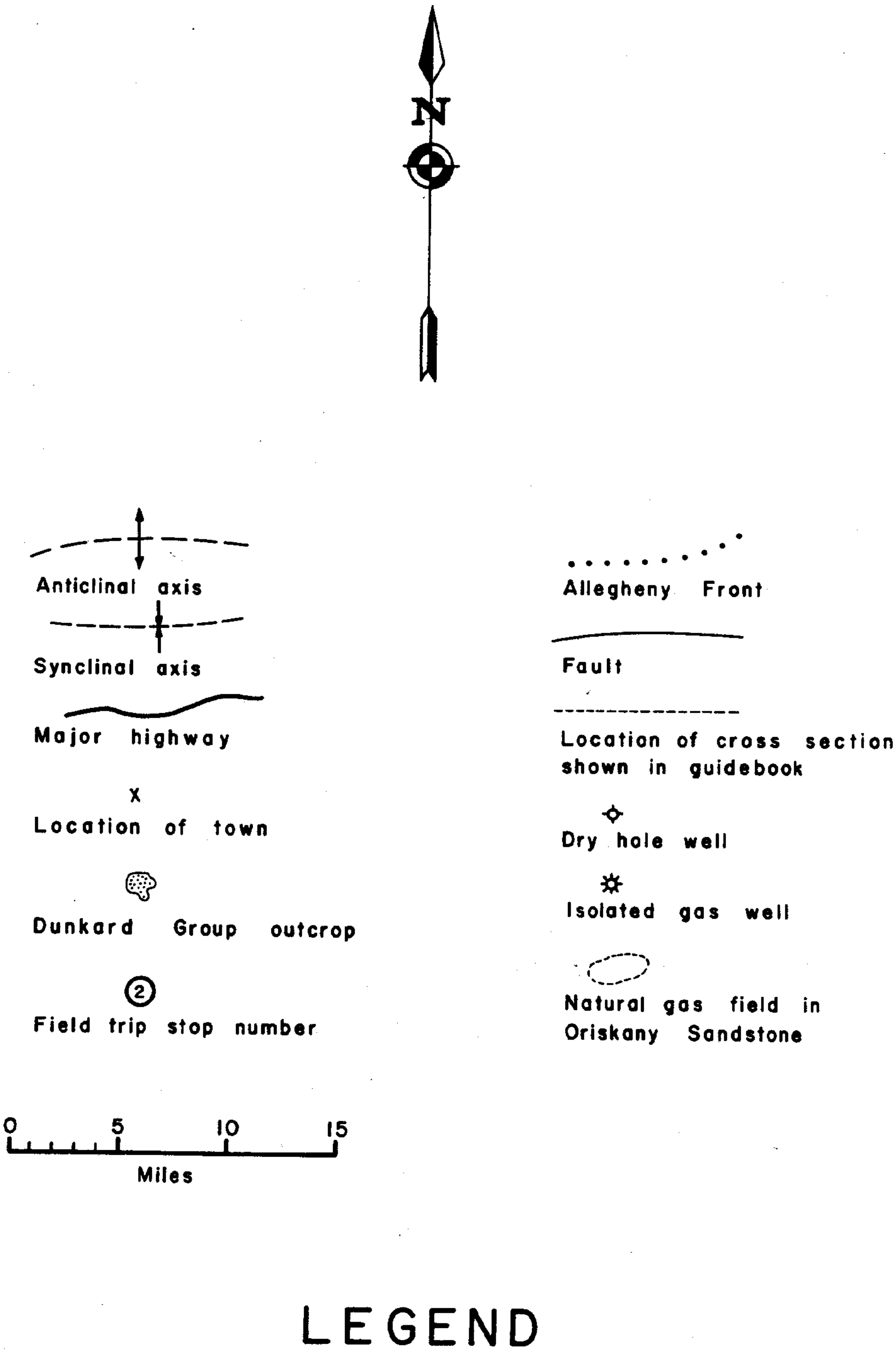
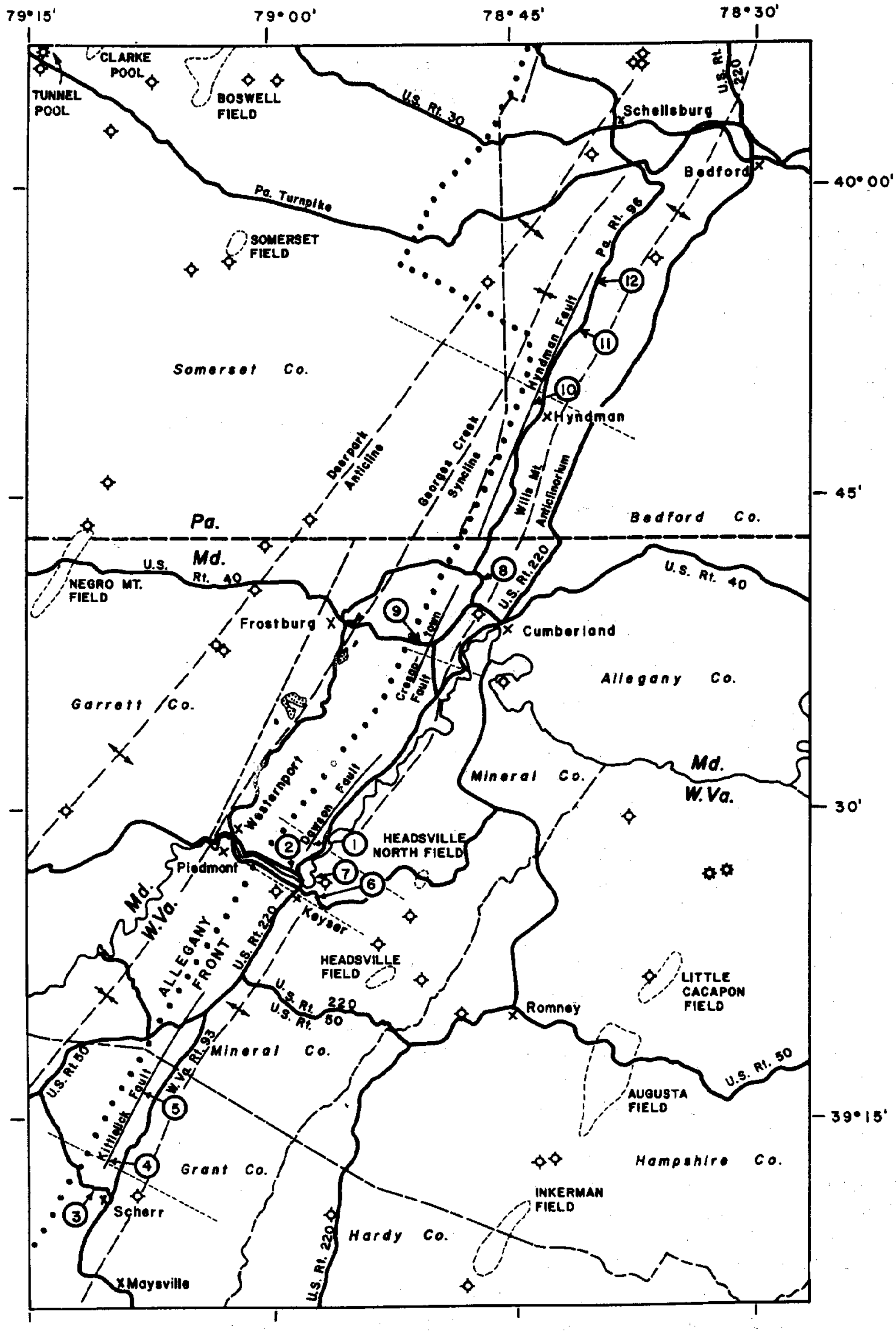


Figure 1 - Location map of field trip route and stops.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79°00'
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CLARKE POOL
TUNNEL POOL
BOSWELL FIELD
U.S. Rt. 30
Schellsburg
U.S. Rt. 220
Bedford
Pa. Turnpike
SOMERSET FIELD
Pa. Rt. 96
Somerset Co.
Hyndman Fault
Hyndman
Deerpark Anticline
Georges Creek Syncline
Wills Mt. Anticlinorium
Bedford Co.
Pa.
Md.
U.S. Rt. 40
NEGRO MT. FIELD
Frostburg
Cumberland
Allegany Co.
Garrett Co.
Cresap-town Fault
Westernport
Dawson Fault
Mineral Co.
Md.
W. Va.
HEADSVILLE NORTH FIELD
Piedmont
Keyser
ALLEGANY FRONT
HEADSVILLE FIELD
U.S. Rt. 220
U.S. Rt. 50
LITTLE CACAPON FIELD
Romney
U.S. Rt. 50
W. Va. Rt. 93
Kitzmiller Fault
Mineral Co.
AUGUSTA FIELD
Grant Co.
Hampshire Co.
INKERMAN FIELD
Scherr
Hardy Co.
Maysville
1
2
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11
12

GENERAL SUMMARY OF FORMATIONS EXPOSED ALONG FIELD TRIP ROUTE

<u>Pennsylvanian System</u> (2,150 feet)
- Dunkard Group (296 feet)
- Monongahela Group (336 feet)
- Conemaugh Group (900 feet)
- Allegheny Group (260 feet)
- Pottsville Group (360 feet)

<u>Mississippian System</u> (1,800 feet)
- Mauch Chunk Formation (970 feet)
- Greenbrier Limestone (two limestone zones with intervening redbeds) (410 feet)
- Pocono Group (300-500 feet)
  - Burgoon Sandstone (90-220 feet)
  - Manheim Formation (informally named by Dally, 1956) (58-200 feet)

<u>Devonian System</u> (7,500-9,800 feet)
- Hampshire Formation (1,700-2,200 feet)
- Greenland Gap Group (2,320-3,885 feet)
  - Foreknobs Formation (1,320-1,860 feet)
    - Pound Sandstone Member (23-179 feet)
    - Blizzard Member (405-471 feet)
    - Briery Gap Sandstone Member (39-92 feet)
    - Mallow Member (740-1,100 feet)
  - Scherr Formation (960-2,025 feet)
- Brallier Formation (1,800-2,200 feet)
- Harrell Shale (240 feet)
  - Burket Member (20-160 feet)
  - Tully Member (0-40 feet)
- Mahantango Formation (150-600 feet)
  - Clearville Siltstone Tongue (0-170 feet)
  - Frame Member (0-400 feet)
  - Chaneysville Siltstone Member (0-80 feet)
  - Gander Run Shale Member (0-150 feet)
- Marcellus Shale (450-800 feet)
  - Purcell Member (shale and limestone) (20-50 feet)
- Tioga Bentonite (3 feet)
- Needmore Shale (120-140 feet)
- Oriskany Sandstone (180 feet)
- Helderberg Group (460 feet)
  - Shriver Formation (85-160 feet)
  - Mandata Shale (15-20 feet)
  - Corriganville Limestone (formerly New Scotland Limestone) (27 feet)
  - New Creek Limestone (formerly Coeymans Limestone) (15 feet)
  - Keyser Limestone (upper part) (Total Keyser Formation 280-300 feet)
    - La Vale Limestone Member (35 feet)
    - Jersey Shore Limestone Member (100 feet)

GENERAL SUMMARY OF FORMATIONS EXPOSED
ALONG FIELD TRIP ROUTE (CONTINUED)

<u>Silurian System</u> (2,200 feet)

- Keyser Limestone (lower portion)
  - Big Mountain Shale Member (0-15 feet)
  - Beyers Island Limestone Member (160 feet)
- Tonoloway Limestone (600 feet)
- Wills Creek Formation (400-450 feet)
- Mifflintown Formation (310 feet):
  - Williamsport Sandstone (25-30 feet)
  - McKenzie Formation (250 feet)
  - (Williamsport Sandstone and McKenzie Formation: Bloomsburg Formation red-bed tongues (0-25 feet))
  - Clinton Group (450 feet)
    - Rochester Shale (28 feet)
    - Keefer Sandstone (8 feet)
- Rose Hill Formation (420 feet)
  - Cresaptown Iron Sandstone Member (10-30 feet)
- Tuscarora Sandstone (350 feet)

<u>Ordovician System</u> (1,000+ feet)

- Juniata Formation (600-800 feet)
- Oswego Sandstone (100-200 feet)
- Martinsburg Shale (Reedsville Formation) (1,600-2,000 feet)

THE ALLEGHENY FRONT FROM BEDFORD COUNTY, PENNSYLVANIA TO GRANT COUNTY, WEST VIRGINIA

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Washington, D. C.

and

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Introductory Remarks on the Allegheny Front

In southern Pennsylvania, western Maryland, and adjacent northern West Virginia, the Allegheny Front is a conspicuous escarpment, generally with more than 1,000 feet of relief, composed of rocks ranging in age from Devonian to Pennsylvanian. The Front separates the much folded and faulted older Paleozoic rocks in the Valley and Ridge Province to the east from the younger gently folded or nearly flat lying younger Paleozoic rocks in the Allegheny Plateau Province to the west (Fig. 1). In this area, the Allegheny Front is the east limb of the south-plunging Wellersburg-Georges Creek-Northern Potomac syncline. A relatively narrow strike valley separates the Allegheny Front from the west limb of the Nittany anticlinorium, which is represented here by the Wills Mountain anticline.

Outcropping bedrock shows a marked decrease in dip westward across the Front. Commonly, the dip of Devonian rocks along the foot of the escarpment in the strike valley is close to vertical, and locally the strata are overturned to the east. In contrast, the Pennsylvanian rocks on the western back slope of the escarpment dip gently into the Georges Creek syncline at 15 degrees or less. In the past, many workers noted the discordance of dip at the Front and showed the diminution of dip in regional cross sections. They also noted the apparent absence of thrust faults in the Allegheny Plateau west of the Front and assumed that thrust faults were not associated with the steeply dipping strata in the valley between the Front and the adjacent Wills Mountain anticline. Only during the past 20 years has detailed mapping provided the data necessary to document the existence of several thrust faults of considerable stratigraphic displacement and geographic extent along this segment of the

Allegheny Front (Dennison, 1955; Dennison, 1963; Dennison and Naegele, 1963; de Witt and Colton, 1964; Dyott, 1956; and Dennison, Travis, and Ferguson, 1966).

Prior to the deep exploratory-drilling program for gas and oil in the 1950's and the intensive structural studies engendered by this program, the classic concept of folding and faulting in this part of the central Appalachians was "thick skinned" and was based on the premise that the Precambrian basement rocks were actively involved in the folding. It was assumed that the major thrust faults cut down into the crystalline rocks of the basement and that basement rock formed the core of each of the larger anticlines. Thrust faulting was assumed to stop at or well east of the Allegheny Front.

Relatively recent studies and syntheses of the structure and tectonics in this part of the Appalachians by Rodgers (1963), Gwinn (1964), and Perry (1964, 1971), based on surface and subsurface data both geological and geophysical, clearly showed that the concept of "thick-skinned" tectonics with basement involvement is incorrect. Instead, they demonstrated that most of the thrusting and folding was confined to the Paleozoic cover and that the Precambrian basement was little involved in the deformation which encompassed the Valley and Ridge. They used the term thin-skinned tectonics for this type of deformation in the central Appalachians.

They demonstrated that several thick zones of soft relatively ductile rocks--shale, evaporites, mudstone, and thin-bedded limestone or siltstone intercalated with shale or mudrock--acted as slip zones or decollement zones. Nearly flat thrust faults within the slip zones permitted the overlying strata to slide and buckle while the strata below the slip zone remain essentially undeformed. These slip zones, in ascending stratigraphic order, are Cambrian Waynesboro Formation and its lateral equivalent the Rome Formation, Upper Ordovician Reedsville-Juniata sequence, Upper Silurian Wills Creek-Tonoloway-Salina sequence, and the Lower and Middle Devonian shale sequence. These zones of relatively incompetent strata are sandwiched between thick zones of resistant relatively nonductile brittle rocks. The resistant units, in ascending stratigraphic order, are Lower Cambrian clastic sequence, Cambro-Ordovician carbonate sequence, Lower Silurian clastic sequence, and Upper Devonian-Lower Mississippian clastic wedge.

Rodgers (1963) and Gwinn (1964) showed that much of the shortening within the near-surface rocks in the western part of the Valley and Ridge and the adjacent part of the Allegheny Plateau was accomplished by thrusting along nearly flat bedding-plane thrusts in the Waynesboro and Reedsville-Juniata slip zones. Gwinn demonstrated that large anticlines formed in the overriding thrust plate at localities where the major décollement thrust cut up steeply across a sequence of resistant strata in passing from one slip zone to the next successively younger zone. The overlap of thick parts of the stratigraphic sequence as the eastern plate of rock overrode the edge of its western neighbor produced stresses, which were relieved by the formation of an anticline in the eastern overriding plate. Commonly, in the eastern part of the Valley and Ridge, faults cut to the surface on the west flank of the growing anticlinal fold, permitting the anticline to override the adjacent western syncline. In the western part of the Valley and Ridge, adjacent to the Allegheny Front, the overall slip on the major décollement was less, although it was in the order of a number of miles, and fewer thrusts cut through the full stratigraphic sequence to the earth's surface.

Deep drilling for gas and oil adjacent to the Allegheny Front confirmed that nonoutcropping flat-thrust faults with great slip pass under the Front and extend for many miles under the Allegheny Plateau. As in the Valley and Ridge, where the flat-thrusts ramp up section from one slip zone to another, they produce a surface anticline. Structure in the gas-productive Ridgeley Sandstone is commonly very complex with several faults on both sides of the anticline (Gwinn, 1964, p. 875), whereas the anticline in the younger near-surface beds is a broad gentle symmetric fold. Apparently, much of the slip on the faults is absorbed by adjustments in the thick sequence of shaly Devonian rocks above the Ridgely as the faults do not cut into the Mississippian or younger strata.

Hyndman Region

North of Corriganville, the Wills Mountain anticline increases in amplitude and the width of Wills Creek valley decreases as the Allegheny Front trends northeast toward Wills Mountain at a low angle. The horizontal distance between the basal Pennsylvanian sandstone at the top of the Front and the top of the Tuscarora Quartzite on the west flank of Wills Mountain decreases from about 14,000 feet at Corriganville to a minimum of slightly less than 10,000 feet at Hyndman. A small amount of the thinning is due to increased dip and the extinction of local folds, but most of the difference in distance results from strata being cut out by thrust faulting along a zone of faults, which is here informally named the Hyndman fault zone.

In contrast to the Kittlelick thrust fault in Grant and Mineral Counties, W. Va., which seems to be a single fault zone, displacement in the Hyndman area occurred along several faults at different places in the stratigraphic sequence. The total stratigraphic displacement of the several faults in the Hyndman zone (cross section in Fig. 2) is about 3,000 to 3,500 feet at its maximum. Commonly, one or more east-dipping relatively steep thrust faults cut outcropping Lower and Middle Devonian strata, and one or more faults of lesser stratigraphic displacement may cut exposed strata as old as Late Ordovician on the west face of Wills Mountain or lie concealed by a blanket of alluvium along the mountain's west flank. The Hyndman fault zone is shown as a single line on the generalized geologic map (Fig. 1). Although individual faults in the Hyndman zone may cut up or down in the stratigraphic sequence, they commonly occur in sequences of incompetent shaly strata or in sequences of thin-bedded siltstone or limestone intercalated in shale or mudrock. Faults can be expected in the Reedsville, Rose Hill, Wills Creek, Tonoloway, Needmore, Marcellus, Brallier, or Scherr Formations. Because of extensive cover of alluvium and colluvium in the valleys of Wills and

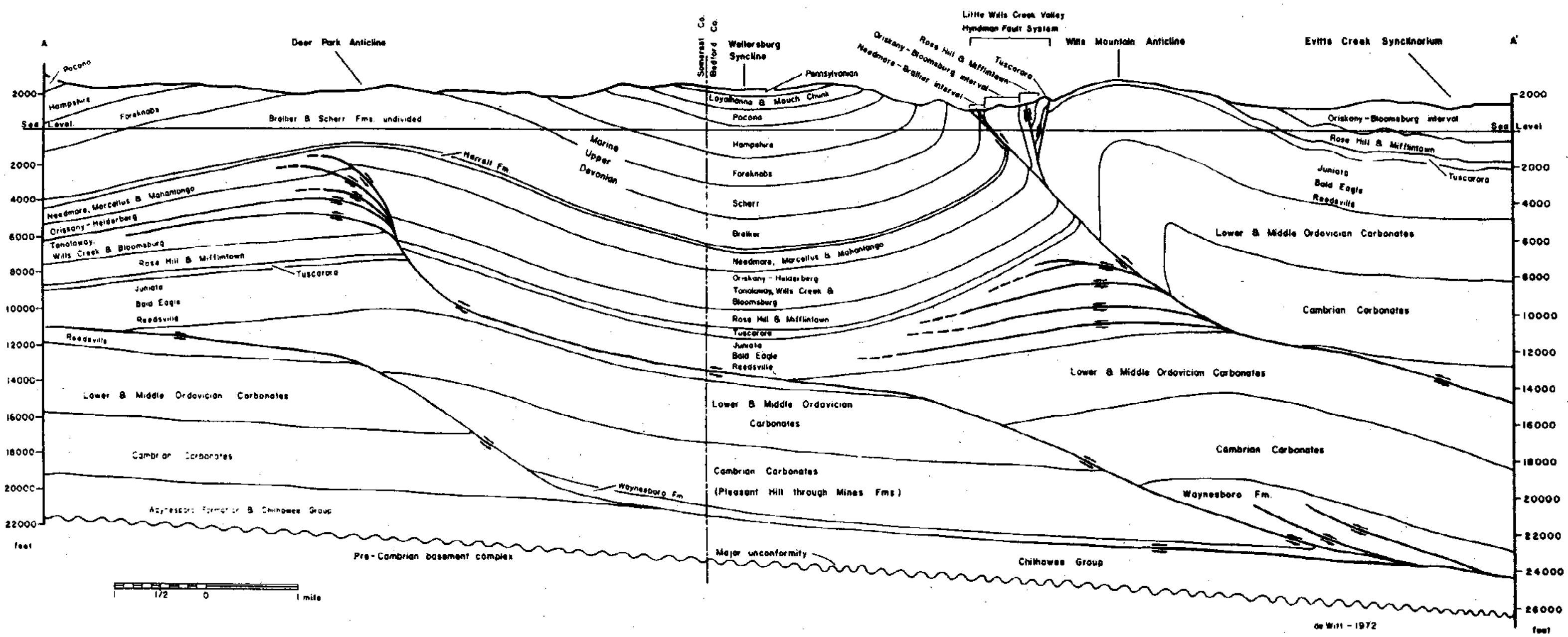

Figure 2 - Cross section of the Allegheny Front near Hyndman, Pennsylvania.

Little Wills Creeks and the absence of long-continuous exposures across the regional strike, faults in the Hyndman zone are difficult to locate in the field and are generally revealed by the absence of or duplication of key beds observed in detailed mapping. For example, a thrust in the Hyndman zone has cut out about 700 to 800 feet of beds in the Brallier Formation along Wolf Camp Run, west of Madley, Pa. (Stop 11); however, the position of the fault within this monotonous sequence of thin-bedded turbidites is hidden.

At Hyndman, the Hyndman fault zone is indicated mainly by an east-dipping thrust which carried strata in the lower part of the Brallier Formation west into contact with rocks in the middle and upper part of the Scherr Formation. This fault has a stratigraphic displacement of about 2,500 to 2,800 feet in the narrow ridge between the town of Hyndman and the crossroads of Wills Creek (Stop 10) 0.5 mile to the north. Detailed mapping in progress suggests that at this locality another thrust located 500 feet to the east in the Marcellus-Mahantango sequence has cut out more than 200 feet of soft strata in the lower part of that sequence. At least one other thrust is present in the valley of Little Wills Creek cutting strata in the Tonoloway-Keyser sequence. All of these faults are surface manifestations of greater faulting at depth.

In addition to the east-dipping thrust faults, a steeply inclined west-dipping high-angle reverse fault, an up-limb thrust, of small stratigraphic displacement commonly is associated with the west over-steepened limb of the Wills Mountain anticline or drag folds on the west side of the anticline in close proximity to the Hyndman fault zone. In these up-limb thrusts, the sense of movement is from west to east in contrast to the major thrusts in which movement was from east to west. The sharp ridge of Tuscarora Sandstone on the west side of Reservoir Hollow, a deep indentation on the flank of Wills Mountain east of the crossroads of Wills Creek, is a conspicuous example of an up-limb thrust. The fault cuts the west-dipping limb of the Wills Mountain anticline, and the steeply dipping beds of Tuscarora in the west plate of the fault moved up and east over the more gently dipping Tuscarora in the sole block. Up-limb thrusts are not uncommon in the Appalachians (de Witt and Colton, 1964; Englund, 1964; Perry, 1971; Pierce, 1966; Wood and Kehn, 1968) and are commonly associated with east-dipping thrusts of greater displacement. Apparently, the up-limb thrusts form on the east limb of synclines as compression squeezes material up and out of the core of the syncline during folding. Thrust faulting with movement to the west relieves much of the stress, but some stress is removed by high-angle faulting along the conjugate shear to the main thrust. The conjugates are the up-limb faults which generally show less stratigraphic displacement and steeper dip than the associated east-dipping thrusts.

Other indications of deformation in the Hyndman fault zone include drag folds, slickensides and incipient fracture cleavage in the shaly units and gash veins, crushed zones, brecciation, and disharmonic folding associated with small displacement thrusts in the thin-bedded limestones. Most of the small-scale features are difficult to find, because they are rarely observed except in quarries or other artificial exposures.

The Hyndman fault zone roughly parallels the Allegheny Front from Ellerslie at the Maryland-Pennsylvania State line north to the town of Hyndman where the fault zone is abruptly crossed at right angles by Wills Creek. North of Hyndman, the faults lie in the valley of Little Wills Creek for about 4 1/2 miles to the vicinity of Gravel Pit Station. Northward to Madley and Bard, the main fault in the Devonian rocks lies in the low hills west of the creek. Scant data indicate that the fault within the Brallier-Scherr sequence decreases in stratigraphic displacement north from Hyndman to Bard and has an offset of about 800 feet in the section along Wolf Camp Run west of Madley (Stop 11).

The faults in the Hyndman fault zone are surface manifestations of much greater faulting at depth as indicated on the cross section (Fig. 2). The interpretation shown, which is one of several possible reconstructions, is based upon surface data, scant well data, geophysical estimates of depth to the Precambrian basement, thickness of the stratigraphic sequence, and "thin-skinned" folding. Thrusts in the Hyndman fault zone rise as splays from a deeply buried nonoutcropping flat thrust, here informally designated the Wills Creek thrust, which apparently sheared or ramped upward from the main décollement in the Cambrian Waynesboro slip zone under Evitts Mountain, the anticline next east of the Wills Mountain fold. The Wills Creek thrust cut up through the stratigraphic sequence, and much of the movement along the fault was taken up by repeating parts of the Late Ordovician Reedsville-Juniata sequence under the west flank of Wills Mountain at depths of about 8,000 to 13,000 feet below sea level. Smaller displacement faults rose from the Wills Creek thrust and broke the surface rocks in the Hyndman fault zone. Whether or not the main Wills Creek fault passed into a bedding-plane thrust in the Reedsville-Juniata slip zone and extended west to join other faults rising to this zone under the Appalachian Plateau is conjectural.

The Kerr-McGee Mary Martin #1 well, which was drilled high on the east flank of the Wills Mountain anticline about 10 miles northeast of Hyndman, encountered a major, nonoutcropping thrust in the basal part of the Cambro-Ordovician carbonate sequence at 4,400 feet below sea level and partly penetrated an overturned section of Reedsville-Juniata strata below the thrust (Wagner, 1966). These data show that the highest nonoutcropping thrust under Wills Mountain, which is probably the Wills Mountain thrust, lies in and is involving rocks in the Reedsville-Juniata slip zone.

The depth to the Precambrian basement and thickness of the stratigraphic sequence determined, in part, from deep-well data indicate that the wedge of rock above the main décollement in the Cambrian Waynesboro Formation under Wills Mountain is about double the thickness of the normal stratigraphic section, which suggests the presence of another fault ramping up from the main décollement under the Wills Mountain fold. This intermediate thrust, here informally named the Wellersburg thrust, cuts up section from the Waynesboro slip zone across the Cambro-Ordovician carbonate sequence and into the Ordovician Reedsville-Juniata slip zone under the Wellersburg basin. The fault continues to climb in the stratigraphic section. To the west on the contiguous Deer Park anticline, the Peoples Natural Gas Co. Nellie R. Mowery #1 well at Mt. Zion shows that the Wellersburg fault breaks up in several splays in the overthickened sequence of thin-bedded limestone and evaporites in the Late Silurian slip zone. Corroboration of the western rise of the Wellersburg thrust can be found in the Schellsburg dome which lies about midway between the Wills Creek and Deer Park anticlines and north of the end of the Wellersburg basin. In the Jesse Miller #1 well, which was drilled on the crest of the Schellsburg dome, a nonoutcropping thrust repeats almost all of the Tuscarora Quartzite and the lower part of the overlying Rose Hill Formation--units which are intermediate between the Reedsville-Juniata slip zone and the Late Silurian slip zone.

In turn, the major décollement leaves the Waynesboro slip zone under the Deer Park anticline and ramps up section to the Reedsville-Juniata slip zone where it passes from a high-angle thrust to a near-bedding-plane thrust. Most probably, the fault continues to ramp upward across the stratigraphic section to the west into the Late Silurian slip zone under the Negro Mountain anticline. Data are lacking to determine if the near-bedding-plane Wellersburg thrust died out in the Berlin syncline west of the Deer Park anticline or if the thrust persisted to the west and joined the ramping major décollement in the Negro Mountain anticline.

Corriganville to Cresaptown Region

From Ellerslie southward to Jennings Run at Corriganville a seemingly complete Devonian stratigraphic section exhibits no evidence of faulting in the steeply dipping beds on the west flank of the Wills Mountain anticlinorium. Dennison has pieced together a nearly continuous measured section of these strata at Corriganville, using plane table surveys to project various exposures to their proper place in the composite stratigraphic column. The Cash Valley-Wills Creek Valley is exceptionally wide at Corriganville, resulting from the greater and complete thickness of the Romney Group (Needmore through Harrell Shales) and the Brallier Formation (Woodmont Shale of older Maryland literature).

