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*I hereby recommend that the thesis prepared under my supervision by* Laurence H. Lattman

*entitled* Geomorphology of the Allegheny Mountains of east - central West Virginia

*be accepted as fulfilling this part of the requirements for the degree of* Doctor of Philosophy

*Approved by:*

John L. Rich

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# Geomorphology of the Allegheny Mountains of east-central West Virginia

A dissertation submitted to the faculty of the Graduate School of Arts and Sciences of the University of Cincinnati

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Doctor of Philosophy

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by

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## Abstract

The Allegheny Mountains of east-central West virginia were imperfectly peneplained in pre-Schooley time. There is no evidence that any external base level has affected this region since uplift of the pre-Schooley surface, i. e., no peneplains controlled by a base level outside the area have developed since pre-Schooley time. The region has been lowered by differential mass-wasting ever since this uplift.

The resistance to erosion of the various rocks has exerted the dominant influence in the development of the present topography. Topographic height is a direct function of rock type, thickness and attitude. The resistant rocks stand topographically above the adjacent weak rocks in all cases. Locally, low relief areas are developed on flat lying rocks. Homogeneous groups of tilted rocks have been lowered uniformly by mass-wasting, so that today they form low relief surfaces at various levels unrelated to regional base levels.

While the general levels of the rocks in the anticlines are controlled in detail by rock type, the gross elevations are controlled by the level of the streams draining these folds (the level below which mass-wasting cannot work). Therefore retreat of caprock waterfalls with little or no loss in height has resulted in local, topographically high areas on weak rock above the caprocks.

Various high-level terrace remnants along the major streams are demonstrated to have been developed independently along these streams as they slowly cut down at grade behind resistant rock barriers across their courses. These terraces along the various streams are not related to any common base level outside the area.

The apparently anomalous position of Tygart River behind an isolated bedrock hill south of Elkins is discussed. It is shown that despite the superficial appearance of the river having adopted this course at a comparatively late stage in its history, it has in reality probably always flowed around the hill.

The Penckian concept of parallel retreat of waterfalls on homogeneous rock is shown to be invalid in this region. Two examples are presented, one where a caprock falls vanished when it cut back into homogeneous rock, and another where the falls are now in process of being lowered almost in place on homogeneous rock after having retreated parallel to itself as a caprock falls.

## Purposes of investigation

The possible rewards of a detailed geomorphic study of the part of east-central West Virginia that lies west of the Allegheny Front (see figure 1) were brought to the writer's attention by Dr. John L. Rich, who had previously noted and discussed some of the age-stage problems, ledge-terrace relationships and possible misinterpretation and miscorrelation of peneplains in this area (Rich 1939 a; 1939 b). This region has had no previous detailed geomorphic study of which the writer is aware. Due to the pronounced difference in lithologic types exposed here, and since it is in a temperate zone and therefore subject to Davis' normal erosion cycle, it seemed an ideal location in which to study in detail the effect of rock control upon the geomorphic development of a region.

The purpose of this investigation was to determine, if possible, the geomorphic history of this area. Minor geomorphic problems not directly concerned with the main purpose were also studied and are discussed in appropriate places in the paper.

Acknowledgements

Special thanks are extended to Professor John L. Rich, of the University of Cincinnati, who introduced the writer to the problem and gave freely of his time and help, both at the University of Cincinnati and in the field.

Professor George B. Barbour, of the University of Cincinnati, maintained a stimulating and constructive interest in the investigation and spent several days with the writer in the field.

Dr. Aureal T. Cross, of the West Virginia Geological Survey, and Mr. Richard H. Durrell, of the University of Cincinnati, also gave help and advice in the field.

To these four geologists the writer expresses his sincere gratitude.

Aerial photographs and most of the field expenses were paid for by the Fenneman Fund of the Department of Geology of the University of Cincinnati.

## Introduction

### Location:

The general position of the area studied is given in fig. 1. A detailed topographic map compiled from U.S.G.S. topographic quadrangles is given in fig. 2 (enclosed at end of report).

The region lies in the east-central part of West Virginia in the "Allegheny Mountain section" of the Appalachian Plateau (Fenneman, 1938). This section is differentiated by Fenneman (p. 284) from the adjoining Allegheny Plateau section primarily on the basis of a dendritic drainage pattern in the latter. The Allegheny Mountain section has a pattern "more or less controlled by structure".

The investigation covered parts of Randolph, Barbour, Pendleton, Tucker and Grant counties, for all of which the West Virginia Geological Survey has prepared geologic maps (see bibliography). Adjacent areas were studied in less detail as needed to complete the regional picture. The region involves the following U.S.G.S. topographic quadrangles:

All of: Horton, W.Va.; Davis, W.Va.; Elkins, W.Va.; Parsons, W.Va.; Belington, W.Va.

Parts of: Onego, W.Va.; Thornton, W.Va.; Greenland Gap, W.Va.; Kingwood, W.Va.; Fairmont, W.Va.; Philippi, W.Va.; Sago, W.Va.; Bruceton, W.Va.-Pa.; Oakland, Md.-W.Va.; Morgantown, W.Va.-Pa.;

Elk Garden, W.Va.-Md.; Accident, Md.-W.Va.-Pa.; Blocksville, W.Va.-Pa.

The area is bounded on the east by the Allegheny Front, on the west by Tygart River (west of Laurel Ridge), on the south approximately by the 38°45' parallel and on the north approximately by the 39°15' parallel.

The most intensive study was confined to the area extending about 25 miles north and east and about 10 miles south and west of Elkins, Randolph County.

Climate:

This is a moist-temperate area with an average rainfall of 50 to 60 inches per year. Snow falls from November to April and averages 45 to 50 inches per year (Reger, 1931). Locally snow has fallen as late as July at Davis, Tucker County, which has an elevation of approximately 3000 ft. A.T. (oral communication, local residents).

Stratigraphy:

The nomenclature used is that of the West Virginia Geological Survey as contained in that organization's county reports.

The rocks exposed in this area range in age from Genesee (Devonian) to Dunkard (Permian ?). A summary of the generalized stratigraphy is given in fig. 3, together with a description of the physiographic expression of the various

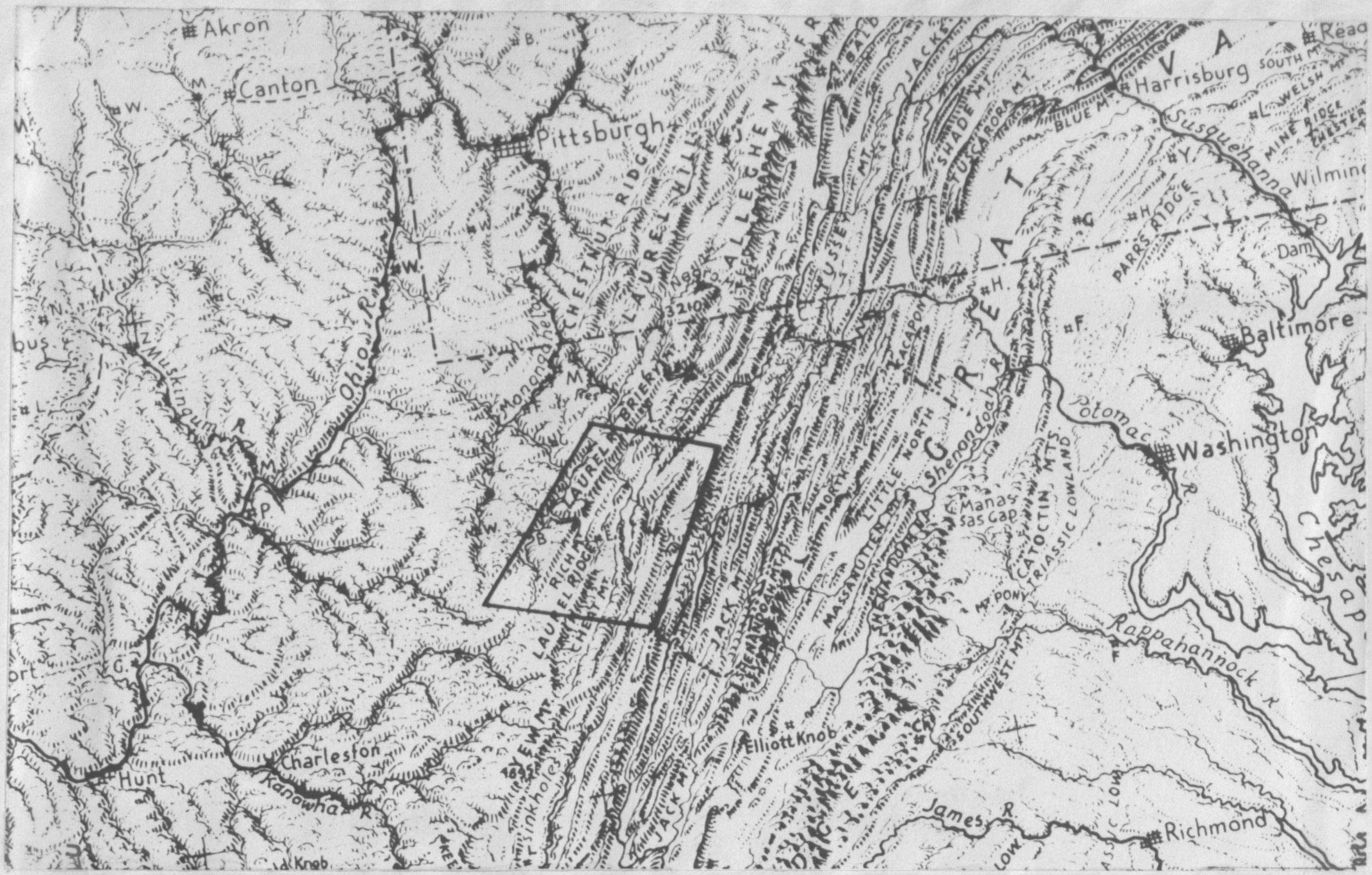



Fig. 1 The area studied is included within the heavy black line. The letter "E" in this area is the town of Elkins.

Generalized Stratigraphy

modified from Reger (1931)

| Period | Formation | Thickness | Description |
| --- | --- | --- | --- |
| Permian | Dunkard | variable | sandstones; generally a resistant series of rock capping hills or ridges |
| Pennsylvanian | Monongahela ) Conemaugh ) Allegheny ) | very variable | sandstones, shales and coal; generally fairly resistant rocks - more resistant than Devonian, less resistant than Pottsville. |
| | Pottsville | 800-1000 ft. | conglomerates and sandstones; most resistant rocks in area, persistent ridge-former; is a caprock overlying Mauch Chunk shales |
| Mississippian | Mauch Chunk | 1000 ft. | predominantly red shale; local hard sandstone sequences; these beds are stripped back in a slope to form Pocono - Greenbrier bench |
| | Greenbrier | 200- 400 ft. | limestone; together with the Pocono this series is a bench-former |
| | Macready | 0 - 50 ft. | limestone and shale; no definite topographic expression |
| | Pocono | 50 -250 ft. | sandstones; very resistant rocks - a bench-maker wherever present in slope |
| Devonian | Catskill | 600-1200 ft. | shales and sandstone; variable resistance to erosion; may be more or less resistant than Chemung |
| | Chemung | 2500-3000 ft. | sandstones and shales; give rise to rounded, turret-like hills with steep slopes |
| | Portage | 2000-2500 ft. | weak siltstones and shales; give rise to a gentle, rolling topography |
| | Genesee | 200 ft. | black shales, weakest rocks in area, very low relief developed on these rocks |

Figure 3.

rock units. A geologic map of the area and cross-section is given in fig. 4.

In this geomorphic investigation no attempt has been made to separate the formations by fossils. Where a lithologic distinction is apparent, this has been used in the field. Where the lithology is not distinctive, the county geologic maps have been relied on; if these were not accurate enough for the purposes of this study, the rocks have been described and no name assigned to them.

Geologic maps of this area are published as part of the West Virginia Geological Survey county reports. These are reconnaisance maps, omitting the finer details of the structure. That structural information obtained during this investigation which is considered important is recorded on fig. 2.

General Structure:

The rocks underlying this area are folded into broad anticlines and synclines (fig. 2 and 4). These folds strike about N 15° E and are from 6 to 12 miles wide.

Generalized dip measurements on these structures must be confined to the competent beds because the Devonian shales and siltstones within the anticlines are drag-folded and crumpled extensively. The dips of the Pottsville series vary from almost 0° around Davis, Tucker County, to a maximum of 17° - 20° in Laurel Ridge northwest of Elkins, Ran-

Figure 4

Geologic map and cross - section

from the: Geologic map
of West Virginia by
the West Virginia Geological
Survey 1932


CARBONIFEROUS

Pennsylvanian

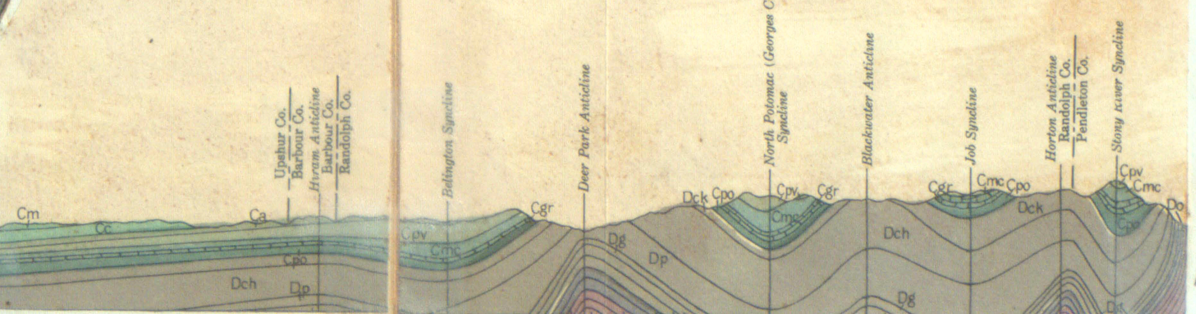
- Cd — Dunkard series (*coal-bearing shale and sandstone*)
- Cm — Monongahela series (*coal-bearing shale and sandstone*)
- Cc — Conemaugh series (*coal-bearing shale and sandstone*)
- Ca — Allegheny series (*coal-bearing shale and sandstone*)
- Ck — Kanawha group (*coal-bearing shale and sandstone*)
- Cnr — New River group (*coal-bearing shale and sandstone*)
- Cph — Pocahontas group (*coal-bearing shale and sandstone*)
- Cpv — Pottsville series (*coal-bearing shale and sandstone*)

Mississippian

- Cbl — Bluestone group (*red and green shale*) and Princeton conglomerate (*conglomeratic sandstone*)
- Chn — Hinton group (*red and green shale and sandstone*)
- Cbf — Bluefield group (*red and green shale and sandstone*)
- Cgr — Greenbrier and Maccrady series (*limestone, red shale and sandstone*)
- Cpo — Pocono series (*quarried for stone*)
- Cmc — Mauch Chunk series (*red and green shale and sandstone*)

DEVONIAN

- Dck — Catskill series (*shale and sandstone*)
- Dch — Chemung series (*fossiliferous shale and sandstone*)
- Dp (Dp) (Dg) — Portage and Genesee series (*thin gray, green to black shale and fine sandstone*)
- Dhm (Dhm) (Dm) — Hamilton, Marcellus and Onondaga series (*fossiliferous shale and sandstone*)
- Do — Oriskany sandstone (*high-grade glass-sand in places*)
- Dhl — Helderberg limestone (*quarried for lime*)



dolph County.

The folds are not uniform in width along their length. The Deer Park anticline (fig. 2) bifurcates west of Parsons, the main axis of the fold continuing to the northeast and the minor axis continuing north. The North Potomac - Georges Creek syncline becomes markedly shallower and wider north of Dry Fork. All of these irregularities are clearly reflected in the topography.

General Physiography:

A shaded relief-diagram of the area is given in fig. 5.

The Allegheny Mountains consist of long, sub-parallel ridges trending northeast-southwest. The ridges are upheld in all cases by rocks of the resistant Pottsville series.

The floors of the anticlines, underlain by relatively weak Devonian rocks, are lower than the floors of the adjacent synclines, which are held up by the Pottsville rocks.

This relation of structure to topography is apparent in fig. 2 and 4.

The following description may be clarified by reference to figures 2, 4 and 5.

Rich Mountain and Laurel Ridge at the extreme west of the area are Pottsville ridges marking the western side of the Deer Park anticline. The highest point on these ridges is Lonetree (3563 ft. A.T.) on Rich Mountain about 7 miles southwest of Elkins. The general elevation of Rich Mountain is between 3250 and 3500 feet. The axis of the anticline


Fig. 5 Shaded relief map

Scale: 1" = about 10 miles

reproduced from the

"Relief map of West Virginia"

by the W. Va. Geol. Survey (1937)

east of Rich Mountain is followed by Tygart River, whose floodplain is at 1900 - 1950 ft. A.T. The Tygart river leaves the anticline through a gap in Rich Mountain - Laurel Ridge at Aggregates, just west of Elkins. Laurel Ridge has an elevation of 3037 feet about one mile north of the narrows of the Tygart and maintains a fairly uniform height northward to the Preston County line. North of this point it decreases in height. The Deer Park anticline east of Laurel Ridge is drained by Leading Creek, a tributary of Tygart River. The former stream's floodplain is at 1925 - 1950 ft. A.T.

About eight miles west of Parsons, Tucker County, the main axis of the Deer Park anticline turns due east almost as far as Parsons and then turns northeast; the minor axis continues northeast without turning. Between these two axes of the Deer Park anticline northwest of Parsons is the Hannahsville syncline, which preserves beds as high as the Pottsville. The syncline stands about 1500 feet above the valley of Cheat River on Devonian rocks to the south.

The eastern edge of the Deer Park anticline (and western edge of the North Potomac - Georges Creek syncline) is marked by Cheat Mountain and McGowan Mountain south of Dry Fork (southeast of Parsons) and by Backbone Mountain north of this stream. The eastern limb of the North Potomac - Georges Creek syncline south of Dry Fork is Shavers Mountain. Between Shavers Mountain and Cheat Mountain the syncline is 4 to 5 miles wide and has a general elevation of 3250 feet reaching 4008 feet at Bickle Knob (on Cheat Mountain 6.5 miles east of Elkins). North of Dry Fork the syncline becomes broader as the dip of the beds toward the axis becomes very low. In this area, locally called the Davis plateau, the width of the syncline is about 9 miles. This increase in width corresponds with an eastward swing in the axis of the Blackwater anticline bordering the syncline on the east.

The Blackwater anticline south of Dry Fork is bordered on the west by Shavers Mountain and on the east by Rich Mountain. The center of the fold, on Chemung rocks, is a "turtleback" (has anticlinal form). Shavers Mountain has an average elevation of 3600 feet and Rich Mountain frequently attains a height of 4000 ft. A.T. Middle Mountain (the turtleback in the center ) has a general elevation of 3500 feet. All three of these ridges decrease in height northward.

Where the axis of the Blackwater anticline turns temporarily east along Dry Fork there is a structural dome bringing a broad area of Devonian beds to the surface in the vicinity of Mozark Mountain (8 miles southeast of Parsons). The northeastward continuation of the Blackwater anticline (east of the Davis plateau) has a structural high along the axis which makes the anticlinal, cigar-shaped Canaan Valley. Although lower than the Pottsville ridges around it, the floor of Canaan Valley has a general elevation of 3200 feet. In the center is a low range of hills reaching 3450 ft. A.T.

(a turtleback). The rocks of Canaan Valley are Pocono in the center (the turtleback) surrounded by Greenbrier limestone (the low area around the turtleback). The eastern edge of Canaan Valley is marked by Cabin Mountain with a general elevation of 3800 ft. locally reaching above 4000 ft. A.T. Cabin Mountain also marks the western edge of the Stony River syncline whose eastern edge is the Allegheny Front.

South of Dry Fork, Rich Mountain on the eastern limb of the Blackwater anticline is the western edge of the narrow (4 miles wide) Job syncline. This fold also turns east along the same line as the folds further west and apparently joins the Stony River syncline.

East of the Job syncline is the Horton anticline which dies out where the Job syncline turns east to join the Stony River syncline.

Where the axes of the Job and Stony River synclines meet are Flatrock Plains and Roaring Plains underlain by almost horizontal Pottsville rock and having a general elevation of 4200 feet.

The most striking feature of the elevations in this area is the decrease in height northward and westward. The decrease in height westward is by far the larger and is due to the general decrease in height of the resistant Pottsville series in this direction.