As one proceeds southward from Corriganville along the Cash Valley Road, the valley becomes much narrower, marking the north terminus of another splay from the main Wills Mountain thrust, a fault named the Cresaptown fault by Dyott (1956) who first detected it near Cresaptown. Earlier mapping of Allegany County (O'Harra, 1900; Colton and others, 1956) had failed to recognize this fault because of insufficient knowledge of Devonian shale stratigraphic details. Dennison and Naegele (1963) mapped the full extent of the fault (Fig. 3 of present guidebook). A cross section prepared from surveys at the Sears Town shopping center in La Vale is shown as Figure 4. This is at Stop 9 of this field trip. In 1963 the surface trace of the Cresaptown fault was thought to pass with shallow dip into the Martinsburg Shale beneath Haystack Mountain (Wills Mountain anticline), based by analogy with Dennison's experience with a much smaller fault at Queens Point near Keyser (Dennison and Naegele, 1963, p. 29-31). Now Dennison would favor redrawing Figure 4 of this guidebook, having the Cresaptown fault dip more steeply and be a splay fault rising from the main décollement. The Cresaptown fault seems to be essentially

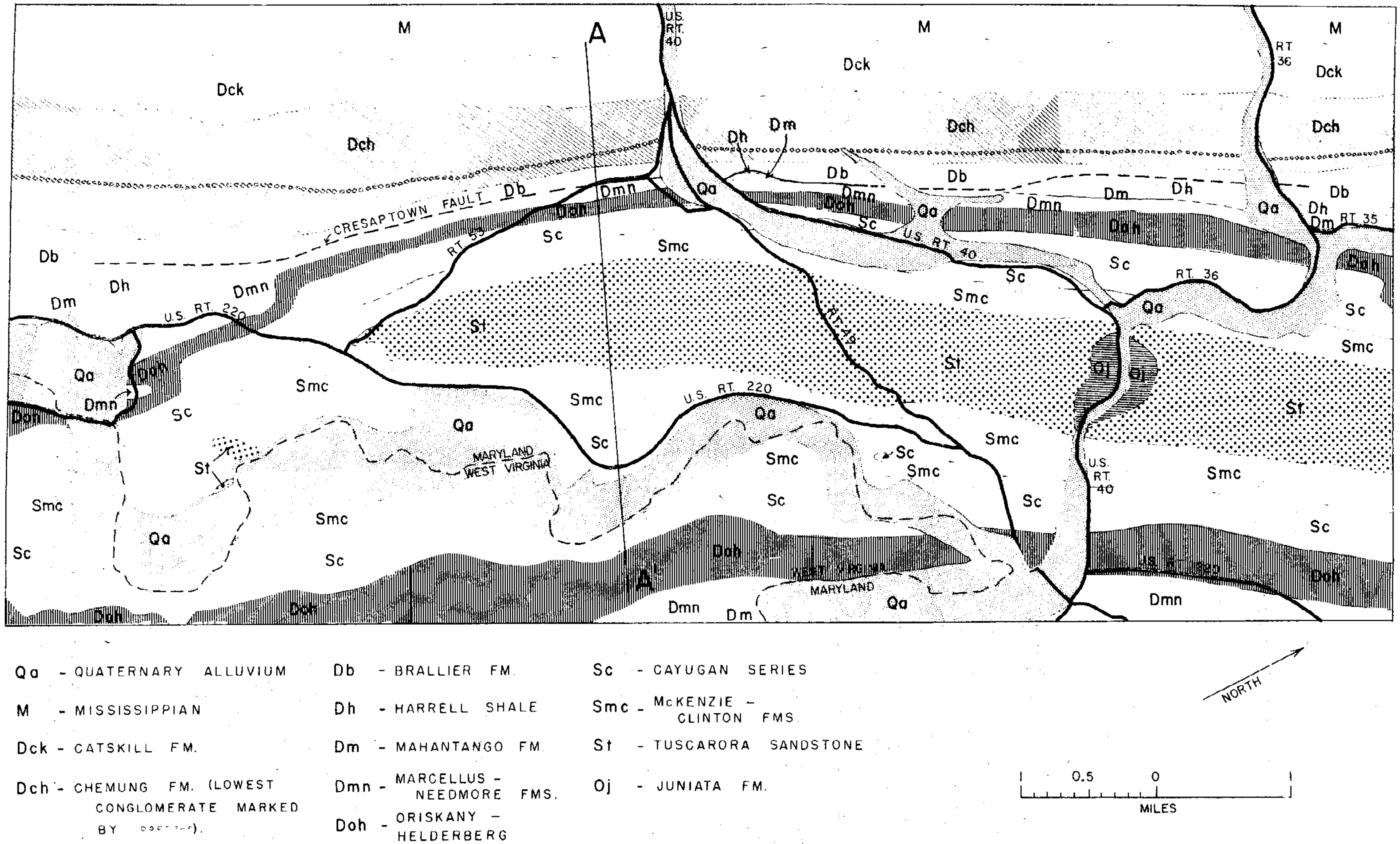

Figure 3 - Geologic map of Cresaptown fault (from Dennison and Naegele, 1963).

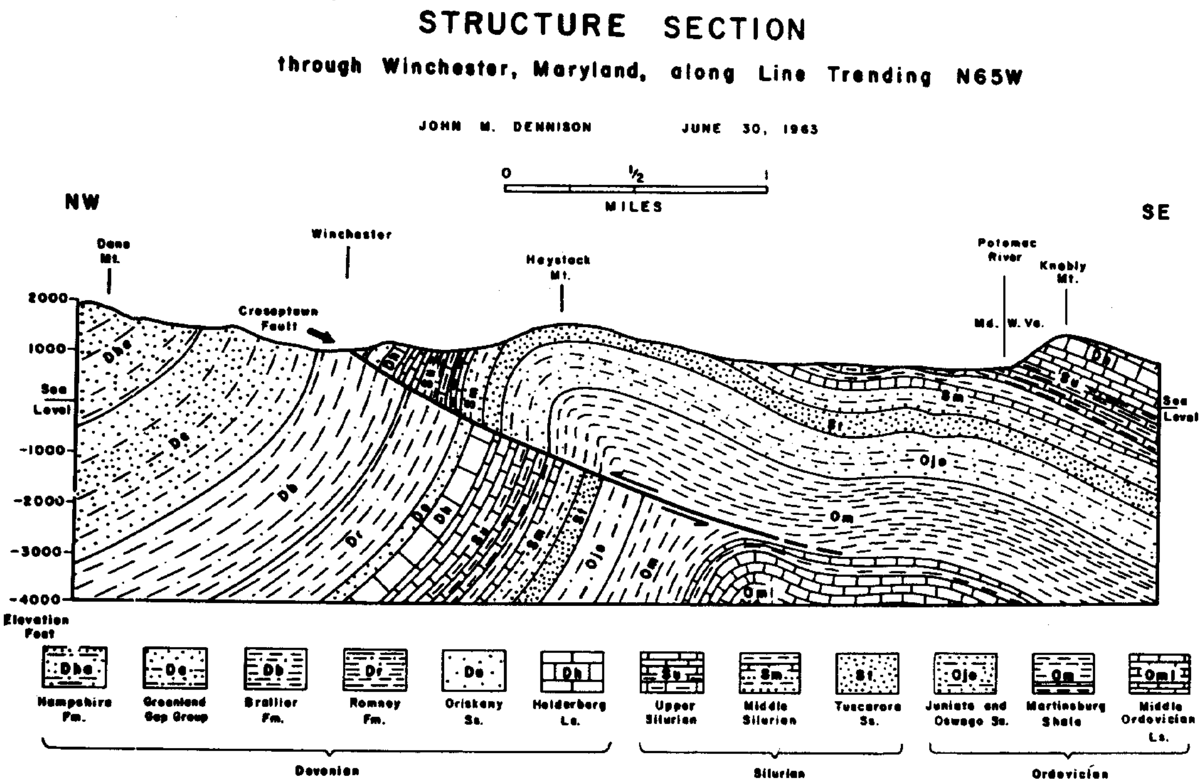

Figure 4 - Cross section of Cresaptown fault at line of section shown on Figure 3 (after Dennison and Naegele, 1963).

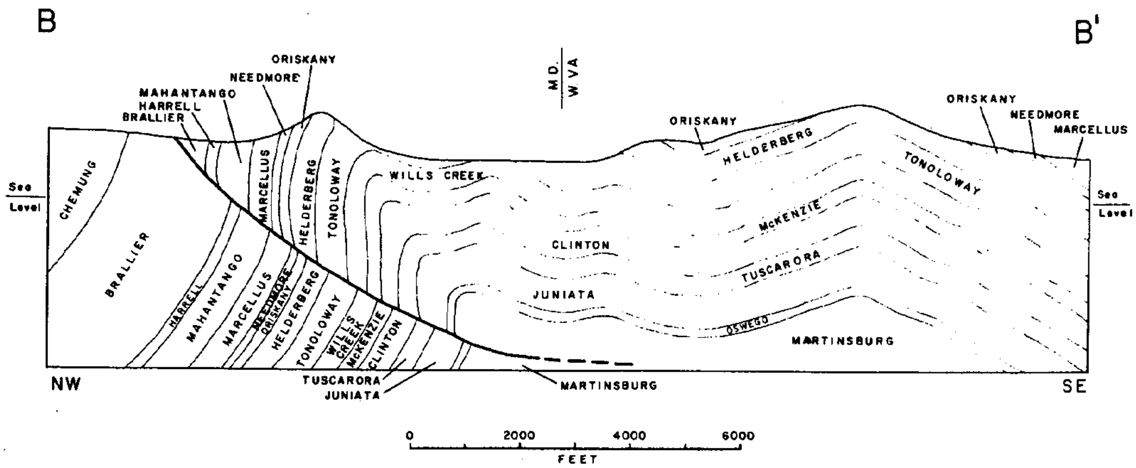

Figure 5 - Cross section of Dawson fault at Dawson (from Dennison and Naegele, 1963).

a single fault throughout its entire extent, and is shown as a single line on the Geologic Map of Maryland (Cleaves, Edwards, and Glaser, 1968). The Cresaptown fault is detectable only by thinning of the Brallier Formation outcrop belt, and is thought to be localized within the upper Brallier, based on the subtle stratigraphic division of the Brallier which Dennison thinks he can recognize in the Cumberland region. Hasson (1966; also this guidebook) showed the omission of some of the Burket Member of the Harrell Shale in an exposure at the State Police building in La Vale, which would either be caused by a sliver of the Cresaptown fault or represent attenuation of the weakest portion of the Harrell Shale in a sort of boudinage effect. Maximum displacement on the Cresaptown fault is at the Sears Town shopping center, where on the east side of Route 53 there are exposures of lower Marcellus Shale, with uppermost Brallier Formation exposed on the west bank of the road. Some 2,000 feet of strata are omitted by the fault there.

The southernmost extent of the Cresaptown fault is near Pinto, at which point the Brallier outcrop belt broadens into a stretch extending several miles southward without known faulting.

Southern Allegany County

The deformation in southern Allegany County is not as great as near La Vale, but a thrust fault does cause omission of up to 800 feet of Brallier strata near Dawson. Dennison first detected it in 1956, and later slightly revised the map of the south terminus (Dennison, 1963). The full extent of the fault is delimited on the new Geologic Map of Maryland (Cleaves, Edwards, and Glaser, 1968). The exact position of the Dawson fault cannot be located within the monotonous succession of Brallier strata, but it is thought to be localized as a zone within the upper portion of the Brallier Formation. The Dawson fault is described in some detail by Dennison and Naegele (1963, p. 31-33), which is the source of Figure 5 of this guidebook. The fault in this cross section probably should be redrawn to show steeper dip, so that the Cresaptown fault would be a splay from the main décollement.

Keyser Area

Repeated study of the Keyser area has revealed no surface expression of faulting along the Allegheny Front (Reger and Tucker, 1924; Dennison, 1963). From Keyser to New Creek several small anticlines have been mapped in the Oriskany Sandstone through Mahantango Formation stratigraphic interval. It is believed that the Devonian Marcellus through Scherr stratigraphic interval is thicker here than anywhere else along the Allegheny Front (Fig. 6), and absence of surface faulting may result simply because there is great enough thickness of shale to absorb stresses by folding.

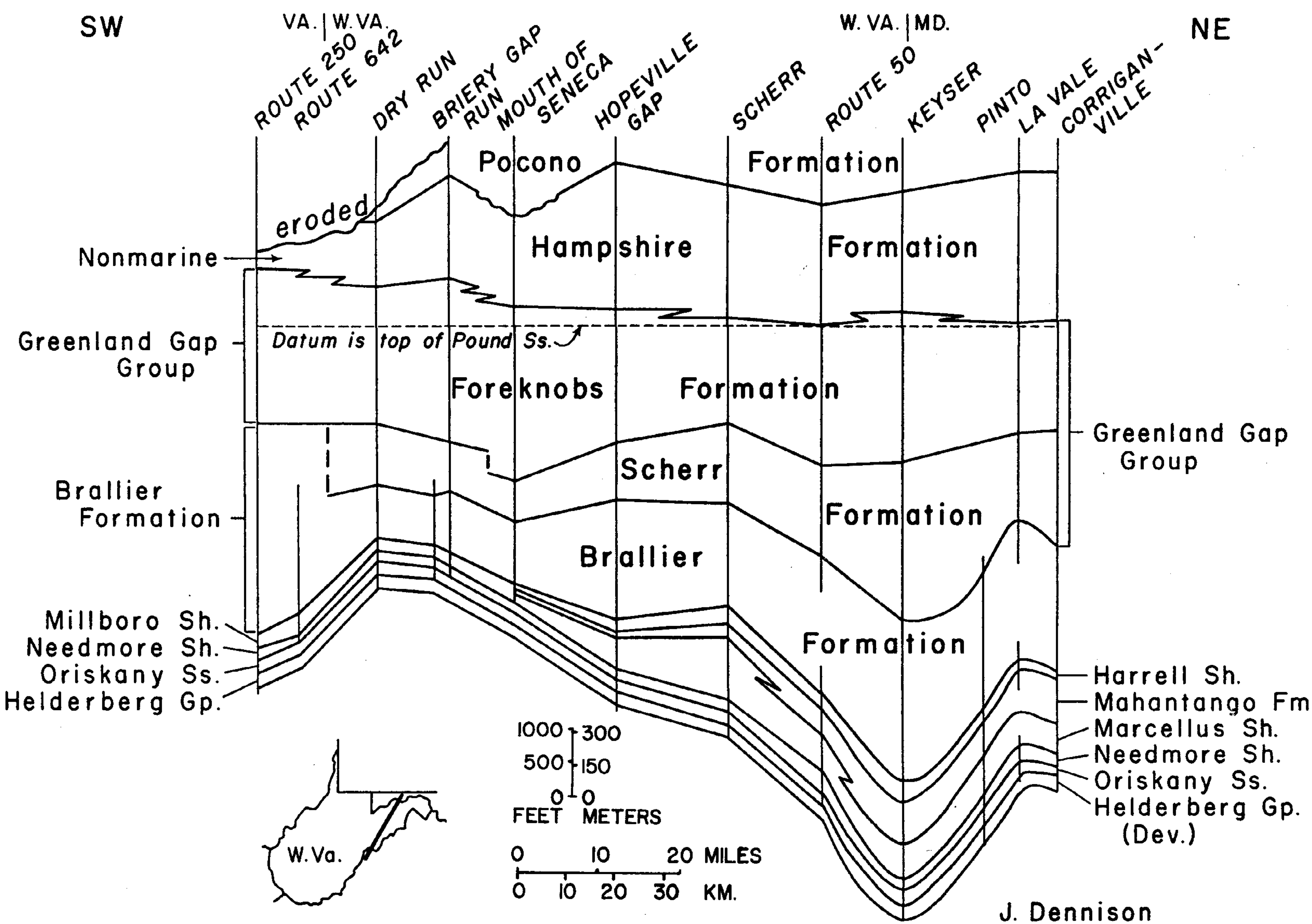

Figure 6 - Generalized stratigraphic cross section of Devonian System along the Allegheny Front outcrop belt (from Dennison, 1971).

The Davis No. 1 well drilled by Pittsburgh Plate Glass Company is in an amazing location (Fig. 1), considering surface geology only. It occurs a mile west of Keyser, spudded into the Hampshire Formation with a steep upturned dip along the Allegheny Front. This seismic prospect was drilled for an Oriskany high, either caused by faulting or folding. The structural style of Oriskany Sandstone is commonly with folds about a half-mile in wave-length. This manner of folding is displayed in the Oriskany itself in outcrops from Keyser to New Creek, and is thought to continue westward toward the Allegheny Front, based on anticlines mapped by Dennison near New Creek in the Needmore-Mahantango shaly interval. The seismic structural high drilled near Keyser probably represents another of these anticlines in Dennison's judgment, although it could represent back-thrusting in the subsurface. In all his detailed surface mapping from Scherr to Corriganville, Dennison has never detected an outcrop pattern of faulting which could be interpreted as a back-thrust, but this does not preclude back-thrusting at depth, especially in the more gently dipping beds to the west beneath the Allegheny Front.

The structurally simple cross section based on careful mapping in the Keyser area (Fig. 7) is shown here as a reminder that the common style of deformation along the Allegheny Front from Pennsylvania to Virginia is simple folding of near-surface strata rather than the more spectacular thrust faults shown in most of the cross sections illustrating this guidebook. Of course, the extent of known faulting will only increase as mapping progresses in greater detail, but probably all the significant faults cutting the Devonian clastic sequence have been discovered in the Allegheny Front outcrop belt extending a distance of 150 miles from Bedford County, Pennsylvania, to Highland County, Virginia.

Kittlelick Fault Segment

Dennison and Naegele (1963, p. 37) suggested a possible fault within the Brallier Formation where crossed by U. S. Route 50. Evidence for a fault became compelling when excavations and drill cores were examined at the Keyser Reservoir site (Stop 5 of this guidebook). Dennison, Travis, and Ferguson (1966) named this the Kittlelick fault, from Kittlelick Ridge near the Mineral-Grant County boundary. All the faulting seems localized in the upper part of the Brallier Formation. Figure 8 portrays the stratigraphic displacement along the Kittlelick fault, attaining an estimated maximum of about 1,300 feet.

An actual fault plane cannot be located within the Brallier Formation, perhaps partly as a result of the monotony of the stratigraphic succession. At the west end of Kittlelick Ridge a mashed zone occurs in the uppermost Brallier (which Formation is only 280 feet thick there), with the conjugate shear fracture pattern illustrated in Figure 9. Both shear planes strike N28°E. The average dip of the two shear sets is 32°NW and 46°SE. Kittlelick fault is presumed to dip about 46°, and such an estimate seems good, since a projection of 46° from the fault trace almost exactly intersects the level of a major fault encountered in the Shell Oil Co. Greenland Lodge No. 1 well 1.6 miles east of Scherr.

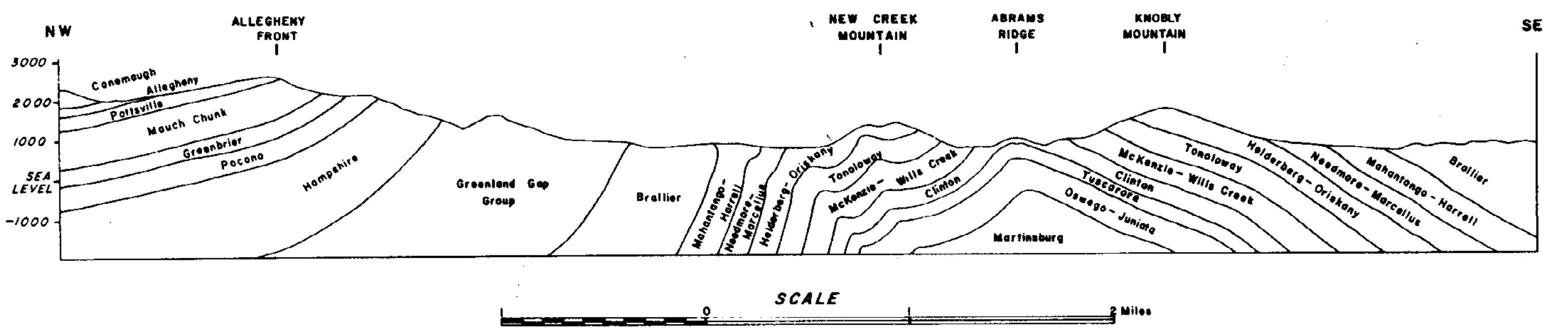

Figure 7 - Cross section of the Allegheny Front near Keyser, West Virginia (after Dennison, 1963).

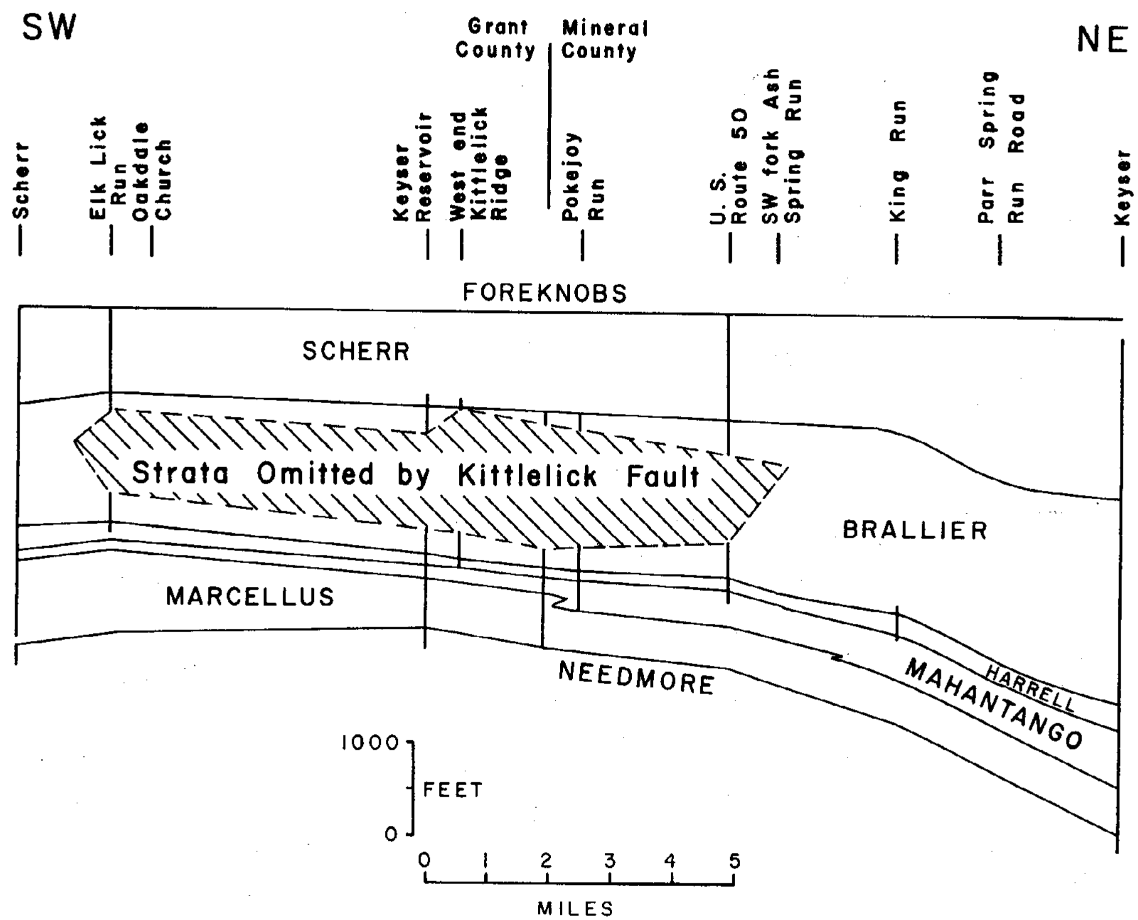

Figure 8 - Stratigraphic displacement in Brallier Formation caused by Kittlelick Fault (stratigraphic nomenclature modified from Dennison, Travis, and Ferguson, 1966).

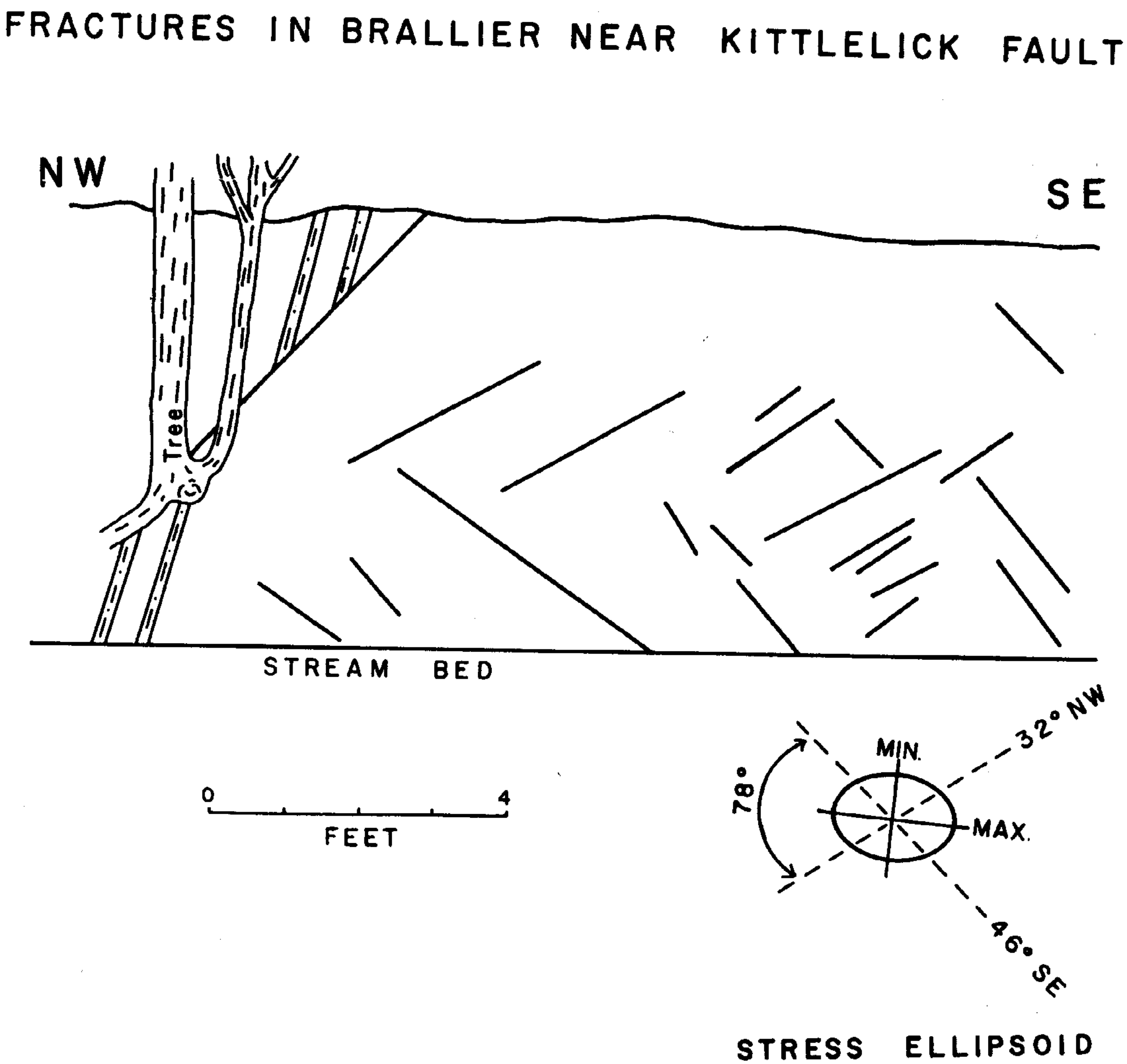

Figure 9 - Conjugate shear pattern exposed at west end of Kittlelick Ridge in Grant County, West Virginia. The Kittlelick fault is a zone of fractures dipping 46 degrees to southeast, rather than a single fault plane in the Brallier Formation.

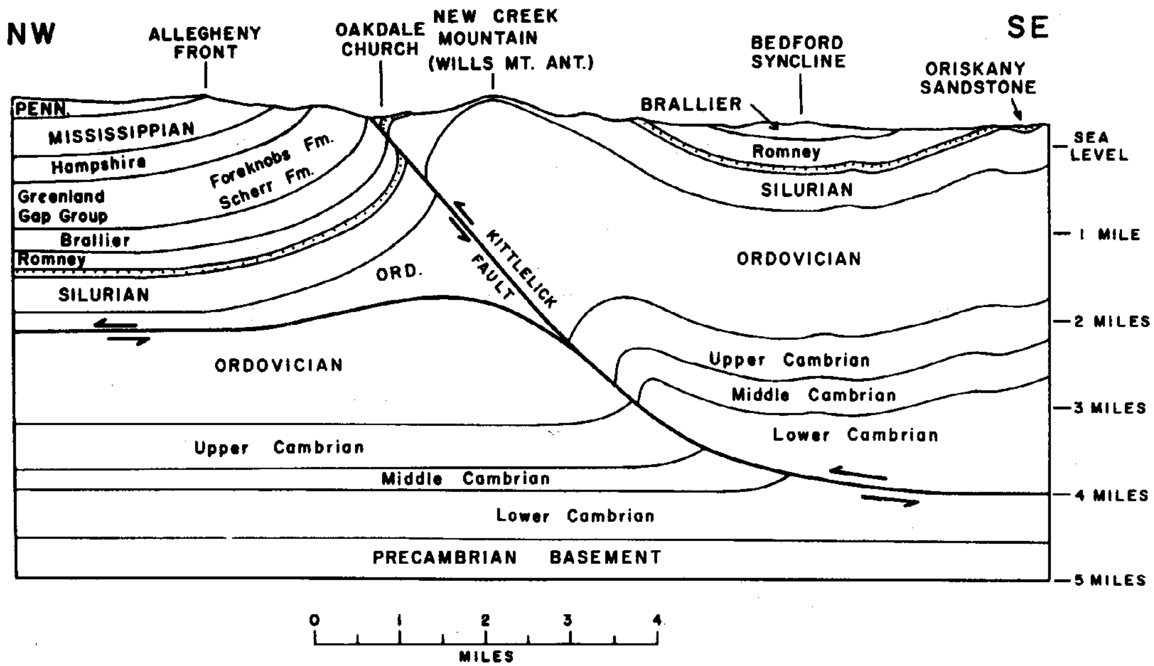

Figure 10 - Cross section of Wills Mountain anticlinorium and the Allegheny Front at Oakdale Church, Grant County, West Virginia (modified from Dennison, Travis, and Ferguson, 1966, to update stratigraphic nomenclature).