A more detailed discussion of the physiography and its origin in the light of this investigation is deferred until later in this report.

Drainage:

A drainage map for this region is given (fig. 6). East of Laurel Rdige - Rich Mountain, the drainage has a trellis pattern. West of this ridge line the pattern is dendritic. This is the criterion used by Fenneman (1938, p. 284) to distinguish the Allegheny Mountain section (trellis pattern) from the Allegheny Plateau section (dendritic pattern).

The western side of the Deer Park anticline from its southern end to just above Montrose, Randolph County, (10 miles north of Elkins) is drained by Tygart River and its tributaries. The eastern side of this anticline and all the folds to the east are drained by the Cheat River drainage system. Both of these streams flow northward. Tygart River joins the West Fork river just below Fairmont, West Virginia, to form the Monongahela river. Cheat River joins the Monongahela river at Point Marion, Pennsylvania. Much of the area studied in this investigation has been set aside as the Monongahela National Forest for the purposes of flood control of Monongahela River.

A more detailed discussion of the drainage is given in a later part of this report.

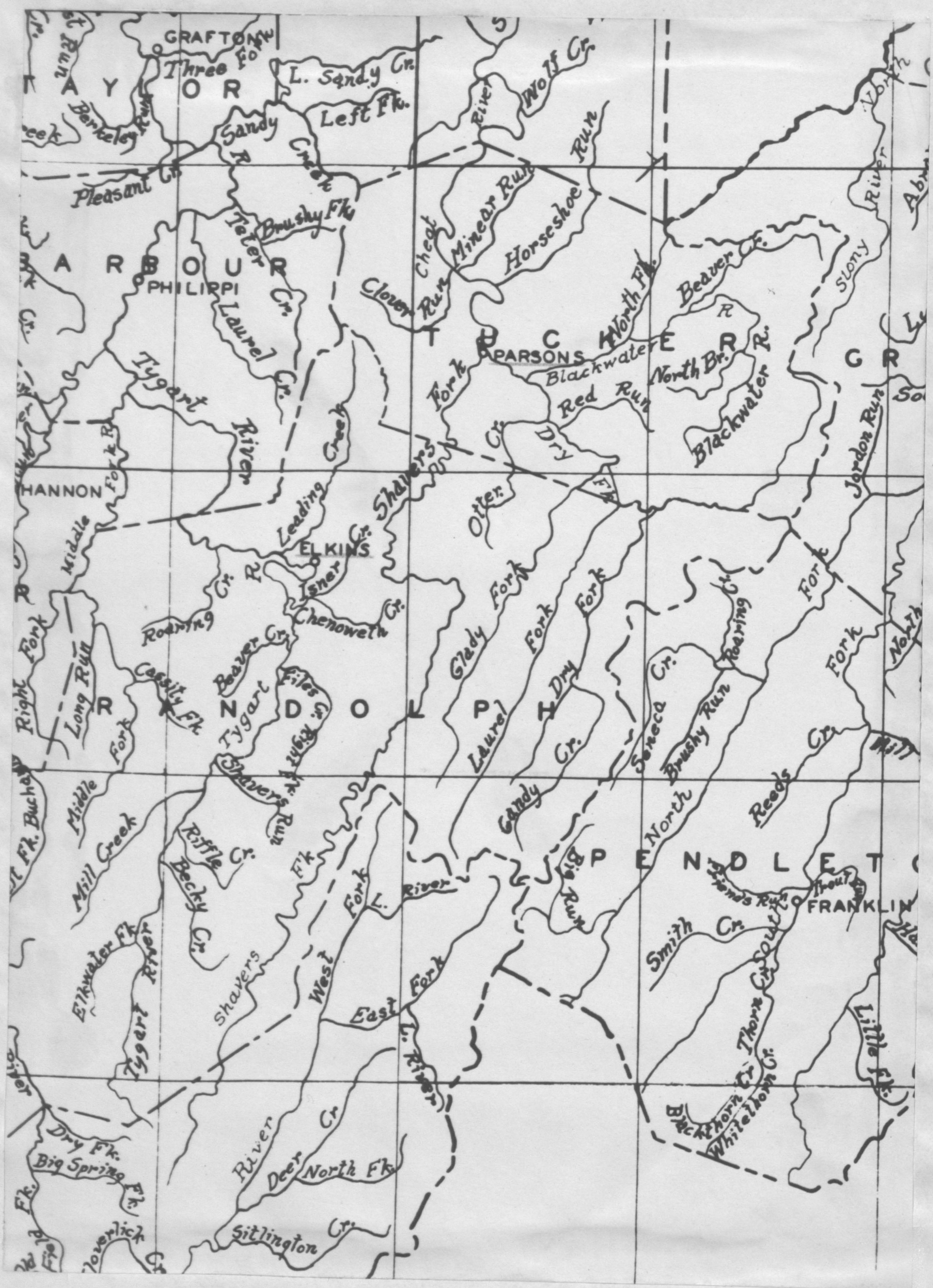



Fig. 6 Drainage map ( reproduced from "Drainage map of West Virginia" by Paul H. Price)

## Faulting

David Reger (1931, p. 124) stated:

> "Faults, in the classic sense of beds which have been broken, vertically displaced or thrust over each other, were not observed in Randolph County."

This investigation revealed one possible and two probable faults in the western part of the area, in the vicinity of Elkins (fig. 2). All of the faults were inferred from geomorphic observations and the presence of two of them was supported strongly by stratigraphic evidence.

Fault just east of Laurel Ridge:

This fault is marked 1-1 on fig. 2. The possibility of a fault here was brought to the writer's attention by Dr. John L. Rich after examination of the aerial photographs.

The following section (modified) is given by Reger (1931, p. 153): Morgantown Pike section, Leadville district (crossing Laurel Ridge about 5 miles northwest of Elkins): starting on the old Morgantown Pike, 0.3 miles southeast of the summit of Laurel Ridge and 3 miles northwest of Gilman, and traversing eastward 0.3 miles down the pike; dip northwest $35^{\circ}$ to $40^{\circ}$; thickness partly estimated; measured by David B. Reger and arranged in descending stratigraphic order:

| | | Thickness |
|---|---|---|
| | Mauch Chunk series | |
| 1. | Shale, red, not measured (2555'B.) | |
| | Unconformity, no Greenbrier or Macready series present | |

| | |
|---|---|
| Pocono series | 111 ft. |
| Catskill series | 515 ft. |
| Chemung series | 20 ft. |

Reger attributed the lack of Greenbrier limestone and Macready shales and limestone to an unconformity. The Macready shales and limestone are locally missing at many places in this area, but the Greenbrier limestone is the most persistent known stratigraphic unit as regards presence and thickness throughout eastern West Virginia, in surface outcrops and well logs (Russell Flower, West Virginia Geological Survey, oral communication).

The absence of the Greenbrier along Morgantown Pike is the more striking because it is present at several places around Elkins. These are

(1) in Bickle Knob, east of Elkins (pt. A, fig. 2) where it is about 200 feet thick,

(2) in the east face of Rich Mountain, southwest of Elkins (pt. B, fig. 2) where it is 150 feet thick along the Parkersburg Pike,

(3) in the south slope of the narrows of Tygart River at Aggregates, west of Elkins (pt. C, fig. 2) where it is about 180 feet thick (Elkins Limestone Company Quarry).

(4) in the north slope of the narrows of the Tygart (pt. D, fig. 2) where its thickness is indeterminable (abandoned quarry),

(5) east of Kirt, Barbour County, 13 miles north of Elkins (pt. E, fig. 2) where its thickness is indeterminable (abandoned quarry).

Despite the persistence of the Greenbrier it is a difficult formation to find in this area unless it has been quarried. Pottsville float, often consisting of large blocks, is extensive on the slopes of Rich Mountain and Laurel Ridge. The soil cover is in general about 4 feet thick. The writer has been unable to find Greenbrier float except around a quarry. The Pocono in this area is locally absent and it is difficult in the field to separate the red shales of the upper Catskill which are beneath the Greenbrier from the red shales of the Mauch Chunk which overlie the Greenbrier. This is partly due also to the discontinuity of exposed sections. For this reason the method used to determine the presence or absence of Greenbrier in a section was observation of outcrops up the section to the Pottsville, which is easily recognized, taken at sufficiently close intervals so that there was no room for 100 or more feet of limestone to be present and not be discovered. By this means the Greenbrier can be shown to be absent from the sections exposed in the east slope of Laurel Ridge along Morgantown Pike and the two traverse lines A-A and B-B (fig. 2). Although it was not found, there is room for it in the section along the road that crosses Laurel Ridge west of Victory School, about 10.5 miles north of Elkins (p.t F, fig. 2). Along this road and along the road east from Kirt, (pt. E, fig. 2) the subsequent drainage on the weak beds of the upper Catskill is well developed. In the light of the persistence of the Greenbrier limestone in the vicinity of Elkins, and especially its presence west of the crest line of Laurel Ridge (pts. C and D, fig. 2), its absence along the east face of Laurel Ridge (northwest of Elkins) is attributed to faulting rather than local unconformity.

This fault is believed to be a thrust from the east for the following reasons.

1. Along Morgantown Pike, Catskill and perhaps Pocono beds to the east are in contact with Mauch Chunk beds on the west. This relative position of the older and younger beds is compatible with a thrust from the east.

2. Along Morgantown Pike the general dip of Devonian rocks is about 35° NW. At the place where Reger (loc. cit.) placed the Catskill (Pocono) - Mauch Chunk contact, the Catskill beds dip 60° NW. This steepening of dip is explainable by drag above a thrust fault from the east.

3. Referring to fig. 2 it is notable that the axis of the Deer Park anticline, as determined by the outcrop of the oldest beds (Genesee shales) is shifted about 1½ miles westward from opposite the narrows of the Tygart as far north as the road to Kirt.

The southern limit of the fault is placed in the vicinity of the narrows of the Tygart because the Greenbrier limestone is present in the east slope of Rich Mountain south of the narrows and because the westward displacement of the axis of the Deer Park anticline occurs here. The northern limit of the fault is unknown since traverses up the east face of Laurel Ridge north of the road to Kirt reveal no Greenbrier, but there is room in the observed section for it to be present.

The bulge eastward in the crest-line of Laurel Ridge east of Kirt is worthy of special mention. The Greenbrier is quarried at pt. E of fig. 2 and the Pocono and Catskill beds are exposed in the sides of the road west of pt. E. The Pocono forms a distinct ridge and a subsequent stream has opened a valley along the Catskill rocks. Just east of the Catskill "low" is another ridge which is capped by a massive sandstone about 20 feet thick which may be Pocono but is probably a resistant facies of the lower Catskill. This is a normal section and the fault must therefore pass east of the bulge. The most reasonable explanation for this is an upwarp in the fault plane so that the fault emerges at the surface here further east than it does to the south.

Fault along Leading Creek:

The evidence for a fault (2-2, fig. 2) along Leading Creek (extending NNE of Elkins) is highly circumstantial.

The presence of a fault here was first suspected because of the course of Leading Creek.

The rocks exposed along the axis of the Deer Park anticline are the weakest in the area. They are the black, fissile Genesee shales. Tygart River south of Elkins follows these weak beds exactly, diverging from them at only one point about 2 miles west-south-west of Elkins. North of Elkins, Leading Creek flowing south does not follow the weak Genesee shale belt but parallels the latter about a mile to the east, where its banks are cut in Portage beds. The area of Genesee outcrop along the fold axis is a lowland of low relief. The tributaries entering Leading Creek from the west open out wide alluvial flats where they cross the Genesee belt. A low range of turret-like hills of Portage rocks separates the Genesee shale zone along the axis from the valley of Leading Creek to the east.

Since Leading Creek flows parallel to the structure it is remarkable that it does not follow the Genesee shales. In light of the close adjustment to structure of Tygart River south of Elkins, Leading Creek seems to be following either a zone of weakness in the Portage shales that parallels the structure or another outcrop of Genesee shales east of those along the axis.

The stratigraphic evidence for this fault is purely negative. The absence of outcrops in the valley of Leading Creek prevented a determination of the beds on which the stream is flowing. The rocks in both banks show a typical Portage lithology.

The possibility that there is a secondary axis of the

Deer Park anticline which brings the Genesee to the surface in the valley of Leading Creek cannot be completely rejected. Doubt is cast on it however by the dip of the beds in the banks of the stream. As carefully as can be determined in these contorted shales, the beds on the east side of the valley and the beds on the west (in the range of hills between Leading Creek and the Genesee belt) both dip to the east. There seems to be no secondary axis present.

A fault along Leading Creek would create the postulated zone of weakness, or it might have brought up the Genesee shales in the wide flat of Leading Creek now covered by alluvium and still allow for the dips observed.

If the valley of Leading Creek is projected northward beyond the valley head along the regional strike, this line of projection would cross Pifer Mountain at a point (pt. F, fig. 2) where a zone of shales stands vertically (see plate 1). Immediately east and west of this zone the beds are practically horizontal. There is clearly a line of disturbance passing through here. If the valley of Leading Creek is projected due south it would pass through the settlement of Sullivan, about 1.5 miles SW of the center of Elkins. The rocks in this area are contorted but show no evidence of a fault. This is not unexpected, since the Laurel Mountain fault also does not appear to extend south of an east-west line through the narrows of Tygart River and Elkins.

Plate 1

Zone of disturbed beds in Pifer Mountain

The West Virginia survey has only two well records for this area (Russell Flower, West Virginia Geological Survey, personal communication). One well (pt. G, fig. 2) located 5.2 miles south of 39°05' and 2.95 miles west of 79°45', is just east of the town of Kerens on the east side of the Leading Creek Valley; the second well (pt. H, fig. 2) is located one mile due west of the first almost on the axis of the Deer Park anticline. Thus, the two wells bracket Leading Creek. The first well on the east side of the valley shows a repeat of over 1000 feet of section at a depth of 3000 feet. The second well shows no repeat of section in its log. It may be that a steeply dipping fault plane, striking about N-S and dipping steeply east, perhaps associated with the Laurel Ridge fault, comes to the surface between these two wells along the valley of Leading Creek. It must be noted however that the surface rocks show no displacement approaching 1000 feet, although if the fault plane were dipping steeply enough, a sliver of Genesee could be present under Leading Creek.

Elkins Fault:

A possible fault (3-3, fig. 2), striking approximately east-west through the narrows of Tygart River and Elkins and extending east through the water gap of Shavers Fork of Cheat River where this stream crosses Cheat Mountain and possibly farther east through Alpena Gap in Shavers Mountain, is physiographically the most important one of the three.

The possibility of this fault was first suspected because of the alignment of the water gap by which Tygart River leaves the Deer Park anticline and the gap by which Shavers Fork leaves the North Potomac - Georges Creek syncline (fig. 2). Among the various likely reasons for this alignment is stream capture along a zone of weakness. (This point will be more fully discussed later.) This fault continuing eastward may be responsible for the presence of a "low gap" (fig. 2 and 7) at Alpena (11 miles east of Elkins). This gap does not show up clearly on the topographic map, but is striking in the field and on the aerial photographs (plate 3). It is in the same general east-west line as the narrows of Tygart River and Shavers Fork.

In the narrows of the Tygart the Greenbrier limestone is being quarried in the south bank of the river at pt. C of fig. 2. North of the river it outcrops in a single quarry at D (fig. 2). At C the limestone strikes on the average N $15^\circ$ E and dips 20 - $22^\circ$ NW. From the quarry at D an alidade shot 1890 ft. long exactly along the strike of the Greenbrier (N $15^\circ$ E) shows the limestone at D to be 85 feet above the top of the limestone at C. This offset (plate 2) could be due to a change in thickness, a local warp in the beds, or a fault.

A coal seam in the Pottsville series is being mined on both sides of Alpena Gap. Similar alidade shots here show that the coal north of the gap is about 50 feet higher than

Plate 2

Narrows of Tygart River west of Elkins

Points C and D of this plate correspond to points C and D of fig. 2

Limestone at C is 85 feet below same limestone at D.

reproduced from U. S.
Soil Conservation Service
photograph DDF-17-110


D
C
N

Plate 3

Stereo vertical photographs of Alpena Gap

reproduced from U. S.
Soil Conservation Service
photographs



3


Fig. 7 Alpena Gap and vicinity Scale: 1"=1 mile
( from U.S.G.S. Horton,W.Va. quadrangle)

that to the south, although it is not absolutely certain that the two coals are the same. The aerial photos of Alpena Gap (plate 3) show a small offset in Shavers Mountain at this point. The northern ridge appears to have moved westward relative to the southern ridge. It has not been possible to make similar measurements in the narrows of Shavers Fork.

The Chemung shales in Kelly Mountain between Elkins and the narrows of Shavers Fork are poorly exposed but are locally highly contorted and crumpled. There is no striking topographic low here, but this is not anomalous in the light of the general weakness and contortion of the Chemung.

The two faults previously discussed appear to end along an east-west line through Elkins.

All of this suggests the possibility of a tear fault associated with the other two possible thrust faults. If this is so, and the fault is of the strike-slip type, a relative horizontal movement (the northern block moving west with respect to the southern block) of about 200 feet would account for the offsets found. The extension of the fault as far east as Alpena Gap is tentative.

Since the Pottsville, which exerts a controlling influence on the topography, is very competent, a small movement such as postulated above would cause local brecciation and thereby greatly reduce the resistance of the formation. This would cause the fault to have marked geomorphic influence.

Folds:

The folds have been briefly discussed under structure in the introduction. A few observations of relatively greater importance to the geomorphology are mentioned here.

1) The Deer Park anticline is the westernmost large fold. The area west of Laurel Ridge - Rich Mountain contains several broad, gentle folds. The folding dies out westward in the Allegheny Plateau.

2) The compressive force responsible for the folding came from the east, and the folds are either symmetrical or slightly asymmetrical with the western limb dipping more steeply than the eastern limb.

3) It is anomalous that the westernmost anticline (Deer Park) should be the most asymmetrical as it is furthest from the compressive force. Perhaps this is due to the very fact that it is the one in contact with the relatively undisturbed area opposite to the direction from which the folding force came. The folds to the east are not so asymmetrical because the area against which they were being thrust (the folds to the west) yielded and folded. The area west of the Deer Park anticline did not yield so readily. In this connection it should be pointed out that the Deer Park anticline is the only one in which faulting was found. The asymmetry of this fold is exaggerated on the geologic map (fig. 4) because of a secondary fold axis which was found east of the major one (fig. 2).

4) Using the structure contours on the coal beds within the Pottsville formation (geologic map of Randolph County, Reger 1931) for the determination of the dip, the following approximate values have been obtained for the heights of the base of the Pottsville projected to the axes of the Deer Park and Blackwater anticlines: These results are anomalous for the Deer Park anticline.

a) Base of Pottsville in Deer Park anticline at Elkins equals 4000 ft. A.T. The dip of the Pottsville on the western limb of this fold is twice that on the eastern limb. Therefore, in the ideal case, the axis should be one third of the way across the fold from the west limb. This condition is approximately met although north of Elkins the axis is somewhat closer to the west limb.

b) Blackwater anticline west of Alpena equals 5200 ft. A.T. (base of Pottsville). This fold is symmetrical.

Checking these results by stratigraphic thicknesses gives good agreement for the Blackwater anticline but a serious disagreement for the Deer Park anticline:

Blackwater anticline:

(1) Height of base of Pottsville (see above) here = 5200' AT

(2) Highest point of anticline east of Alpena ≅ 3000' AT

(1-2) Thickness of rocks removed (below base of Pottsville) = 2200'

The thickness of the rocks in the limbs of this fold between the oldest rocks exposed at the axis and the base of the Pottsville is 2200 feet. This checks with the value determined above by calculation.

Deer Park anticline: (south of Elkins to eliminate effects of faulting)

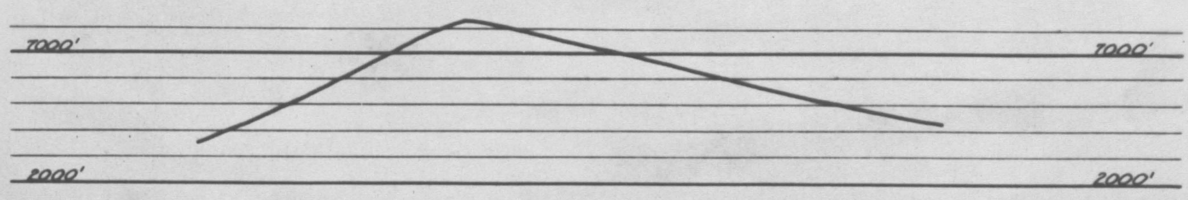
| | | |
|---|---|---|
| (1) | Height of base of Pottsville (above axis south of Elkins) | = 4000' |
| (2) | Height of axis south of Elkins | ≅ 2000' |
| (1-2) | Thickness of rocks removed (below Pottsville) | = 2000' |

Thickness of rocks from Genesee at axis to Base of Pottsville in Rich Mountain ≅ 6000'.