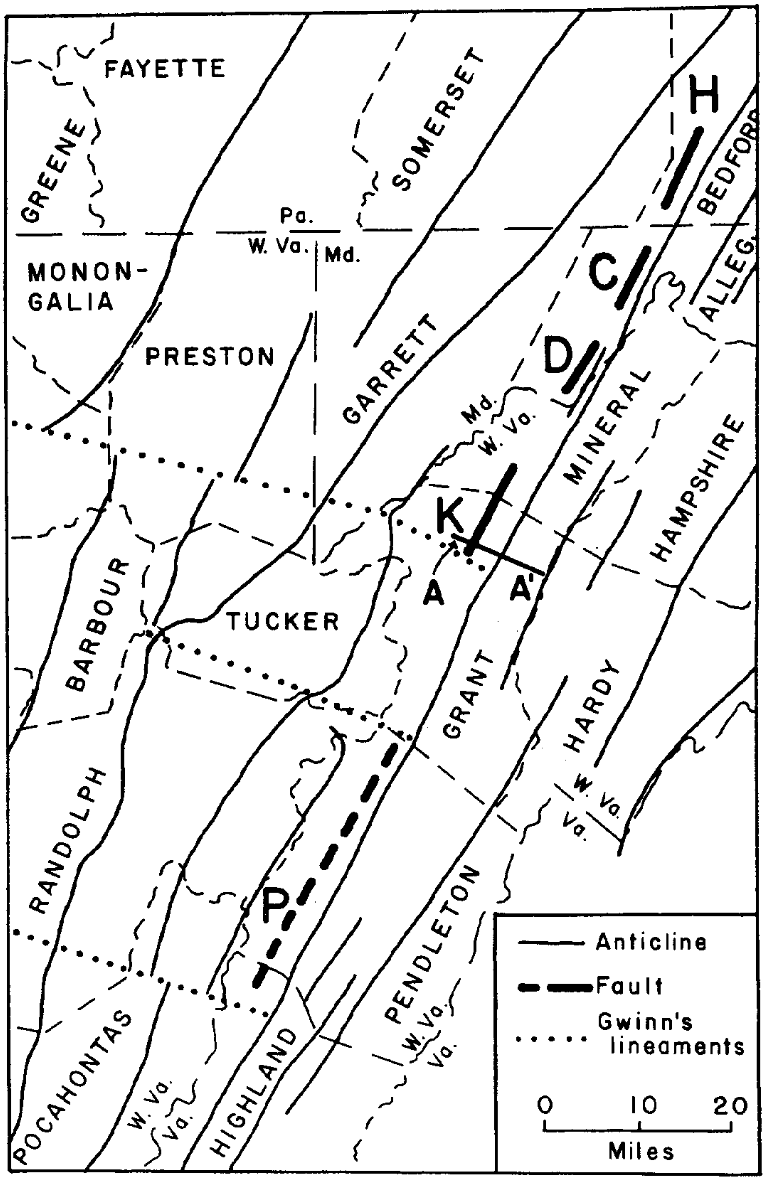

Figure 11 - Fault zones along the Allegheny Front located relative to subsurface faults delimiting structural blocks postulated by Gwinn (1964) beneath Appalachian Plateau (from Dennison, Travis, and Ferguson, 1966).

The structural section drawn at Oakdale Church (Fig. 10) is generally consistent with drilling data on open file with the West Virginia Geologic and Economic Survey.

From Scherr southward along the Allegheny Front no major faulting has been detected in the Devonian strata. Dennison, Travis, and Ferguson (1966) have postulated relationships (reprinted as Figure 11 of this guidebook) between different patterns of structural behavior along the Allegheny Front with the lineaments which were postulated by Gwinn (1964) to form boundaries of strike-slip fault blocks in the subsurface beneath the Appalachian Plateau.

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ROAD LOG OF FIELD TRIP

Friday, October 6, 1972

Mileage from Start	
0.0	Leave Holiday Inn in north edge of Bedford, Pennsylvania.
0.1	Turn right on access road to U. S. Route 220.
0.5	Wills Creek and Bloomsburg Formations in road cuts.
0.7	Merge right onto U. S. Route 220 heading south.
1.9	Northeastward plunging Wills Mountain anticline forms ridge on right.
4.1	Bloomsburg and McKenzie Formations in road cuts.
5.3-7.3	Tonoloway Limestone strike belt outcrop on left. Wills Mountain on right is formed by Tuscarora Sandstone.
11.1	Pump station on Texas Eastern pipeline.
16.7	Ridge at left (with red house and white barn) is held up by Williamsport Sandstone. Low ridge 100 yards right of highway is held up by Rabble Run Bed (redbed) of McKenzie Member of Mifflintown Formation.
19.0	Centerville.
20.0	Red coloration of Bloomsburg Formation in county road cut on right.
20.5	Wills Creek Formation.
22.9	Ridge on left is held up by Oriskany Sandstone and Shriver Chert.
24.1	Top of Bloomsburg Formation on right.
24.4	Bloomsburg Formation and Williamsport Sandstone on right.
27.1	Tonoloway Limestone on left.
27.7	Maryland-Pennsylvania border. Hill summit is formed by

Oriskany Sandstone.

28.0 Tioga Bentonite is poorly exposed in right road bank at top of Needmore Shale.

28.7 Devonian shales form hills to left.

29.0 Marcellus Shale.

31.4 Mahantango Formation (Gander Run Member).

31.5 Junction of U. S. Route 220 with U. S. Route 40. Continue south on merged Route 220-40.

32.8 Shriver Ridge on right is type section of Shriver Chert (Schuchert, Swartz, Maynard, and Rowe, 1913, p. 91).

33.7 Junction of U. S. Routes 40 and 220. Turn left on Route 220. Do not cross railroad.

33.9 Turn right across railroad tracks.

34.3 Turn left at Algonquin Hotel. Large church is at site of Fort Cumberland (1754). Tradition records an escape and water tunnel (beneath church) leading from old fort to Wills Creek.

34.4 George Washington's headquarters in French and Indian War (small log building on left).

34.6 Ridge one mile to left with electric poles on summit is type locality of Ridgeley Sandstone (Schuchert, Swartz, Maynard, and Rowe, 1913, p. 92), a name proposed by the Maryland Geological Survey with a type section in West Virginia. This name was once widely used in Pennsylvania, Maryland, and West Virginia. Use of the name Ridgeley Sandstone has been largely superseded by Oriskany Sandstone, especially in West Virginia which contains the type locality of the Ridgeley Sandstone.

35.3 Oriskany Sandstone exposed on right.

35.4 Bear left on U. S. Route 220.

35.8 U. S. Route 40 Freeway west leads up hill through Braddock Gap, a wind gap described by O'Harra (1900, p. 41-45). General Raddock's ill-fated march on Fort Duquesne (present Pittsburgh) traversed this route and led through Braddock Gap (1755). Continue south on U. S. Route 220.

36.1	Mahantango Formation on left.
38.0	Ridge on left in West Virginia across North Branch of Potomac River is held up by Oriskany Sandstone and Shriver Chert.
38.2	Approximate location of structural cross section shown as Figure 2 of this guidebook.
38.4	Rose Hill Formation exposed in road cuts.
39.2	Cedar Cliff on face of Knobly Mountain on left is type section of Cedar Cliff Limestone Lentil of Williamsport Sandstone (Swartz, 1923, p. 41; Hoskins, 1961, p. 11).
39.4	Celanese Corporation textile plant.
40.2	Enter Cresaptown.
40.4	Junction Maryland Route 53 and U. S. Route 220. Field trip will return to this point later in day. Continue south on U. S. Route 220.
40.5	Exposure of hematite-cemented Cresaptown Iron Sandstone Member (named for Cresaptown community by Swartz, 1923, p. 28-31) of Rose Hill Formation.
42.3	Marcellus Shale. Approximate south end of Cresaptown fault in Brallier Formation in trees on right.
42.9	Allegheny Ballistics Laboratory on left on land surveyed by George Washington in about 1746. Cliffs at base of Knobly Mountain are Tonoloway Limestone. Knobs are hog-backs capped by Oriskany-Shriver-Corriganville Formations.
45.0	Approximate north end of Dawson fault in Brallier Formation to right of road.
45.9	Oriskany Sandstone in northeastward plunging Fort Hill anticline.
48.8	Dawson village.
50.4	Tracey's Grocery and American gas station.

STOP 1. Discussant: Kenneth Hasson

Coral biostrome in upper Mahantango Formation rests on firmer base of Clearville Siltstone Tongue. The accompanying stratigraphic column (Fig. 12) illustrates the lithologic sequence and the outcrop sketch (Fig. 13) shows the general distribution of

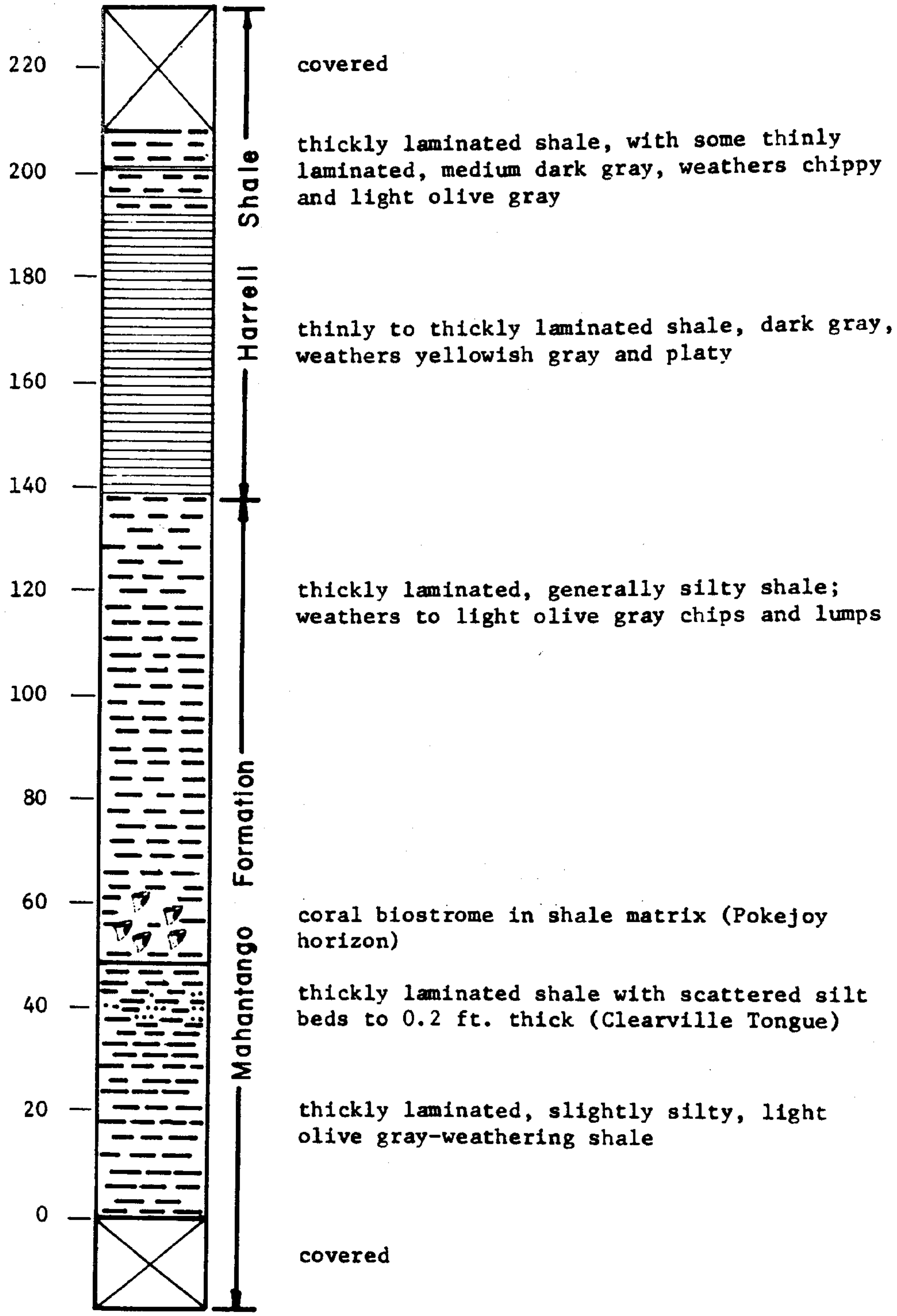

Figure 12 - Columnar section of strata associated with coral biostrome near Dawson, Maryland.

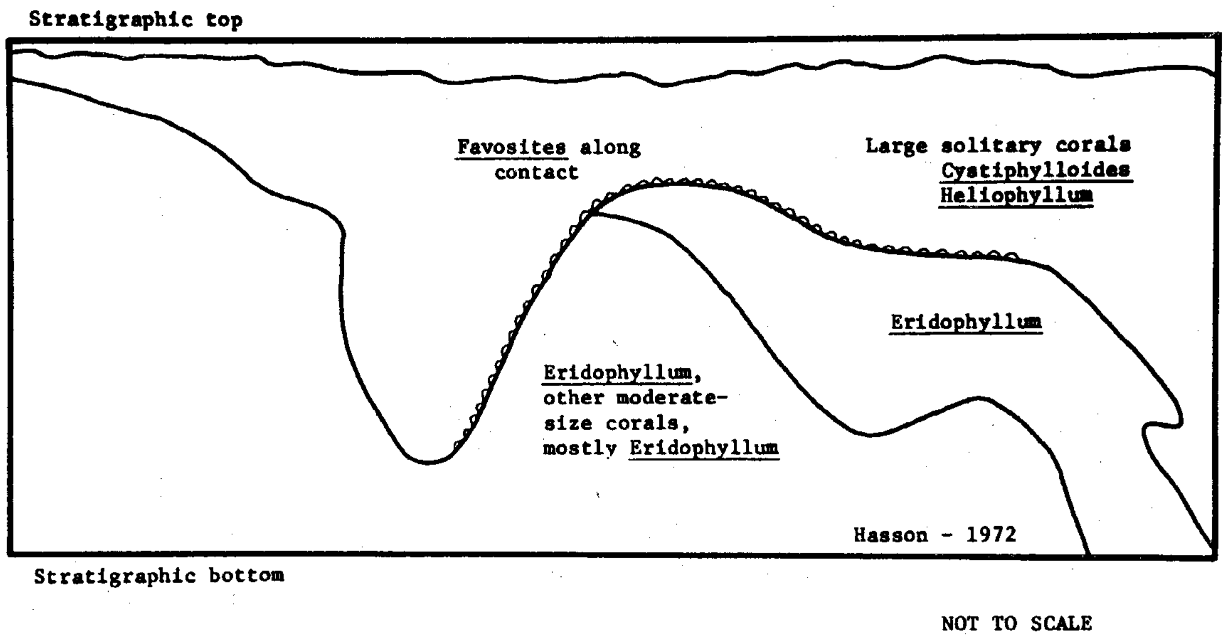

Figure 13 - Distribution of corals in cross section of biostrome in Mahantango Formation near Dawson, Maryland.

coral genera in this biostrome. This general sequence of corals occurs elsewhere in West Virginia on the Clearville Tongue and is currently being studied (Hasson and Cocke, in preparation).

This exposure is the thickest of the biostromes at this horizon in Maryland, West Virginia and southern Pennsylvania, and apparently is similar to the coral zones described in Middle Devonian rocks of eastern Pennsylvania and western New York. These occurrences do not appear continuous, and at least in West Virginia and Maryland probably represent patch reefs built on firm siltstone bottoms; southwestward the coral horizon is represented by limestone beds and concretions.

The relationship between the biostrome and part of the siltstone is not clear here, and it appears that the siltstone either built up over the coral mound or the coral mass subsided. In a stream bed about 500 feet north of this stop the coral horizon, about 4 feet thick and calcareous, is overlain by about 15 feet of Frame Shale; about 40 feet of Harrell Shale is also exposed here.

Cliffs to east of Route 220 are formed by Oriskany Sandstone.

This stop is at approximate site of structural section shown in Figure 5 of this guidebook.

51.4 High Rock on left is formed by Keyser-New Creek-Corriganville Limestones. Ridge crest is Shriver Chert.

51.8 Road cut in Oriskany Sandstone.

52.3 Approximate south end of Dawson fault.

53.6 Angular unconformity separating Pleistocene(?) stream boulder deposit from vertical Brallier Formation. Did North Branch of Potomac River once cross this divide? Dennison (1955, p. 73-81) proposed a drainage history for this area.

54.0 Chat and Chew Drive-in.

STOP 2. Discussant: John Dennison

Panoramic view of stratigraphic section of Devonian delta measured in bed-by-bed detail in 1961 by Dennison and Orville D. Naegele at Keyser

(Fig. 14). Regional thickness relations of Devonian strata are illustrated in Figure 6. Published geologic maps are by Reger and Tucker (1924) and Dennison (1963a).

Outcrops along road cut exhibit Mahantango, Harrell, Tully and Brallier strata.

54.6 Enter West Virginia at North Branch of Potomac River. Quarry in line with radio tower about a mile to left is type section of Keyser Limestone (Ulrich, 1911, p. 563, 590, 591, pl. 28). Stop 6 of this guidebook is near radio tower.

55.0 Junction with W. Va. Route 46 in Keyser. Continue ahead on U. S. Route 220. Keyser changed hands 14 times in Civil War.

55.2 Potomac State College (junior college branch of West Virginia University). Approximate position of structural cross section shown as Figure 7 in this guidebook.

56.5 Davis No. 1 well drilled by Pittsburgh Plate Glass Company in 1967 is located about one mile to right on back side of first knob of Foreknobs capped by Hampshire Formation. Well spudded in Hampshire Formation, drilled 9,131 feet total depth, reaching Oriskany at 8,731 feet with gas show.

Mountain at skyline is Allegheny Front, capped by Pottsville Formation. Pocono Formation forms middle line of Foreknobs.

57.5 New Creek Mountain on left is formed by vertical Oriskany Sandstone.

59.8 Wide valley is partly caused by two minor anticlines in Devonian shale.

60.8 Village of New Creek. Trilobites occur in Needmore Shale behind Post Office on right.

62.0 Junction of U. S. Route 220 with U. S. Route 50. Continue ahead on Route 50. Cuts on left are type section of New Creek Limestone, a name proposed by Bowen (1967, p. 1, 3) for what was formerly called Coeymans Limestone in West Virginia (Woodward, 1943, p. 67-82). Helderberg stratigraphy in quarry at left was described by Head (1969).

62.5 Pinnacle forest fire observation building on right at summit of the Allegheny Front (elev. 3,150 feet)

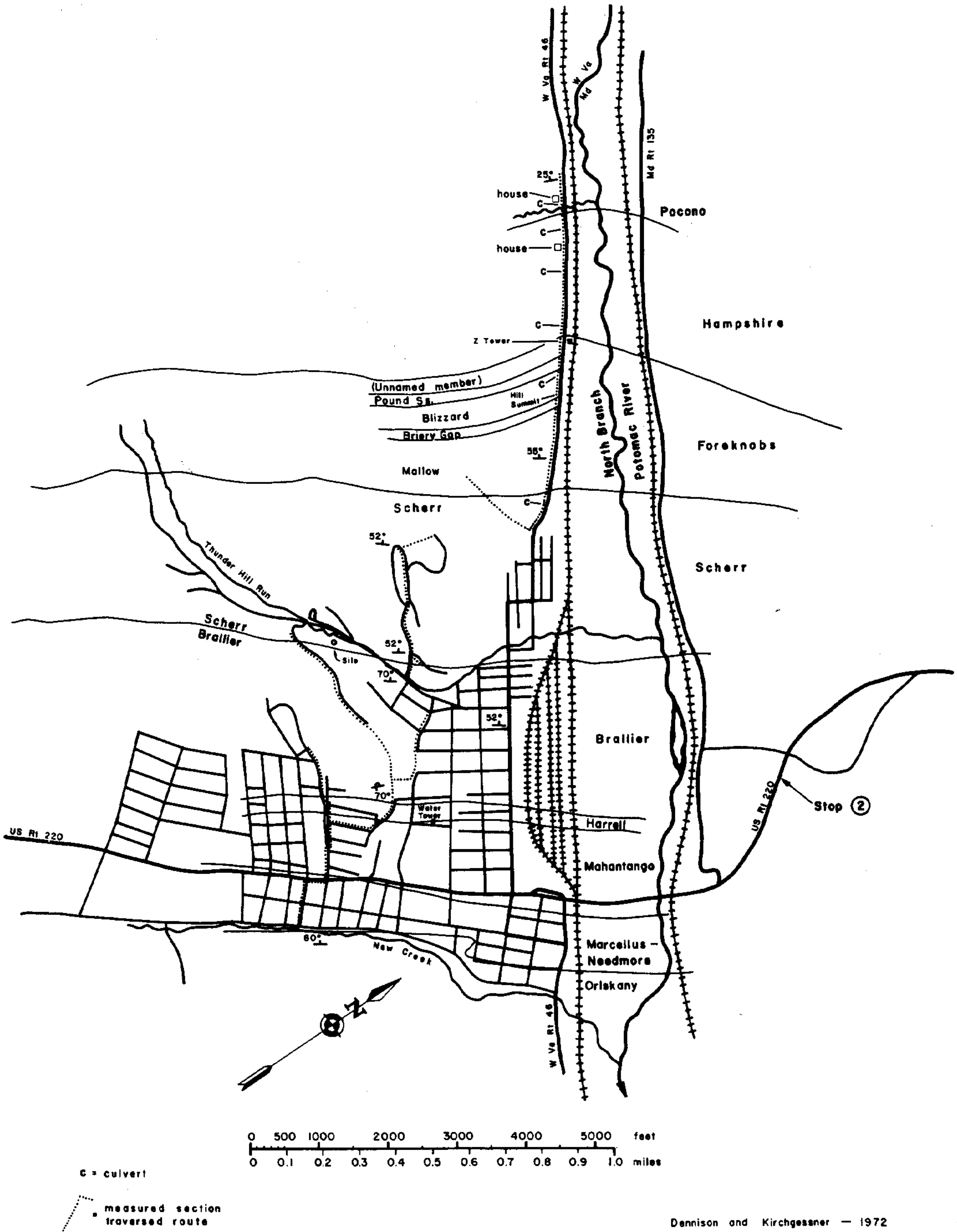

Figure 14 - Map view of Devonian delta exposures measured near Keyser, West Virginia. Observation position is labelled as Stop 2.

capped by Pottsville Formation. Valley floor elevation here is 1,000 feet.

64.7 Junction of U. S. Route 50 and W. Va. Route 93. Continue ahead on Route 50. Field trip route returns to this point later today.

Start ascent of Allegheny Front in Route 50 section of Devonian delta measured in bed-by-bed detail in 1962 by Dennison and Orville D. Naegele. This section previously was described by Reger and Tucker (1924, p. 152-153) and their section was modified by Woodward (1943, p. 512). These workers did not recognize presence of Kittlelick fault.

Outcrops in cut to right of highway intersection are Mahantango Formation.

65.4 Cross approximate trace of Kittlelick fault (Dennison, Travis, and Ferguson, 1966) in Brallier Formation.

66.1 Tavern (for reference only).

66.3 Mallow Member of Foreknobs Formation (sharp bend overlooking valley is near base of Mallow Member).

66.9 Briery Gap Sandstone Member of Foreknobs Formation (on right).

67.0 Redbeds are small nonmarine delta lobe in Blizzard Member of Foreknobs Formation. Here in this section is the only known occurrence of truly nonmarine beds within Foreknobs Formation exposures studied by Dennison along Allegheny Front (see Figure 15). Figure 15 adds considerable detail to earlier published descriptions of Upper Devonian stratigraphy along the Allegheny Front (Dennison, 1963b; Dennison and Naegele, 1963).

67.1 Contact between the Hampshire Formation (red) and Foreknobs Formation. Top of Foreknobs Formation here is Pound Sandstone (with overlying unnamed upper member of Foreknobs Formation absent here).

67.8 Base of Pocono Formation or Group. Pocono Group section here was measured by Dally (1956, p. 227-228) who recognized Burgoon Sandstone Member (220 feet) overlying 58 feet of Manheim Member (name was never formally published). Dally envisioned intertonguing of Hampshire and Pocono strata in this exposure.

68.1 Greenbrier Limestone. The Greenbrier occurs in two limestone benches here, separated by at least 30 feet of redbeds (which are probably a tongue of Mauch Chunk

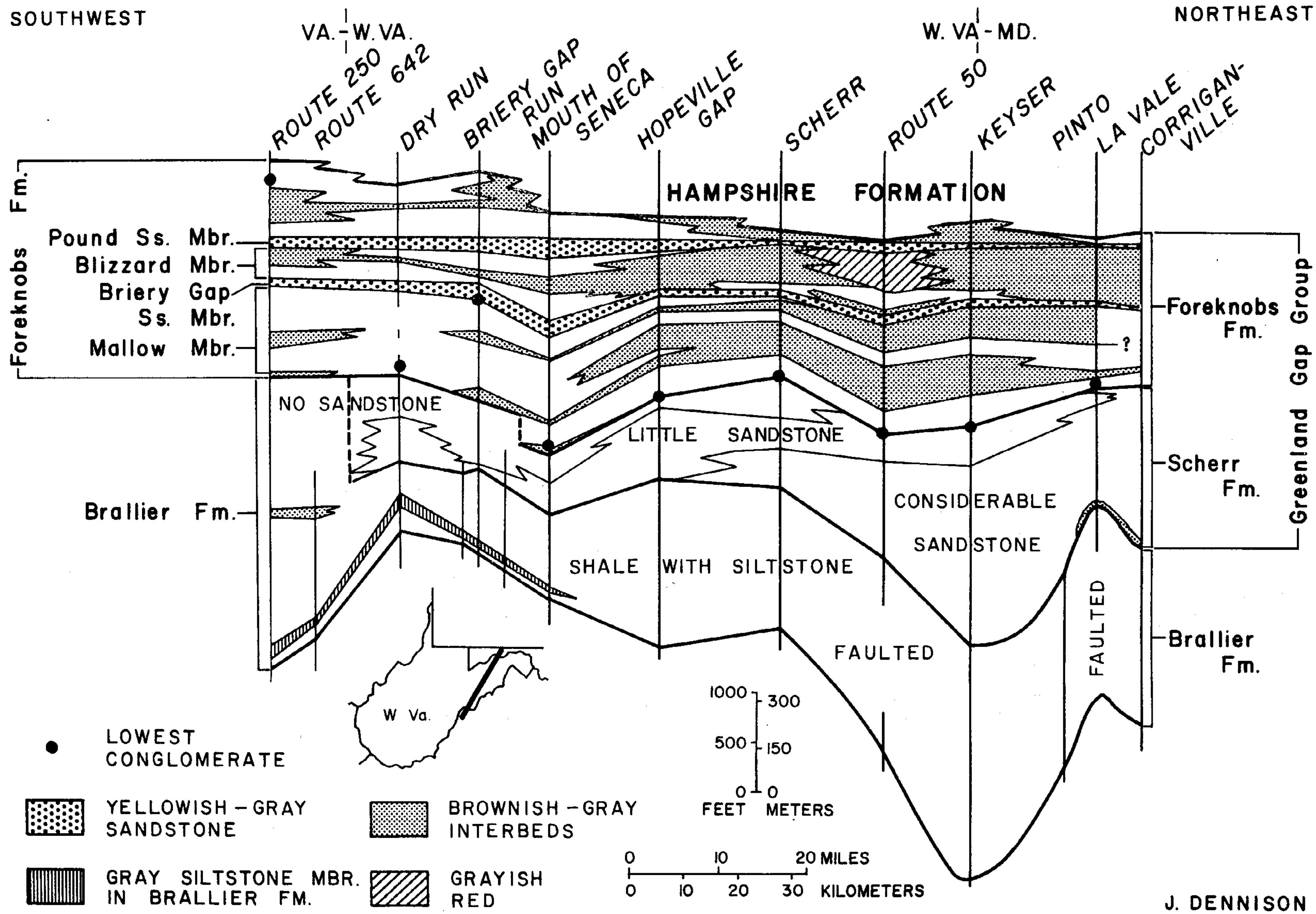

Figure 15 - Stratigraphic cross section of Upper Devonian marine beds along the Allegheny Front (from Dennison, 1970, 1971).

Formation extending from the north).

68.7 Quarry on left produces dimension stone from Pocono Formation.

69.2 Dolls Gap, notch on left in New Creek Mountain, is wind gap through Wills Mountain anticlinorium. Michael Clark did a dissertation study at Pennsylvania State University (1967) on relation between structure and geomorphology of the series of gaps through New Creek Mountain. Boulder fields formed by Tuscarora Sandstone float were studied by Clark (1968) who recognized periglacial effects in high mountains as far south as southern Virginia.

Legend maintains that Nancy Hanks, the mother of Abraham Lincoln, was born on east side of Dolls Gap.

69.4 Junction U. S. Route 50 and W. Va. Route 42. Continue ahead on Route 50.

69.8 Pottsville Formation boulders.

70.3 Summit of Allegheny Front (elev. 2,840 feet) capped by Allegheny Formation here.

70.6 View of Schooley Peneplain surface (elevation about 2,800-3,000 feet). Do you believe it?

72.9 Grant-Mineral County border. Grant County was formed in 1866 and named for General Grant.

73.6 Cross Abrams Creek.

73.8 Scar of 1944 Shinnston tornado is barely visible in trees behind church on left.

74.7 Abandoned mine on left in coal. This is North Potomac coal basin.

77.1 Mount Storm village (elev. 2,850 feet). Turn left on W. Va. Route 42.

77.2 Smoke stacks at 2 o'clock on right are VEPCO Mount Storm power plant.

80.1 Strip mines on left are in Bakerstown, Harlan, and Elk Lick coals of Conemaugh Group. Used to fuel VEPCO power plant. Reclamation follows new mining law.

81.7 W. Va. Route 93 leads 3.4 miles to VEPCO power plant. Continue ahead on Route 42.

82.2 Summit of Allegheny Front capped by Pottsville Formation.

82.4 Disconformable(?) contact between Pottsville and Mauch Chunk Formations.

83.0 "Greenbrier strip" of clearings in limestone soil extends as a strike belt for 200 miles across West Virginia.

83.4 Top of Pocono Formation.

83.5 STOP 3. Discussant: John Dennison

Leave bus here and walk 1.8 miles down through Pocono, Hampshire, Foreknobs, and Scherr Formations to reboard bus near top of Brallier Formation. Figure 16 is map of geology along W. Va. Route 42.

Dally (1956, p. 220-226) measured Pocono Group here, recording 98 feet of Burgoon Sandstone overlying 201 feet of Manheim Formation (name was never formally published).

This is type section of Scherr and Foreknobs Formations, and description given by Dennison (1970) is as follows. This is summary of section measured in bed-by-bed detail by Dennison and Orville D. Naegele in 1962. Section is from Southeastern Geology (Dennison, 1970, v. 12, p. 79-80).

Along W. Va. Route 42 with base of section 0.3 mile northwest of Scherr, Grant County, West Virginia. This is designated as the type section for the Scherr and Foreknobs Formations and for the Greenland Gap Group, all of which are proposed here. Base of Scherr Formation is at 39°11'45" N. Lat., 79°10'48" W. Long. Measured by J. M. Dennison and O. D. Naegele in 1962.

	Thickness feet
Hampshire Formation (1890 feet, total thickness)	
20. Grayish red to brownish gray, micaceous, fine to very fine, quartz sandstone and grayish red to brownish gray micaceous siltstone which weathers lumpy to chippy. Contains a few greenish gray to light olive gray sandstones. No marine fossils	1789
19. Covered.	27
18. Sandstone, very fine, thinly bedded, weathers light olive gray	7
17. Covered.	10
16. Sandstone, thinly bedded, very fine, weathers light olive gray	3
15. Sandstone, very fine, thin- to medium-bedded, brownish gray	29
14. Sandstone, very fine, yellowish gray	1
13. Covered.	15

Greenland Gap Group (2325 feet)	
Foreknobs Formation (1321 feet)	
Unnamed member (77 feet)	
12. Sandstone and siltstone, weathers yellowish gray, contains Cyrtospirifer and other marine fossils	24
11. Siltstone, brownish gray to light olive gray	28
10. Siltstone and sandstone, weathers light olive gray, contains Cyrtospirifer	25
Pound Sandstone Member (30 feet)	
9. Sandstone, rather massive, weathers yellowish gray to light olive gray, contains plant stem fragments, brachiopods, and pelmatozoan plates; has some siltstone layers	30
Blizzard Member (405 feet)	
8. Sandstone, siltstone, and shale, interbedded greenish gray and brownish gray; contains a few thin beds of conglomerate	405
Briery Gap Sandstone Member (67 feet)	
7. Sandstone, rather massive, conglomeratic, weathers yellowish gray; contains marine fossils	67
Mallow Member (741 feet)	
6. Interbedded sandstone, siltstone, and shale, greenish gray with considerable brownish gray; a few thin beds of conglomerate	471
5. Sandstone, siltstone, and shale interbedded; greenish gray. Some conglomeratic layers are associated with sandstones. Sandstones are more massive than unit below; bottom of Mallow Member is marked by base of massive sandstones which are several feet thick, along with some conglomerates	270
Scherr Formation (1004 feet)	
4. Shale and siltstone, with no sandstone in float; weathers light olive gray. Very poorly exposed, yet unit 4 as a weak resistance horizon is continuous at least 20 miles along strike in both directions	380
3. Mostly siltstone, much shale, but almost no sandstone; medium dark gray, weathers light olive gray; partly covered	292
2. Mostly siltstone, with considerable shale and fine-grained sandstone; medium dark gray when fresh, weathers light olive gray. Distinct basal contact is placed at base of ball-and-pillow structure (Pettijohn and Potter, 1964, p. 285) sandstone just beneath sandstone beds 0.5 and 0.8 foot thick	332
Brallier Formation (1323 feet, total thickness)	
1. Mostly shale with some interbedded siltstone in distinctly bounded beds; medium dark gray, weathers light olive gray	1323

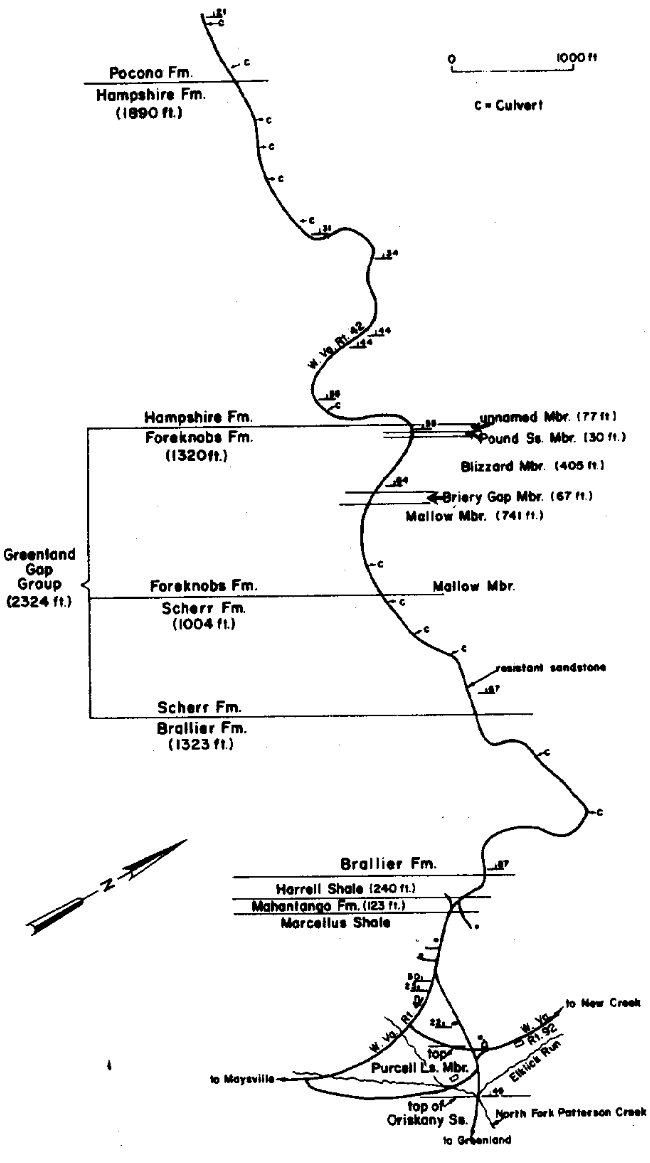

Figure 16 - Map of type section of Scherr and Foreknobs Formations along W. Va. Route 42 (From Dennison, 1970).

84.1 View of Greenland Gap, a water gap formed by North Fork of Patterson Creek cutting the Wills Mountain anticlinorium. The Greenland Lodge No. 1 well drilled in 1965 by Shell Oil Company was spudded in Rose Hill Formation on mountain crest at top left side of gap. White Cliffs in center arch are Tuscarora Sandstone. Secondary cliffs are Oriskany Sandstone on flanks of fold. Hampshire Formation in road cuts on left.

84.7 Hampshire-Foreknobs Formation contact, with top of massive, cross-bedded Pound Sandstone Member 77 feet below contact.

85.3 Reboard buses. Outcrops in road cut are Brallier Formation.

85.8 Harrell Shale.

85.9 Mahantango Formation here is represented by two tongues of silty, gray shale (Fig. 17). Mahantango is fast changing facies to south and west to merge into Millboro Shale, named from Bath County, Virginia by Butts (1940, p. 308) to encompass the black shale interval from the top of the Needmore Shale to the base of the Brallier Formation. Only three miles to the east at east end of Greenland Gap the Mahantango Formation has coarsened to contain conspicuous siltstones. Depositional strike of Mahantango Formation here was essentially north-south.

86.1 Scherr village. Turn north (left) on W. Va. Route 93. Scherr is most southern community on field trip route.

Note broad valley here, which has unfaulted, full thickness of Devonian shale sequence.

86.2 Dip slope of Oriskany Sandstone on right. Greenland Lodge No. 1 well was drilled 13,000 feet two miles to southeast.

87.3 STOP 4. Discussant: Kenneth Hasson

The Brallier Formation and part of the Harrell Shale, including the Tully, are exposed along farm road on west side of Elk Lick Run (Fig. 18). The Harrell is not completely exposed, but the Tully-Burket relationship can be clearly seen; the calcareous shales and limestones of the Tully occur well within the black shale. This is also the thickest development of Tully in West Virginia outcrops. The Brallier is exposed in the quarry. This exposure is near the south terminus of the Kittlelick thrust fault (Dennison, Travis, and

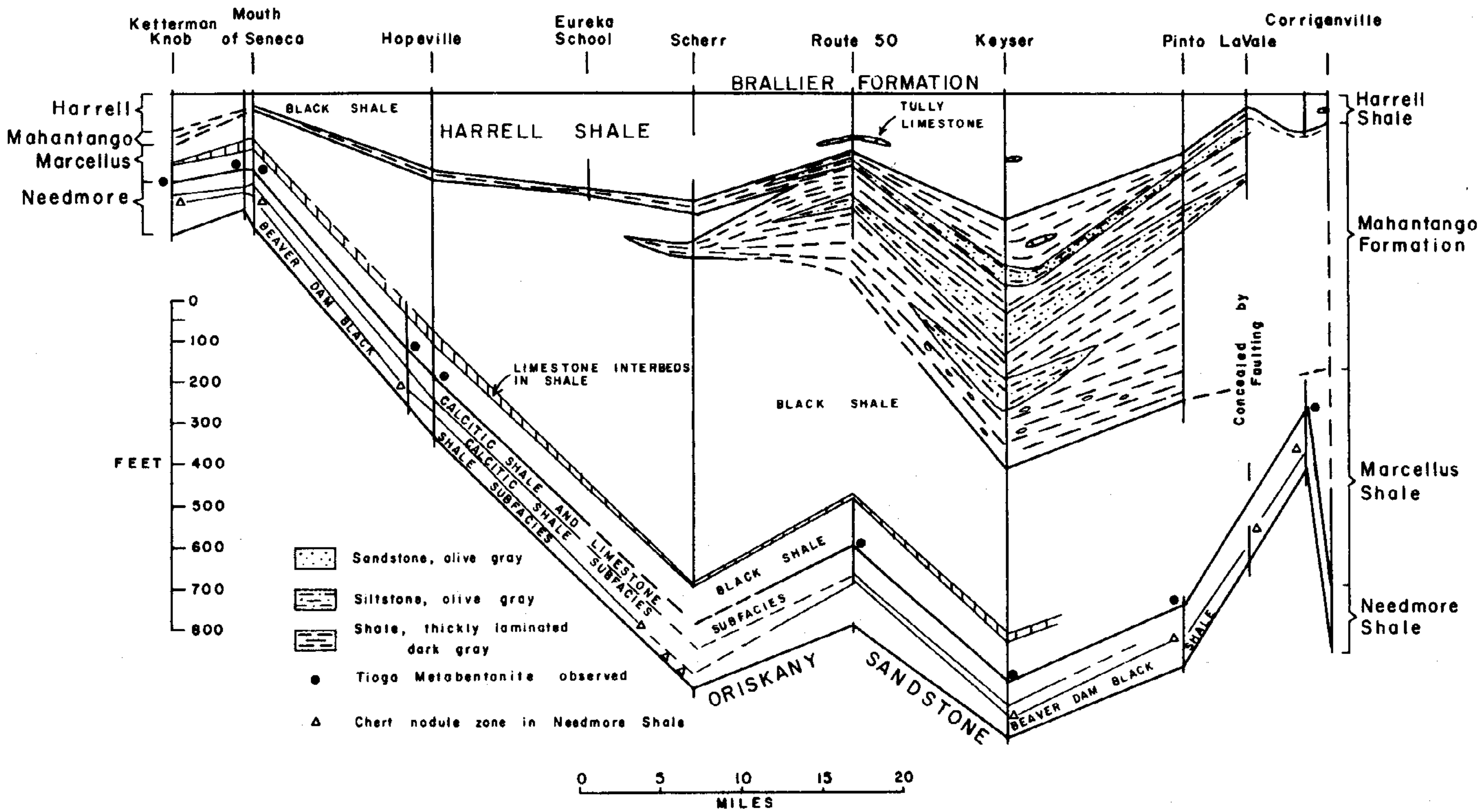

Figure 17 - Facies relations along the Allegheny Front of Middle Devonian strata (from Dennison and Naegele, 1963). Work by Hasson (1966) showed that Tully Limestone is nearly a continuous marker bed.

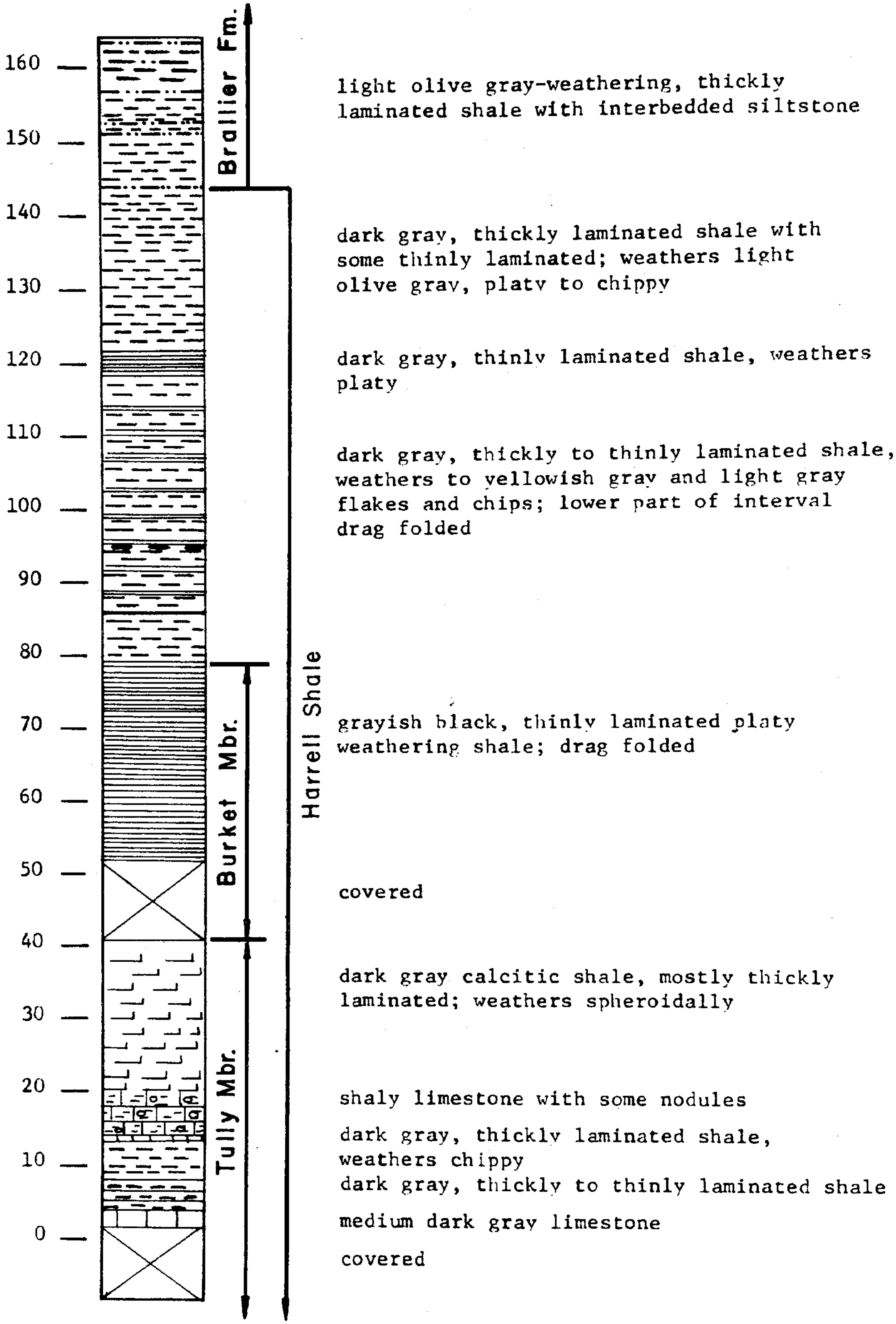

Figure 18 - Stratigraphic column showing Harrell Shale and Tully Limestone at Elklick Run 2.1 miles northeast of Scherr, Grant County, West Virginia.

Ferguson, 1966), which causes omission of much of the Brallier Formation along a distance extending about 12 miles to northeast (see Figure 8 of this guidebook). An estimated 900 feet of Brallier Formation are omitted at this locality.

89.6 Oakdale Chapel. This is position of structural section shown as Figure 10 of this guidebook.

90.5 Summit of Walker Ridge (elev. 2,068 feet), the drainage divide between North and South Branch of Potomac River. Quarry on left produced limestone from Keyser Limestone.

93.1 Turn left on dirt road.

93.6 LUNCH STOP. City of Keyser Reservoir (New Creek Watershed Project Dam Site 14).

STOP 5. Discussant: John Dennison

Test borings and excavations for earth-fill dam provide clear evidence for structural section shown in Figure 19.

Leakage along Tioga Bentonite zone was discovered after impounding of water, requiring special grouting. Purcell Member (shale and limestone) of Marcellus Shale crops out in creek bed below dam.

Valley is very narrow here because of maximum development of Kittlelick thrust (esimated maximum displacement 1,340 stratigraphic feet). Compare cross section of dam (Fig. 19) and regional cross section (Fig. 10).

Return toward W. Va. Route 93.

94.1 Junction with W. Va. Route 93. Turn north (left).

94.9 Note periglacial scree on New Creek Mountain on right.

95.0 At west end of Kittlelick Ridge on left is location of fracture patterns diagrammed in Figure 9 of this guidebook.

96.3 Grant-Mineral County boundary. Mineral County was formed in 1866 and named for its mineral deposits.

98.8 Bosley log cabin on left is boyhood home of two Phi Beta Kappa's.

98.9 Oriskany Sandstone cliff on right with abandoned quarry

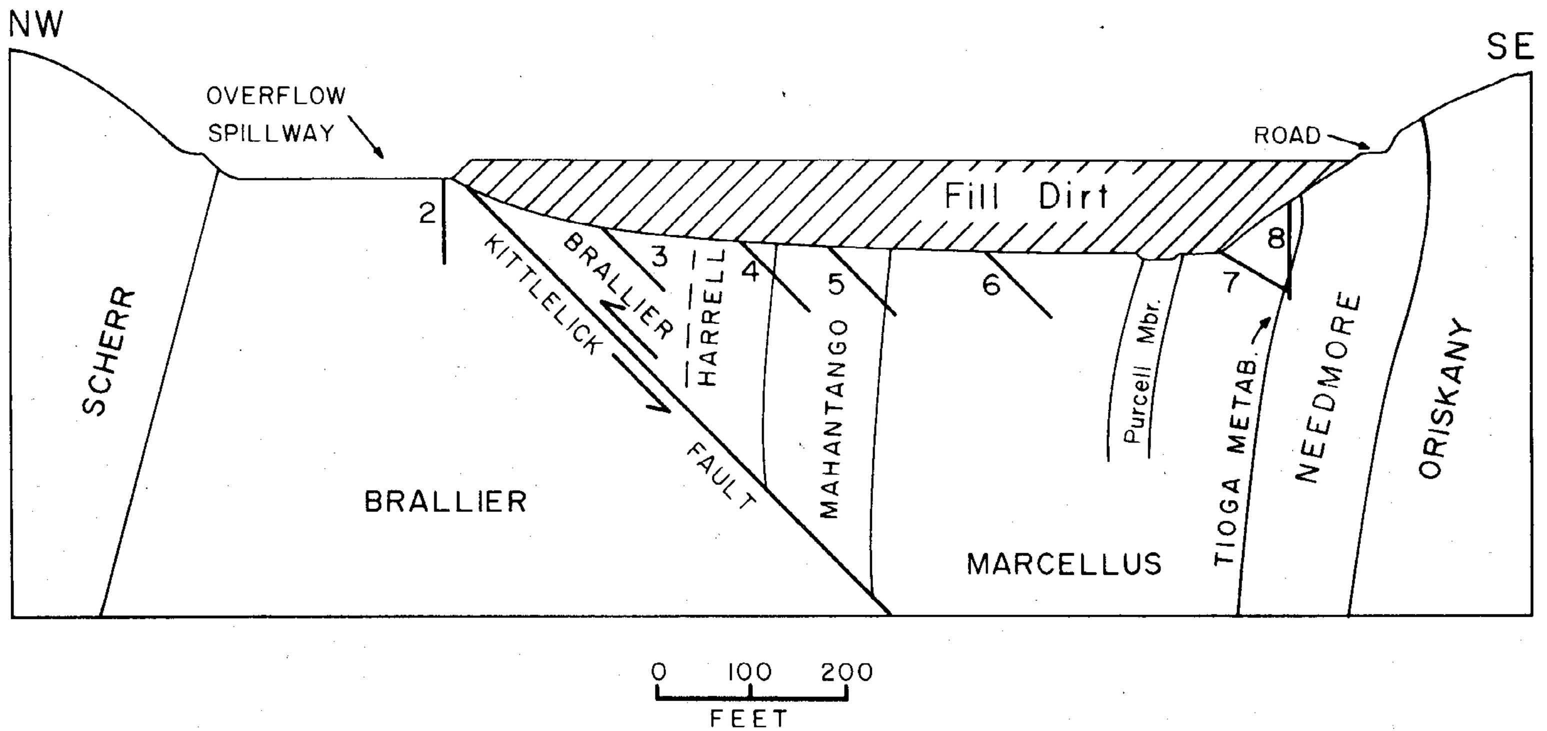

Figure 19 - Cross section of Keyser Reservoir, Grant County, West Virginia (modified from Dennison, Travis, and Ferguson, 1966).

in weathered Shriver Chert.

99.2 Junction W. Va. Route 93 and U. S. Route 50. Turn right on Route 50 and begin retrace of field trip route to Keyser.

101.4 Junction of U. S. Routes 50 and 220 at New Creek. Proceed left on Route 220.

106.6 Enter Keyser. Queens Point (sometimes called Monster Rock) a mile ahead is Oriskany Sandstone at crest of Fort Hill anticline.

107.5 Junction U. S. Route 220 and W. Va. Route 46. Turn right on Route 46.

107.6 Left turn on Route 46.

107.8 Right turn on Route 46.

107.9 Cross New Creek.

108.2 Large stone house on left was used as Civil War hospital.

108.3 Chert quarry in weathered Shriver Chert is used for road material.

108.5 Type section of Keyser Limestone is in quarry on back side of hill to left (Ulrich, 1911, p. 563, 590, 591, pl. 28). Very distinct contact between Keyser and Tonoloway Limestone is exposed in road cut on left.

108.7 Intersection of W. Va. Route 46 and County Route 8. Turn left onto Route 8, and park bus at intersection.

STOP 6. Discussants: Donald Hoskins, James Head, and John Dennison

Opportunity to walk through section of McKenzie Formation to lower Keyser Limestone (Fig. 20).

Section of Williamsport Sandstone with Bloomsburg redbed tongue was described as follows by Hoskins (1961, p. 61-62).

Wills Creek Formation
Claystone, variegated, portions calcareous and fissile.

Williamsport Member (27 feet)	Thickness Feet
1. Sandstone, very-fine-grained, silty.	2

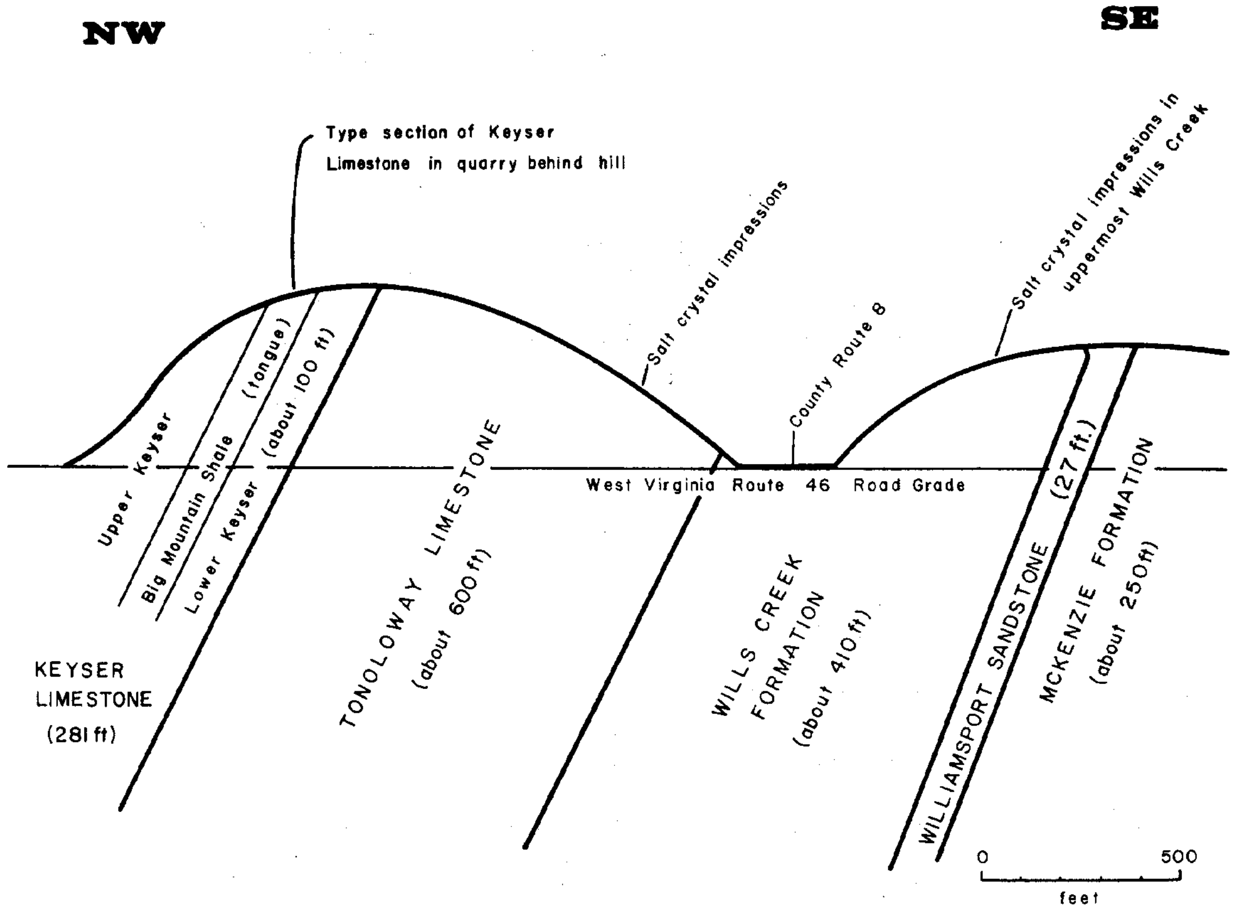

Figure 20 - Exposures of McKenzie Formation to Keyser Limestone in cuts along W. Va. Route 46 one mile east of Keyser.

2. Interbedded siltstone and claystone, light-olive-gray, claystone fissile. 3
3. Limestone, shaly, dark-gray to medium-dark-gray. Fossiliferous-Ostracoda: *Kloedenia normalis* (C), *Dizygopleua halli* (C), *D. ventrisulcata* (VR), *Herrmannina* sp. (C). 2
4. Covered. Very weathered zone. 6
5. Claystone, light-olive-gray, weathers hackly. 6
6. Claystone, grayish-red, in one bed. 1.5
7. Sandstone, very-fine-grained, silty, light-olive-gray. Top 8 inches grayish-red grading down to other color. Resistant. Base of unit and member placed at change from nonfissile to fissile. 6.5

Wills Creek Formation and Tonoloway Limestone contain impressions of salt crystals (square outlines and cubic corners of crystals). In 1881 I. C. White noted that residents spoke of pioneer salt springs along Limestone Run 0.5 mile from here, but salt crystal impressions were not discovered near Keyser until 1970.

See article by Ludlum (1969) for more discussion of exposures of Cayugan salt crystal impressions elsewhere in West Virginia. Geologic maps of this area have been prepared by Reger and Tucker (1924) and Dennison (1963).

109.1 Well testing for Silurian salt was drilled in fields to right about 1945. Well was spudded in Middle Silurian (below evaporite) horizons.

109.2 Flex-o-lite manufacturing plant.

109.6 Forge Hill at Keyser sewage treatment plant.

STOP 7. Discussant: John Dennison

Oriskany Sandstone through Marcellus Shale (Fig. 21).

Regional facies relations of the Needmore Shale were described by Dennison (1961). The chert nodule zone in the Needmore is a feather-edge tongue of Huntersville Chert. This chert nodule zone can be traced for 60 miles in Needmore outcrops along the Allegheny Front (Dennison and Naegele, 1963; also

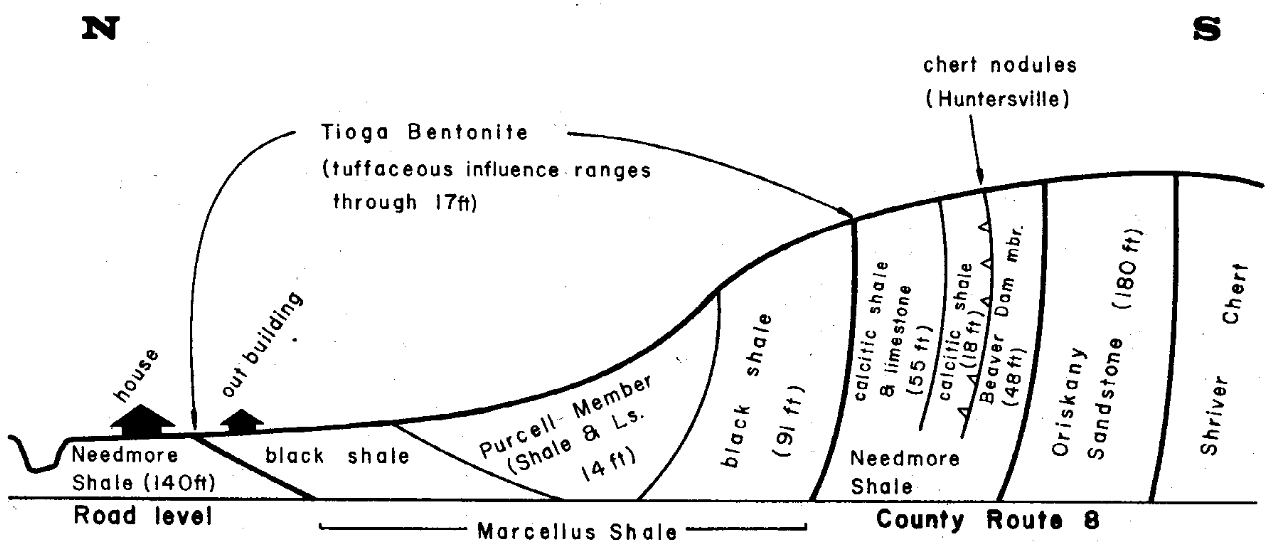

Figure 21 - Exposures of Oriskany Sandstone to Marcellus Shale in Noswad Syncline along County Route 8 two miles northeast of Keyser, West Virginia.

Fig. 17 of this guidebook). The chert zone is interpreted by Dennison as a time-line.