About 4000 feet of rocks which are shown would not be exposed if the dips projected from the structure contours are used. Local changes in formational thickness cannot account for this large difference. It seems clear that the dip of the Pottsville, due to the asymmetry of the Deer Park anticline, was much steeper in the area from Rich Mountain east to the crest (as shown in fig. 8). On the basis of thickness of rocks present, the height of the base of the Pottsville at the crest would be about 8000 ft. A.T. This requires an average dip of about 20$^{\circ}$ of the Pottsville from its present position in the east face of Rich Mountain to the crest. Measurements on the Pottsville at the crest of Rich Mountain give values of about 17$^{\circ}$ - 20$^{\circ}$ which checks quite well.

In summary:

| | |
|---|---|
| Height of base of Pottsville at crest of Deer Park anticline south of Elkins | = 8000'AT |
| Height of base of Pottsville at crest of Blackwater anticline east of Alpena | = 5200'AT |




Restoration of base of Pottsville over Deer Park Anticline. Horizontal Scale 1" = 2 miles
Vertical exaggeration X2

Fig. 8 Base of Pottsville over
Deer Park anticline

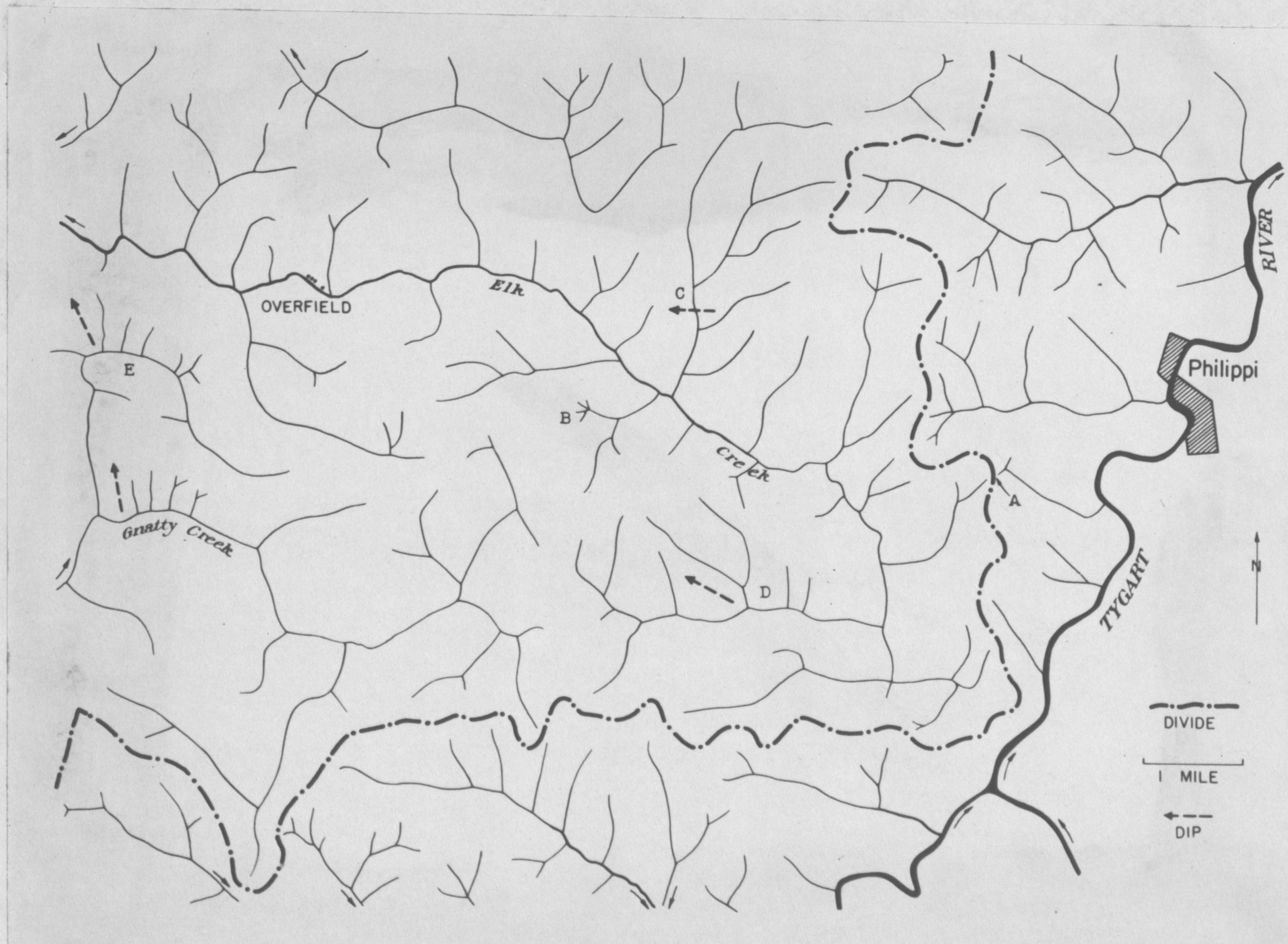
Drainage details

Tygart River system:

West of Laurel Ridge, Tygart River turns and flows northward past Philippi, Barbour County (fig. 4). At Philippi, the Tygart is about 300 feet higher than the West Fork river to the west at Clarksburg. As a result, the east-side tributaries of the West Fork have captured many of the west-side tributaries of the Tygart. An outstanding example of this capturing may be seen in the area west of Philippi (fig. 9). Here capture of Elk Creek in the vicinity of Overfield has shifted the divide to within ½ mile of the Tygart. The original course to the Tygart appears to have been past point A of fig. 9. Further details of these captures are given by Reger (1918, pp. 29 - 32).

Several interesting cases of one-sided tributary development are shown by the streams in this area (fig. 9, C,D,E,F).

It is well known that streams flowing approximately parallel to the strike of gently dipping sedimentary rocks of differing resistances to erosion often develop longer tributaries on the up-dip side. An example of this is found on coastal plains where the resequent tributaries to subsequent streams are longer than the obsequent tributaries. The streams in this area however in some cases (fig. 9, D,E,F) develop their longer tributaries on the down-dip side. Climatic differences cannot be responsible because the climate is uniform in this small area. Differential solar heating




DRAINAGE WEST OF PHILIPPI

Fig. 9 Drainage west of Philippi, Barbour County of north and south facing slopes is not effective because some of the streams flow north and south. An examination of the valleys of the streams shown in fig. 9 brings to light a new factor controlling tributary length which is advanced as the cause of the asymmetrical development of tributaries in this region.

The field evidence indicates that the tributaries in this area are best developed on the up-dip side of streams flowing approximately parallel to the strike of the rocks when resistant rocks crop out high in the valley sides. When resistant rocks crop out low in the section the tributaries are better developed on the down-dip side.

The beds underlying the area of fig. 9 have a variable dip direction but always a gentle angle of dip. The dip directions at the critical streams are indicated by arrows on fig. 9.

Racoon Creek (fig. 9, E) and Gnatty Creek show locally strong one-sided tributary development. Where this occurs, the more resistant beds of the upper Conemaugh and lower Monongahela series crop out low in the valley sides. The rocks high in the valley sides are weaker middle Monongahela beds. Similarly in Indian Fork (fig. 9, D) the relatively weak Monongahela overlies the Conemaugh. The valleys of all these streams have steeper slopes near the bottom due to the harder rocks there. In these three cases the tributaries are best developed on the down-dip side of the main stream.

Stewart Run (fig. 9, C) is cut into Monongahela and Conemaugh rocks but the rocks present on top of the hills here are the very resistant Dunkard series. The valley cross-profile shows steep slopes at the top and gentle slopes at the bottom. This stream's tributaries are best developed on the up-dip side.

The conclusion drawn from the field evidence is confirmed by deductive geomorphology. Fig. 10 shows idealized profiles parallel to the dip of sedimentary rocks of differing resistance to erosion. Case A of fig. 10 shows resistant rocks occurring immediately under the old age surface. The dotted lines are the progressive longitudinal profiles of tributaries to the main stream flowing perpendicular to the page. It is apparent from inspection that the tributaries on the up-dip side (left hand side of fig. 10, A) have less of the resistant rock to cut through. They will reach the weak rock more quickly than the tributaries on the down-dip side and will hence be better developed at any particular time.

Case B of fig. 10 shows the case where the weak rocks crop out high in the section. Here inspection shows that the tributaries on the up-dip (left hand) side will encounter the resistant rock first and their development will be slowed up, whereas the down-dip side tributaries will continue to develop in weaker rock.

If the main stream remains at the same level for a sufficiently long time, tributaries on both sides should become ideally the same size in either case (depending on load and hydraulic factors). This is indicated by the dashed line

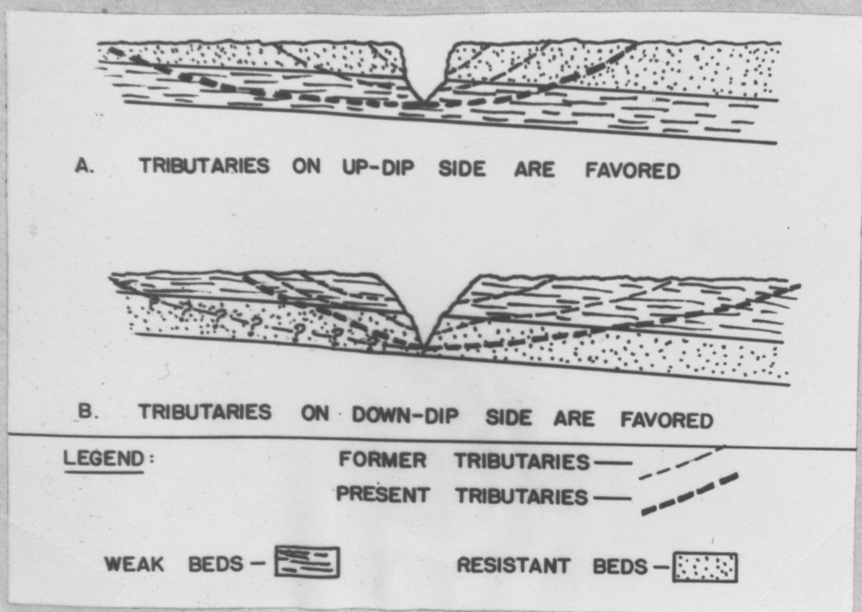



Fig. 10 Diagram to illustrate the control of one-sided tributary development by rock type.

with question marks in fig. 10 B.

Case B of fig. 10 should be the rarer of the two. The more time the differential erosion has had to manifest itself on an upraised old age surface, the less common will be cases where weak rock is exposed highest in the section.

The writer has used this idea several times to determine generalized dip directions in this area. Inspection of stream valleys on aerial photographs often indicates whether weak or resistant rock is exposed higher in the valley sides. This information coupled with the development of one-sided tributaries makes it possible to ascertain the dip direction. There are six cases in the area just north of the one shown in fig. 9 in which this method was used. In all cases the conclusions drawn checked with the field evidence.

It is apparent from the map of the area west of Laurel Ridge that Tygart River downstream from the narrows through Laurel Ridge - Rich Mountain disregards structural control. Its course crosses the axis of the gentle Hiram anticline three times within Barbour County (fig. 4). The river through here is ungraded. Several rapids exist, one of the most conspicuous being just south of Philippi. Its gradient (Reger 1918, p. 33) is variable from Belington to the Barbour-Harrison County line. It has a gradient of 30.8 ft/mile from Belington to Tygart Junction (11.7 miles) and 14.2 ft/mile from Tygart Junction north to Big Sandy Creek (20.8 miles). This ungraded condition over a long distance is important geomorphically and will be further discussed below. The steepest gradients are found where the river is flowing on the Pottsville sandstone and conglomerate. The stream shows marked floodplain development only on the outside of meander bends at and north of Philippi, and at Belington. These meanders are just upstream from points where the stream flows over the Pottsville (exposed low in its banks) showing clearly that the Pottsville, wherever met, acts as a local base level. There is no floodplain where the river is cutting into the Pottsville rocks.

Tygart River from Belington upstream through the narrows is ungraded. From Elkins to Belington it has a gradient of about 12 ft/mile. From Elkins upstream to Mill Creek (about 25 miles south of Elkins) it has a gradient of less than 3 ft/mile. The aerial photos of Tygart River south of Elkins show a mature river on a well developed floodplain with many ox-bow lakes. Clearly the Tygart here is locally base leveled to the Pottsville in the narrows.

The behavior of the Tygart in the vicinity of, and just upstream from, Elkins is in need of explanation. This area is shown in fig. 11 and plate 4. The course of the river is here traced from Beverly (fig. 2 and 11) on the east side of the valley about 5.5 miles south of Elkins, to the narrows at Aggregates. The distances are airline miles unless otherwise stated.

1. From Beverly, 4.5 miles northward the river is a normal mature stream in a floodplain about 3 times as wide

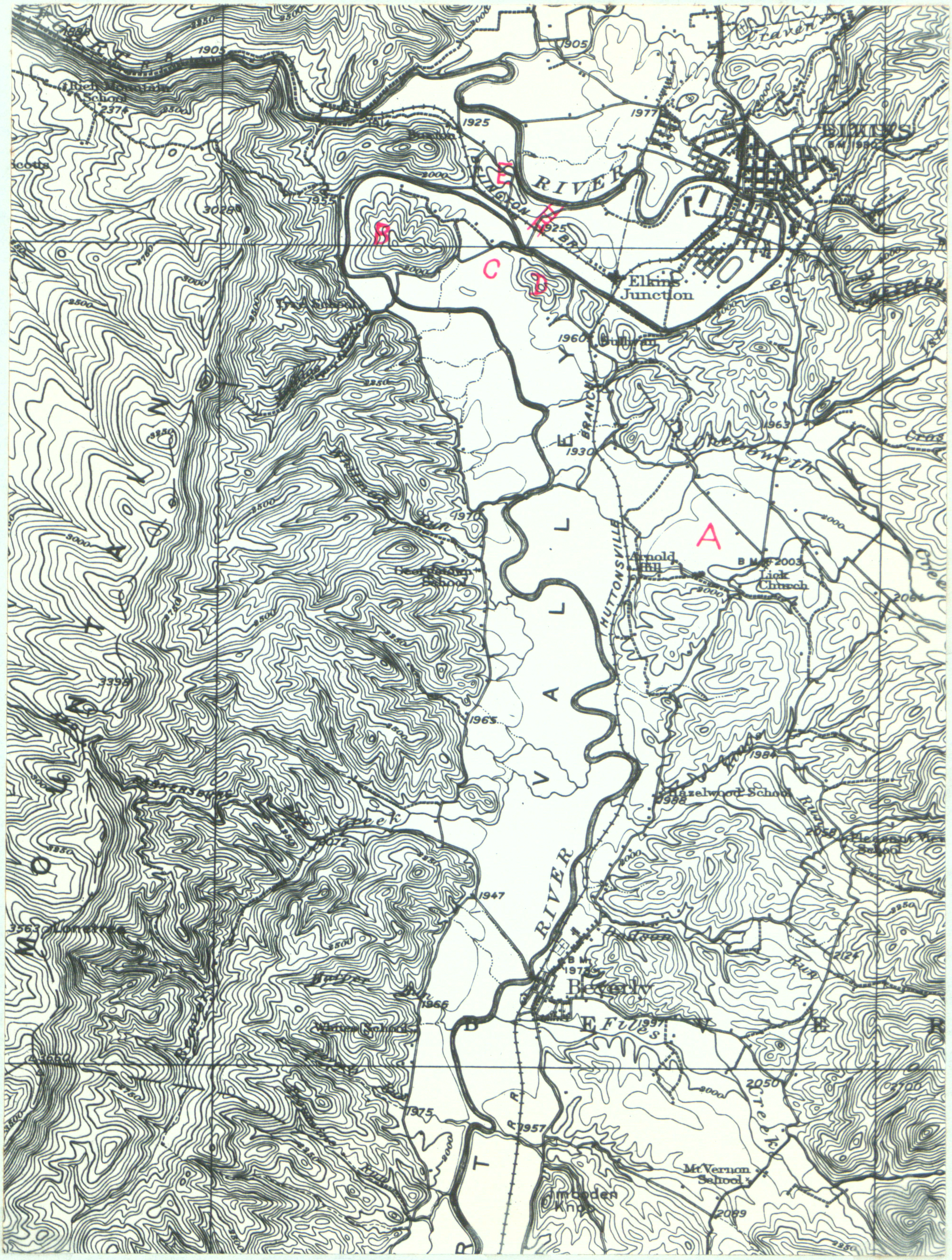



Fig. 11 Map of Elkins area Scale: 1" = 1 mile

= flood control spillway

( reproduced from U.S.G.S. Elkins,W.Va. quad.)

Plate 4

Aerial photograph of Elkins and vicinity

Letters correspond with those on fig. 11

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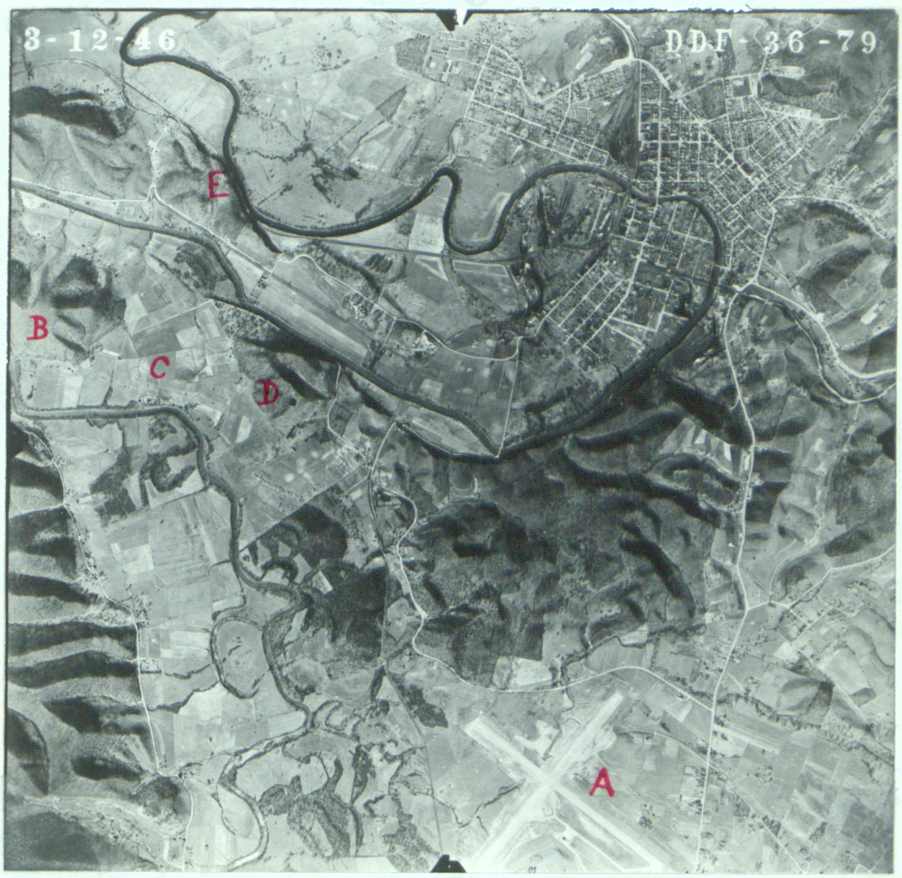
Soil Conservation Service
photograph


3-12-46
DDF-36-79
E
B
C
D
A

as its meander belt. About 3.5 miles north of Beverly a wide area of low relief (A of fig. 11 and plate 4) is found on the east side of the valley. The Elkins Airport is built here (plate 4).

2. 4.5 miles north of Beverly the river makes a wide swing to the west and passes around a hill of Chemung beds (B of fig. 11 and plate 4) about 400 feet high. East of this hill, and in line with the valley to the south is a flat alluvium-covered low sag (C of fig. 11 and plate 4) separating the hill from a bedrock ridge (D of fig. 11 and plate 4) to the east. This low sag will be referred to as the "threshold".