The Tioga Bentonite consists of several tuff layers and tuffaceous shale ranging here through 16 feet of section. Middle coarse zone is chief Tioga marker, generally with 3 or 4 layers of sand-size tuff in an interval of 1-3 feet of strata. This is the main Tioga zone which merges to a single ash layer found in upper part of Onondaga Limestone of New York. Regional relations of Tioga Bentonite are described by Dennison and Textoris (1970, 1971). Source volcano (or volcanoes) was near Charlottesville, Virginia in the Piedmont. Ash spread throughout Appalachian basin with hundreds of Tioga occurrences noted in Tennessee, Kentucky, Virginia, West Virginia, Maryland, Pennsylvania, Ohio, New York, and Ontario in wells and outcrops. Over 120 outcrops have been identified by Dennison. Tioga Bentonite is Known in wells in Illinois Basin (Indiana, Kentucky, and Illinois) and probably is the middle Devonian bentonite which occurs in the Michigan Basin.

The Purcell Limestone was named for shaly limestone in the Marcellus Shale in wells drilled in the Purcell gas field of eastern Bedford County, Pennsylvania (Cate, 1963, p. 232). It is generally sparsely fossiliferous (contrasting with the very fossiliferous limestones of the upper Needmore Shale), occurs in concretionary to lenticular limestone beds (contrasting with the sharply bounded beds of limestones in the Needmore), and often contains very distinctive nodules resembling golf balls with a radiating interior structure. Dennison, Hoskins, Hasson, and de Witt have found this to be a distinctive marker zone in nearly all Marcellus outcrops in Pennsylvania, Maryland, West Virginia, and Virginia. It occurs at a regular stratigraphic position relative to the Tioga Bentonite, so the Purcell zone is thought to be a good time marker. Subsurface work in Pennsylvania and New York suggests strongly that a tongue of the limy Purcell beds reaches through to New York outcrops to form the Cherry Valley Limestone.

The Purcell zone is recognized only as a few concretions in the railroad cuts at the famous Twenty-First Bridge section (Prosser, Kindle, and Swartz, 1913, p. 59-63) 0.5 mile to the northwest of the exposure illustrated as Figure 21.

Reboard buses and return toward Keyser.

110.5 Intersection of County Route 8 and W. Va. Route 46. Turn right on Route 46.

111.4 Turn left on Davis Street following W. Va. Route 46.

111.5 Turn right on Center Street on W. Va. Route 46.

111.6 Intersection in Keyser of W. Va. Route 46 and U. S. Route 220. Turn right on U. S. Route 220 and retrace route to Cresaptown.

111.8 Queens Point on right held up by Oriskany Sandstone.

125.9 Junction in Cresaptown of U. S. Route 220 and Md. Route 53. Turn left onto Route 53.

Route from here to Bedford passes within sight of all 5 stops scheduled for tomorrow's portion of the field trip. For detailed road log, see mileage schedule for October 7.

126.1 Low ridge straight ahead is southwestward plunging Tuscarora Sandstone forming Haystack Mountain.

126.5 Rose Hill Formation shale outcrops on right.

128.6 Cross trace of Cresaptown fault at crest of hill. Fault parallels highway, with Marcellus Shale in right road bank and Brallier Formation in left road bank.

128.7 Sears Town shopping center. This is site of Stop 9 on Saturday's road log.

129.3 Junction Md. Route 53 and U. S. Route 40 at La Vale. Turn east (right) on Route 40.

131.7 Turn left on Long Drive (also known as Cash Valley Road).

135.0 Intersection with Md. Route 36. Quarry visible ahead is site of Stop 8 on Saturday's road log.

135.1 Intersection at Corriganville of Md. Route 36 and Md. Route 35. Turn right on Route 35.

137.8 Maryland Route 35 becomes Pennsylvania Route 96 at Mason and Dixon line.

145.4 Hyndman. Continue north following Pa. Route 96.

161.8 Junction of Pa. Route 96 and Pa. Route 31. Follow Route 31 toward Bedford.

165.2 Junction of Pa. Route 31 and U. S. Route 30. Take U. S.

Route 30 east (right) toward Bedford.

168.1	Exit right on cloverleaf from U. S. Route 30 onto U. S. Route 220 northbound.
170.6	Exit right to access road.
170.9	Holiday Inn, Bedford, Pennsylvania.

Saturday, October 7, 1972

Mileage from Start	
0.0	Leave Holiday Inn in north edge of Bedford, Pennsylvania.
0.1	Turn right on access road to U. S. Route 220. Follow Route 220 south to Cumberland, Maryland, tracing detailed road log presented for October 6 field trip route.
33.7	Junction in Cumberland of U. S. Routes 220 and 40. Turn west (right) on U. S. Route 40 following Henderson Avenue.
34.5	Bridge over railroad tracks. Water gap of Wills Creek through Wills Mountain is visible ahead. Type locality of Rose Hill Formation (Swartz, 1923, p. 28) is Rose Hill located on south side of Wills Creek Valley at east base of Wills Mountain.
34.7	Flood protection wall for Wills Creek built by U. S. Army Corps of Engineers. The active portion of the Chesapeake and Ohio Canal was in Cumberland near confluence of Wills Creek and North Branch of the Potomac River. Barges ceased activity about 1924.
34.9	Cross Wills Creek. White cliffs on left are Tuscarora Sandstone, with redbeds of Juniata Formation in cuts along railroad track at right.
35.3	Crest of Wills Mountain anticline with white arch of Tuscarora Sandstone. Reger and Tucker (1924, p. 436) report a well drilled 500-600 feet (into Martinsburg Shale) yielded enough gas to flare a lighted pipe.
35.7	Tuscarora Sandstone dipping steeply on west end of Wills Mountain anticline.
35.8	Junction of U. S. Route 220 and Md. Route 36. Turn right onto Route 36.
36.4	Quarry on right once operated by Martin-Marietta Corp. to produce glass sand from Tuscarora Sandstone. Property is now owned by Cumberland Cement and Supply Company.

36.6 Abandoned quarry on left in Tonoloway Limestone.

37.5 Famous Cumberland Bone Cave with diverse Pleistocene vertebrate fauna in Western Maryland Railroad cut at end of hill to left. Excavated 1912 (Gidley 1913; Gidley and Gazin, 1938) and again in early 1950's (Nicholas, 1954).

37.6 Turn right onto quarry road.

STOP 8. Discussant: James W. Head

Corriganville Quarry operated by Cumberland Cement and Supply Company.

The Corriganville quarry section is one of the finest continuous exposures of upper Silurian and lower Devonian rocks in western Maryland. Unfortunately, steep slopes and overhangs left by quarrying operations have made portions of the section inaccessible, particularly in the middle and upper Keyser. The section is located less than one-half mile east of Corriganville just north of where Wills Creek turns eastward to first abut Wills Mountain. This locality has previously been known as the Devil's Backbone section (Swartz, et al., 1913, p. 147) because in earlier days some of the upper beds of the New Creek Limestone formed a topographic prominence resembling a backbone. Subsequent quarrying of these beds removed all traces of the structure and produced the terraced quarries seen today. The quarry and adjacent outcrops expose in near vertical beds the Silurian upper Tonoloway Limestone, the Silurian and Devonian Keyser Limestone, and the Devonian New Creek and Corriganville Limestones, Mandata Shale, Shriver chert, and parts of the Oriskany Sandstone. Some of the Keyser exposures along the old Huntington Division of the Pennsylvania Railroad, although long exposed, are covered by varying thicknesses of quarry dust. In some of the most recently worked sections of the quarry, the Keyser exposures have not weathered sufficiently to show their internal structure. For these reasons, this section should be studied in conjunction with exposures in the railroad cut less than one-half mile to the south across Wills Creek. Here the upper 200 feet of the Keyser through the basal Shriver is well exposed and sufficiently weathered to show internal structure.

Figure 22 shows a columnar section and the corresponding points of interest within the quarry.

1) Tonoloway Limestone (Silurian) - Thin-bedded to laminated generally unfossiliferous limestone and dolomitic limestone. Represents supratidal to shallow subtidal facies existing just prior to the more normal marine Keyser environments. Contact with the overlying Keyser is often erosional.

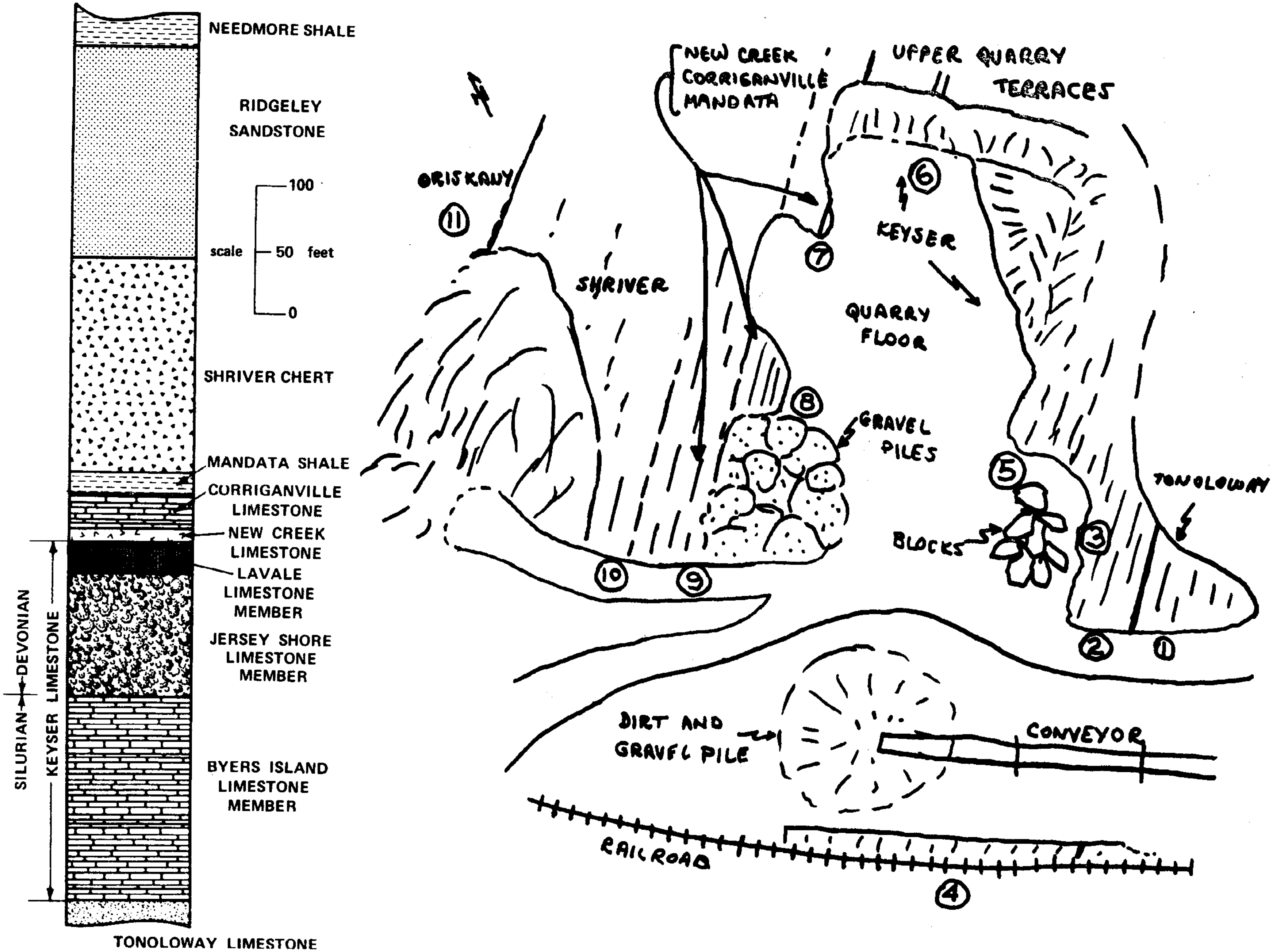

Figure 22 - Sketch of Helderberg Group in Cumberland Cement and Supply Company Quarry at Corriganville, Maryland.

2) Keyser Limestone (Lower Byers Island Member; Silurian) - Variably bedded, locally cherty, somewhat nodular lime muds, silts, and sands. Burrowed; thin, laterally irregular interbeds of fossil hash; some dolomitic limestone. These lower beds represent dominantly intertidal and shallow subtidal environments. To the northeast along the outcrop belt as one travels toward the western basin margin, more restricted environments dominate this part of the section. To the south (as at the type section at Keyser) more normal marine environments are seen in this stratigraphic position.

3) Keyser Limestone (Middle Byers Island Member; Silurian) - Abundant stromatoporoids and favositid corals occur in the quarry wall in this area in subtidal carbonate environments.

4) Lower Keyser - Approximately 90 feet of lower Keyser and uppermost Tonoloway are exposed along the railroad tracks just south of the dirt and gravel pile.

5) Keyser Limestone (Upper Byers Island Member - Lowermost Jersey Shore Member; Silurian and Devonian) - A variety of limestone types ranging from massive to thin-bedded and shaly; lime sands and silts often interbedded; some chert. Brachiopods are locally abundant; in particular, the Gypidula prognostica peak zone appears within this interval. Subtidal carbonate sand environments tend to dominate this part of the section. Elsewhere in the depositional basin during this time interval the regional transgression was establishing distinctly subtidal environments in central Pennsylvania and New York.

6) Keyser Limestone (LaVale Limestone Member) - Thin to medium bedded, often laminated and mudcracked stromatoporoid-rich limestones are exposed in mostly inaccessible outcrops in the far quarry wall. The fauna is generally restricted to stromatoporoids occurring in beds up to about 3 feet in thickness and occasionally scattered throughout. Bryozoans and some brachiopods are also present. These beds represent deposition in tidal channel, intertidal, and some supratidal environments and represent a regressive phase within the general transgression of this time period.

7) New Creek Limestone and the contact with the underlying Keyser Limestone - The New Creek is a thick-bedded generally coarse to very coarse grained limestone (dominantly biosparites and biosparudites)

containing abundant crinoid and brachiopod skeletal debris. It represents a sub-tidal wave-influenced environment which shows regional variations in characteristics. This contrasts to the immediately underlying intertidal and supratidal Keyser (Byers Island) facies over which the New Creek environment transgressed. This produced a distinct erosional contact often with several inches of relief and Keyser clasts in the basal part of the New Creek. This contact is exposed in the north quarry wall but is more accessible at point 7. It is an interesting example of normal carbonate facies relationships which in the past have often been interpreted as more significant regional unconformities.

8) Corriganville Limestone (proposed) - Thin to medium bedded, fine to medium grained, very cherty limestones with an abundant brachiopod fauna. Brachiopods tend to be more biplanate and have wider hinge lines than in the underlying higher-energy New Creek facies. This and the generally finer grain size suggest a quieter, less-agitated, more offshore environment. A shallow shelf area just offshore of New Creek type environments seems likely. Good specimens of silicified brachiopods are found in this unit. This is the "New Scotland Limestone" of many previous authors.

9) Mandata Shale - A blocky to platy weathering mudstone and shale with occasional lenses and thin beds of calcarenite towards the base. A variety of brachiopods is found towards the base and phosphate nodules are common there also. A wide variety of burrows occur in this facies. This unit appears to have been deposited predominantly in the median portion of the basin, seaward of the Corriganville and New Creek facies.

10) Shriver Chert - Dark gray to black, buff and tan weathering extremely cherty silty argillites and calcareous siltstones. The sparse epifaunal remains coupled with the number of burrows and the thoroughness of organic reworking suggest that this environment existed in deeper water in the central part of the basin and was characterized by a soft substrate. Stratigraphic relationships support this concept.

11) Oriskany Sandstone - Massively bedded medium to coarse grained calcareous quartz sandstone and sandy limestone. The transitional nature of the upper very calcareous Shriver and the overlying Oriskany is well displayed here and suggests that in this area the two environments may have been transitional.

Reboard buses and return to Route 36.

Turn east (left) onto Route 36 and retrace route for 1.7 miles.

39.3 Junction of Md. Route 36 and U.S. Route 40. Turn west (right) on U.S. Route 40. Shale exposed on left bank of Route 40 is Rose Hill Formation.

41.6 Braddock Gap on left, a wind gap through Haystack Mountain. Named for General Braddock's march through gap toward Pittsburgh in 1755.

42.5 Turn left at traffic light onto Campground Road. (Road named for first campground of the British Redcoats under Braddock as they marched west from Fort Cumberland toward Fort Duquesue in 1755.) (To right at traffic light is only exposure of Mahantango Formation along Cresaptown fault zone; the Burket and Tully Members are omitted by faulting however. See Figure 23 of this guidebook.)

42.7 Merge right onto Vocke Road.

43.3 Junction of Vocke Road with Md. Route 53. Continue straight across Route 53 and park bus at east end of Sears Town Shopping Center.

STOP 9. Discussant: John M. Dennison

The purpose of this stop is to walk through the section extending from the upper Brallier Formation to the Greenbrier Limestone.

Figure 23 is a detailed map of the outcrops in the section along the valley of Braddock Run. The surrounding area has been shown on geologic maps prepared by the following workers: O'Harra (1900); Dyott (1956); Twigg (1957); Berryhill, Colton, deWitt and Johnston (1956); Dennison and Naegele (1963); and Cleaves, Edwards and Glaser (1968).

The Marcellus Shale is thrust against the upper Brallier Formation along the Cresaptown fault, which surfaces beneath Route 135 at the south corner of the Sears Town Shopping Center. At least some of the Mahantango Formation and Harrell Shale are present in cuts near the Maryland State Police Station (Figure 23), so the Cresaptown fault is locally probably a series of faults rather than a single fracture.

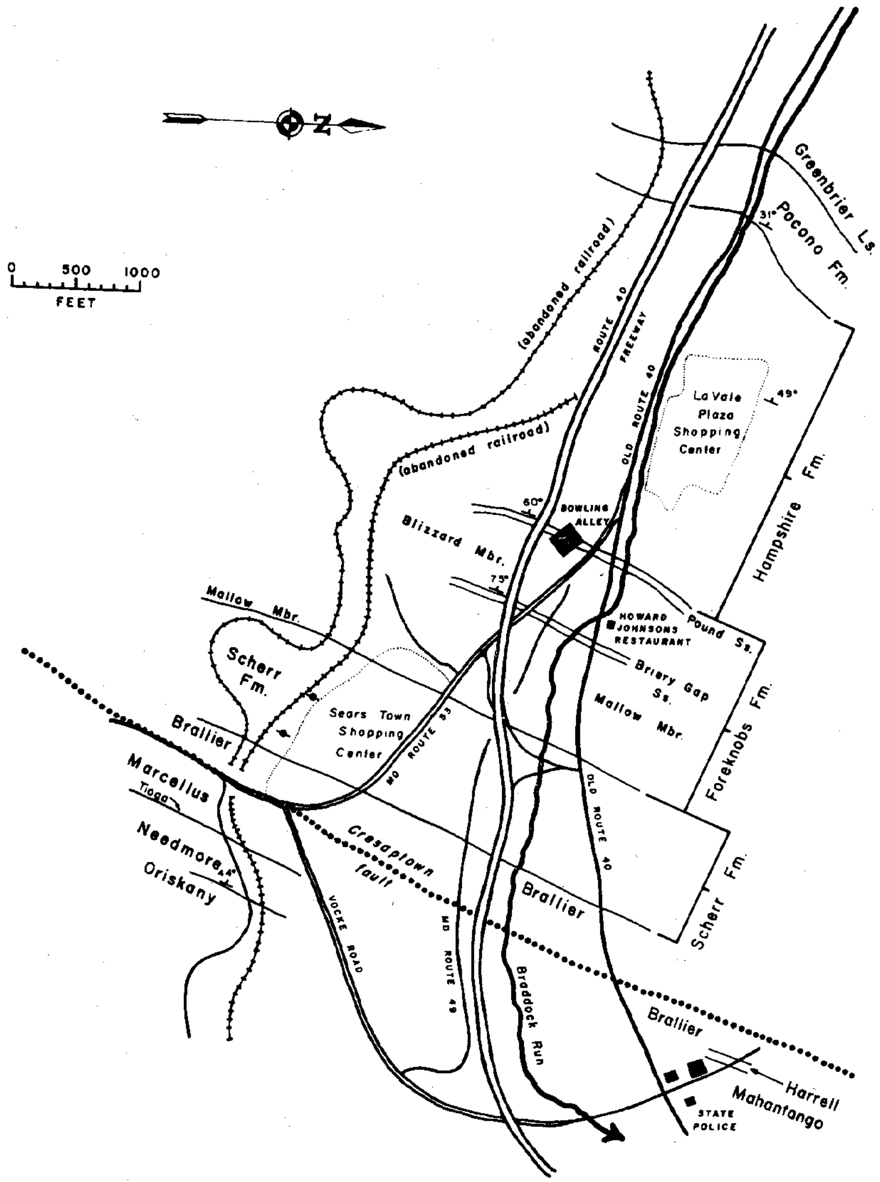

Figure 23 - Map showing Devonian exposures in section at La Vale, Maryland.

The stratigraphic section exposed in cuts at the Sears Town Shopping Center, LaVale Plaza Shopping Center and along the U.S. Route 40 Freeway can be summarized as follows from measurements by Dennison and Naegele:

Greenbrier Limestone (not measured)
Limestone, largely concealed in valley
Redbeds (not measured) (tongue of Mauch Chunk facies)

Pocono Formation (not measured)	
Hampshire Formation	(2.200 feet)
Greenland Gap Group	(2,407 feet)
Foreknobs Formation	(1,449 feet)
Unnamed member	(43 feet)
Pound Sandstone Member	(23 feet)
Blizzard Member	(471 feet)
Briery Gap Sandstone Member	(39 feet)
Mallow Member	(873 feet)
Scherr Formation	(958 feet)
Brallier Formation	(350 feet to Cresoptown fault)

This section was previously measured with good accuracy of total thickness by Swartz (1913 , p. 523-528).

The basal few feet of the Scherr Formation contain the most sandy beds in the Scherr, and the basal 13 feet of Scherr exhibits brownish gray "redbeds" associated with marine fossils. This lower sandy portion of Scherr contains Cyrtospirifer chemungensis (Conrad) identifying these strata as Cohocton Stage rather than a ton Parkhead Sandstone belonging to the Finger Lakes Stage, as interpreted by Swartz (1913, p. 523-528). See separate article by Dennison and deWitt in this guidebook concerning the significance of these redbeds.

The characteristics of the members of the Foreknobs Foundation are described and their environmental significance is discussed by Dennison (1970, 1971). In general, an upward succession in the Greenland Gap Group changes with basin in-filling from deep water sandy turbidites of the Scherr Formation to shallowing marine beds of the Foreknobs Formation, which finally pass upward into the nonmarine Hampshire Formation. The Mallow Member is shallow-water turbidite, passing upward into probable barrier bar marine sandstone deposits of the Briery Gap Sandstone Member. The Blizzard Member is near-shore marine, and the Pound Sandstone Member is probably also another barrier bar deposit. The thin unnamed member at the top of the Foreknobs Formation contains marine fossils. The Mallow Member, Blizzard

Member, and the unnamed upper member all contain brownish gray "redbeds" often with near-shore marine pelecypods and Camarotoechia brachiopod. The dull redish coloration of these marine redbeds results from partial reduction of brighter grayish-red strata swept into the sea marginal to the subaerial Catskill Delta complex. Temporal significance and possible sea level shifts reflected by patterns in these marine redbeds (Figure 15 of this guidebook) are discussed by Dennison (1971).

The Pocono section here should be studied in detail before it is obliterated by grass-cover along the new highway cut. Thin streaks of allochthonous coal and coalified wood fragments suggest nonmarine deposition, especially with an absence of marine fossils. A conglomeratic zone within the Pocono here is the most polymictic conglomerate known to Dennison in any post-Ordovician strata in the Appalachian basin. Does this polymictic conglomerate represent an unconformity?

Several tens of feet of redbeds occur between characteristic Pocono strata and Greenbrier Limestone. Dennison suspects that this redbed zone represents a northward expansion of the middle redbed tongue within the Greenbrier at Keyser (Dennison, 1955, p. 48-49, 129-131; 1963) so that the lower limestone changes facies northward from Keyser toward LaVale and passes over to a Mauch Chunk facies. Some of these pre-limestone redbeds at LaVale are calcareous sandstones. Byron Cooper (1948, p. 260) postulated, without field documentation, that the Greenbrier Limestone disappeared northward by facies change into the Mauch Chunk Formation of Pennsylvania.

Field observations by Dennison suggest the schematic pattern of Greenbrier facies changes indicated in Figure 24. A very significant dissertation research problem would be to study the detailed stratigraphy and sedimentology of the Greenbrier Limestone on both limbs of the North Potomac-Georges Creek syncline throughout its hundred-mile length.

After walking through the LaVale section return to bus which will be parked at west end of Sears Town Shopping Center.

43.6 Buses park at west end of Sears Town Shopping Center for reboarding.

Drive west (up section stratigraphically) along old Route 53.

43.8 Route 53 passes under new Route 40 Freeway.

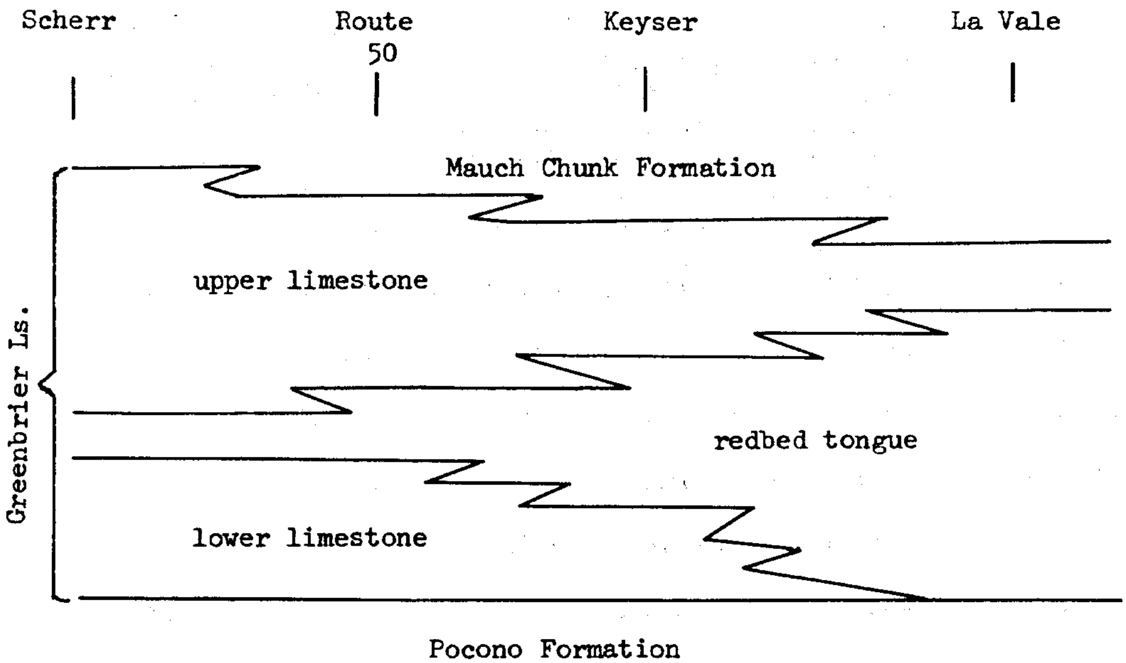

Figure 24 - Schematic diagram showing possible facies change from Greenbrier Limestone into Mauch Chunk Formation.

43.9 Junction Md. Route 53 and U.S. Route 40. Turn west (left) on Route 40.

44.1 LaVale Plaza Shopping Center on right with excellent exposures of Hampshire Formation in excavation behind building. Dennison and Orville D. Naegele described Hampshire strata in detail in these exposures. In a recent open file report for AEC, Dennison and Wheeler (1972) rated the Hampshire Formation as one of the six outstanding stratigrphic units in the Southeast for uranium potential.

44.3 Toll house (built about 1833) on old National Road.

44.5 Pocono Formation forms ridge on left.

44.6 Valley on left is site of Greenbrier Limestone outcrop trace.

45.0 Mauch Chunk Formation redbeds on left.

45.2 Pottsville Formation sandstone float.

45.4 Roadside picnic area on left.

46.4 Junction of U.S. Route 40 and Md. Route 55. Turn left on Route 55.

46.5 LUNCH STOP.

Buffet at Clarysville Inn. Old portion of building was constructed in 1807 and used as hospital by Union forces in Civil War.

Reboard buses and retrace route to LaVale.

46.6 Junction of Md. 55 with U. S. Route 40. Turn right on Route 40.

48.6 Old toll house on right.

49.0 Junction in LaVale of U.S. Route 40 and Md. Route 53. Continue east on Route 40.

49.6 Cross outcrop trace of Cresaptown fault.

50.9 Historical marker labelled "National Highway". What is now U.S. Route 40 was the first national highway (authorized in 1806), built to get pioneers from Cumberland to Ohio River at Wheeling.

51.4 Turn left on Long Road (also known as Cash Valley Road).

51.7 Pass abandoned quarry in Shriver Chert. Proceed along strike beside Oriskany Sandstone dip slope. Narrow valley underlain by Devonian shale results from foreshortening by Cresaptown fault.

52.8	Crest of hill. Note how valley opens up ahead. Normal unfaulted Devonian shale section at Corriganville produces wide valley a mile ahead. Cresaptown fault in Brallier Formation passes approximately under large white house on direct left.
53.2	Cross Western Maryland Railroad tracks. The Corriganville Devonian delta section measured in 1962 by Dennison and Orville D. Naegele is located in part along this railroad. Tioga Bentonite is poorly exposed in first outcrop to right beside railroad tracks.
53.8	Cumberland Bone Cave is in a railroad cut through the end of hill on right. The type section of the Corriganville Limestone (name proposed by James W. Head) is in this same railroad cut.
53.9	Intersection with Md. Route 36. Quarry visible ahead was site of Stop 8. Turn left on Route 36.
54.0	Cross Jennings Run. The Jennings Run section of the Upper Devonian described by Prosser and Swartz (1913, p. 371-376) is located here. It was remeasured by Dennison and Naegele (see Figures 6 and 15 of this guidebook for summary). This is not the type section of the Jennings Formation of Darton (1892) a name used in all the Maryland Geological Survey older Devonian literature; the type area (Darton, 1892) is at Jennings Branch and Jennings Gap in western Augusta County, Virginia. No specific reference section in Augusta County has ever been measured.
54.1	Corriganville. Turn north (right) on Md. Route 53. The highway extends along a largely covered steeply dipping sequence of Middle Devonian strata.
55.6	Marcellus Shale on left.
56.3	Center of Ellerslie, Md. At one time, Ellerslie contained a large fire brick and ceramic plant which utilized flint clays from the Lower Kittanning coal zone. The mine, now long abandoned, is 1.8 miles west of Ellerslie on the Maryland-Pennsylvania State line at the top of the Allegheny Front.
56.4	Cross the Maryland-Pennsylvania State line where Md. Highway 35 becomes Pennsylvania Highway 96. "Big inch" pipeline from Texas to Philadelphia passes a few feet north of State boundary. Valley on right contains Wills Creek, from which the Wills Creek Formation is named (Uhler, 1905).
57.1	Cross the nose of a south-plunging anticline in the Ridgeley Sandstone. The highway trends along the east flank of the anticline for several miles. Ridge crest on skyline at right is Wills Mountain, formed by Tuscarora Sandstone arched up into Wills Mountain anticline.