3. After rounding hill B the river flows SE for about 2 miles, turns NE for about 1.5 miles and then, at Elkins, flows due west, with a meandering course, to the narrows. Within this wide curve is a bedrock ridge, thinly veneered with gravel (E of fig. 11 and plate 4) through which a flood control sipllway (see fig. 11) has been built to protect Elkins. Exposed in the spillway are black shales of typical Genesee lithology. This ridge will be referred to as the "spillway ridge".

The east-west distance across the curve from hill B to Elkins is about 3 miles and is very much larger than any meander of the river upstream.

The two problems here discussed are:

1. The reason for the course of the river around the bedrock hill when a straight short course apparently existed

through the threshold.

2. The origin and meaning of the wide curve through Elkins.

Origin of the course behind the hill:

Important elevations in this region were determined by barometer and are given in plate 5, overlay. In the following discussion the figures given refer to those in plate 5, overlay (figures in circles).

Depth of alluvium figures are hard to obtain in this area. According to the Randolph Builders Supply Company, Elkins, thicknesses of alluvium are quite variable within the town of Elkins itself. The average depth in Elkins is 12 to 14 feet but reaches 27 feet at the U. S. Post Office near the center of town. At the farm of H. Howell (plate 5)(1) a well penetrated 30 feet to bedrock through a "yellow clay with no pebbles or rock fragments in it". The terraces (2) north of the bedrock hill show shale and siltstone chips and fragments on top and in the sides and bottoms of the gullies. No rounded particles were found here. A crowbar can be pushed its length (6 ft.) into the terrace tops and gully bottoms with little effort (H. Howell, Elkins, oral communication). As the rocks in the bedrock hill dip steeply NW the terraces cannot be rock-controlled. A small ridge (3) across the threshold has chips on top as well as a few scattered rounded pebbles of quartz. A single abandoned well here is cased, but a soil auger put down for a distance

Plate 5

Stereo vertical photographs of isolated bedrock hill southwest of Elkins.
(See B of fig. 11 and plate 4)

On overlay:

Figures in circles are station numbers (see text). Figure not in circles are elevations by aneroid.

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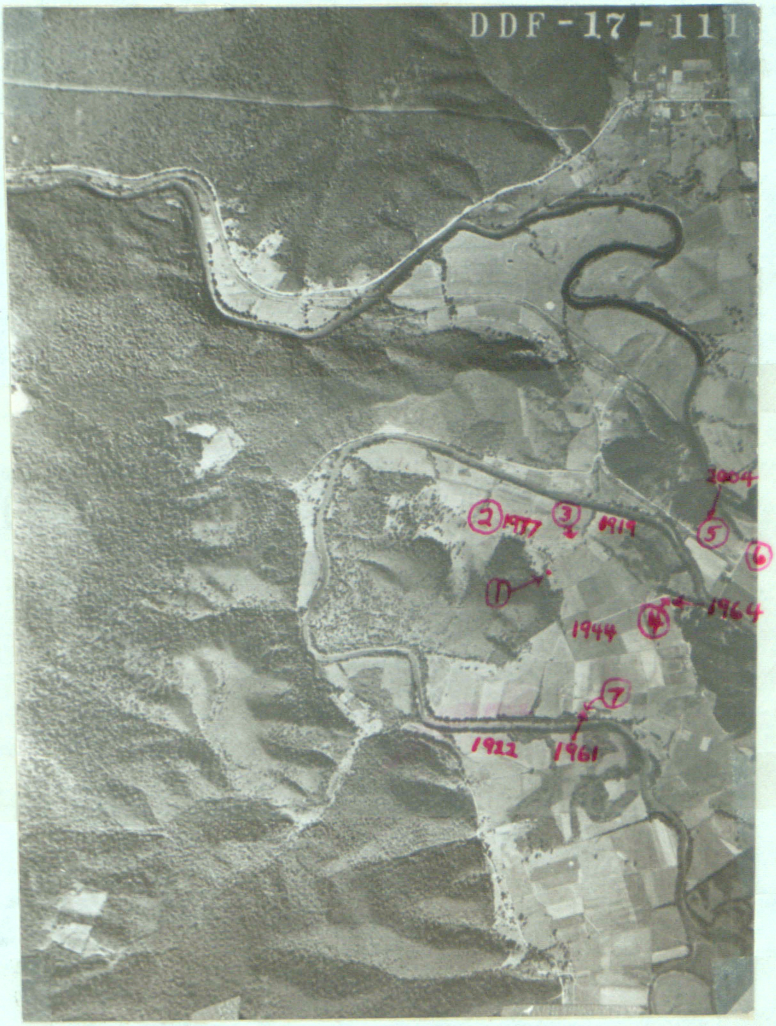
Soil Conservation Service
photographs.


DDF-17-111
2004
2 1977
3 1919
5
6
1
4 1964
1944
7
1922
1961


DDF-17-

of 2.5 feet brought only chips to the surface. Below 2.5 feet the auger penetrated with difficulty and after an additional ½ foot would go no further. This last ½ foot penetration brought to the surface large pieces of siltstone. It is assumed therefore that bedrock was encountered at a depth of 2.5 feet. The terrace at (4) is bedrock overlain by 3 feet of alluvium containing rounded pebbles (pit at Haddix farm). The spillway ridge at (5) has some scattered quartz pebbles on it but bedrock is only about 8 inches below the surface. At (6) the pebbles are more common and bedrock is about 2 feet below the surface. The small isolated hill south of the threshold (7) is bedrock overlain by about 2 feet of alluvium. At various points upstream the thickness of material over the bedrock on the terraces on each side of the stream as indicated by water wells is about 35 feet (fide, Joe Bennet, well digger, Beverly, W.Va.). This would place the bedrock here at about 6 feet above the level of the present Tygart River. Close to the river at Beverly the alluvium is 4 to 8 feet deep and just south of the bridge the river is flowing on bedrock.

In summary, the thickness of alluvium upstream from the threshold indicates that the river is not alluviated there. The alluvial material under Elkins and to the west as found in wells and foundations consists of a dense blue clay and "a quicksand fine enough to polish glass" (fide, Mr. Nelson Taylor, Elkins, W.Va.). Samples of this "quicksand" show that it is actually a very fine silt. The blue clay - silt alluvium below the surface at and west of Elkins is totally unlike the alluvium upstream from the threshold which is sand and pebbles. The only place where the clay and silt alluvium was seen in place was in the excavation for an extension to the Methodist Church near the center of Elkins. Here an 8 foot pit had been dug. The piling was driven an additional 17 feet to bedrock (fide, Mr. Ray Vanscoy, Elkins, W.Va.). In this pit the upper 5 feet were visible, consisting of:

surface

0.5 feet debris, unrecognizable (brick, wood, asphalt fragments)

1.5 feet sandy alluvium with a few scattered pebbles

1.5 feet of brown clay - no pebbles, or sand, some silt

1.5 feet of fine brown silt with a 1" blue clay parting 11" from the top

concealed.

The section was about 8 feet wide and the silt-clay contact was level for this distance.

From the above information the following history of the development of Tygart River in the vicinity of Elkins is deduced:

1. Tygart River has never flowed through the threshold. Its course behind the 400 ft. hill (B, fig. 11 and plate 4) was inherited from a higher level. In the course of downcutting the large meander at Elkins became ingrown to its present position. This is indicated by the alluvium which covers the spillway ridge. The origin of these meanders

will be further discussed in the next section. No mechanism can be conceived by this investigator to put the river around the bedrock hill, if, as may appear at first glance, it had ever flowed through the threshold. Alluviation alone could have caused the river to abandon a course through the threshold and to follow a valley behind the hill that had perhaps been made by Mathias Run (southwest of the hill). The evidence presented however shows that no alluviation has occurred any place upstream from Elkins. The river is on bedrock at Beverly. Without alluviation it is extremely implausible that the river could have abandoned an original shorter course through the threshold in favor of its present one. The narrowness of the valley behind the hill as compared with the valley upstream may be accounted for by the fact that the river is flowing in the Chemung around the hill, while flowing on the less resistant Portage and perhaps Genesee upstream from here.

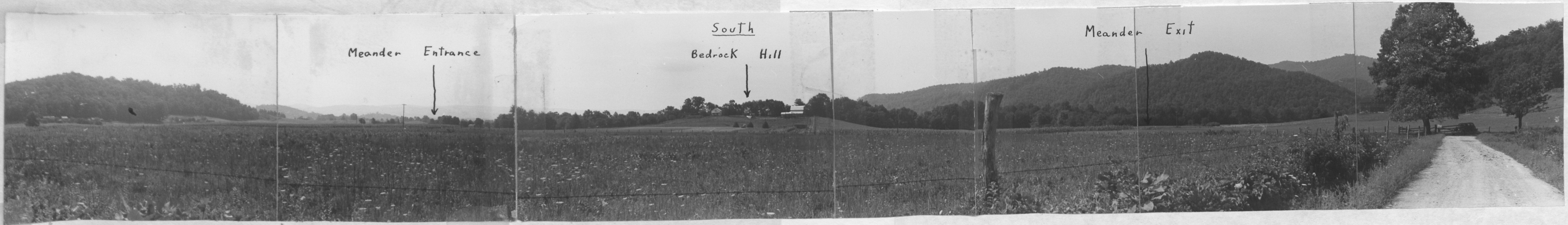
2. The threshold is due to meandering of the river. This is a likely place because the weak Portage and possibly Genesee underlie it. The first meander entered from the north at the level of bedrock in the ridge at (3) - plate 5 (about 2.5 feet under the present surface). How far it extended south into the threshold is unknown, but no cut-off of the meander around the bedrock hill occurred. At a later date, after this meander through the threshold was gone, a meander entered from the south. This was fairly recent as the level of the southern floor of the threshold is only about 20 feet above present floodplain. This meander en-

croached north as far as the inside of ridge (3), which is made of bedrock (plate 7). Plate 5 shows this ridge stereoscopically and on the photos the south side of the ridge shows a curved pattern opening to the south. This meander failed to encroach far enough north to effect a cut-off before it itself was cut off leaving the isolated bedrock hill south of the threshold (7 of plate 5). A panoramic view south from the center of the threshold (plate 6) clearly shows the path of this meander and the isolated bedrock hill. This hill in the south central part of the threshold is in a very unlikely position to have survived if the river flowed through the threshold. These conclusions are borne out by the elevations and depths of alluvium around the threshold.

3. The alluvial material more than 2 feet under the surface at Elkins is so markedly different from that upstream that it appears probable that it is of different origin. The clay and interbedded extremely fine silt look like lake deposits, but not enough was exposed to be certain. This material is too widespread under Elkins to be due to a buried ox-bow lake. It is however not unlikely that a small lake existed in the Elkins region in the not too distant past. That such a lake could have formed because of damming in the narrows is shown by the formation of a lake about 25 feet deep due to a rockfall caused by blasting in the quarrying of material for road metal just east of the Elkins Limestone Company plant in the narrows (Mr. Shephard, President, Elkins Limestone Company, personal communication).

Plate 6

Panorama looking south from " threshold " showing old meander course and small bedrock hill.



Meander Entrance
South
Bedrock Hill
Meander Exit

Plate 7

View from " threshold " looking north at meander scar inside ridge 3 of plate 5. Howell farm ( 1 of plate 5 ) is at extreme left.

This lake lasted for several days until the dam was removed by blasting. Examination of air photos (plate 2) shows what appears to be an old rock fall or perhaps landslide scar on the south side of the narrows. Plate 8, a ground view of the area from the north side of the river, does not show the scar as well as the air view (plate 2). A series of steps about 50 feet high and 50 to 300 feet wide are present here. By calculating the volume removed from a smooth slope to give the present stepped slope, an estimate of the amount of material that may have fallen into Tygart River here may be obtained. This material, if introduced into the present Tygart River at the foot of the slope would make a dam about 45 feet high. This material would contain a large amount of Pottsville rocks, so it is unlikely that the river could quickly remove it. A lake 45 feet deep at the narrows and extending upstream from this point would account for the possible lake beds around Elkins. No old shore levels or delta-like deposits are to be found, but the lake may not have persisted long enough to make shorelines that would have survived to the present.

Origin of the wide meanders at and south of Elkins:

Tygart River south of the threshold has a floodplain from 0.75 to 1.5 miles wide. Its meander belt measured from the aerial photographs is about 0.5 miles wide. The meander of the Tygart behind the bedrock hill (plate 4, B) and the wide eastward swing through Elkins require explanation, if, as

Plate 8

Looking south from the north bank of Tygart River in the narrows west of Elkins. The step-like southern slope of the narrows is shown.

postulated above, the course of the river behind the hill is the original course.

Chenoweth Flats (fig. 11, A) are believed due to a recently abandoned meander of the Tygart. This meander is shown in overlay (plate 9). The entire flat is not due directly to this meander. The eastern part of the flat was probably made by Chenoweth and Isner Creeks (fig. 11) when they were graded to this meander. There are several bedrock levels locally thinly veneered with alluvium in the eastern part of Chenoweth Flat apparently made when these creeks were graded to Tygart River at a higher level. Several streams to the south, notably Files Creek at Beverly (fig. 11) show the floodplains developed by tributaries graded to the present Tygart. These creeks south of Chenoweth Flats are the same size as Chenoweth and Isner Creek and are flowing on the same type of rock. It is therefore believed that Chenoweth and Isner Creeks themselves could not be responsible for Chenoweth Flats. The curvilinear scarp south and east of the airport looks very much like a meander scarp. The single isolated alluvium covered bedrock hill (plate 9, A overlay) is best explained by meander cut-off. Chenoweth Creek today flows on bedrock.

The height of the top of the bedrock hill southwest of Elkins (B, plate 4) indicates that the river had a meandering pattern here when it was about 400 feet above its present level. Whether the meander in Chenoweth Flats existed at this time, or whether it came into existence at a later stage

Plate 9

Chenoweth Flats south of Elkins.

Overlay shows outside of old course of Tygart River. "A" is an isolated, alluvium-covered bedrock hill.

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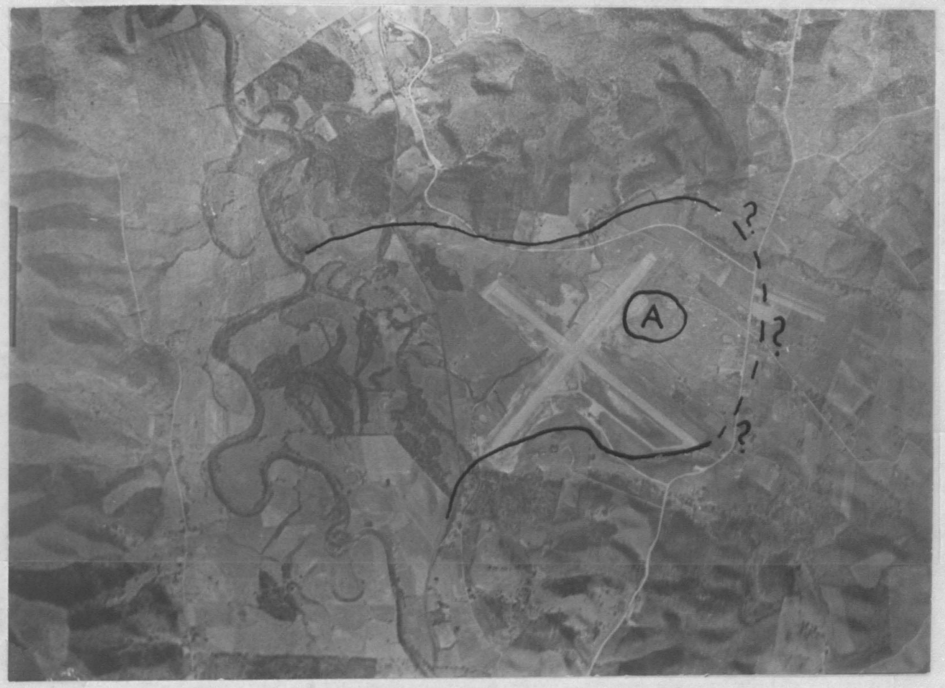
Soil Conservation Service
photograph DDF-36-78


A

is indeterminable. The valley further upstream (south) shows that the stream there has always been within the present floodplain.

The following reason is advanced for the presence of large meanders immediately south of Elkins and the lack of them further upstream. For reasons discussed later it is believed that the present ridge crests represent a former peneplain at close to their present height. The height of Rich Mountain just west of Tygart River here is about 3250 feet. Projecting this height (the ridge heights rise to the southwest but this may be neglected here) across Tygart River and projecting the Portage - Chemung contact (west of the river) eastward at a 17° dip it is seen that at an elevation of 3250 the Chemung was present over the axis but the Portage was quite close to the surface. This is obtained from the following calculation:

| | |
|---|---|
| Distance of Chemung - Portage contact west of axis (river) | = .75 miles (av.) |
| Height of Chemung Portage contact west of axis (where determinable) | = 2000 ft. A.T. |
| Height of Chemung - Portage contact projected east to axis<br>0.75 miles x 17° x 90'/mile/° | = 1125 ft. + 2000 ft. A.T. |
| | = 3125 ft. A.T. |

This figure is about 900 feet below that obtained by using the height of the base of the Pottsville as 8000 ft.A.T. at axis (see page 34) and subtracting 4000 feet (thickness of beds from base of Chemung to base of Pottsville) to obtain a height of 4000 feet A.T. for the height of the base of

Chemung at the axis. The figure of 3125 feet is however believed to be the correct one because the 8000 feet height to the base of the Pottsville is an average one and takes into consideration the "domes" in the axis of the anticline. The figure of 3125 feet A.T. for the height of the Chemung - Portage contact just south of Elkins is determined from dip and distance values measured there.

After the development of the peneplain across the ridge tops, uplift would cause the rivers to cut down. Tygart River upstream from the narrows would cut down quite slowly because the Pottsville at the narrows acted as a temporary base level. The river above the narrows was working in homogeneous Chemung rocks and would develop meanders along its course close to this point of base level which might grow to considerable size. As the stream regraded it would of course be downcutting as it slowly worked through the Pottsville, at the narrows. A small amount of downcutting would expose the Portage which is distinctly weaker than the Chemung. South of Elkins there are several cases in which streams opening floodplains on the Portage have none on the Chemung. As shown clearly by the present floodplain of the Tygart, this river closely follows the weak Portage beds, never (except just southwest of Elkins) leaving them to enter the Chemung. It is suggested by this that, once the weak Portage beds were exposed several miles south of Elkins, meander sweep dominated over meander swing and no meanders were developed which extended outside the Portage belt. This explanation accounts for the position of the river behind the <u>Chemung</u> hill (plate 5, B) and the presence of only smaller meanders within the Portage beds upstream.

The large meander through Elkins is ingrown as pointed out previously, but never leaves the Portage beds.

Cheat River system:

All of the area east of the Tygart drainage system within the Allegheny Mountain section here is drained by Cheat River and its tributaries (see fig. 6). Cheat River leaves the Allegheny Mountain section through a gap between Laurel Ridge (on the south) and Briar Mountain in Preston County. This gap is northwest of Rawlesburg, Preston County (fig. 4). Cheat River proper starts at Parsons, Tucker County (fig. 2) where it is formed by the confluence of Shavers Fork and Dry Fork. The river from Parsons to Point Marion, Pa. flows a distance of 75 miles, falling at an average rate of 11.2 feet/mile (Reger, et al. 1923). Of this stream, Reger,et al. (1923, pp. 25 - 26) state:

> "Its course through Tucker County and through Preston as far as Rawlesburg is relatively placid but from Rawlesburg northward it is a turbulent stream with a high rate of fall per mile, its channel being littered with large boulders from the sandstone cliffs that line a considerable portion of its steep and narrow valley. In Tucker there are wide meanders formed during the time of the supposed Cretaceous peneplain, its valley at present being U-shaped for the most part, indicating a considerable advance toward another cycle of peneplanation."

In its course from Parsons the river (see fig. 2 and 12) flows north across NE trending folds, viz., the eastern branch of the Deer Park anticline, thence across the Hannahsville syncline, then across the western branch of the Deer Park anticline, then out through the gap west of Rawlesburg.

The following data is from Reger et al (loc. cit.):

| Cheat River | fall '/mile of river distance | Total Distance / Airline Distance |
|---|---|---|
| Parsons to St. George, Tucker County | 9.31 | 2.37 |
| St. George to Preston-Tucker County line | 6.96 | 1.55 |
| Preston-Tucker County line to Rawlesburg | 7.4 | 2.2 |

Thus the ratio of total distance to airline distance is considerably smaller where the river crosses the Hannahsville syncline. The part of the river upstream from here (approximately from St. George to Parsons) shows wide meanders and at least one cut-off at Anvil (fig. 2 and 12). The gradient of the river is less steep on the soft Chemung rocks of the anticline to the south than it is on the Catskill rocks of the Hannahsville syncline where the river has only recently succeeded in cutting through the hard Pocono sandstones. The cut-off meanders and wider floodplain and valley south of the Hannahsville syncline attest to the fact that the Pocono in the syncline formerly acted as a local base level, because the river north of the syncline shows a much smaller floodplain and narrower valley. The effect of this local base level on the terraces and waterfalls upstream will be


Fig. 12 Cheat River north of Parsons Scale: 1"=1 mile
(reproduced from U.S.G.S. Parsons,W.Va. quadrangle)

fully discussed later.

Shavers Fork of Cheat River followed upstream from Parsons flows along the eastern side of the Deer Park anticline. It is flowing in Chemung beds close to the Chemung - Catskill contact. While the Chemung in general is weaker than the Catskill there is a red shale zone close to the top of the Catskill which is considerably weaker than the Chemung. This zone is less than 100 feet thick in the Catskill here, while the rocks which are mapped (on the West Virginia County geological maps of this region) as upper Chemung contain several hundred feet of an olive-drab colored shale. The stream here is following the weak beds of the upper Chemung. (In the Blackwater anticline the upper Catskill contains several hundred feet of soft red shales which control stream position there.) Along the postulated E-W tear fault the river makes a sharp turn east to enter the North Potomac - Cabin Creek syncline. About 5 miles east the course turns abruptly south in the syncline. The river here is in a steep canyon until just south of Bemis. Here a waterfall is preserved by a resistant caprock. South of this point the river is in a broad shallow valley. The canyon has clearly been made by retreat of a caprock-protected waterfall.

Dry Fork of Cheat River: (See fig. 2 and 6)

Dry Fork has one major and several minor tributaries. The stream drains the folds to the southeast and east of

Parsons.

Dry Fork itself originates in the southern part of the Job syncline and flows north. South of its junction with Gandy Creek it is an intermittent stream. It flowed for one day after a heavy rain (July 1952) and then ceased. This is due to the fact that it is flowing on the Greenbrier limestone. The stream bed is a mass of cobbles and pebbles and no sink holes were seen. There is little doubt however that the stream is usually dry because the water goes underground into the limestone.

Downstream from (north of) the point where Gandy Creek enters Dry Fork, the latter is a permanent stream with a floodplain. It flows northward to the point where the northeastward swerve in the axis of the Blackwater anticline causes this fold to cut across the Job syncline, bringing Devonian rocks to the surface in a structural dome (see fig. 4). Here it turns and flows northwest. As it flows across this dome it receives Laurel Fork and Glady Fork from the south. These two streams drain the Blackwater anticline on the east and west side respectively. Their position is controlled by the weak red shale belt near the top of the Catskill series.

After Dry Fork crosses the dome it continues northwest across the North Potomac - Cabin Creek syncline to Parsons. Just east of the western ridge (McGowan Mountain - Backbone Mountain) of this syncline it is joined from the northeast by Blackwater River at Hendricks, Tucker County (see fig. 2).

Blackwater River drains Canaan Valley (northern extension of the Blackwater anticline) and the Davis plateau. In Canaan Valley the stream is a small meandering creek in a well developed floodplain. It enters the Davis plateau east of Davis and is still graded although it has almost no floodplain in the resistant Pottsville. About 2 miles southwest of Davis, it flows over Blackwater Falls (plate 10) and enters Blackwater Canyon (plate 11). This latter is a steeply cut gash in the plateau. Pendleton Run draining the northern part of the Plateau between Davis and Thomas is a graded stream which spills over the side of the canyon in a very steep descent. Beaver Creek which enters Blackwater River at Davis upstream from the falls, is still graded to the latter. Without doubt Blackwater Canyon was made by the retreat of Blackwater Falls. This falls is of the caprock type, the Pottsville overlying the weak Mauch Chunk being the resistant rock. The canyon walls flare progressively wider downstream because mass-wasting has had a progressively longer time to operate there.

It appears certain that a waterfall formerly existed in the course of Dry Fork for the following reasons:

1. Where Dry Fork flows through McGowan Mountain (southeast of Parsons) the Pottsville caprock is underlain by the Mauch Chunk shales. (This is the western limb of the North Potomac - Georges Creek syncline.) A caprock fall would certainly be developed here after uplift of the pre-Schooley peneplain. So long as the resistant rock

Plate 10

Blackwater Falls

The caprock action of the bed of conglomerate within the Pottsville rocks is apparent.

Plate 11

Blackwater Canyon and Davis plateau (looking northeast)

The caprock Pottsville is clearly visible at the top of the canyon sides. In the right distance is Davis; in the center distance, Thomas. Pendleton Creek may be seen flowing south between these towns.

photograph by John L. Rich

underlain by weak beds was present, the fall would retreat at the level of the caprock. At Hendricks the fall would continue to retreat up both Dry Fork and Blackwater River. As previously discussed the fall is still present in the course of Blackwater River nine miles upstream from Hendricks. There is no waterfall along the course of Dry Fork today.

2. The valley of Dry Fork where this stream crosses the North Potomac - Georges Creek syncline is a deep, steep-sided canyon which is best explained by waterfall retreat.

3. Dry Fork at Parsons is about 300 feet below Tygart River at Elkins. However, the Devonian rocks of the Blackwater anticline stand 1700 feet above those of the Deer Park anticline. The rocks in the center of the Blackwater anticline (Middle Mountain) are about 1000 feet higher than Glady and Laurel Forks on either side. These two facts indicate that the streams draining the Blackwater anticline have cut down to their present position relatively recently, having been at a higher level during the time Tygart River was lowering the rocks of the Deer Park anticline. This is most satisfactorily explained by a caprock waterfall along Dry Fork upstream from Parsons.

4. Glady and Dry Forks give further evidence of the disappearance of a fall along Dry Fork. Both of these tributary streams show ingrown meanders (plate 12 a, b). This type of meander developed on weak (Devonian) rocks is best explained by Dry Fork's slowly cutting down through the Pottsville rocks after the fall had retreated so far east into

Plate 12 a

(Plate 12 b on following page)

Stereo vertical photographs of Glady Fork meanders.

reproduced from U. S.
Soil Conservation Service
photographs DDF-11-82
DDF-11-83

Plate 12 b

Oblique aerial photograph of meanders of Glady Fork just north of Alpena. ( looking north )

the syncline that the Pottsville rocks were no longer dipping upstream (due to the dome present along Blackwater anticline where it is crossed by Dry Fork) or the weak Mauch Chunk beds were no longer exposed in the fall. In either case the caprock effect of the Pottsville would cease and the stream apparently slowly cut down.

Thus Blackwater River and Dry Fork give strong evidence for the belief that unless a caprock is present a waterfall will not retreat parallel to itself upstream. This is a direct contradiction of the views of Penck (1924) and Meyerhoff and Hubbard (1928).

The drainage of this area will be referred to again with certain amplifications of details under "Geomorphic Development".

Big Run and Red Creek, the small northern tributaries of Dry Fork, are cutting into Canaan Valley (fig. 2) from the south and appear destined to capture the headwaters of Blackwater River for three reasons:

1. The course of Blackwater from its junction with Dry Fork at Hendricks to its headwaters in the southern part of the Canaan Valley is much longer than the course along Red Creek and Big Run and Dry Fork to Hendricks between these same points.

2. Blackwater River is much higher in the southern Canaan Valley than the two small tributaries of Dry Fork because Blackwater River is still base leveled to Blackwater Falls whereas Dry Fork has no waterfall.

3. A tributary of Dry Fork working headward in Canaan Valley encounters no extremely resistant rock, while Blackwater River still has about three miles of Pottsville sandstone to conquer, without benefit of the undermining action associated with a waterfall.

## Geomorphology

Stream terraces:

Remnants of stream terraces occur along the valley sides of Tygart River, and Dry Fork and Shavers Fork of Cheat River. Reger (1931) listed some of these terraces (fig. 13) and assigned them to five terrace levels based on their height above the present stream (fig. 13). He stated (p.42):

> "The close harmony of terraces on all the major tributaries of the Ohio in the State leads to the belief that a common cause was responsible for them all. Those of the Ohio have been attributed by Dr. White (White, 1878) to varying levels of the ice gorge near Beaver, Pennsylvania, resulting in unequal rates of erosion farther upstream. All later evidence would appear to show that the influence of this great ice dam, ....was felt many hundreds of miles from its actual site, although still water, from this cause, could not have existed at elevations clearly above any probable height of the dam. There must have been, however, successive stages when erosion along the lower waters almost entirely ceased, followed by other stages when a break or partial destruction of the dam caused wild currents which rapidly reduced the profile of the Ohio bottoms and its tributaries until practical equilibrium and a normal rate of erosion was restored for an interval in which the dam stood practically intact, only to be followed by other breaks and other cycles of erosion. If such a theory be accepted it would follow that the terraces of the Monongahela and Great Kanawha, and hence those of the tributaries in Randolph County are of Pleistocene age."

These various terraces in Randolph County are not built of alluvium but are cut on bedrock and veneered with alluvial material of varying thickness. Reger did not imply alluviation but rather grading and downcutting followed by regrading, several times to a progressively lower regional base level.

Terrace remnants along Tygart River (modified from Reger 1931)

Elevation by Aneroid

| Location | Height feet A. T. | Distance from Aggregates along Tygart River (miles) |
|---|---|---|
| State Rd. 1.5 miles NW of Elkins | 1970 | 4.0 |
| 0.6 miles SE of Buxton | 2000 | 4.4 |
| East of threshold | 1954 | 9.0 |
| West of threshold | 1990 | 9.8 |
| SE of Sullivan | 1995 | 12.5 |
| East end of Chenoweth flat | 2000 | 13.5 |
| 0.5 miles S of Beverly | 2000 | 19.4 |
| 2 miles SE of Beverly(Files Creek) | 2065 | 20.0 |
| 0.5 miles NE of Dailey | 1972 | 22.4 |
| 0.5 miles NW of Dailey | 2000 | 22.4 |
| 0.7 miles SW of Dailey | 2010 | 24.0 |
| 0.8 miles S of Valley Bend | 2135 | 26.3 |
| 0.8 miles S of Huttonsville | 2155 | 34.8 |
| 2.4 miles S of Huttonsville | 2165 | 35.4 |
| 2 miles NE of Elkwater | 2135 | 39.5 |
| 1.3 miles NE of Elkwater | 2115 | 40.2 |
| 0.4 miles SE of Elkwater | 2195 | 41.9 |

Floodplain

| | |
|---|---|
| Elkins | 1920 |
| Sullivan | 1925 |
| Dailey 0.5 miles N | 1952 |
| Valley head | 2388 |

Figure 13.

Close study of Reger's arguments casts doubt on the existence of five real terrace levels along the streams in Randolph County and the control of these various terraces by a common base level. The evidence indicates rather that the terrace levels along the various streams are independent from stream to stream, that five positions of a common base level did not exist and that the terraces are due to hard-rock-controlled temporary base levels on the individual streams. The terraces listed by Reger and those found by the present writer are shown on fig. 2. The terrace remnants are plotted on fig. 14 as topographic height (above sea level) versus actual distance along the present stream.

Discussion:

1. The grouping of the terraces into five different and distinct levels is based on very weak evidence. For example, the second level is supposedly represented by remnants from 75 to 90 feet above the present streams. Along Tygart River (fig. 13), twelve remnants are listed by Reger (1931) as belonging to this second level. Of these, only four fall within the range from 75 to 90 feet.

Only two remnants along Tygart River are assigned to the first level. It seems unlikely that the older level should be so much better represented than the younger, since the older one would be exposed to mass-wasting and erosion for a greater length of time. The remnants from

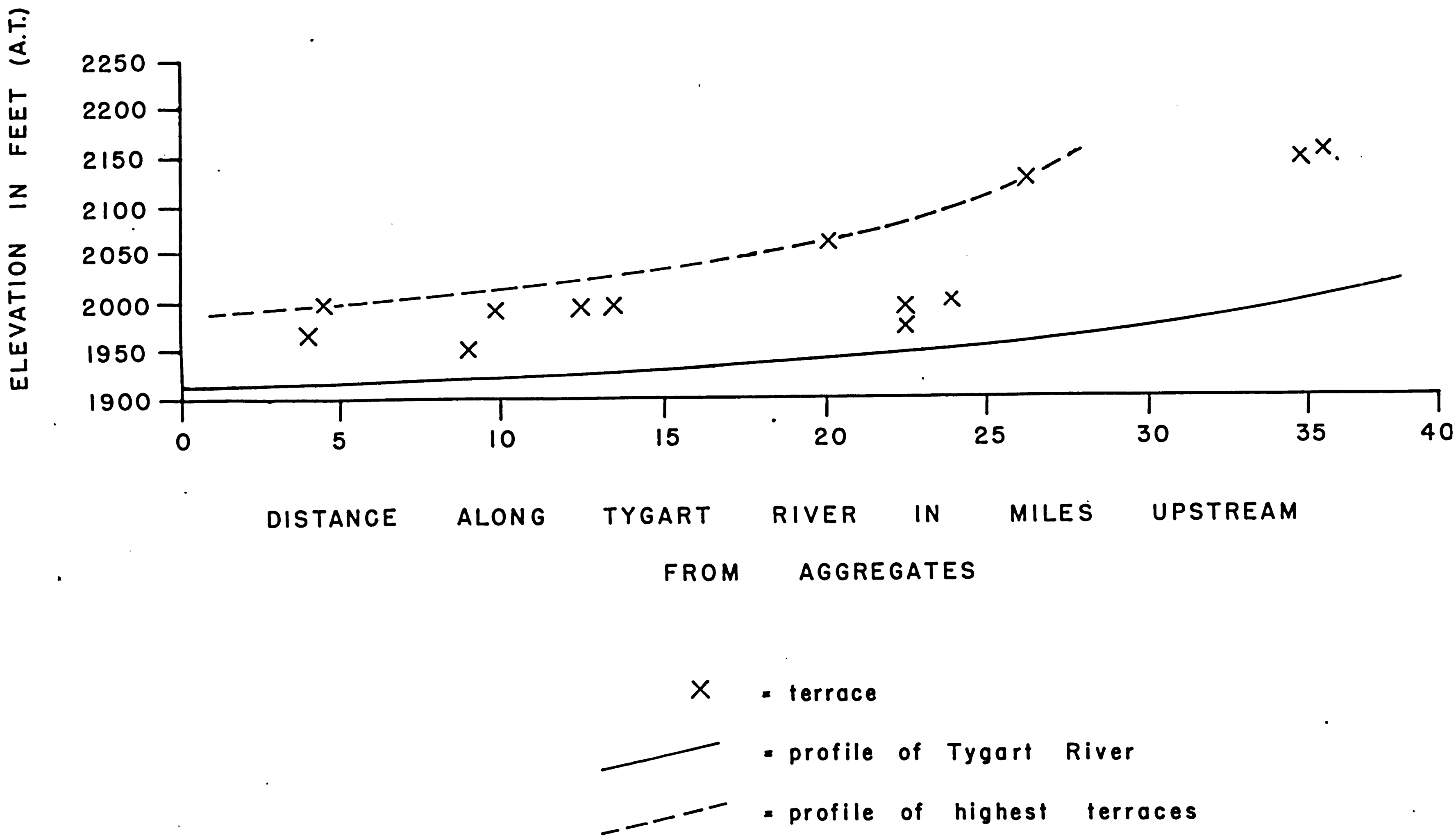



Fig. 14 Graph of Tygart River Terraces

Poundsmill Run to Elkwater along Tygart River (see fig. 13) belonging to the second level decrease in height 35 feet upstream.

A glance at fig. 14 shows the extremely subjective nature of any attempt to place these terraces into five distinct levels. Any evidence from them is extremely fragmentary and indistinct.

2. Since Tygart River helps form the Monongahela river near Fairmount, W.Va. and Cheat River enters the Monongahela river near Point Marion, Penna., any base level of the Monongahela downstream from Point Marion could theoretically affect both of these streams in Randolph County. The common base leveling of these streams in Randolph County by an ice dam ponding the Monongahela at Beaver, Pennsylvania is highly doubtful for the following reasons.

The elevation of glacial Lake Monongahela formed by this damming was 1100 ft. A.T. (H.M. Fridley, personal communication). This is almost 1000 feet below the present Tygart Valley. Despite this great difference in elevation the change in base level at the dam is supposed to have caused terrace levels along the streams in Randolph County, whose vertical distances apart are about 25 feet. This seems highly unlikely; especially so because of the long ungraded stretches of the present Tygart and Cheat Rivers. In this connection it is of paramount importance to recognize that these terraces occur along both of these streams only upstream from resistant rocks in the stream courses.

The terraces <u>cannot</u> be found along Tygart River in Barbour County downstream from the point where this stream leaves the Deer Park anticline across the resistant Pottsville conglomerate. If these terraces are due to the effect of a base level far downstream why are they absent except behind local base levels? It is unreasonable that no remants at all can be found today in the resistant Carboniferous rocks of Barbour County where the stream is downcutting today in a steep-sided narrow valley. Reger's (op. cit.) fourth and fifth terraces are missing in the Tygart Valley. The first and fifth are missing from Elkwater River (in the extreme south of Randolph County). Yet, they are all represented along Shavers and Dry Forks of Cheat River.

There are two possible explanations for the absence of the fourth and fifth levels along Tygart River:

a) The two upper terraces were present but were removed later;

b) The two upper terraces were never present.

Neither of these two possible explanations withstands analysis if five area-wide terrace levels are assumed.

a) It is doubtful that the wide Tygart Valley would be swept clean of all bedrock remnants of two terrace levels while all the levels are present in the narrow valley of the graded Shavers Fork. In the wider valley of the Tygart there would seem to be a better chance that at least some small remnant should be spared, but a careful search of the valley sides failed to reveal any alluvium more than

150 feet above the present stream. A similar search up the tributaries of Tygart River likewise failed to reveal any higher terraces. The absence of these terraces along the tributary streams is even harder to understand if their absence is due to removal after formation. It is unlikely indeed that mass-wasting destroyed these two upper levels when they are ostensibly present in the nearby Shavers Fork.

The above arguments apply equally to the absence of the first and fifth levels along Elkwater River.

b) If it is assumed that the fourth and fifth terrace levels never were present in the Tygart Valley a new difficulty is introduced. If various levels of an ice dam at Beaver, Pennsylvania are responsible for the terraces it is almost inconceivable that the upper two levels should be formed along the smaller tributaries of Cheat River but not along the large Tygart River. It may be possible that some of the lower levels could be missing along one of the streams because in its downcutting between the terraces it encountered a resistant rock barrier in its course upstream from the ice dam and so was no longer graded to this dam, or simply that the effect of this base level never reached this far upstream. However, for the absence of the upper two levels along the large stream and their presence along minor streams no reasonable explanation can be offered. In other words, it seems a very remote possibility that the upper two levels affected the tributaries of Cheat River but not Tygart River, while the lower three levels affected both.

A similar argument applies to Elkwater River.

This difficulty could be circumvented by assuming the supposed three levels along Tygart River to be the third, fourth and fifth, and that one and two are missing. This, however, would destroy the interstream terrace correlations based on height above present rivers.

It is significant, as discussed above, that <u>all</u> five terrace levels are ostensibly found along Shavers and Dry Forks of Cheat River, which two streams have a common base level at Parsons, whereas all five levels are not present along Tygart and Elkwater Rivers, which are not related to the Cheat River drainage system.

3. The terrace levels on Shavers Fork are best developed on the slip-off slopes of the meanders. They appear therefore to be ordinary rock-defended terraces of a graded, slowly downcutting stream rather than true floodplain terraces related to various base levels.

Conclusions:

In summation, the weakness and subjectivity of the evidence in support of five area-wide terrace levels, the several theoretical arguments against this occurrence, and the presence of terraces along these streams only upstream from temporary base levels, all indicate that the terraces are not interrelated, with a common base level, but rather that they formed independently and are related to temporary base levels on each of the several streams. This hypothesis is supported not only by the above negative evidence but by the following positive evidence.

An examination of fig. 14 leads to some important conclusions.