58.6 Stringtown, Pennsylvania. Fossiliferous beds of east-dipping Ridgeley Sandstone crop out along the left (west) side of the highway at Stringtown. Fossiliferous calcareous nodular-bedded siltstone of the Shriver Formation can be observed at the axis of the anticline along the secondary road 0.1 mile west of Stringtown. Exposures of Tioga Bentonite and Purcell Member of Marcellus occur near cemetery to right of highway.

59.5 Crossroads of Palo Alto. An up-limb thrust of small displace- in the Ridgeley Sandstone on the west limb of the anticline is clearly observable in the winter and spring on the north side of the Kennells Mills road 0.15 mile west of its junction with Route 96.

60.0 Cross crest of anticline in the Ridgeley Sandstone. The highway continues north along the west flank of the fold for about a mile, mainly upon much folded and mashed Needmore and Marcellus Shales and mudrock. Such low folds are common in the Oriskany Sandstone from New Creek to Hyndman at the base of Allegheny Front and on west flank of Wills Mountain anticlinorium. Do the folds persist to the west in the subsurface?

60.8 Cross the axis of a second small south-plunging anticline in the Ridgeley Sandstone, which lies en echelon to the anticline at Palo Alto. The highway runs mainly along a narrow belt of steeply dipping Needmore, Marcellus, and Mahantango rocks. The main thrust faults in the Hyndman zone are in the open fields and low ridges west of Route 96. The first set of knobs is supported by nearly vertical beds of sandstone and conglomerate of the Foreknobs Formation; the intermediate knobby ridge is underlain by the sandy Pocono Formation dipping about 70° to the west; and the ridge at the sky line, the top of the Allegheny Front, is supported by pebbly sandstone and conglomerates in the Pottsville and Allegheny Groups.

61.7 Long exposure of steeply dipping fossiliferous mudrock and intercalcated argillaceous limestone in the upper part of the Needmore Shale. The trilobite Phacops cristata is locally abundant. Bedding planes are marked by Taonurus caudagalli. Note how valley has narrowed as result of Hyndman fault.

63.4 Enter Hyndman, once an important quarry town in the past century. On the right (east), an abandoned quarry in the Keyser Limestone; 0.1 mile north on the left (west) another abandoned quarry in the nearly vertical Keyser Limestone. Stone from these and other quarries in the vicinity was shipped to Pittsburgh for use as blast-furnace flux (Stevenson, 1882, p. 105). Hyndman also contained a ceramic factory which manufactured fire brick from Pennsylvanian-age flint clays mined in the Wellersburg basin a few miles to the west and refractory brick from ganister quarried locally from the Tuscarora Quartzite.

63.6 First stop light in Hyndman. Turn right with Route 96 and follow Route 96 through Hyndman. Railroad tracks are main line of Baltimore and Ohio Railroad linking Cumberland and Pittsburgh via Connellsville.

63.9 Cross Wills Creek.

64.6 Junction of Pa. Route 96 and back road to Hyndman. Shriver calcareous nodular-bedded siltstone dipping 75° east crops out by the stop sign. Ridgeley Sandstone overturned and dipping 63° east crops out in the small hillock 0.05 mile north on the east side of the Penn. Central R.R.

64.8 Junction of Pa. Route 96 and Tiger Run Road--the crossroads community of Wills Creek.

STOP 10. Discussant: Wallace de Witt

To the south in the shallow gap, the black-topped road lies mainly on Needmore and Marcellus Shales. The white frame house at the base of the gap marks the basal part of the upper massive fossiliferous silty mudrock of the Mahantango Formation. The barn to the right (west) of the frame house marks the approximate location of the Burket Black Shale Member of the Harrell Shale, the base of the Upper Devonian sequence. The dense plantation of pines west of and above the barn is underlain by the Brallier and Scherr Formations. The main fault in the Hyndman fault zone is within this sequence of beds. The pebbly sandstones and thin-bedded conglomerates in the base of the Foreknobs Formation form the low knob on the ridge to the right of the pine plantation. The basal beds of the Foreknobs cross Tiger Run 0.25 mile west of Route 96, but the conglomerate is not exposed at stream level. Blocks of pebbly sandstone and small outcrops of conglomerate are present on the south end of Coughenour Ridge north of Tiger Run.

Return to bus.

Drive north on Pa. Route 96. The massive to slabby beds of conglomerate and sandstone of the Foreknobs Formation support Coughenour Ridge immediately west of the highway. The basal conglomerate of the Foreknobs crops out on the east face of the ridge, and the shaly beds in the upper part of the Scherr Formation are poorly exposed at places low on the east side of the ridge. The valley of Little Wills Creek, along which Route 96 trends, is underlain by nearly vertical beds in the Scherr, Brallier, Harrell, and Mahantango Formations. The low hills to the east at the foot of Wills Mountain are formed by the Ridgeley Sandstone and Shriver Formation of the Oriskany Group. The main thrust in the Hyndman fault zone lies in the Scherr-Brallier sequence in Little Wills Creek valley and is well concealed by alluvium. Two-feet thick sandstone beds in Foreknobs Formation on left. Foreknobs Formation crops out near valley floor because of Hyndman fault zone.

67.3 Village of Fossilville on the right. Fossilville was named for the fossiliferous hematitic iron ores associated with the Keefer Sandstone Member of the Mifflintown Formation which were mined many years ago along the west flank of Wills Mountain about 0.5 mile of the village. The iron ore was known locally as the "fossil" ore because of the contained marine fossils, and the village was named for the locally exploited iron ore. The ore was used as feed for several short-stack blast furnaces in the area during the middle of the past century (Stevenson, 1882, p. 107, 320).

68.2 Gravel Pit Church on the right (east). The Hyndman fault lies in the covered interval near the church.

68.7 On the left (west), the Burket Black Shale Member of the Harrell Formation crops out back of the barn. Abundantly fossiliferous Mahantango silty shale and mudrock exposed in cuts on the left (west) side of the highway 0.15 mile to the north.

69.5 Lybarger Church on the left. Route 96 lies in a cut in the top of the Needmore Shale with black Marcellus Shale exposed on the left (west) side of the highway in front of the church. Fragments of Tioga Bentonite have been found in road cut on left. To the east (right) nearly vertical beds of Ridgeley Sandstone form the crest of the small ridge 0.04 mile east of the highway. The large and conspicuous quarry in the Tuscarora Quartzite in Buffalo Mountain, the west flank of the Wills Mountain anticline, to the left (east) is the quarry of the Leap Ganister Rock Co. of Hyndman. The Tuscarora was quarried for ganister for refractory uses.

69.7 Madley, Pennsylvania village, junction of Pa. Route 96 and Wolf Camp Run. Turn left (west) on the Wolf Camp Run Road and proceed 0.2 mile.

69.9 STOP 11. Discussant: Wallace deWitt.

Cross the road to the north bank of the run. The vertical beds of the upper gray shale member of the Harrell and the basal massive beds of siltstone in the Brallier form the bed of Wolf Camp Run. Note the similarity of the section to the Brallier in the section at Scherr. The Brallier is exposed more or less continuously westward along Wolf Camp Run for about 1,000 feet. The bedding is nearly vertical. To the left (east), the uppermost massive fossiliferous beds of the silty Mahantango Formation are exposed back of the house, as are the younger black shale beds of the Burket. A thrust fault of small displacement has moved the upper beds of the Mahantango westward over the basal Burket and masked the stratigraphic position of the Tully Limestone.

Return to bus and ride west 0.2 miles.

West along Wolf Camp Run Road approximately 1,000 feet at sign, turn left (south) and fight your way through the briars to the run (watch out for those thorns). Here the brownish-gray "purple-weathering" silty mudrock and argillaceous siltstone beds at the top of the Brallier are about 10 feet thick in the cliff on the south bank of the stream. If the water is low, you may splash across, but the stones are deceptively slippery and an unanticipated dunking might result. Poorly preserved scattered fossils of the "Chemung" Cyrtospirifer fauna are scattered in the 50-foot sequence of silty mudrock and siltstone in the basal Scherr west of the "purple-weathering" Brallier. The formation boundary is the top of the "purple-weathering" beds.

Return to vehicle and to Route 96 at Madley.

70.5 Turn left (north) on Route 96.

72.3 Bard, junction of Pa. Highway 96 and the West End Road. Turn left (west) and proceed 0.8 mile along the West End Road to the proposed site for the New Enterprise Stone and Lime Co.'s Bard quarry.

73.1 STOP 12. Discussant: Wallace deWitt.

Site of the proposed quarry of the New Enterprise Stone and Lime Co. The light-gray and white pebbly quartzose coarse-grained sandstone in the quarry, here informally deisgnated as the Bard bed, is the basal member of the Foreknobs Formation in a part of southwest Bedford County. The member has been traced by de Witt south along Lybarger Hill and Coughenour Ridge to the vicinity of Tiger Run and northwest to the crest of Dry Ridge east of the hamlet of West End. South and west of these localities, the bed cannot be identified with certainty, because it resembles other thin beds of conglomeratic sandstone in the Foreknobs Formation. At the proposed quarry site, the Bard bed consists of 70 feet of massive to slabby sandstone

(J. R. Barnicle, oral commun., 1972) showing an abundance of discoidal to ellipsoidal pebbles as much as 2 inches long, many steeply inclined planar to lenticular crossbeds, commonly with west dip, and a general absence of material finer than medium-grained sand. Although marine fossils are uncommon in the strata in the quarry, they occur in the pebbly sandstone less than one-half mile to the west. See Figure 25 for histogram of grab sample of pebbly sandstone.

The grain size, geometry, and stratigraphic association of the Bard bed suggest that the unit was deposited in a high-energy environment. The bed is believed to be an offshore bar which accumulated close to the mouth of a river which supplied a large volume of sand and pebbles. The westward thinning and diminution of grain size and the presence of a marine fauna indicate that the deposit was not a sand-filled channel on a deltaic flood plain.

Although erosion has removed much of the bar north of the quarry site, the remaining part should be of great interest to petroleum geologists, because it is the surface exposure of a bar similar to many of the oil- and gas-productive pebbly sand bars in the Upper Devonian sequence in western Pennsylvania and the adjacent parts of New York and West Virginia. This thick conglomerate is near the base of the Foreknobs Formation, well below the stratigraphic position of the massive frequently pebbly Briery Gap and Pound Sandstone Members. Presence of this conglomerate so low in section suggests from regional facies patterns that entire Appalachian Plateau region of Pennsylvania could contain lenticular deposits of similar lithology. Would you like to drill into this stratum on a structural high?

The small hill one-half mile northeast of the proposed quarry site is a remanent of the Bard bed which was involved in the folding and faulting along the west flank of the Wills Mountain anticline. The strata are vertical or steeply inclined. In contrast to the undeformed rock at the proposed quarry site, the beds in the hill to the northeast have been considerably mashed. Locally, the small-scale drag folds show disharmony. Many of the elongate pebbles have been shattered, brecciated, and recemented with silica. The effects of deformation of the Wills Mountain fold are clearly evident in the outlier of the Bard bed.

73.9 Buses turn around for reboarding at Stop 10. Junction of the West End Road and Pa. Route 96 at Bard. Turn left (north) with caution and proceed north along Route 96.

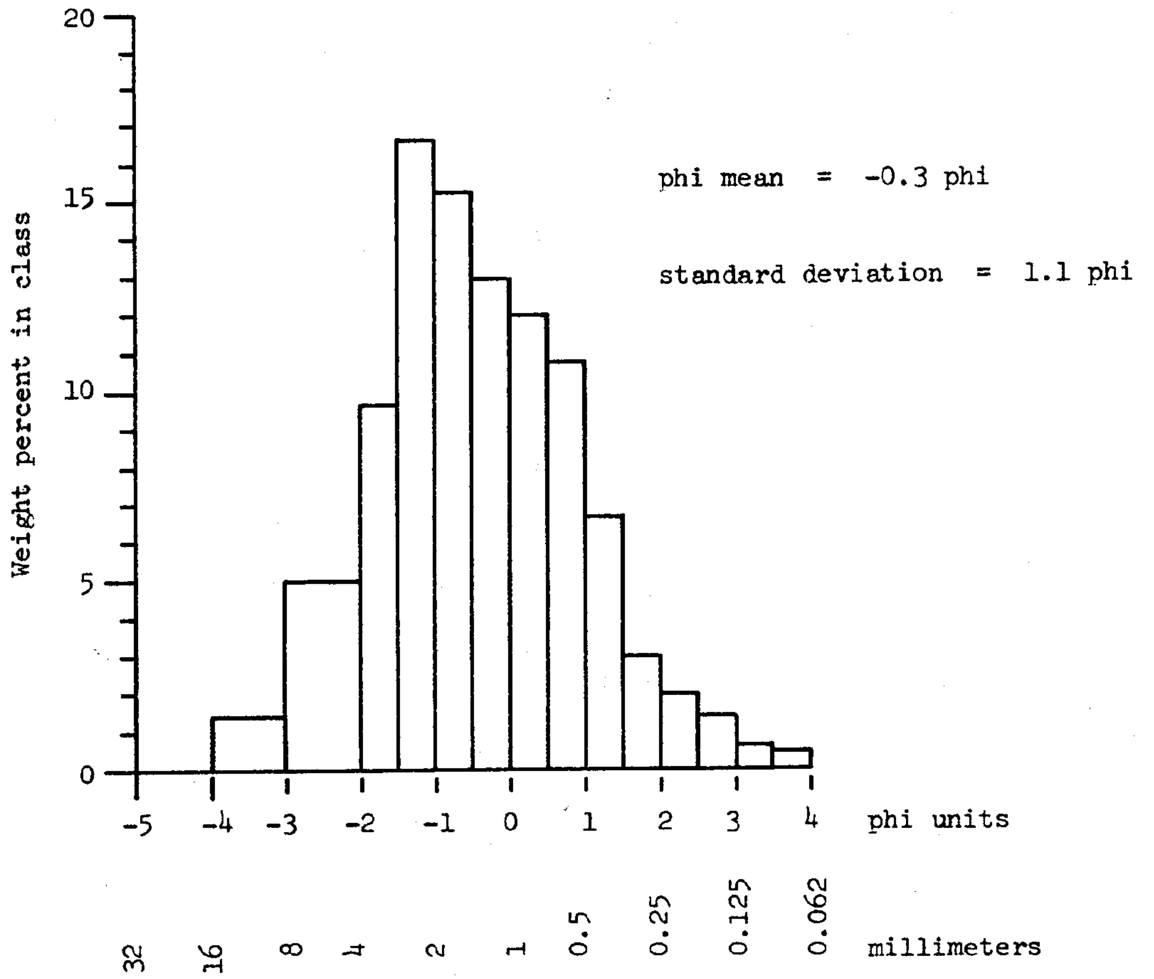

Figure 25 - Histogram of mechanical analysis data from specimen of pebbly sandstone from Foreknobs Formation at quarry site near Bard, Bedford County, Pennsylvania.

76.4 Red barn with hex sign is southern limit in this valley of Pennsylvania Dutch culture.

75.3 Buffalo Mills to the right (east), the site of several small quarries in the Keyser Limestone in the ridge on the north side of the village.

76.3 Brallier Formation exposed on left.

78.2 Road leads east 1.4 miles to White Sulphur Springs Hotel dating from 1886. Hotel situated on upper part of Reedsville Shale in breached dome of Wills Mountain anticline. Mary Martin No. 1 well was drilled 6,676 feet deep near hotel by Kerr-McGee in 1963. Mountains on left have receded as the Allegheny Front trace (Figure 1) moves to west of Schellsburg Dome with Keyser Limestone exposed at core of dome.

80.1 Junction of Pa. Route 96 with Pa. Highway 31 in the village of Manns Choice. Continue northeast along Route 31 in the valley of the Raystown Branch of the Juniata River. The Tuscarora Quartzite holds up Kinton Knob at the north end of Milligans Cove, the conspicuous knob about 2 miles northeast of Manns Choice. The Wills Mountain anticline plunges north sharply from Kinton Knob, and the Tuscarora Quartzite passes below drainage on the nose of the anticline in the vicinity of Wolfsburg about 2.5 miles north of the knob.

81.4 Cut along Pennsylvania Turnpike 0.2 mile to left exposes section of Mahantango Formation, Tully Limestone, Harrell Shale and Brallier Formation.

81.6 Cross Raystown Branch of Juniata River.

82.6 Tonoloway Limestone in road cuts.

83.4 Junction of Pa. Route 31 and U.S. Route 30. Stop, then turn east (right) on Route 30 with caution.

86.1 Exit right on cloverleaf from U.S. Route 30 onto U.S. Route 220 northbound.

88.6 Exit right to access road.

89.0 Holiday Inn, Bedford, Pennsylvania.

HAVE A SAFE TRIP HOME.

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STRATIGRAPHY AND STRUCTURE OF THE HARRELL SHALE
AND PART OF THE MAHANTANGO FORMATION
BETWEEN BEDFORD, PENNSYLVANIA AND SCHERR, WEST VIRGINIA

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This portion of the guidebook is a summary of the regional stratigraphic setting of the Harrell Shale and the upper part of the Mahantango Formation (Fig. 26). The regional setting is important to understanding what will be seen on this field trip because the itinerary is between areas of significant facies change in the Harrell and Mahantango. The interpretations which follow are a brief summary of a regional study (over 12,000 square miles) of this stratigraphic interval (Hasson and Dennison, in preparation). The present day stratigraphy and structure are shown in Figure 27. Figure 28 is an interpretive restored section of the same area. These two figures are principally from information included in a master's thesis done at the University of Tennessee (Hasson, 1966).

Harrell Shale

The Harrell Shale is a dark gray to grayish black fissile shale of latest Middle Devonian to early Late Devonian age which crops out in linear belts east of the Allegheny Front in the folded portions of south central Pennsylvania, western Maryland and West Virginia. The formation averages approximately 240 feet thick in northern areas but thins to the southwest along strike. Eastward it grades into coarser and lighter colored clastics. Southwestward along strike and westward in the subsurface the Harrell passes laterally into a thicker sequence of black shale (Millboro Shale, Butts, 1940, p. 308). Harrell Shale is not recognizable as a distinct unit south of southern Pendleton County, West Virginia, because the underlying gray beds of the Mahantango Formation change facies southwestward to black Millboro Shale. The Harrell Shale, therefore, constitutes a northeastward-extending tongue of the thicker Millboro Shale Formation. The Harrell is everywhere overlain by the Brallier Formation and is underlain by the Middle Devonian Mahantango Formation. The Tully Limestone forms the basal member of the Harrell Formation in the northeast, but to the southwest the Tully Member becomes a tongue within the Harrell Shale Formation.

The formation was named by Butts (1918) for exposures at Horrell Station, Blair County, Pennsylvania. In the same paper he also designated the basal black shale portion of the Harrell as the Burket Member. The

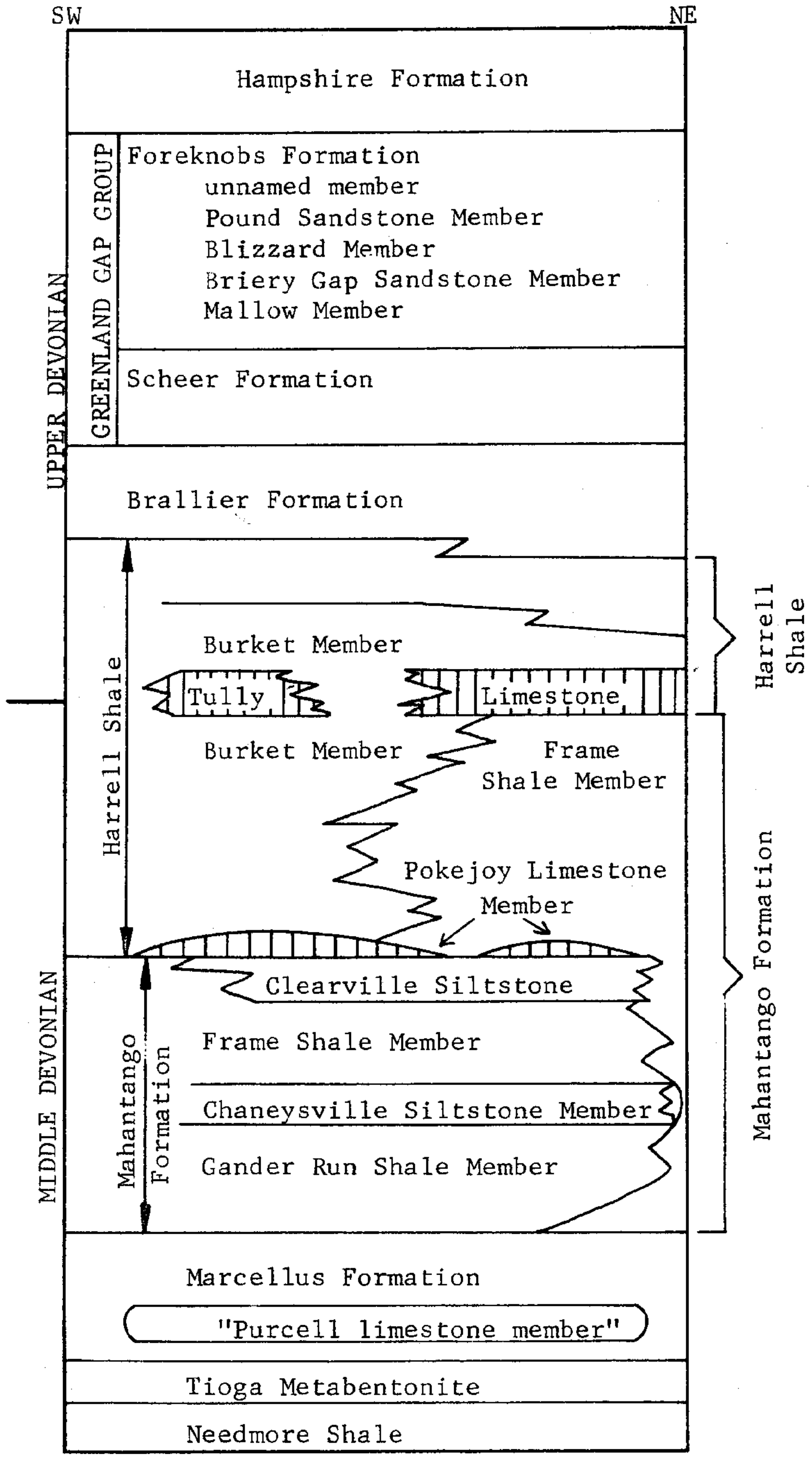

Figure 26 - **Summary of Middle and Upper Devonian nomenclature applied along the Allegheny Front between Corriganville, Maryland and Scherr, West Virginia.**

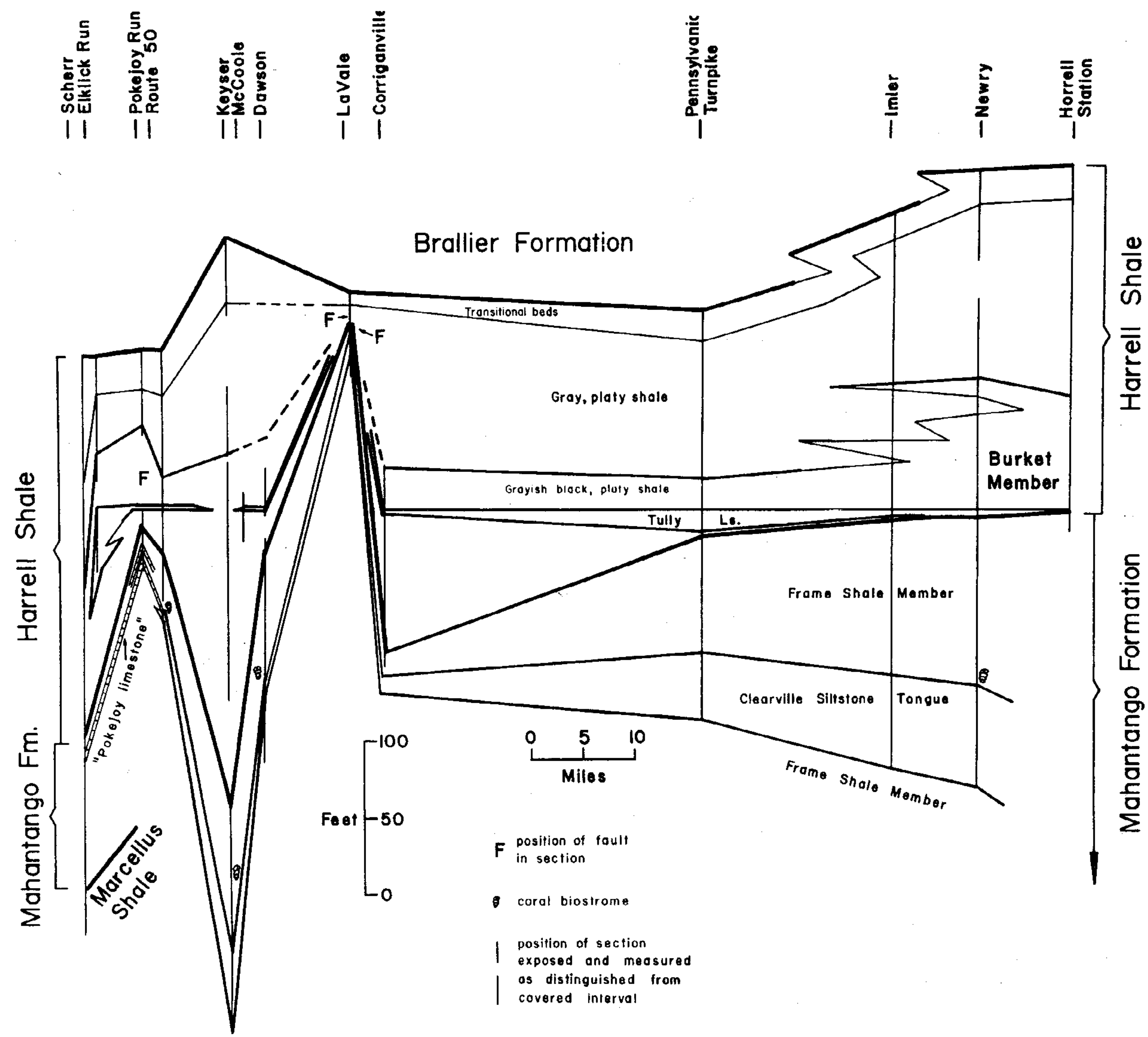

Figure 27 - Cross section illustrating stratigraphy of the Harrell Shale and part of the Mahantango Formation between Horrell Station, Pennsylvania and Scherr, West Virginia.

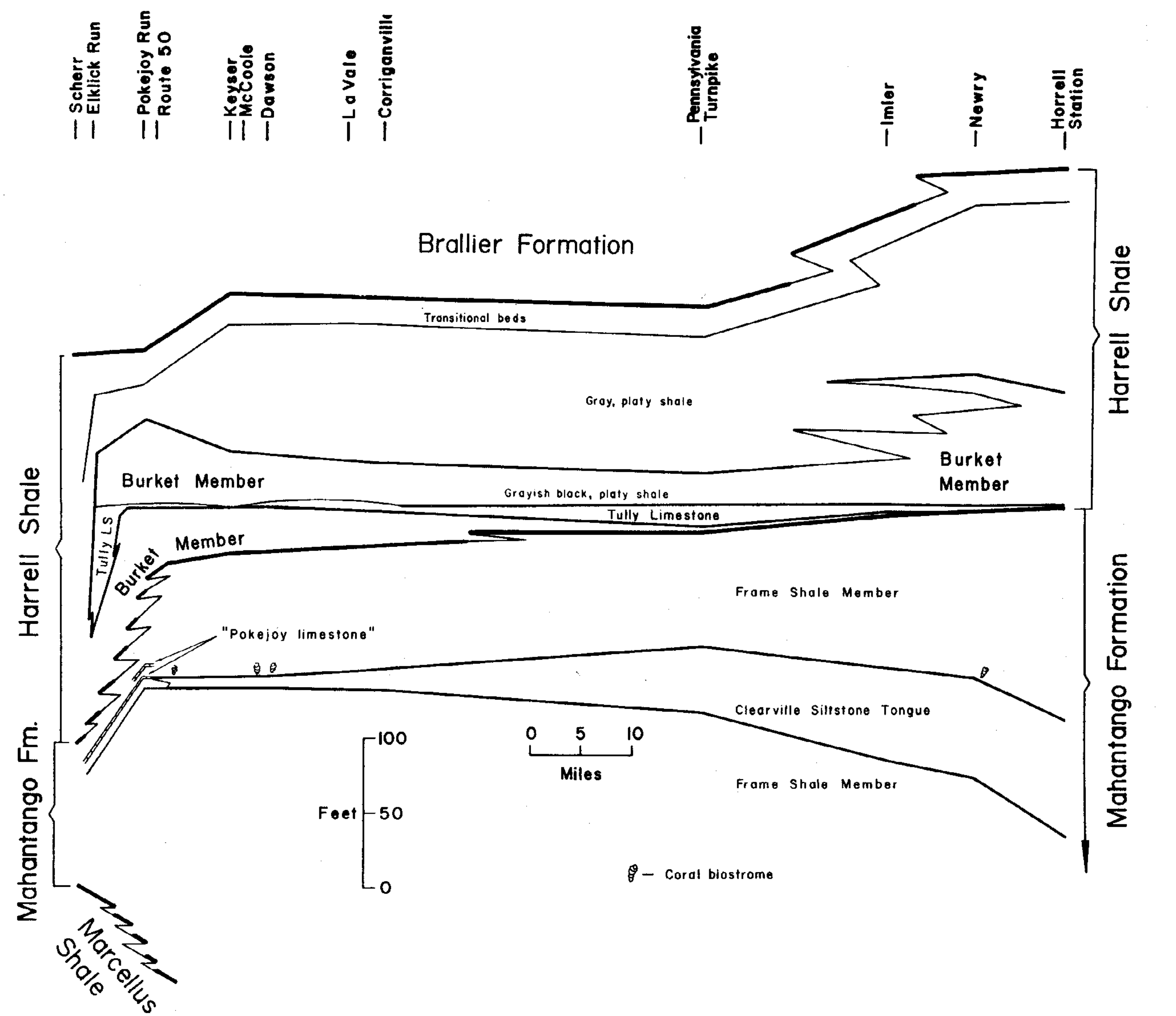

Figure 28 - Interpretative cross section of Harrell Shale-Mahantango Formation removing effects of structural deformation.

name Burket is taken from a former Altoona suburb which has since been engulfed by that city and no longer exists. The term Harrell is apparently a printing or transcription error which has become established in the literature. The type locality appears in the Hollidaysburg-Huntingdon folio (Butts, 1945) as Horrell. The term Harrell is now used by the Maryland Geological Survey for part of the Jennings Formation (abandoned) and by the West Virginia Economic and Geologic Survey for rocks previously termed Genesee.