1. No distinct terrace levels are present. This indicates that these terraces were not made during distinct standstills of the streams followed by downcutting and a new standstill at a lower level, but rather that the terraces were made continuously by a stream cutting down very slowly at grade. That is to say, they are normal bedrock terraces, such as are expected to be made by a slowly downcutting graded stream.

2. Especially noticeable along Tygart River is the increasing number of these terrace remnants downstream toward the narrows. If the resistant Pottsville in the narrows acted as the temporary base level for this stream during the making of these terraces it is entirely expectable, indeed it follows, that a greater number of these remnants would be found close to this base level.

3. By far the most powerful evidence for the control of these terraces by local base levels is the converging of the terrace heights downstream toward hard rock barriers across the stream courses. Although no distinct terrace levels can be drawn, because there were no distinct standstills of the streams, a smooth curve can be drawn to connect the highest terrace remnants. The longitudinal profile

of the present stream is also drawn. The convergence of these lines, bounding the terrace heights, toward a particular point downstream is strong evidence that a base level existed at that point. In the present case, the lines converge to a point downstream from the Pottsville barriers, but this is expectable because the streams were slowly cutting down through this local base level while the terraces were being made. In other words, the terrace formation was controlled by a slowly lowering local base level.

Peneplains:

1) Upland Peneplain (equivalent in name to Upland Peneplain of Wright, 1925 and Schooley Peneplain of Reger, 1932).

The tops of the Pottsville uplands in this area are usually considered to be remnants of the Schooley Peneplain. The strongest evidence for the former existence of a peneplain besides the general level of ridge crests is the presence of imminent captures (referred to previously) and the position of Blackwater Falls. Blackwater Falls has retreated about nine miles from the junction of Blackwater River and Dry Fork at Hendricks, Tucker County, to its present position. No indication of the speed of retreat is available but the relatively short distance of retreat indicates that the area must have been base leveled at least once since original folding and uplift. In other words, if the present drainage system had been established early in the history of the region as concluded above, it appears highly unlikely that this falls has been retreating ever since the drainage pattern was first formed, but rather that it has been retreating only since uplift of the Upland Peneplain. The presence of imminent captures likewise indicates that the drainage is not perfectly adjusted, as it certainly would have been by this time if the region had never been base leveled. A detailed discussion is given by Reger (1932), who stated (p. 34):

> "At present, and as modified by subsequent uplifts and erosion, the Schooley Peneplain is now evidenced by the long ridges of Allegheny Mountain with a general height of 4000 feet and upwards; by Rich Mountain west of Dry Fork and Little Mountain with a similar height; by Middle Mountain at 3500 to 3700 feet; by Shavers Mountain and Back Allegheny with general elevations of 3700 to 4500 feet, there being a gradual increase in height from north to south; by Laurel Ridge and Rich Mountain west of the Tygart River with heights of 3000 to 3500 feet; by Point Mountain and Ganley Mountains with heights of 3700 to 4000 feet; and still farther northwest by the gradually descending ridges west of Rich Mountain with summits of about 2500 feet along the Barbour, Upshur County lines."

Reger also lists several possible monadnocks rising above the general ridge levels:

> "On Allegheny Mountain it is possible that the westward promontory of the Roaring Plains four miles northeast of Harman, with an elevation of 4760 feet, belongs above the Schooley. On Little Middle Mountain, Pharis Knob, at 4674 feet is probably a monadnock; and on Rich Mountain, west of Dry Fork, Haines Knob at 4272 feet appears to be a remnant. On Middle Mountain monadnocks are not evident but on Shavers Mountain and Back Allegheny, which together form a connected ridge, the conspicuous high tops from north to south are Big Knob, 3825 feet; Spruce Knob, 3815 feet; certain unnamed knobs farther south at 4620, 4646 and 4790 feet; and Bald Knob in Pocahontas County, 4842 feet. On Cheat Mountain the outstanding tops from north to south are Bickle Knob, 4008 feet;

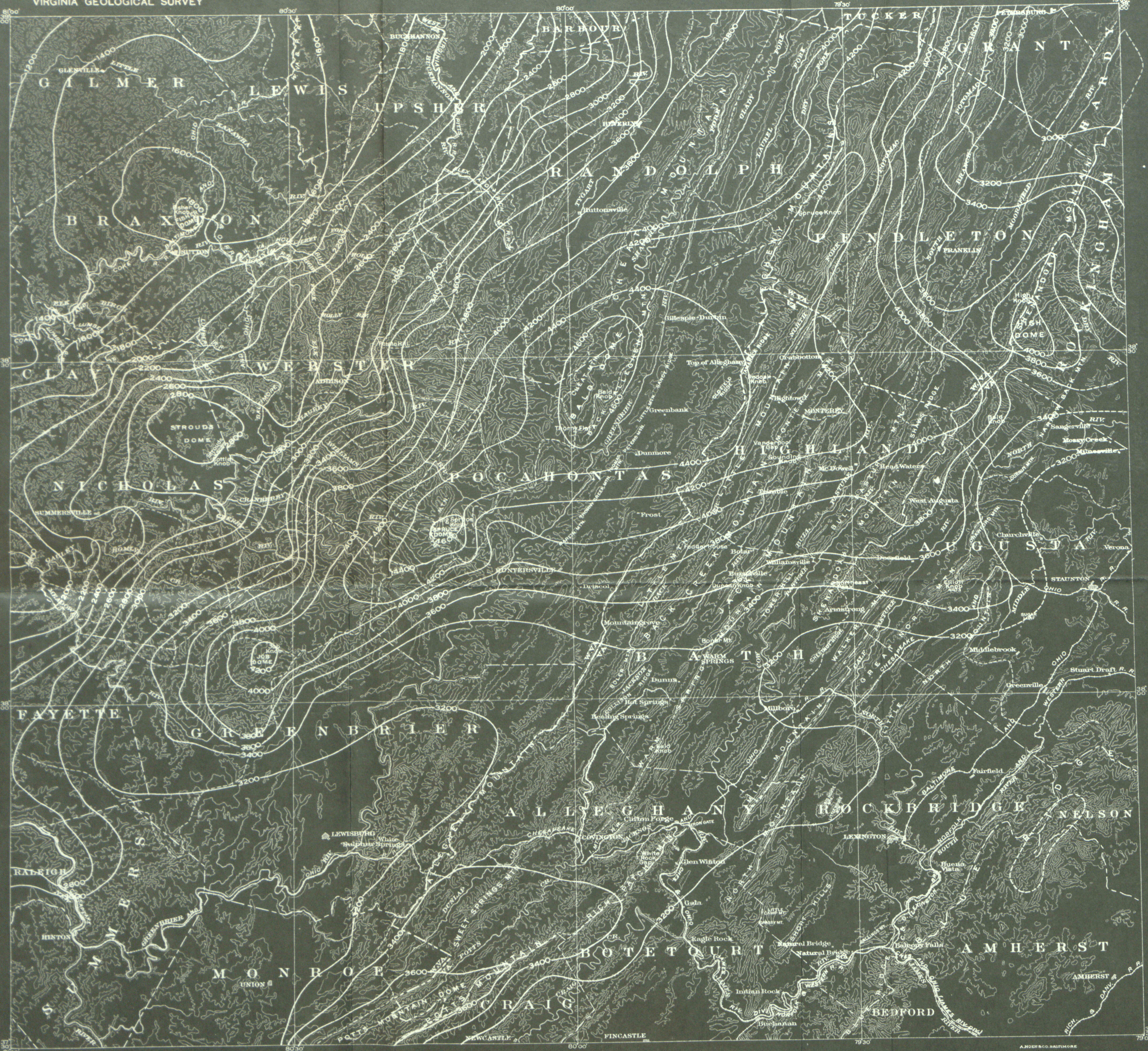
> Pond Lick Mountain, 4005 feet; Barton Knob, 4433 feet; Crouch Knob, 4562 feet; Snyder Knob, 4612 feet; and Mace Knob at the edge of Pocahontas, 4705 feet.
>
> West of Tygart Valley, there are no conspicuous tops on Laurel Ridge, but on Rich Mountain Lonetree Knob at 3563 feet may be a monadnock...."

Wright (1925) working primarily in the region just south of the area covered in this investigation studied the Upland Peneplain. By means of 26 projected profiles he contoured this surface. His map is reproduced in fig. 15. This contour map is based upon present topographic height of the ridges. Hence differential lowering of these ridges by erosion after uplift of the peneplain is not considered. The dangers inherent in the failure to recognize the effects of differential erosion on an uplifted peneplain whose remnants are supposedly preserved only on narrow ridges have been pointed out by Ashley (1935) and Rich (1938).

Wright's main effort was directed toward the upper James River basin. The geologic map (fig. 4) of eastern West Virginia shows that this area differs structurally from the area to the north of it, covered in this investigation. The pronounced folding in the present area dies out southward and is not as extensively represented in the area that Wright covered.

On the basis of his map (fig. 15) Wright postulated several domes and warps in the Upland Peneplain.

The major dome in the northern part of the map is Bald Dome on the Randolph - Pocahontas County line. Wright attributed this dome to warping of the Upland Peneplain rather




**Contour map of the restored Upland (Cretaceous) Peneplane showing its strongly warped character.**

*Note the presence of what appear to be local domes in addition to zones of greater upwarping.*
*Present surface contour interval, 500 feet; peneplane contour interval, 200 feet.*

(Base: U. S. Geological Survey Topographic Maps)

SCALE $\frac{1}{500,000}$

0 10 20 30 40 50 kilometers

0 5 10 15 20 25 miles

1924

Fig. 15 Map of Schooley Peneplain south of area investigated.

( reproduced from Wright, 1925 )

than to unreduced headwater regions or hard rock areas on this erosion surface. As evidence for this belief he cites the fact that the average drop of the Upland Peneplain as he has contoured it is 80 feet per mile for a distance of about 35 miles northwest of the dome. He feels that this gradient is too steep for the late-mature to old streams that made the Upland Peneplain and hence warping occurred during or after uplift. Thus he apparently ignores the effect of differential erosion since uplift. The presence of streams flowing across the domes (such as Williams River at Spruce Dome) indicates to Wright that these domes are not unreduced headwater regions or hard rock areas on the original surface.

Drainage on Upland Peneplain:

Of critical importance in a discussion of peneplains in the area investigated is the time of establishment of the present drainage pattern. In the area of the Folded Appalachians south of the Allegheny Ridges of Randolph County, Wright (loc. cit.) noted (p. 19):

> "The drainage lines in the Newer Appalachians province at the end of the Upland Peneplain cycle must have been in a considerable degree adjusted to the structure of the underlying rock. But the presence of numerous windgaps just below the level of the peneplain indicates that the adjustment was by no means complete, or that the southeastward flowing streams were born on the upwarped Upland Peneplain."

Further:

> "...In the Allegheny Ridges all traces of early radial drainage (due, he believes, to the domes) may be entirely lost through the extensive development of subsequent streams on the weak rock belts."

The present investigation of the Allegheny Ridges reveals a striking sparsity of windgaps below the crests of the Pottsville ridges. All of the low sags in these ridges (such as the one just north of Haines Knob on Rich Mountain, east of Alpena, where this ridge is crossed by route 33) are probably due to streams working back headward from either side of the ridge. The valleys have, characteristically, amphitheater shaped heads, and the low sags, which have a curved profile when viewed at right angles to the ridge, are made by the intersection of two amphitheaters from either side of the ridge. When two opposing streams are absent, the ridge profile shows no sag. None of the sags investigated contained alluvial material. The curved profile of the sags, their presence only where two amphitheater shaped stream heads are working toward each other, and the absence of any vestige of alluvial material indicate that they are in all probability not windgaps. None of the major sags or "gaps" in the ridges shows an alignment such as might be due to a stream flowing across the ridges. Furthermore, all the sags on Little Middle Mountain, for example, are at 3500 + feet, as are those on Rich Mountain (just west of Little Middle Mountain). The equal heights of the sags is explained by streams draining down opposing slopes to the same subsequent streams on both sides. It appears therefore that these sags are controlled by streams flowing parallel to the ridges and acting as base levels for the small streams working up the slopes. This is supported by the general increase in height of the sags on Rich Mountain (east of Laurel Fork) southward. This is the upstream direction along the streams on either side.

Two possible exceptions to the above description are Alpena Gap and Collett Gap in Shavers Mountain. Alpena Gap has been discussed previously in connection with faulting. A displacement of the ridge crest was noted at this point. Route 33 crosses Shavers Mountain at Alpena Gap, and a fair section in the gap is shown along the road. The gap is filled with colluvial material. The contact of this colluvium with the underlying bedrock is not sharp, but no alluvial material was found in the roadside between the topmost bedrock exposure and the lowest undoubted colluvium. In the roadside park at the gap, loose pebbles are present, too far from the road to be due to construction. These pebbles (plate 13) are all of the size of the typical Pottsville conglomerate pebbles and in several cases the common sand cement of the Pottsville conglomerate is still attached to them. These pebbles cannot therefore be considered alluvial. Alpena Gap is attributed to a zone of weakness due to faulting rather than to a former stream. The problem presented by Collett Gap will be discussed later (p.129 ).

It is possible that the gaps in Shavers Mountain south of Alpena (and Alpena Gap itself) may be windgaps although

Plate 13

Pebbles from Alpena Gap

Arenaceous Pottsville cement may be seen on the two pebbles at the right of the upper row.

they were never occupied by through-flowing east-west streams, They may be due to streams that originally flowed west off the Blackwater anticline and later were captured by Glady Fork working headward (south) along the weak beds in the Catskill series. The streams flowing westward off the anticline would have had a steep gradient following the dip of the Pottsville beds (which are now stripped off the fold). Because of the steep gradient no evidence of the streams would now be found in the relatively low anticline west of Shavers Mountain. In any event whether these gaps were made by headward working of two opposing tributaries or by streams flowing off the Blackwater anticline, they were decidedly not water gaps during the existence of the Upland Peneplain, indicating that in this region good adjustment to structure had been achieved before the end of the Upland cycle.

The general absence of abandoned water gaps of through-flowing east-west streams in the Allegheny Ridges and of windgaps formed after the Upland cycle argues strongly for the very complete adjustment to structure of the drainage on the Upland Peneplain in this region. Even allowing for the certain lowering of the Pottsville ridges since uplift of this peneplain, the absence of gaps is striking, especially so in the broad flat areas around Davis and at Roaring Plains, which are underlain by essentially horizontal Pottsville beds and have therefore probably been lowered relatively little, for it is in these little lowered areas that gaps and abandoned valleys could be expected to be preserved. It is therefore felt that the present, generally excellent adjustment to structure was attained during, or perhaps before, the Upland cycle in the Allegheny Ridges and was retained during uplift. Once the streams had found a way across the resistant ridges, in the case of Tygart River and Shavers Fork along probable zones of fracture, it seems highly unlikely that they would abandon them even in the old age stage of the cycle.

Analysis of present topographic heights:

The previous work on the Upland Peneplain has depended on topographic height of ridges.

It is immediately apparent from an examination of the topographic maps that the heights of the present Allegheny Ridges fall off to the northwest. In other words the ridges decrease in height downstream along the present drainage. The major "warp" in the Upland Peneplain discussed by Wright (see fig. 15) is the one running approximately east-west through Bald Dome and High Dome. He points out that this is the general divide west of the Allegheny Front between the northwest drainage to Monongahela River and the southeast drainage to James River. He stated (p. 20 - 21):

> "The doming appears to be a notable factor in controlling the drainage even in the Ridges, as is indicated by the fact that the axis of uplift extending eastward from Bald Dome to High Dome is the main divide between the northeast and southwest flowing streams in this region. One must consider the possibility that this uplifted zone may be explained, as in the case of the other domes, either as an

> unreduced headwater region on the peneplain or a product of subsequent warping. A divide established long ago, during the development of the Upland Peneplain, might be considered as persisting to the present. This assumption would require a delicate balance between north and south flowing streams continuing for an enormous lapse of time and in spite of subsequent undoubted tilting of the peneplain. This seems more improbable than the explanation based on later warping. The average slope toward the south is today about 30 feet per mile. This is altogether too steep for a peneplain surface in its original position, and its explanation must be sought in subsequent deformation."

This writer is not in complete agreement with Wright's conclusions. It appears that the present topography is controlled more by present drainage and especially by rock type and structure, than it is by warps and domes in the Upland Peneplain surface, as is brought out in the following discussion.

According to Fenneman (1938) the Allegheny Front makes a jog westward north of Monterey, Virginia. The Allegheny Ridges east of Elkins, (Allegheny Mountain section) are absent south of Bald Dome (fig. 15). The geologic map of West Virginia (fig. 4) shows that the Deer Park anticline and the Georges Creek (North Potomac) syncline disappear south of the Pocahontas - Randolph County line. The drainage east of the Allegheny Front (south of the ridges) is through the Greenbrier River to the south and James River to the east. West of the Front the drainage is northwestward north of the Bald Dome - High Dome divide and westward south of this divide. In other words, this divide coincides almost exactly with the dying out southward of the folds that make the Allegheny Ridges. Bald Dome itself is located on the southernmost tip of the Georges Creek (North Potomac) syncline. This is the farthest south in this immediate area that the resistant Pottsville formation crops out. The Pottsville is rising southward along this syncline from the north. Since the Pottsville is structurally highest at the end of the syncline and absent to the south, it stands to reason that the end of the syncline will be a topographic high without the necessity of doming the Upland Peneplain surface.

The divide between the north and south flowing streams appears to be controlled also by the dying out of the Allegheny Folds. The Pottsville rings these folds and interposes a barrier between north and south flowing streams. The north flowing streams (Tygart River and Shavers Fork) are restricted by these borders of Pottsville. The divides are shown on the map (fig. 15) as a dashed line. Notice that Bald Dome is a divide on the east, west and south sides and is drained to the north by Shavers Fork following the axis of the Georges Creek (North Potomac) syncline.

Further to the west and south the Pottsville is present in the Allegheny Plateau section where the drainage is westward with a dendritic pattern.

The presence of the divide along the line where the Pottsville is structurally highest (and where the major folds die out) negates Wright's argument that too delicate an adjustment between north and south flowing drainage for too great a length of time is required if this divide is due to preservation of headwater regions or resistant rock masses. However the general picture of the drainage in this whole area during the making of the Upland Peneplain may be visualized, the sparsity of windgaps in the Allegheny Ridges and the fact that many of the principal streams had acquired anticlinal courses, indicates that the present drainage pattern was established here in its basic outlines during or before the Upland Peneplain cycle.

All of this leads to the conclusion that the "domes" and "warps" are not deformational phenomena but are due to the structural position of the resistant Pottsville formation and the control it exercises on mass-wasting and drainage development. The northwestward decrease in height of the summits of the Allegheny Ridges in the area investigated is a natural consequence of the fact that the streams which made the Upland Peneplain, essentially the same as the present streams, flowed northwestward, and that west of the folded belt the Pottsville sandstone dips northwestward. The almost perfect adjustment to structure of these streams, together with the lack of evidence for major drainage changes since uplift (wind gaps) indicate that the Upland Peneplain of Wright was not a perfect one but that the Allegheny Ridges dominated it as they do the present topography, although, of course, not as strongly.

These conclusions are in general agreement with Fenneman (1938), who stated (p. 288 - 289):

"It is a fair assumption that the summits of the Allegheny Mountains represent an imperfect phase of the Schooley Peneplain. (Called Kittatinny by those who do not treat the Schooley and Kittatinny peneplains as identical.) As seen at a distance, say from one of the Allegheny ridges, the horizon strongly suggests a peneplain, but any attempt to fix its position requires that some of the higher masses be regarded as rising above it. It will be recalled that in the Ridge and Valley province altitudes are closely related to the breadth of outcrop of the mountain-making sandstones. Other things being equal, low-angle dips, as at the ends of pitching folds, are accompanied by higher altitudes. It is only to be expected, therefore, that the gentle folds of the Allegheny Mountains would be imperfectly reduced to the Schooley level. That the structure was an important factor in controlling the level of the surface, both during the Schooley cycle and later, is indicated by the manner in which altitudes rise and fall with changing hardness, thickness, and dip of a resistant formation....

It must be assumed that this agreement between altitude and structure reflects not only the imperfections of the Schooley peneplain but also unequal subsequent lowering of the surface.

With these elements of uncertainty in mind, the altitude of the Schooley surface, where it most strongly suggests a former base level, may be tentatively placed at 2300 to 2500 feet in northern Pennsylvania, a little higher in the middle, and at 2700 feet in western Maryland.