Four general subdivisions of the Harrell are recognizable in the field trip area: a basal Burket Member, a middle gray shale portion, an upper zone transitional with the Brallier, and the Tully Limestone Member.

The contact between the Harrell and Brallier is gradational; the base of lowest distinct siltstone bed is taken as the boundary between the two formations. Below the contact the uppermost Harrell resembles the Brallier shales but lacks siltstone. The uppermost Harrell shales are thickly to thinly laminated, medium dark gray when fresh, somewhat silty and weather to light olive gray plates and chips. The transitional zone varies in thickness, averaging approximately 25 feet.

Below the transitional zone and above the Burket Member the Harrell consists of very dark gray, thinly to thickly laminated shale which weathers to yellowish gray plates and sheets. The formation changes facies eastward and in the vicinity of the West Virginia-Virginia border is thinner and contains considerable interbedded siltstone and lacks the black Burket facies. The Harrell is not a mappable unit in this extreme eastern area, and in fact may be totally absent with Brallier resting directly on Mahantango Formation. Southwestward along the Allegheny Front the Harrell grades laterally into the main mass of black Millboro Shale.

The average thickness of the Harrell (including the Burket) in the field trip area is about 240 feet, but it is unusually thick (386 feet) at Keyser, West Virginia, one mile south of Stop 2. This thickening may be partly due to sedimentation (the Mahantango, Brallier, Scherr and Foreknobs Formations are thicker near Keyser also) but appears to be due primarily to repetition by folding, because the upper part of the Harrell section is intensely drag-folded.

Burket Member

The basal Burket Member is a grayish black, thinly laminated, platy weathering shale. It is about 80 feet thick at the type Harrell locality and there overlies the Tully Limestone. The Burket overlies the dark gray, olive-weathering Mahantango Formation and thins and grades laterally into the Millboro Shale southwestward along the Allegheny Front.

The Harrell fauna is essentially the Devonian Naples fauna described by Clarke (1898, 1902). This is a unique assemblage characterized by small and thin-shelled pelecypods. In the darker portion of the Harrell, including the Burket Member, the fauna is generally dominated by abundant _Buchiola retrostriata_ associated with _Paracardium doris_ and _Pterochaenia fragilis_. _Styliolina_ is generally abundant and orthocone and goniatite cephalopods occur sparingly.

The fauna changes somewhat in the transition zone, apparently reflecting change to siltier shales. In this interval Pterochaenia fragilis is most abundant, as it is in the lower beds of the Brallier.

Structurally, the Harrell is generally incompetent with most deformation, either drag-folding or faulting resulting mostly from attenuation, occurring in the still more incompetent Burket Member. Interestingly, the Harrell is not badly deformed at any of the sections examined between the type section and Bedford. At LaVale, Maryland (Stop 9) both the Burket and upper part of the Harrell are faulted.

Tully Member

The Tully Limestone is a thin, widespread unit which crops out from New York across Pennsylvania into West Virginia in the Allegheny Front region and is also present to the west in the subsurface. Three facies are recognizable in the Pennsylvania belts (Heckel, 1969): (1) an upper wavy-bedded or knobbly facies consisting of shaly calcilutite (2) a platy limestone facies of essentially unfossiliferous calcilutite and (3) a lower calcareous shale facies of nonskeletal to skeletal calcilutite.

The Tully is mapped as the basal member of the Harrell Shale in central Pennsylvania (Hoskins, 1963). However, southwestward from the type Harrell the base of the Burket changes position relative to the Tully so that the Tully Member occurs within the black Burket Shale rather than at its base. This calcitic Tully zone is traceable into the Millboro Shale.

Along the Allegheny Front in Maryland and West Virginia the Tully is generally very dark gray, thickly to thinly laminated, calcitic shale with some interbedded argillaceous limestone. Calcareous zones or limestone nodules within the Burket have been described previously by Dennison and Naegele (1963), de Witt and Colton (1964), and Hasson (1966). The thickness of the Tully interval (lowest to highest calcitic shale or limestone) ranges from about 2 feet to 30 feet. The Tully is present in the subsurface west of the Allegheny Front and is traceable as a concretion zone eastward into Hampshire County, West Virginia.

This calcareous horizon provides the closest approximation to a isochronous surface in this general stratigraphic interval and hence serves as a datum for interpreting the black shale sequence. Conodont faunas from four outcrops of the Tully in south-central Pennsylvania have been compared with the faunas obtained from three localities in West Virginia (Hasson and Liebe, 1968). The Pennsylvania localities are: Horrell Station, Newry, Immler and Bedford; the West Virginia localities are Burlington, Landes and Judy Gap.

The Pennsylvania faunas suggest the Polygnathus varca zone (latest Middle Devonian). However, the occurrence of Polygnathus normalis in these samples indicates the lower Polygnathus asymmetrica zone (earliest Late Devonian) since P. normalis is known only from the early Frasnian. The Burlington and Landes faunas are also early Frasnian (Ancyrodella rotundiloba and Polygnathus foliata).

The New York Tully, on the basis of conodonts, has been assigned a latest Middle Devonian age (Oliver, et al., 1969). However, ammonoids indicate an early Late Devonian age (House, 1962). Ammonoids and conodonts from the matrix in the Landes, West Virginia, Tully sample are both early Frasnian. The ammonoids there are Epitornoceras paracutum Hall and Pharciceras galeatum Wedekind. The only other known specimens of Pharciceras in the U. S. are from the uppermost Tully in New York. However, Pharciceras galeatum is not conspecific with P. amplexum and Epitornoceras ranges somewhat above the Tully (House, personal communication, 1967). At Ketterman Knob, Pendleton County, West Virginia, the Tully horizon contains Chonetes aurora.

Because the Pennsylvania fauna has some suggestions of the Polygnathus varca zone, there is a possibility that some of the Tully there is slightly older than in West Virginia and that the Tully is somewhat time-transgressive from New York across Pennsylvania into West Virginia. But within the limits of stratigraphic resolution by conodonts it appears that the calcitic shale and limestone horizon within the Burket Member of the Harrell Shale is correlative with the Tully of south-central Pennsylvania and can be used as a correlation datum.

The only good Tully to be seen on this field trip is at Elklick Run (Stop 4) where it consists of shaly limestone and calcitic shale with relatively abundant fossils.

Mahantango Formation

The Mahantango Formation (Middle Devonian) along the Allegheny Front in Maryland and West Virginia consists of thickly laminated, usually very silty, light olive gray-weathering shale with much interbedded siltstone and some limestone. Typically the shale weathers to chips, lumps and splinters, although spheroidal weathering is not uncommon. The formation is approximately 600 feet thick in the Keyser area and 100 feet thick at Scheer. It thickens and coarsens to the east and northeast; to the southwest it is replaced from the base upward by black, fissile shale of Marcellus lithology and eventually grades laterally into the Millboro Shale.

The name Mahantango was introduced by Willard (1935) for post-Marcellus and pre-Tully rocks in central Pennsylvania. The type section is on the North Branch of Mahantango Creek, Juniata County, Pennsylvania. The name is now formally recognized in both Maryland and West Virginia, and replaces Hamilton of earlier reports

Along the Allegheny Front between Corriganville, Maryland, and Scheer, West Virginia, the Mahantango is divisible into several distinct members. There are two prominent siltstone zones 100-150 feet apart near the top of the formation, both identified as tongues of Clearville Siltstone (Cate, 1963) within the Frame Shale Member of the Mahantango. Both members thin and change lithologically along the Front between Keyser and Scheer, West Virginia. At the latter locality the siltstone has changed to tongues of thickly laminated, silty, dark gray shale within the black

Marcellus-type shale.

A coral biostrome rests on the upper Clearville Tongue at several localities in Mineral County, West Virginia, and is particularly well developed at Dawson, Maryland (Stop 1). Here the biostrome or patch reef consists of solitary rugose corals in a silty shale matrix. The corals are not in growth position. In this exposure four coral genera occur in a general upward zonation. Eridophyllum is associated with the colonial genus Favosites in the basal zone (with rare Cystiphilloides). The large forms Cystiphylloides and Heliophyllum occur in the upper portion of the exposure.

This sequence (basal Eridophyllum zone followed by Cystiphylloides and Heliophyllum) is similar to that described by Oliver (1951) for coral beds in the Hamilton of central New York.

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PETROGRAPHY AND DIRECTIONAL FEATURES OF THE UPPER DEVONIAN GREENLAND GAP GROUP IN VIRGINIA, WEST VIRGINIA AND MARYLAND

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Introduction

This paper is to serve as a preliminary report on a larger study of the sedimentology and sedimentary petrology of the Greenland Gap Group which was delimited by Dennison (1970) in Virginia, West Virginia and Maryland. Samples and measurements were taken from the following nine stratigraphic sections shown in Figure 29: Route 250, Dry Run, Briery Gap Run, Mouth of Seneca, Hopeville Gap, Scherr, Route 50, Keyser and LaVale. All 113 measurements of directional features taken thus far have been included, while only 12 samples are represented in the petrographic descriptions.

Directional Features

The 113 measurements which comprise this section and appear in Figure 30 have been segregated into three groups: cross-beds, ripple marks and double-ended features. Cross-beds and ripple marks are self explanatory while the heading "double-ended features" includes oriented plant or wood fragments, parting lineations, grooves or drag marks, and any other feature which might represent either of two diametrically opposed directions. The resultants for double-ended features and ripple marks are plotted in the western two quadrants simply because this is the accepted general direction of the paleoslope. Since the ripples are almost invariably symmetrical, a rotation of the resultant by 180 degrees may be just as acceptable. In some cases the availability of acceptable sites to measure was low and the small number of measurements may not be representative.

There are two reasons for separating directional features into three categories. The first is for diagramatic clarity; the second is the fact that these features predominate in different, though not necessarily mutually exclusive, environments.

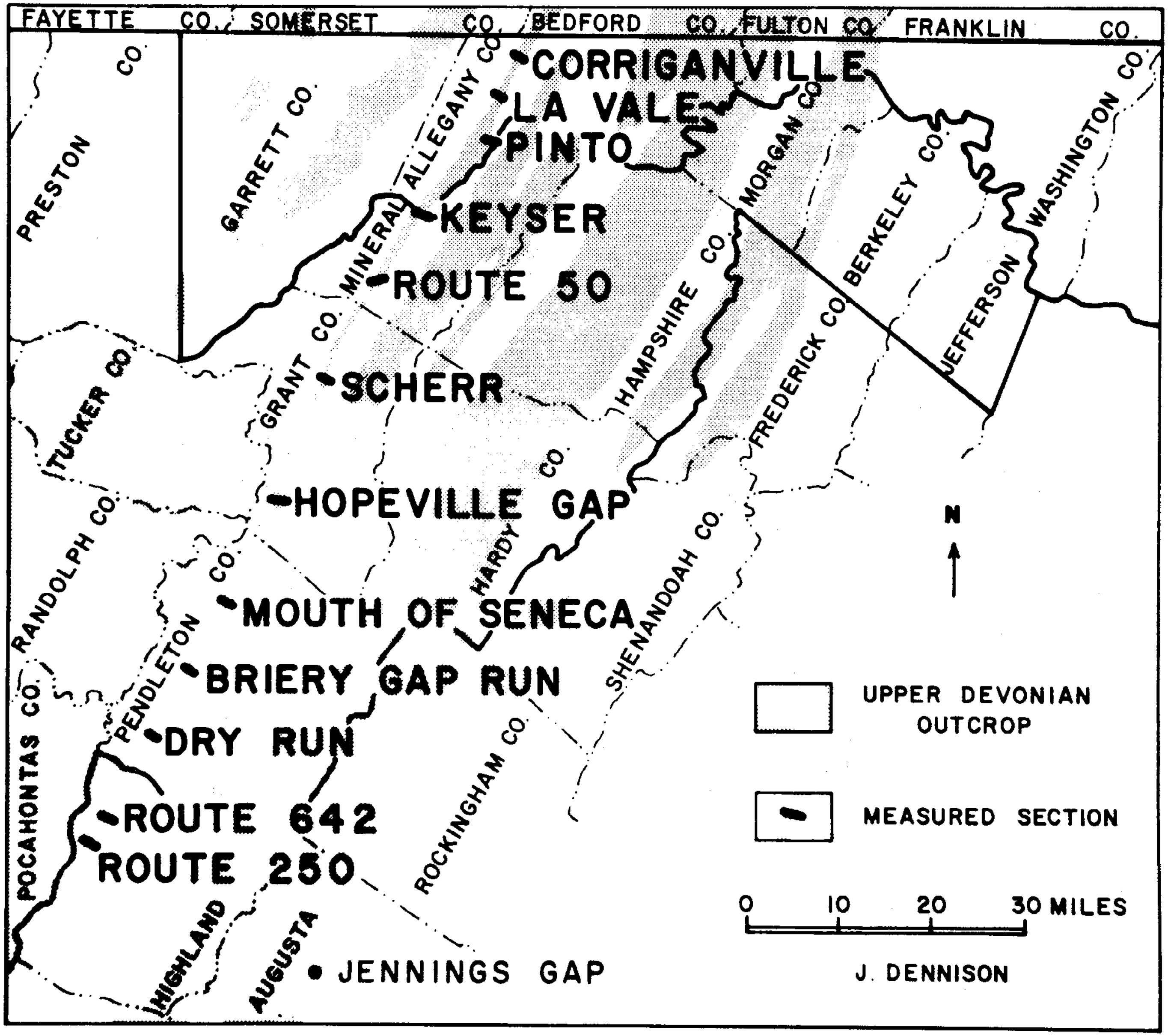

Figure 29 - Location of stratigraphic sections sampled along Allegheny Front in Maryland, West Virginia and Virginia (from Dennison, 1970).

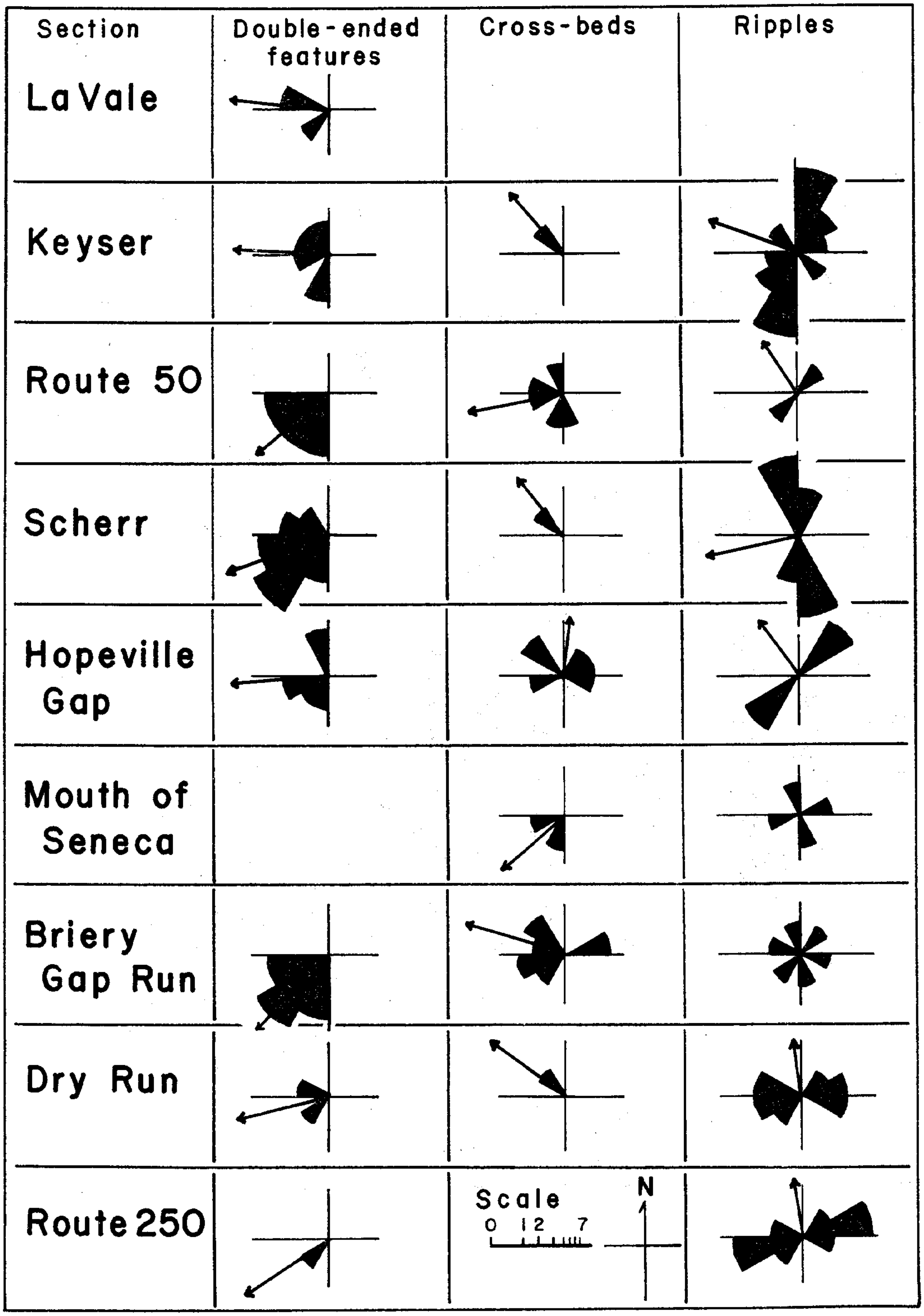

Figure 30 - Rose diagrams and resultant vectors of 113 directional measurements. Arrow indicates vector mean direction.

The double-ended features are found throughout the section, but were the main features in the upper Scherr Formation and lower Mallow Member where turbidite environments predominate. For this reason they are believed to represent the paleoslope most accurately. The west to southwesterly trend shown by the resultants in this column agree fairly well with those reported in the Portage and "Chemung" by McIver (1970) for the same geographic area, but who had more sparse geographic control for samples. The general tendency for a more southwesterly trend in the resultant vectors as one proceeds south through the sections suggests to this writer a dominance of the Fulton Lobe (Willard, 1939) shedding detritus into Grant Bay (Dennison, 1971, p. 1181) exceeding the influence of the Augusta Lobe (Dennison, 1970, p. 66) to the south.

The cross-bedding resultants show, for the majority of sections, a rather high deviation from the resultants of the double-ended features. Again this is explained by the environment of deposition. Since the cross-beds are found in the relatively shallow water environments of the upper Mallow and Blizzard Members, and the bar environments of the Briery Gap and Pound Members, it does not seem unreasonable to suggest that these vectors are governed chiefly by longshore drift in a northwesterly direction.

The ripple mark orientations, which cluster fairly well for a given section, do not seem to have resultants with a consistent relation to the other two types of directional features. At present the writer does not have an explanation for this behaviour.

Petrographic Analysis

Twelve samples, three each from the Pound and Briery Gap Sandstones at both the Briery Gap and Scherr sections, were thin sectioned, stained for potassium feldspar and counted on the basis of 300 points per slide. The average contents (each average given is based on a total of 900 counts) are shown in Table 1. Quantities of less than one percent are omitted. The grain size of the twelve samples ranged from fine sand to coarse silt with the majority classed as very fine sand. No heavy mineral quantities approached one percent but leucoxene, hornblende and zircon were identified. The condition of the sands in general was one of extreme compaction with the matrix being represented either by thin sheathes of sericite, chlorite and probably illite crushed between the grains, or totally sericitized grains which could be counted as nothing else.

McIver (1970) reports somewhat less quartz and considerably more matrix than reported in these analyses because his samples are turbidites found somewhat lower in the sections. However, his general logic of using a high ratio of quartz + chert to feldspar + rock fragments to denote a sedimentary and low-rank metamorphic source seems to apply and is accepted here. Krynine (1940) used the same criteria and arrived at the same conclusion for the "Chemung" of northwestern Pennsylvania.

		Average Content (%)							
		Qtz.	K-spar	Plag.	Matrix	Musc.	Meta. Rock Frags.	Chert	Iron Oxide Stain
Briery Gap Section	Briery Gap Ss.	75.6	6.1	1.6	10.4	1.2	1.0	-	2.8
	Pound Ss.	73.7	5.0	1.7	13.3	1.6	1.4	1.1	1.5
Scherr Section	Briery Gap Ss.	75.8	4.1	-	13.5	-	2.2	-	3.0
	Pound Ss.	75.0	6.2	1.9	12.9	-	2.7	-	-

TABLE 1. Average content of the Briery Gap Ss. and the Pound Ss. at the Scherr and Briery Gap Sections.

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Upper Silurian - Lower Devonian Stratigraphy and Nomenclature in the Central Appalachians

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I. Stratigraphic Framework and Paleogeographic Setting

Upper Silurian and Lower Devonian deposits of the central Appalachians represent a section of carbonate rocks which are literally sandwiched between the Silurian and Devonian quartz clastic wedges (Figure 31). The stratigraphy of these quartz clastic wedges is often a record of basin margin tectonic activity, of the primary constituents of source areas, and other factors which may be largely independent of the characteristics of and processes in the marine depositional basin itself. For instance, materials derived from outside of the basin by exterior basin processes may often inundate the marine sedimentary regime causing drastic changes in environments and masking finer scale characteristics of basin processes and evolution. On the other hand, exclusive study of deeper water sedimentary environments also may not provide these finer scale characteristics since in many cases only major changes are recorded in this regime. In a tectonically quiet region, shallow water biogenic carbonate environments are potentially the best record of the detailed characteristics of sedimentary basin processes and evolution. Just such a record is provided by the Upper Silurian and Lower Devonian rocks of the Central Appalachians.

The northern part of the Central Appalachian basin (New York and Pennsylvania) exhibits the classic sequence of Late Cayugan and Helderbergian units; Rondout, Manlius, Coeymans, Kalkberg, New Scotland, Becraft, Alsen and Port Ewen. Rickard (1962) has documented the distribution and lateral equivalence of many of these units in eastern and central New York State. Epstein et al. (1967) have provided data for the southeasternmost New York area. These lithostratigraphic reconstructions have been studied in order to understand the characteristics of the depositional basin and to outline models for its evolution (Laporte, 1969; Head, 1969). Correlations have been extended to the southeastern New York, New Jersey and northeast Pennsylvania area, in order to take into account both margins and to provide a cross section of the sedimentary basin for the determination of basin geometry. All these correlations indicate that the rocks of the northern part of the basin record a regional transgression beginning in Late Silurian time and

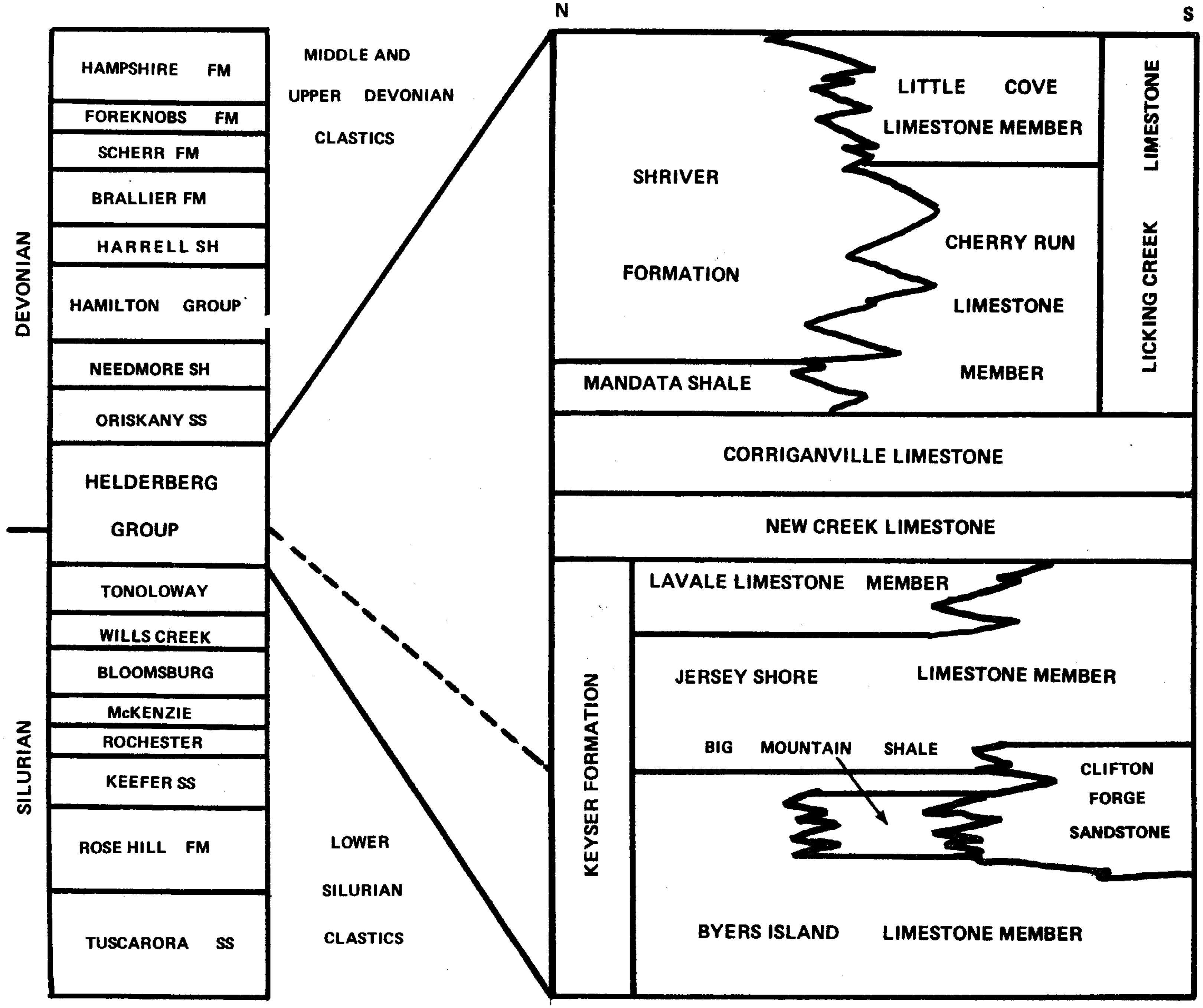

Figure 31 - Stratigraphic nomenclature in the south-central Pennsylvania to western Virginia region.

proceeding well into the Early Devonian. The deeper, more offshore part of the basin generally occupied an area in the vicinity of Kingston, New York, and the deeper basin axis facies had their shoreward counterparts in laterally equivalent stratigraphic units to the northwest and southeast. The symmetrical development of facies combined with an interpreted low average depositional slope provide the primary evidence leading to the proposal of a symmetric epeiric model as the geometric depositional basin model for the northern part of the basin (Laporte, 1969; Head, 1969).

Rocks to the south of New York State area (Pennsylvania, Maryland, West Virginia and Virginia) were then studied and a paleoenvironmental stratigraphic reconstruction was compiled (Head, 1969). This reconstruction provided a third dimension to the New York State basin cross section. Paleogeographic representation of these correlations indicated that a major migration of marine environments proceeded into the Central Appalachian basin from the southwest during Late Silurian time. The basin margins were formed by relict Niagaran reef banks to the northwest and low land areas to the northeast and southeast (Figure 32). A slowly proceeding transgression was interrupted by numerous cyclic regressive phases but ultimately established a northeast-southwest bathymetric axis and brought the basin under continually greater marine influence. This major transgressive phase closes out with the regression and deposition of the Oriskany Sandstone and equivalent units (Head, 1968, 1969).

II. Sedimentary Facies

The Late Silurian - Early Devonian sedimentary basin was characterized by evenly supplied, dominantly biogenic carbonate sediments, deposited on exceedingly low (epeiric) bottom slopes and evenly dispersed throughout the basin without consequential sedimentary buildup or progradation. Regular eustatic changes in sea level were apparently superimposed on even, widespread subsidence of the basin. In general, the governing variable in basin evolution appears to be the general direction of sea level change, all other variables being either constant or proceeding at an even rate.

In a single vertical section of these units the regional transgression is obvious from the contrast in carbonate facies represented by the earlier shallower environments of the Keyser and the later deeper environments of the Corriganville and Shriver. However, the net direction of the transgression and the significance of local reversals (regressions) are not obvious until a three-dimensional picture is constructed from adjacent vertical sections (Head, 1969).