The surface on the Pottsville in middle Pennsylvania rises in ridges and swells as high as 2900 feet, or a probable 400 feet above the peneplain level in that locality. In western Maryland and adjacent states the monoclinal ridges, mentioned above, rise locally above 3100 feet, or 400 feet above the general level. Altitudes continue to increase to the south in West Virginia. Where the mountain ridges end, in latitude 38°30', many points on their crests are above 4000 feet and a few reach 4500 feet. Similar altitudes are found on the horizontal rocks of the adjacent plateau."

A regional study of the high level peneplains in the eastern United States is not within the scope of this investigation, but some conclusions may be drawn concerning the peneplain marked by the uplands of the Allegheny Ridges. Some indication of the relief of the Upland Peneplain of the area studied is also possible.

For reasons discussed previously it is felt that the area has been reduced to an old age stage at least once. The question arises as to why there are almost no windgaps in the Allegheny Ridges. Windgaps in the Appalachian Ridges indicating adjustments below the level of the ridge crests are numerous. It seems therefore inescapable that windgaps were formed in the Allegheny Ridges during adjustment of the streams to structure. Wright (op. cit.) pointed out that there are windgaps in the ridges of the Folded Appalachians just south of the Allegheny Ridges. If the Upland Peneplain of the Allegheny Ridges is the same as Wright's Upland Peneplain of the Appalachian Ridges, differentiated merely by warping, why are windgaps absent in the Allegheny and present in the Appalachian Ridges? This is especially vexing because lowering of the Allegheny Ridges since uplift of this Upland Peneplain has assuredly been slower than the lowering of the Appalachian Ridges, due to the gentler dip of the resistant beds making the former. The windgaps of the Allegheny Ridges could not therefore have been removed by general lowering of the ridge crests while those of the Appalachian Ridges survived, if but a single peneplain was present over both areas.

If the reasoning concerning the sparsity of windgaps is correct, then the following picture of peneplains in this area is consistent:

1. The Allegheny Ridges were reduced to old age in pre-Schooley time.

2. Uplift of this surface (Kittatinny?) followed this reduction. Differential erosion of the area has occured since this uplift, without formation of an old age surface in Schooley time. Thus, the Allegheny Ridges have been exposed to erosion longer since being reduced to an old age surface than the Appalachian Ridges, accounting for the absence of windgaps in the former and their presence in the latter.

If the windgaps of the Appalachian ridges are caused by adjustment to structure by streams after these streams had been superposed across the ridges from a cover of Cretaceous sediments, the sparsity of these gaps in the Allegheny ridges may be due to a lack of this superposition. The absence of a Cretaceous cover over the Allegheny ridges also indicates that they were not reduced to the general Schooley level.

3. The broad "warp" in the "Upland" surface shown in Wright's map (fig. 15) at about latitude $38^{\circ}15'$ coincides exactly with the southern limit of the Allegheny Ridges. If these ridges were not base leveled in Schooley time, then this "warp" is not due to unequal uplift of the Schooley peneplain but rather to the failure of the Allegheny Ridges

to be reduced to old age at this time.

In summary, the Upland Peneplain of the Allegheny Ridges is older than the Schooley peneplain of the Appalachian Ridges, rather than being an upwarped portion of the latter surface. The "warp" or divide on Wright's map (fig. 15) is more correctly a morvan and its separation of north and south flowing streams existed in Schooley time.

There is no indication of the age of the pre-Schooley surface. Some concept of its age could be had if the rate of retreat of Blackwater Falls was known. This falls has retreated about nine miles through the Davis plateau, and its retreat must have commenced with uplift of the pre-Schooley surface. There is unfortunately no method of determining the rate of retreat of these falls.

To obtain some idea of the relief, or degree of perfection, of the pre-Schooley (Upland) erosion surface it is necessary to subtract the effect of differential erosion of the ridges since uplift of this surface, from the present heights. To do this, three reasonable simplifying assumptions must be made:

1. The effect of tilting during and after the Pleistocene epoch is negligible over short distances (10 - 25 miles).

2. If warping during or after uplift is so broad and gentle that it left no evidence in the attitude of the rocks in the area that can be detected in the field, then its effect also may be neglected over short distances. As stated previously there is no evidence in the area of intense local

deformation following the original folding.

3. Climatic variation, and hence differences in rate of erosion due to it, is negligible over short distances within the area.

If these assumptions be granted then the major differences in present relief must be primarily due to attitude and thickness of the Pottsville series. The areas underlain by horizontal resistant beds will be lowered less than ridges underlain by dipping resistant beds. Therefore the horizontal rock areas will stand closest to the height to which the pre-Schooley surface was uplifted.

The Davis plateau is underlain by Pottsville rocks that are almost horizontal. The average height of the plateau is about 3200 feet A.T. Laurel Ridge about 19 miles west of the Davis Plateau is underlain by Pottsville beds dipping about 15° NW. This ridge has an average height here of about 2750 feet A.T. Roaring Plain, 14 miles southeast of the Davis plateau is underlain by high, essentially flat-lying Pottsville rocks. The average height here is 4300 feet A.T.

Roaring Plains and the Davis plateau which have been lowered relatively little since uplift have a difference of elevation of 1100 feet. Laurel Ridge which has been lowered relatively more than the nearby Davis plateau stands only 450 feet below the plateau. This 450 feet is therefore an indication of the amount of differential lowering in one part of the area since uplift of the pre-Schooley surface.

The much greater difference in elevation between the Davis plateau and Roaring Plains must be at least in part therefore inherited from the relief of the pre-Schooley surface. It does not seem likely that warping during isostatic uplift of the pre-Schooley surface could account for all this relief if the warping was too gentle to be detected in the field.

From this the conclusion may be drawn that differences in relief due to differential erosion were present on the pre-Schooley surface; that is, that rather than being a nearly perfect old age surface, it had a local relief of some hundreds of feet.

To summarize: the present Allegheny Ridges in West Virginia are differentially lowered remnants of an imperfect pre-Schooley erosion surface. The adjustment of the drainage to structure apparent today was established before uplift of this surface.

2) Peneplains below Upland Peneplain:

The only study of erosion surfaces below the ridge crests in the Allegheny Ridges is that of Reger (1931) in which he listed (p. 34 - 36) the following peneplains in order of decreasing age:

a) Weverton Peneplain: To this peneplain he assigned a general elevation of 400 to 500 feet below the ridge crests. He stated:

> "In the eastern portion it may be recognized in many windgaps and high spurs or shoulders of Allegheny Mountain, Little Middle Mountain, and Rich Mountain, at elevations of 3500 feet and upwards; and by spurs and gaps of Middle Mountain

at 3000 feet or less. On Shavers Mountain and Back Allegheny, it is witnessed by gaps and high spurs at 3200 to 3800 feet. On the western side of Cheat Mountain, Elliot Ridge at 3200 to 3300 feet, Middle Ridge at 3000 feet, Chestnut Ridge at about 3300 feet, and Swecker Ridge at 3300 to 3400 feet may all represent this old plain. West of Tygart Valley, there are many conspicuous foot-hills of Laurel Ridge and Rich Mountain, standing 400 to 500 feet below the general ridge level and apparently marking the Weverton."

b) Harrisburg Peneplain: To this peneplain Reger assigned a position of about 400 feet below the Weverton or 900 to 1000 feet below the ridge crests. He noted:

"On Allegheny Mountain and Rich Mountain west of Dry Fork, it is mainly noticeable in certain low spurs or shelves, including the belt of smooth farming land west of the latter range. East of Shavers Mountain it is again plainly visible in the long stretch of limestone lands from Mylius School to Alpena and Glady with elevations of 2600 to 2800 feet. West of Cheat Mountain there are dozens of low spurs at 2700 to 3000 feet which mark it, and in the Mingo Flats at about 3000 feet it is conspicuously preserved. West of Tygart Valley it is again evidenced by many low spurs and upland valleys in the foothills of Laurel Ridge and Rich Mountain. Still further west it may be observed in an upland valley northeast of Harding and in certain low plateau lands in the vicinity of Norton, Coalton, and Mabrie, all having a general elevation of about 2200 feet.

c) Somerville Peneplain: This peneplain Reger stated was best observed "in the lower foothills of Cheat Mountain and Rich Mountain." He assigned to it a "general elevation of only about 100 feet less than the Harrisburg."

The present investigation reveals that the erosion surfaces in the area have been formed by 1) temporary local base levels, and 2) differential lowering of homogeneous rock masses. No part of the area has been peneplained to a base level outside the Allegheny Ridges since uplift of the pre-Schooley surface and therefore no erosion surfaces in these ridges can be correlated with any surface outside the ridges. Since uplift of the pre-Schooley surface the area has been constantly differentially lowered under the control of the two factors discussed above.

The most important evidence against the concept of formation of erosion surfaces in the region by an external base level is the absolute absence of any terraces in the water gaps, other than those benches controlled by resistant rock. The establishment of peneplains below the ridge crests extending across the several folds of the Allegheny Ridges would certainly have left evidence of base leveling in the form of terraces in the water gaps.

In the narrows of Tygart River west of Elkins a single terrace or bench is visible (plate 2). This terrace is part of the ubiquitous Pocono - Greenbrier bench found throughout this area. It is not possible to determine the slope of this bench in order to compare it with the dip of the Pocono beds, because of the Pottsville talus accumulation on it. No alluvial material is present.

In the narrows of Shavers Fork where this stream crosses Cheat Mountain a well developed bench is present on the north and south sides of the valley in the vicinity of Bowden. This bench is also formed by the Pocono - Greenbrier series. Quarrying is now being carried on here. A picture of this terrace is given in plate 14. Above the bench red clay shales (Mauch Chunk) are present which have apparently been stripped back to form the bench. The Pocono sandstone in the quarries strikes about N 55° E and dips about 8° SE. At the edge of the bench nearest the river (to avoid the effect of talus as much as possible) hand leveling reveals a slope of about 10° SE. This is in very close agreement with the dip of the underlying bedrock, indicating strongly the rock control of the bench, especially in light of the fact that the bench slopes downward upstream. No alluvial material is found anywhere on the bench.

Along Cheat River north of Parsons several alluvial terraces are visible upstream from the place where the river crosses the axis of the Hannahsville syncline. These are recent stream terraces often having the form of typical meander scars (plate 15 a, b). Benches are present in the gorge where the river cuts through the Catskill beds at the axis of the syncline. Along Route 72 paralleling the stream through this gorge, excellent exposures are found in the roadcuts. Along this road, eleven and one tenth miles north of its junction with Route 219 at Parsons, a massive, grey, fine-grained, micaceous sandstone is exposed in the roadside. One half mile north of this exposure, a pronounced bench is present about 30 feet above the road. This bench is clearly upheld by the massive sandstone which is nearly horizontal at this point. This is the only pronounced bench in these narrows.

In the narrows of Dry Fork southeast of Hambleton, Tucker

Plate 14

Typical Pocono - Greenbrier bench on the south bank of Shavers Fork south of Bowden. The bench is seen just above the quarry.

Plate 15 a

( Plate 15 b on the following page )

Stereo photographs of terraces of Cheat River.

Photographs taken looking SSE from a point about 0.25 miles south of Bethel Church (2.5 miles north of Parsons). See fig. 8

Plate 15 b

Cheat River valley

Upper photograph: Aerial photograph of Cheat River looking north from just south of Parsons. Parsons visible in lower right corner

Lower photograph: Meander scar on terrace about 0.25 miles south of Bethel Church. ( 2.5 miles north of Parsons )

County, benches are present at and west of Elk. The benches west of Elk are supported on a massive, heavy bedded sandstone, while the rocks which are stripped back above the bench are composed of siltstones and shales (about half and half). The benches at Elk are supported on massive sandstone overlain by red shales which has been stripped back.

In the light of this evidence against control of erosion surfaces by an external base level, a re-examination of the peneplains delineated by Reger (loc. cit.) is called for. Several objections to this delineation arise immediately:

1. The Weverton level is supposedly preserved on gaps and spurs at 3200 to 3800 feet on Shavers and Back Allegheny Mountain and by elevations of about 3500 feet on Rich Mountain (east of Laurel Fork). These are all Pottsville supported ridges. However, <u>between</u> these two ridges, which flank the Blackwater anticline, the Weverton Peneplain is preserved on Middle Mountain (on Devonian beds) at 3000 feet. Thus, if present heights are used for delineating peneplains there is a local relief of 500 to 900 feet in the Blackwater anticline.

2. In an area such as this, where rocks of very varied erosional resistance crop out, many spurs or levels of low relief are bound to occur. As shown in 1, above, the peneplains as delineated by Reger have relief of several hundred feet. How is it then possible to separate the Upland, Weverton and Harrisburg peneplains by only 400 feet elevation. Even more uncertain is the Somerville peneplain, which is <u>only 100 feet</u> below the Harrisburg.

3. If the position of the Somerville peneplain is controlled by the same base level which controls the Somerville in its type area near Somerville, New Jersey, why is it present only in the Deer Park anticline and absent in the adjacent Blackwater anticline? This point will be returned to later.

The approach to this problem of erosion surfaces below the ridge crests which appears to be the most profitable is a two-fold one.

a) To make a detailed study of the erosional history of the Tygart Valley and the area north of Elkins in the Deer Park anticline, because this is the only place where all the "peneplains" are present and because the lithologic section exposed here is more varied and complete.

b) To make a general survey of the erosional history of the entire area attempting to apply any principles ascertained by the Tygart Valley study (and the investigation in general) to the determination of the geomorphic development of the area since uplift of the pre-Schooley peneplain.

The erosional history of the Tygart Valley and its northern continuation in the Deer Park anticline:

This valley is drained by Tygart River and its northern tributary, Leading Creek. As previously discussed, there are no terraces other than a rock-controlled one in the narrows of the Tygart west of Elkins. From this the conclusion may be drawn that since uplift of the pre-Schooley surface no base level (if any existed) of Tygart River downstream from the narrows has affected the erosional history of the Tygart Valley. Reger (loc. cit.) finds several "peneplain" levels in the valley. Reger places the Weverton at about 3300 feet A.T. west of Cheat Mountain and about 400 feet below the crest of Rich Mountain. The elevation of the crest of Rich Mountain varies from about 3600 feet at Lonetree to about 3000 feet just south of the narrows of Tygart River. Therefore the elevation of the Weverton peneplain on the west side of the Tygart Valley is 3200 to 2600 feet. Below the Weverton Reger delineates the Harrisburg peneplain at about 2700 to 3000 feet A.T. west of Cheat Mountain presumably at 2800 to 2200 feet east of Rich Mountain. The lowest peneplain, he finds, is the Somerville which is 100 feet below the Harrisburg peneplain.

In order to study these erosion levels, multiple projected profiles running east-west across the Elkins and Belington quadrangles were made. Several views of these profiles are shown in plate 16. Since the regional strike here is northeast, Cheat Mountain is present in the near (southern) profile but vanishes off to the east, north of the tenth profile. Several observations may be drawn from the profiles:

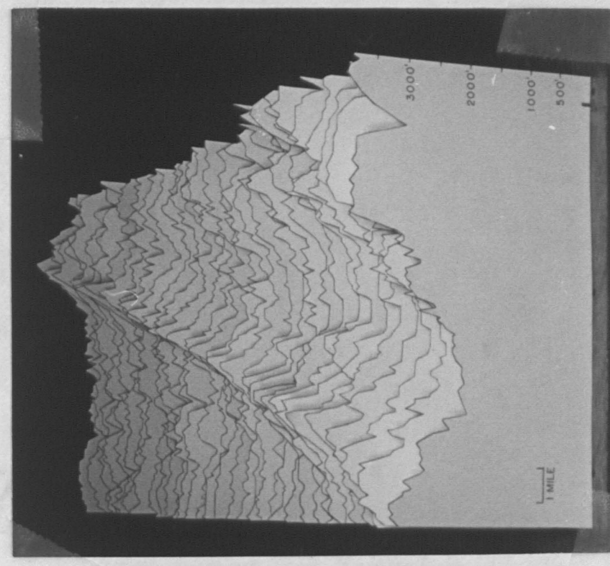
1. Cheat Mountain which is underlain by Pottsville beds dipping less steeply than those underlying Rich Mountain, stands topographically higher and is wider than the latter.

2. There is a distinct sag in Rich Mountain - Laurel Ridge, north and south of the narrows of Tygart River.

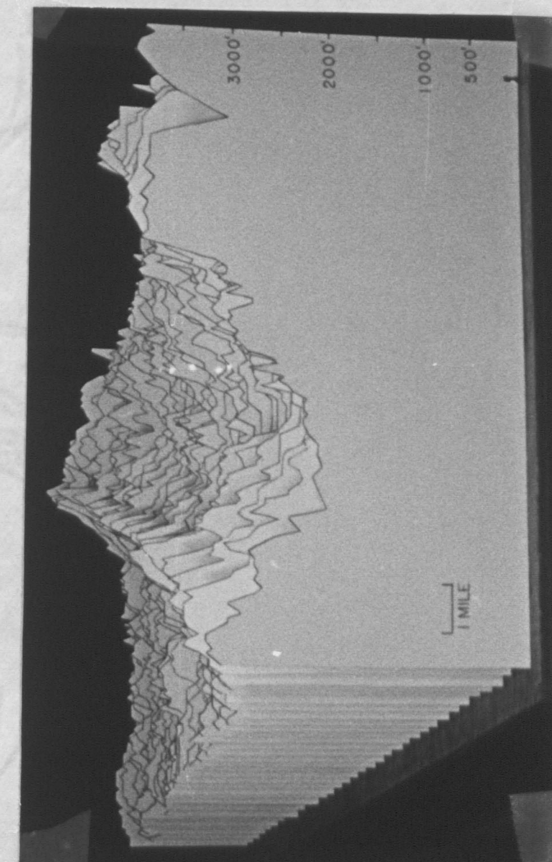
Plate 16

Multiple projected profiles of the Elkins and Belington quadrangles. ( looking north )

Vertical exaggeration = 10


3000'
2000'
1000'
500'
1 MILE


1 MILE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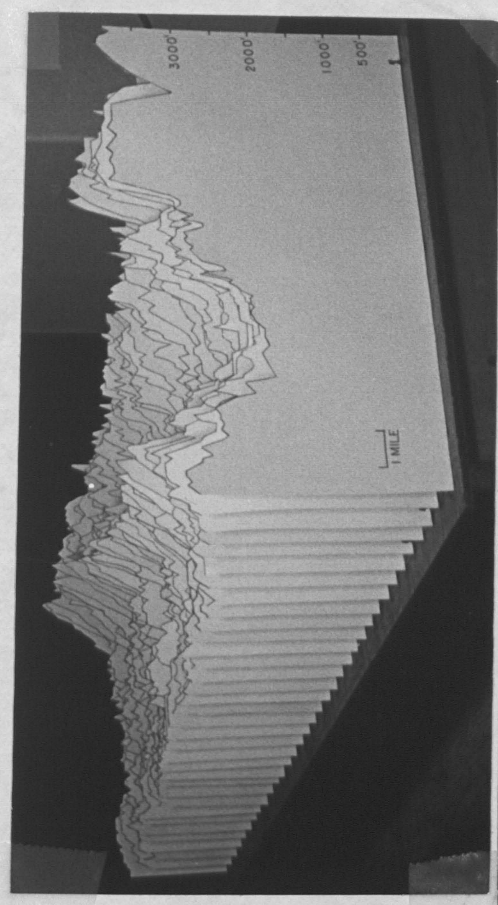
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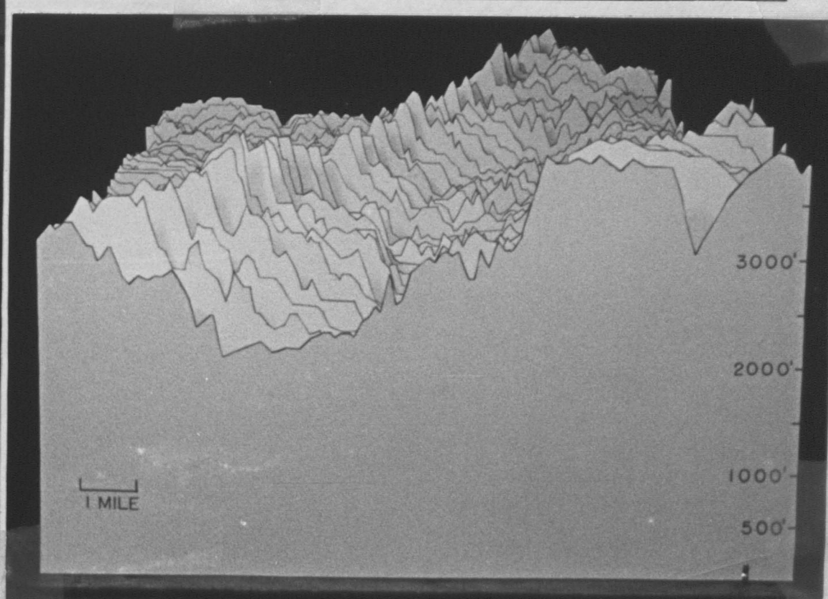

3000'
2000'
1000'
500'
1 MILE

3. The broad low relief area west of Rich Mountain - Laurel Ridge slopes downward from south to north until Tygart River west of the narrows is reached, north of which point the general level is relatively horizontal.