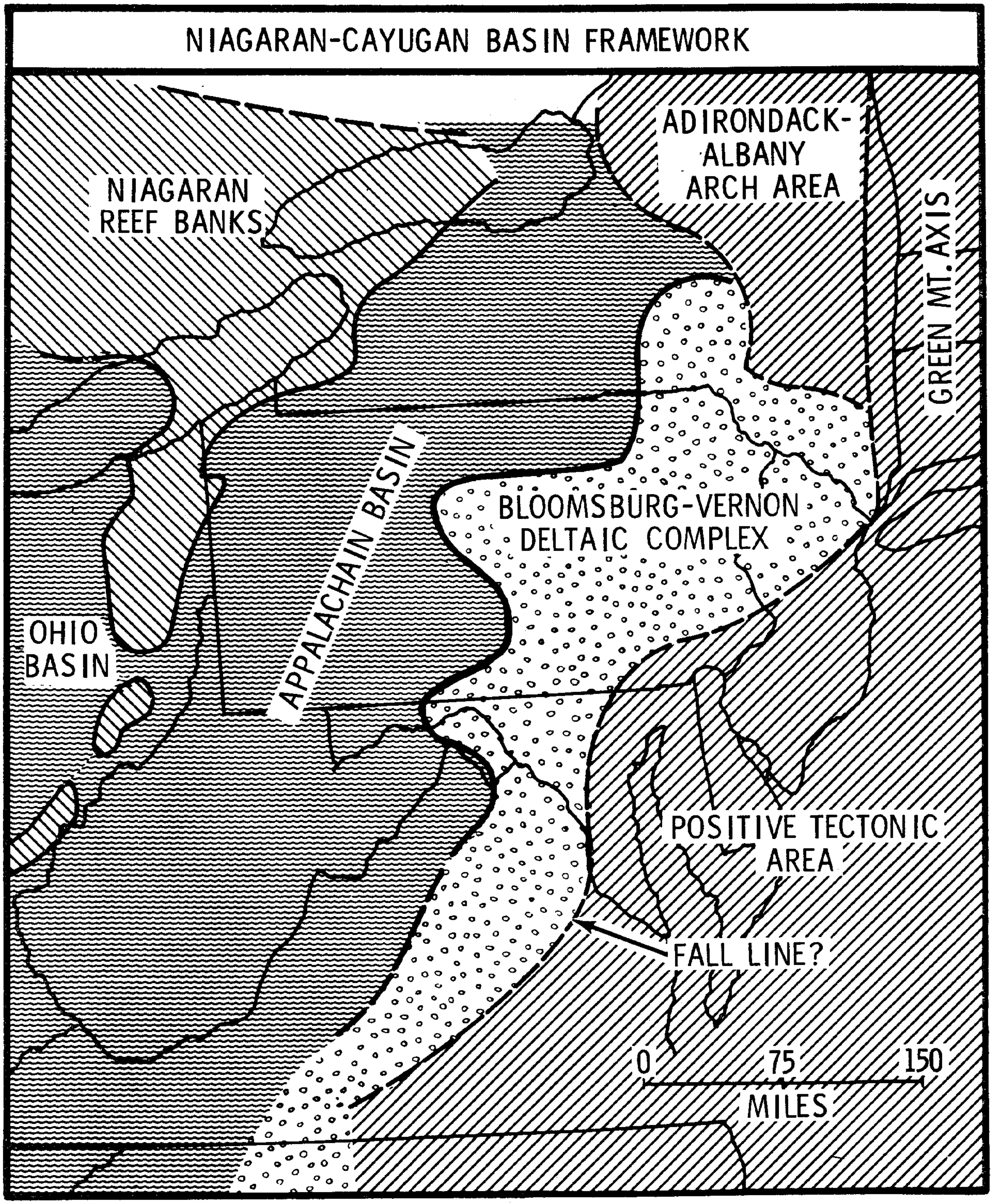

Figure 32 - Niagaran-Cayugan basin framework which continued to provide major basin boundaries into Early Devonian time (after Alling and Briggs, 1961).

The Keyser lithofacies represent environments located near the marine - non-marine interface (shallow subtidal - intertidal - supratidal) (Figure 33). Early in the transgression these facies were located in the central portion of the basin but as the basin came more and more under marine influence, these environments migrated toward the basin margins. While these environments were migrating to the basin edges, more stable subtidal facies were establishing themselves in the developing shallow shelf (New Creek and Corriganville). Finally, even these facies migrated out of the basin axis region as the transgression progressed and the deeper Shriver facies were deposited.

III. Stratigraphy and Nomenclature

Restudy of this part of the stratigraphic section has necessitated a reevaluation of the existing stratigraphic nomenclature since previously described relationships have been clarified, additional characteristics and relationships have been documented through more detailed study, and lithostratigraphic, rather than biostratigraphic criteria have been used in defining units. The following stratigraphic nomenclature discussion summarizes more detailed descriptions in Head (1969) and manuscripts in preparation or review.

The Keyser Formation is subdivided into five lithologically distinct members. The stratigraphically lowest member, the Byers Island Limestone (new), is characterized by the nodularity of many of its beds. It is named for exposures along the Susquehanna River just northeast of Selinsgrove, Pennsylvania, where it is 93.0' thick. It can be traced from central Pennsylvania southward and grades laterally into the Tonoloway Limestone in Pennsylvania and towards the basin margins. Southward into West Virginia, the Byers Island grades laterally into the Big Mountain Shale Member and ultimately in Virginia, into the basin margin Clifton Forge Sandstone. The Jersey Shore Limestone Member (new) occupies an intermediate position in the Keyser and is characterized by an abundance of corals and stromatoporoids around the basin margins and by a wide variety of accessory lithologies elsewhere (Head, 1969). This unit is 35.0' thick at its type locality near Jersey Shore, Pennsylvania. Its lower part passes southward into the upper part of the Clifton Forge, and together with the uppermost Keyser unit, the LaVale Limestone Member (new), the upper Jersey Shore passes laterally southward into the New Creek Limestone in West Virginia and Virginia. The LaVale is characterized by banded and laminated carbonate lithofacies and locally abundant stromatoporoids and is 34.8' thick at its type locality in the Corriganville quarry.

The Middle Helderberg Group consists of the New Creek Limestone (Bowen, 1967) and the Corriganville Limestone (new). The Corriganville replaces the "New Scotland Limestone" which

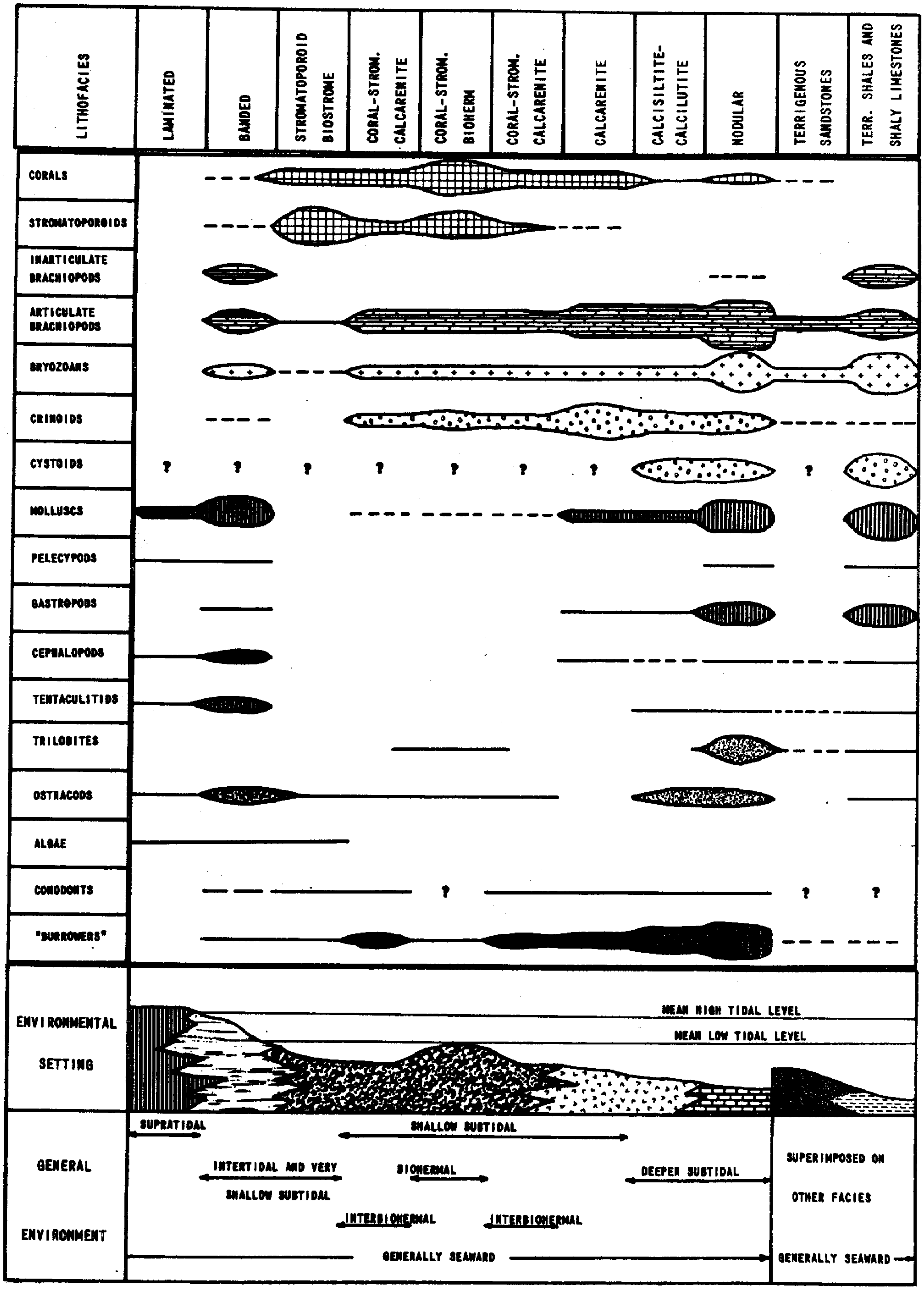

Figure 33 - Environmental relationships of Keyser lithofacies and fauna.

was earlier extended to this area from New York by biostratigraphic rather than lithostratigraphic correlation. The Corriganville is 26.9' thick at its type section at the railroad cut 0.3 miles southeast of Corriganville, Maryland.

The Upper Helderberg Group consists of the Mandata Shale, Licking Creek Limestone, and Shriver Chert Formation. Five major lithofacies are recognized and they are generally characterized by high argillaceous content and chert. They represent environments ranging from subtidal shelf (Licking Creek) to deeper basin axis facies (Shriver). Review of the history of the Upper Helderberg stratigraphic nomenclature has shown the need for the total reassessment of the stratigraphic relationships and terminology (Head, 1969). The Mandata Shale is redefined while the Licking Creek Limestone is redefined and divided into a lower Cherry Run Limestone Member (new) and an upper Little Cove Limestone Member (new). These units are best exposed and have their type localities in the easternmost outcrop of Maryland and adjoining portions of Pennsylvania and West Virginia. The Little Cove is 33.0' thick and the Cherry Run 84.9' at their type localities. The Shriver is 161.9' thick at its reference locality in the Corriganville Quarry. The internal stratigraphy of the Shriver and lithostratigraphic relations indicate that it occupies the basin axis area and that the major portion passes laterally shoreward into lithofacies of the Licking Creek Limestone.

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THE SILURIAN WILLIAMSPORT SANDSTONE FROM SOUTHERN BEDFORD COUNTY, PENNSYLVANIA, TO KEYSER, WEST VIRGINIA

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The Williamsport Sandstone is the nonred lateral equivalent of the grayish red, sandy, Moyer Ridge **Member** of the Bloomsburg Formation of Central Pennsylvania (Hoskins, 1961, p. 11). At Bedford nearly all of the red beds of the Bloomsburg have been replaced by gray shales and limestones of the underlying and overlying Mifflintown and Wills Creek Formations respectively, and only the Moyer Ridge sandstones and a small amount of red claystone remain. Near the Pennsylvania-Maryland boundary, the red coloration is nearly absent from the sandstones and the unit is more properly termed Williamsport.

Re-examination of the outcrops of the Bloomsburg-Williamsport in the Bedford to Keyser area show sedimentary structures in addition to those previously reported that modify, in part, Hoskins' contention (1961, p. 103) that the sediments "were deposited subaqueously and were not exposed to air."

The Williamsport Sandstone is well exposed on the west side of U. S. Route 220, five miles south of Centerville where the section is as follows:

	Feet	Inches
5. Sandstone, olive gray, very weathered and extremely porous; some sand grains up to 3/8 inch in long dimensions		2
4. Claystone, olive gray, shaly, partially covered	5	
3. Sandstone, very fine grained, and siltstone, grayish red and olive gray, bedding surfaces with mudcracks; few traces of bedding remain due to extensive bioturbation from many worm burrows up to 1/8 inch in diameter. Contains discontinuous lenses up to 3 inches thick of laminated, cross-bedded, quartzose sandstone; some		

	Feet	Inches
lenses are apparently fine-grained, cleaner, sand in-fillings of ripples; upper layers contain clasts up to 1 inch diameter of lithology similar to surrounding material.	4	
2. Siltstone to very fine-grained sandstone, olive gray; highly bioturbated with extensive worm burrows of two types: a small tube approximately 1/16 inch diameter and less common burrows of <u>Arthrophycus</u>	7	
1. Claystone, shaly, olive gray, silty	5	
Exposed	21	2

North of this locality approximately one mile, the upper units are exposed where several bedding planes show mudcracks superimposed on a ripple-marked surface.

At the Williamsport exposure to be visited near Keyser on the field trip, similar lithologies to these may be seen, plus the shaly limestone of the Cedar Cliff lentil of the Williamsport Sandstone. Although not well exposed at the field trip stop, the limestones can be seen about 1/2 mile east on West Virginia Route 46 where they consist of about 3 feet of interbeds of light to medium gray shales and finely laminated limestone with ripples and cross laminations. These are underlain by about 3 feet of cross-bedded, sandy limestone and shales with extensive burrows in some beds and other beds composed largely of the large ostracod <u>Leperditia</u>. The limestones are overlain and underlain by olive gray, bioturbated siltstone containing calcareous, rounded clots about 1 inch to 2 inches in diameter.

The sedimentary structures suggest that the depositional history of this area is as follows: the largely muddy and subaqueous deposition of the central Pennsylvania portion of the Bloomsburg and Mifflintown Formations was interrupted by an increase in coarse sediment supply that, in central Pennsylvania (Moyer Ridge Member), was less winnowed and contained more red muds. To the west of the main Bloomsburg, as the coarse sediment was carried further (Keyser-Bedford area) the sediments were more winnowed, resulting in some relatively quartzose layers, particularly the discontinuous ripple lenses and less-red beds. Deposition was at or near sea level on extensive tidal mud and sand flats.

Fauna was restricted largely to in-fauna of burrowing animals and rare concentrations of ostracods. The limestones represent a local lagoonal feature with tidal flats where limestone could form. In this low salinity lagoon, occasional large bursts of ostracod population developed. The clots of calcareous claystone in the Keyser area are similar to features described by Hoskins (1961, Figs. 3 and 4) in Central Pennsylvania and probably represent algal structures forming on mud flats.

The presence of the various sedimentary structures in the Williamsport Sandstone of the area from Bedford to Keyser thus suggest deposition on tidal flats with periodic exposure to drying, producing the mudcracks.

If these suppositions are correct, then the Williamsport to the south and west of the field trip area, where it is largely subsurface, is probably a cleaner, more winnowed continuation of the exposures seen. The additional distance the sands were carried from the source area would have given additional opportunity for winnowing of fines.

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A PRELIMINARY REPORT ON UPPER DEVONIAN MICROFOSSILS FROM THE ALLEGHENY FRONT IN MARYLAND AND WEST VIRGINIA

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Introduction

A palynological investigation of Upper Devonian-Lower Mississippian sediments along a 96 mile exposure of the Allegheny Front from Corriganville, Maryland, to U. S. Route 250 in Highland County, Virginia, was initiated by one of us [K.S.] in 1968, and has been continued by the senior author as a doctoral research project during the past three years.* The research project has three principal objectives: (1) the isolation, identification, and description of microfossils contained in the rocks of the various stratigraphic units under investigation; (2) the determination of microfloral assemblages and the assessment of their stratigraphic value; (3) a botanical and geological comparison of the microfloras with those of similar age described from other parts of the world.

Field Methods

Field work has been conducted during the past four summers in order to collect samples for palynological analysis. Approximately 600 samples from 20 geographic localities have been examined during the course of the study. Although samples have been collected from sediments ranging stratigraphically from the Needmore Shale through the Pocono Formation, the initial phase of the study has been confined to the Scherr and Foreknobs Formations. In addition, although samples have been collected from 18

*Acknowledgements - The writers are indebted to Dr. John Dennison for directing the field expeditions which provided the materials used in this study. Grateful acknowledgement is also due the West Virginia Geological Survey and the National Science Foundation for their financial support of the field work.

localities, the emphasis has been placed on the Corriganville, LaVale, Scherr, Hopeville Gap, Briery Gap Run, and Route 250 sections as described and illustrated by Dennison (1970).

Results

A vast majority of samples collected and examined during the current study were found to be unfossiliferous. In addition, although many samples contained palynomorphs, the degree of preservation somewhat limited the scope of the project.

Of the units examined for microfossils, the Mallow Member of the Foreknobs Formation is the most productive, both with respect to number of samples bearing microfossils and the number of genera and species present. With regard to stratigraphic sections, the Corriganville, LaVale, and Briery Gap Run are the most productive.

Spores, acritarchs, chitinozoa, and scolecodonts have been recorded from the Scherr and Foreknobs Formations. The writer has not yet studied the acritarchs, chitinozoa, and scolecodonts, although it is clear that there is not a high degree of diversity among these groups. More diversity has been found among the spores, 22 genera and 40 species have been identified. The following genera have been identified from the samples:

- Aneurospora
- Apiculiretusispora
- Retusotriletes
- Geminospora
- Anapiculatisporites
- Punctatisporities
- Calamospora
- Ancyrospora
- Hystricosporites
- Dibolisporites
- Camptozonotriletes
- Hoegisphaera
- Verrucosisporites
- Foveosporites
- Convolutispora
- Dictyotriletes
- Diaphanospora
- Rhabdosporites
- Emphanisporites
- Spinozonotriletes
- Spelaeotriletes
- Brochotriletes

At this stage of the research project, it would be premature to comment on microfloral assemblages, their stratigraphic value, and geological and botanical comparisons with previously described microfloras.

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REDBED ZONE PRODUCED BY SEA LEVEL DROP AT BEGINNING OF DEVONIAN COHOCTON AGE DELIMITS FULTON AND AUGUSTA LOBES OF CATSKILL DELTA COMPLEX

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In 1962 Dennison and Orville D. Naegele were doing plane table measurements for the detailed measured section in excavations for the Sears Town shopping center at La Vale, Maryland (Stop 9 of field trip) when they came upon brownish gray shale and siltstone "redbeds" zero to 13 feet above the bottom of the lowest sandstone beds marking the base of the what was then called Chemung Formation, but is now designated as the Scherr Formation. The presence of the lowest occurrence of Cyrtospirifer chemungensis (Conrad) in these sandstones confirms their age as basal Cohocton Stage, since the earliest appearance of this species in appropriate facies is used to identify the base of the Cohocton Stage in the Devonian delta complex (Rickard, 1964). An earlier measurement of this same section failed to identify the presence of Cyrtospirifer (Swartz, 1913, p. 526), and these earlier workers correlated this coarser clastic zone with Parkhead Sandstone, rather than slightly younger Chemung strata. The present authors are now convinced that the Parkhead Sandstone Member of the Brallier or Jennings Formation is totally missing in Maryland west of the Wills Mountain anticline, resulting from facies change into the finer and less massive turbidites of the Brallier Formation.

Dennison and Naegele later that summer identified the same redbed zone in exposures along dirt streets on the hill overlooking Corriganville, and tentatively they suggested the presence of a continuous redbed zone between the La Vale and Corriganville sections, serving as a time line. This simple correlation has grown into an hypothesis of sea level fluctuation here documented for the first time (Fig. 34).

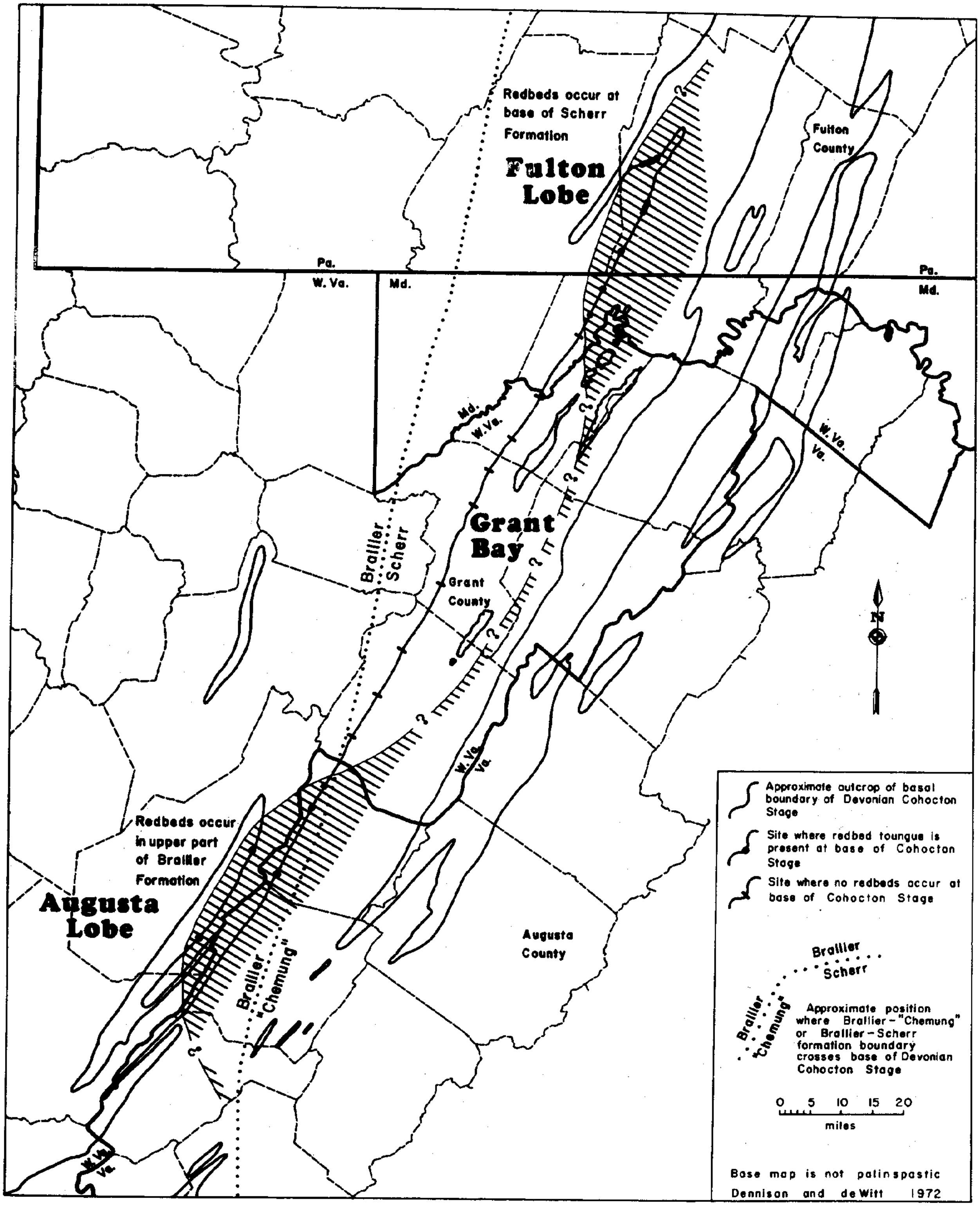

Figure 34 - Marine redbeds at approximate base of Devonian Cohocton Stage delimit general shape of Fulton and Augusta Lobes of Catskill delta complex.

Delta Lobes

As early as 1939 Bradford Willard recognized that the Catskill delta complex was not a single delta, but instead consisted of a complex of delta lobes in Pennsylvania at the time of earliest development (invasion?) of Cyrtospirifer. More recently Walker (1971) has doubted the existence of true delta structures in the Catskill redbed sequence of Pennsylvania, but instead envisions a prograding muddy shoreline. The shoreline need not have been straight, but could have been lobate, perhaps corresponding to the position of major rivers discharging from the eastern landmass into the Appalachian Basin sea. Willard's lobes were identified essentially as westward projections of nonmarine Catskill redbed facies into the basin. Cyrtospirifer was absent in the Devonian strata in lobe areas presumably because the shoreline had prograded westward before the appearance of Cyrtospirifer.

The most southern lobe in Pennsylvania was designated the Fulton Lobe by Willard (1939, p. 273), receiving the name from Fulton County. Perry Bay with marine Cyrtospirifer separated the Fulton Lobe from the Snyder Lobe to the north. These names were taken from Pennsylvania counties also (Willard, 1939, p. 273).

Ideally, a delta lobe would be represented in offshore clastics to the west by a westward extension of coarse clastics, with the more eastward shoreline fringed by brownish gray, marine "redbeds" where the bright-colored grayish red muds from the subaerial portion of the delta were washed into the sea but not totally reduced.

Concentrations of abundant brownish gray marine redbeds at two latitudes in the 96 mile extent of the Devonian delta outcrop belt along the Allegheny Front extending from the south border of Pennsylvania to Highland County, Virginia, prompted Dennison to recognize an Augusta Lobe south of the Fulton Lobe, with Grant Bay (Dennison, 1971, p. 1181) in the intervening area. The names are taken from Augusta County, Virginia (Dennison, 1970), where the lobe appears to be centered, and from Grant County, West Virginia (Dennison, 1971). During the Cohocton Age the actual shoreline lay probably ten or tens of miles east of the present Allegheny Front outcrop belt, but the position of the Fulton and Augusta Lobes can be recognized by geographic concentrations along this outcrop belt of brownish gray redbeds which occur scattered throughout the Cohocton Stage (see stratigraphic cross section in Dennison, 1970 and 1971, and Figure 15 of this guidebook). The present Allegheny Front outcrop belt passes somewhat farther offshore from the Augusta Lobe than from the Fulton Lobe.

The redbed marker zone which is the subject of this paper is the oldest redbed horizon in the Devonian delta outcrops along Allegheny Front studied from Bedford County, Pennsylvania to Highland County, Virginia, occurring at least 1,200 feet below any other redbeds in any of the sections examined.

Augusta Lobe

Extension of the field work southward revealed no redbeds at the general position of the Cohocton Stage base from Pinto, Maryland southward along Allegheny Front through West Virginia. Conspicuous brownish gray redbeds were discovered by Dennison and Travis in 1963 in the middle part of the Brallier Formation at the bridge where Virginia Route 84 crosses Townsend Draft in Highland County, Virginia. Redbeds later were discovered at Route 642 and at U. S. Route 250 in the same strike belt in Highland County. Byron Kulander observed similar redbeds within the Brallier Formation along the east flank of the northern part of the Browns Mountain anticline in Pocahontas County, West Virginia. Kulander (1968, p. 37) described brick-red shale near the middle of the Brallier Formation at an exposure 2.5 miles east of Dunmore.

Acceptance of the hypothesis that there is only one reddish zone in this general part of the stratigraphic column allows one to make a direct physical correlation within the middle Brallier Formation from the Allegheny Front outcrop belt of Highland County to the Browns Mountain anticlinal outcrops. (A prominent turbidite siltstone a few tens of feet above the base of the Brallier probably represents another time-surface clastic pulse which can be correlated in both outcrop belts, a unit Dennison informally refers to as the Back Creek siltstone.)

In December, 1970, Dennison noted a marine redbed marker zone in roughly the same part of the Brallier in cuts along West Virginia Route 39 1.3 miles south of Minnehaha Springs, Pocahontas County.

These five control points (Fig. 34) begin to delimit the shape of the Augusta Lobe by the halo of marine reddish coloration offshore from the nonmarine portion. Redbeds are not known within the Brallier on the west flank of the Browns Mountain anticline. The south limit of this Augusta Lobe redbed zone in the Brallier is not clear, but even the uppermost Devonian has lost nearly all its reddish coloration in exposures as far south as Caldwell, Greenbrier County, so this lowest redbed probably occurs along the east flank of the Browns Mountain anticline only in Pocahontas County. The nature of this redbed zone in outcrop belts east of the Allegheny Front is unknown, but redbeds probably do not extend south of Allegheny or Boutetourt County, Virginia.

The redbeds in the Augusta Lobe occur as shales interbedded with coarse siltstones forming an exceptionally coarse zone in the Brallier Formation. This same coarse sequence becomes even coarser to the northeast along the Allegheny Front strike belt, passing laterally into the sandstones which mark the base of the Scherr Formation in Pendleton County and to the north. No reddish coloration is known in this coarser horizon along the Allegheny Front in West Virginia, however.

Grant Bay

The interpreted base of the Cohocton Stage lacks any reddish coloration in all exposures examined between the redbeds along Route 642 in Highland County, Virginia, and La Vale, Allegany County. This nonred area is centered on Grant Bay, which seems to be located between two major clastic distributary centers that can be identified in lithologic patterns persisting from the Tioughnioga Stage portion of the Mahantango Formation through the latest Cohocton Stage upper portion of the Foreknobs Formation. Except for the basal Cohocton redbed pulse, all brownish gray marine redbeds in the Greenland Gap Group occur in the Foreknobs Formation in the Mallow and Blizzard Members and in an upper unnamed member (Dennison, 1970). The generally decreased abundance of reddish coloration in Pendleton County Allegheny Front outcrops of the Foreknobs Formation distinguishes the interlobate Grant Bay accumulations of that age from the Augusta Lobe and Fulton Lobe deposits with more reddish coloration (Dennison, 1970; 1971; see also Figure 15 of present guidebook).

Isolated synclinal occurrences of basal Cohocton Stage strata in Mineral, Grant, and Pendleton Counties (Fig. 34) have not been examined closely in search of the redbed horizon. Promising potential exists with present outcrop distribution to delimit the exact shape of the redbed fringe quite closely.

Fulton Lobe

In the Allegheny Front outcrops redbeds at the approximate Brallier-Scherr contact have been recognized at La Vale, at Corriganville, near the Grange Hall south of Hyndman, at three localities near Madley (Stop 11 of field trip), and at 5 outcrops south and southeast of Kegg on the south side of the Schellsburg Dome. The redbeds become thicker and more brightly colored to the northeast along this outcrop belt, suggesting that depositional strike along this part of the Fulton Lobe trended a little northward from the present northeast structural trend of the Allegheny Front. In northern Bedford County the Allegheny Front is offset to the west side of the Schellsburg Dome, and to our knowledge these basal Cohocton redbeds have not been recognized in the western belt, although a more intensive search may reveal them.

Dennison placed this redbed zone in the lowest Scherr Formation in Maryland, while de Witt mapped the top of the thin redbed zone to designate the Brallier-Scherr contact in Bedford County.

Implications for Further Study

Careful search for the redbed marker zone near the base of the Cohocton Stage should be made on the west side of the Schellsburg Dome (where they probably are truly absent) and especially farther north near Altoona (where predicted depositional patterns suggest the probable most western extent of the Fulton Lobe).

Because of the apparently simultaneous occurrence of marine redbeds fringing the Augusta and Fulton Lobes, Dennison (1971, p. 1188) interpreted them to result from a slight eustatic lowering of sea level in the Appalachian Basin, with a resulting shoreline shift some tens of miles westward. If they truly are a sea level fluctuation phenomenon, then a similar coloration should be sought fringing the Snyder Lobe and Wyoming Lobe of Willard (1939, p. 272) in Pennsylvania and in the Devonian clastics of New York. Recognition of the effects of sea level change promises to be an important physical means of improving resolution of correlations within the Appalachian Basin.

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