4. Several erosion surfaces are visible in the profiles. These are:

South of Elkins (front of profiles)

| west | center | east |
|---|---|---|
| 3000 feet (local) | | 3000 - 3200 feet |
| 2500 - 2700 feet | | 2500 - 2700 feet (narrow) |
| | 2200 feet | |

North of Elkins

| west | center | east |
|---|---|---|
| 2300 - 2400 feet | | 2500 feet (well developed) |
| | 2000 - 2100 feet dying out northward | |

From these figures three general surfaces below the Pottsville ridges are apparent. They are (plate 16):

Level 1 at about 3000 feet developed only in the southern part of the Deer Park anticline

Level 2 at about 2500 feet. The level is a little lower in the northwest.

Level 3 at about 2100 feet in the center.

Below level 3 are the floodplains of Tygart River and Leading Creek.

In order to demonstrate the relationships of these three surfaces (levels) to the rocks exposed in the Deer Park anticline a map (fig. 16) is given which shows the three surfaces in relation to the major rock groups. In this map the flood-plain levels of the present streams are omitted. The outcrop patterns are traced from the geologic map of Randolph County (Reger 1931); the erosion levels are obtained from the projected profiles. This general method has been used previously by Cole (1935). Several interesting facts are brought to light by this map: (The term "level" as used here and on the map does not designate a horizontal surface but merely a general elevation.)

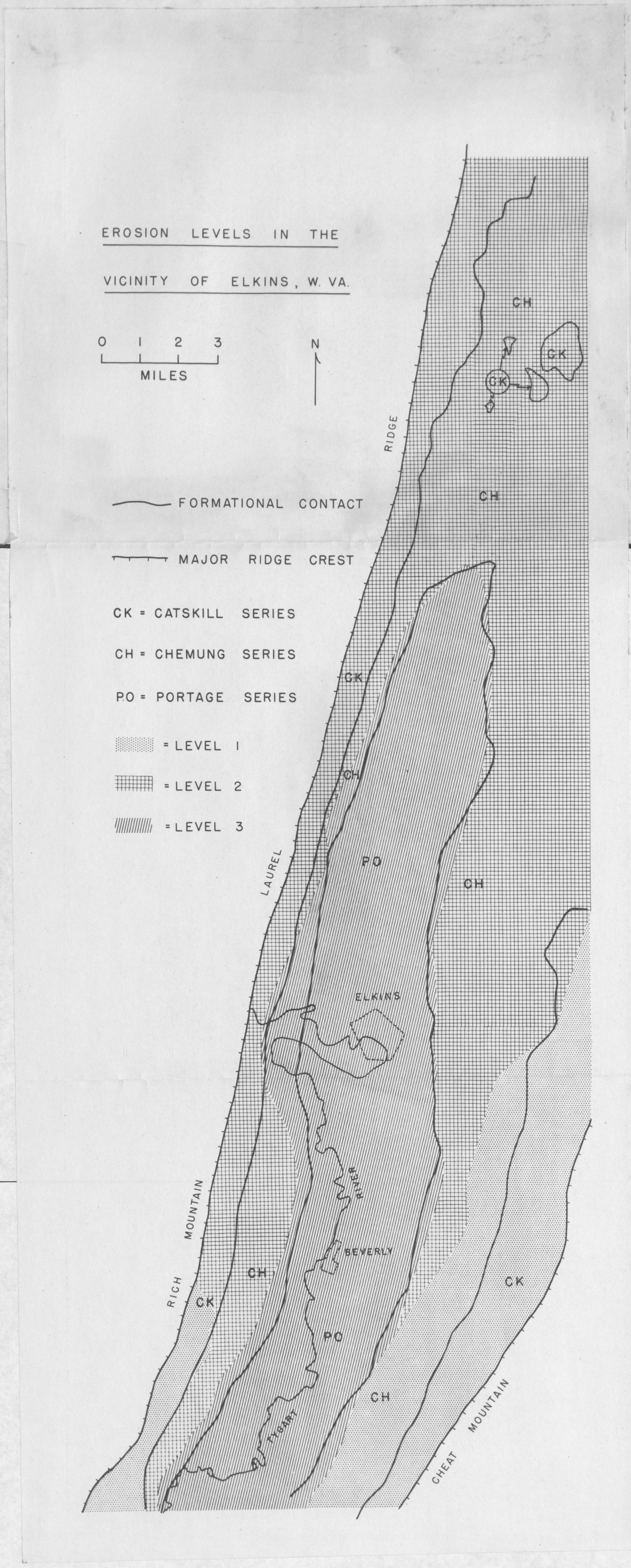
1. The very close agreement of level 3 with the outcrop of the Portage beds is striking.

2. North of Elkins the Chemung beds underlie level 2. Level 2 closes around level 3 in the north where the Portage beds plunge under the surface. This area is folded so gently that for all practical purposes the Chemung beds may be assumed horizontal. The weak beds of the Catskill do not manifest themselves on this map because in reconstructing erosion surfaces from projected profiles present valleys and local differences in relief are ignored.

3. South of Elkins the coincidence of level 2 with the Chemung is not so perfect. East of Tygart River level 2 pinches out southward and level 1 covers Catskill and Chemung. Level 1 is present in the southern part of the Catskill exposures west of Tygart River. South of Elkins the coincidence of level 3 with the outcrop of Portage is still marked however.

Figure 16

Erosion levels in the vicinity of Elkins


EROSION LEVELS IN THE
VICINITY OF ELKINS, W. VA.
0 1 2 3
MILES
N
FORMATIONAL CONTACT
MAJOR RIDGE CREST
CK = CATSKILL SERIES
CH = CHEMUNG SERIES
P.O = PORTAGE SERIES
= LEVEL 1
= LEVEL 2
= LEVEL 3
LAUREL RIDGE
RICH MOUNTAIN
CHEAT MOUNTAIN
ELKINS
BEVERLY
TYGART RIVER
CH
CK
PO

Except at the Catskill - Chemung contact in the south, the coincidence of erosion surfaces with rock resistance to erosion is so strong that there can be almost no doubt that these surfaces are controlled by rock type. These surfaces might well be called "surfaces of mass-wasting". They are not peneplains. The Portage beds being more shaly and hence weaker than the Chemung, have been wasted down to a lower elevation. Since the Portage beds are fairly uniform areally, the surface of the wasting maintains a reasonably uniform height over the area. This same statement applies to the Chemung north of Elkins.

If the rock type is controlling development of surfaces an explanation must be sought for the presence of level 1 (fig. 16) south of Elkins and especially its development on both the Catskill and Chemung east of Beverly. This explanation is readily found by studying the change in lithology of the Chemung and Catskill beds from north to south. North of Elkins the Catskill beds (delineated by Reger, op. cit.) as exposed along Morgantown Pike and in the extreme north of the area are about 80 % shale, 10 % shaly sandstone and siltstone, and 10 % sandstone. No sandstone bed over 1 foot thick is found. Southeast and southwest of Beverly and due east of Elkins the Catskill series exposed in the slopes of Cheat Mountain and Rich Mountain is composed of about 35 % sandstone (some beds up to 3 feet thick) and 65 % shale. The Chemung beds are in general more resistant than the Catskill but in the southern part of the area the Catskill stands above the Chemung except southeast of Beverly. It is difficult to determine the percentages of sandstone and shale in the Chemung beds due to the poor exposures and intricate drag folding. Southeast of Beverly however the Chemung has several beds of pebble conglomerate in it which are not present elsewhere in this series, and the sandstones are more massive than those in the Chemung north of Elkins. Although it cannot be clearly demonstrated by field observation, the writer feels that the Chemung southeast of Beverly is more resistant than the Chemung elsewhere in the Deer Park anticline.

The changes within the Catskill and Chemung series account for the presence of level 1 (fig. 16) on the Catskill in the southern part of the area and indicate inconclusively the reason why level 1 is found on the Chemung southeast of Beverly. The variation of lithology within a series and concomittant development of different surfaces is in accord with the whole picture of rock control of erosion surfaces brought out by the profiles and map (plate 16 and fig. 16).

Conclusions:

From the above discussion of peneplains below the ridge crests the following conclusions are drawn:

1. The Allegheny Ridges in the area investigated have not been peneplained below the ridge crests, i. e. the effect of an external base level has not been felt over the entire area.

2. Since uplift of the pre-Schooley peneplain, erosion and mass-wasting controlled by rock resistance alone, has given rise to the present topography.

A systematic survey of the physiography of the region, with these two conclusions in mind, follows.

## Systematic Physiography

a) West of Laurel Ridge:

The area immediately west of Laurel Ridge is underlain by the very gently dipping rocks of the Belington syncline which rise farther west to form the Hiram anticline. This area is one of low relief sloping northward as shown in the profiles (plate 16). Plate 17 is a view westward over this area from the fire tower located on Laurel Ridge at the point where this ridge is crossed by the Morgantown Pike northwest of Elkins. The low relief of this area is apparent in this picture.

The high level valley northeast of Harding (fig. 2) mentioned by Reger (1931) as a remnant of the Harrisburg peneplain appears to be rather a subsequent valley opened out by a north-south trending stream developed on weak shales underlying coal. The coal seam is being strip-mined at present. The rocks underlying the valley dip westward and the valley shows a westerly slope.

b) Deer Park Anticline in Randolph County:

The drainage and the origin of the erosion levels in this area have already been discussed in detail. The development of subsequent streams on the Catskill shales on either side of the anticline is pronounced (fig. 2). Plate 18 is a panorama from Bickle Knob fire tower looking east, south and west. The southwestern and western part of the panorama

Plate 17

Looking west from Laurel Ridge over the Belington syncline.

Photograph taken from fire tower located where Morgantown Pike crosses Laurel Ridge.

Plate 18

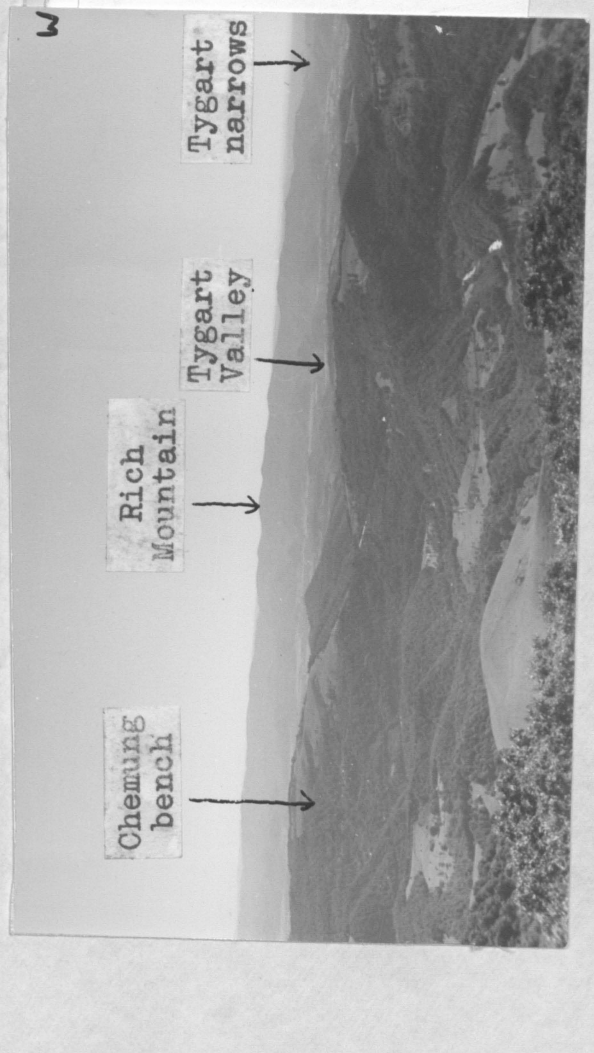
Panorama ( east - south - west ) from Bickle Knob. ( point A of fig. 2 )

Note syncline between Cheat Mountain and Shavers Mountain.

Photographs by John L. Rich


E
Alpena Gap
Shavers MT
Collett Gap
S
Cheat Mountain
Catskill lowland
Chemung bench
Rich Mountain
Tygart Valley
W
Tygart narrows

Shavers
Mountain



overlook the Deer Park anticline. Clearly visible on plate 18 is Cheat Mountain and the lowland developed on the shaly Catskill series immediately to the west. The broad level on the Chemung series may also be seen. In the distance is Rich Mountain. The mass-wasting levels previously discussed may be seen below Rich Mountain by careful observation. At the extreme right of the panorama is the narrows of Tygart River. The sag in the crest of Rich Mountain at the narrows is clearly visible. In the foreground of the western section of the panorama the cleared fields mark the Pocono - Greenbrier bench. A short segment of Shavers Fork of Cheat River visible in the west is part of the meander south of Canfield School (fig. 2).

Plate 19 is another panorama from Bickle Knob Tower looking east, north and west. To the west the general level on the Chemung is visible in the middleground. In the distance is Laurel Ridge with its knobby crest. Plate 20 is an aerial view of the crest of Laurel Ridge taken from over the village of Kerens. The crest of Laurel Ridge is much more uneven than the crest of Rich Mountain. This is due probably to the fact that the Pottsville rocks of Laurel Ridge dip westward somewhat more steeply than do those of Rich Mountain and hence Laurel Ridge is being more rapidly dissected. The Pottsville ridge (Cheat Mountain) and the Pocono - Greenbrier bench show clearly on plate 19. In the northern part of the Deer Park anticline (A of plate 19) is a broad flat area. This is the area north of the outcrop

Plate 19

Panorama ( east - north - west ) from Bickle Knob. ( point A of fig. 2 )

photographs by John L. Rich

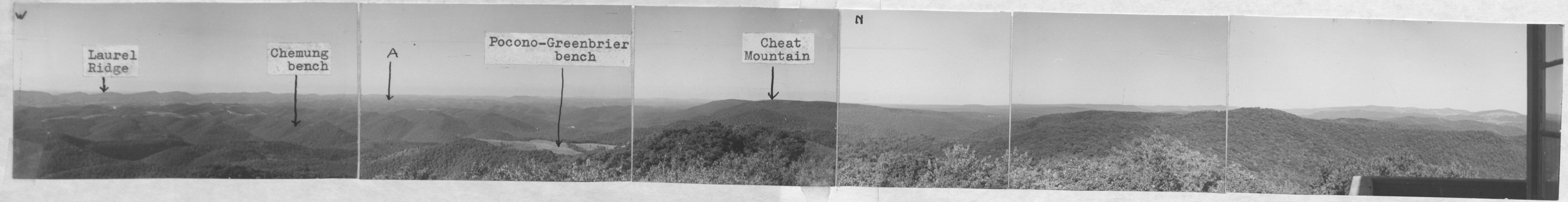

W
Laurel Ridge
Chemung bench
A
Pocono-Greenbrier bench
Cheat Mountain
N

Plate 20

Laurel Ridge. Aerial photograph looking west from a point about 2000 feet over Kerens.

of the Portage beds on fig. 16. This region is not a peneplain but is more accurately a plateau. The rocks are folded but dip so gently that they act toward erosion as horizontal rocks. Plate 21 is a view of this plateau area from one of its ridges.

Plate 22 is a view from the same location as plate 17 southeast over the Deer Park anticline showing the mass-wasting surfaces. In the distance is Cheat Mountain and the water gap of Shavers Fork. Plate 23 is a stereo-oblique aerial photo looking west into the narrows of the Tygart west of Elkins.

Shavers Fork west of Cheat Mountain flows northward toward Parsons. On the geologic map of Randolph County it is represented as flowing on Chemung beds rather than the Catskill beds which are immediately to the east. The Catskill rocks in the northern part of the Deer Park anticline are weaker than the Chemung. The rocks exposed in the west bank of Shavers Fork here however are quite shaly and regardless whether the beds on which the stream is flowing are Catskill or Chemung it is clearly following the strike of a weak shaly group of beds.

c) North Potomac - Georges Creek Syncline:

This syncline east of the Deer Park anticline is drained by Shavers Fork of Cheat River and by Otter Creek and at the north, by Blackwater River. Much of the area south of Dry Fork is inaccessible except for the parts traversed by a few U. S. Forest Service roads.

Plate 21

Looking northward from Mt. Zion Ridge to Pifer Mountain.

Plate 22

Looking southeast from Laurel Ridge over Deer Park anticline.

Photograph taken from fire tower located at point where Morgantown Pike crosses Laurel Ridge.

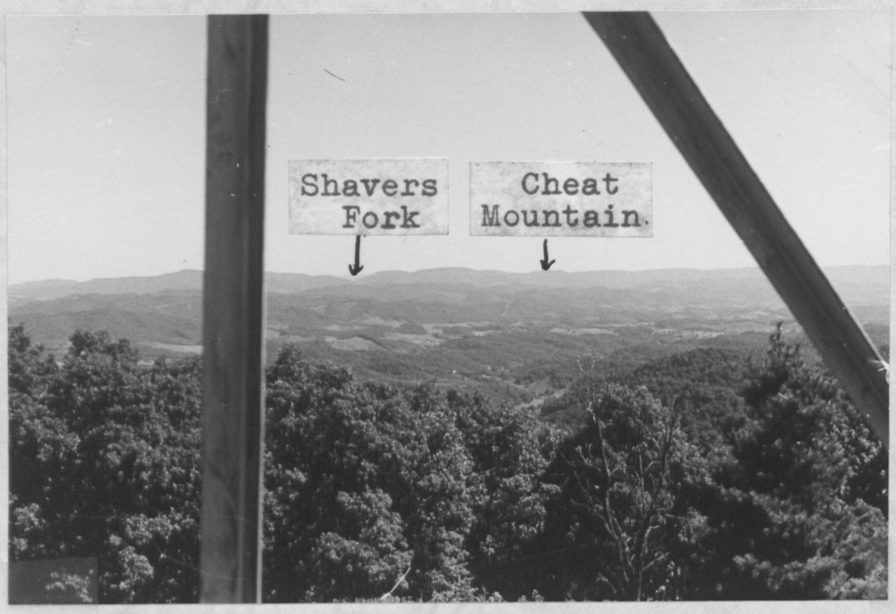

Shavers Fork
Cheat Mountain

Plate 23

Stereo aerial photographs looking westward toward the narrows of Tygart River.

The entire area is topographically high, being a synclinal mountain. Where the resistant Pottsville series comes to the surface on the east and west, high ridges called Shavers Mountain and Cheat Mountain respectively, are formed. The center, where the coal measures above the Pottsville are preserved, is topographically lower than the flanks. Cheat Mountain and Shavers Mountain are about the same average height and both decrease in height northward.

Shavers Fork drains the syncline along its axis south of the possible fault through Alpena Gap. South of (upstream from) Bemis it is in a broad shallow valley. Just above Bemis it spills over a waterfall in which the Pottsville beds act as a caprock. From this falls until it leaves the syncline it is in a steep sided canyon, (plate 24). The position of Shavers Fork where it leaves the syncline across Cheat Mountain may be controlled by the possible fault which passes through Alpena Gap and the narrows of Tygart River. The steep canyon has obviously been made by the retreat of the caprock falls.

From Bemis to where it turns west at Chestnut Grove School (fig. 2) the stream is swift and has numerous rapids. Its gradient is about 45 feet per mile. From Chestnut Grove School until it leaves the syncline the river is broad, shallow and smooth. It has a gradient of about 20 feet per mile which it maintains to its mouth at Parsons. The sharp difference in gradient upstream and downstream from Chestnut Grove School is paralleled by a sharp difference in valley

Plate 24

Aerial photograph of the canyon of Shavers Fork. Looking south from just north of Chestnut Grove School.

cross-section. Upstream from Chestnut Grove School the valley is narrower and the valley sides steeper than downstream from this point. This difference in gradient and valley cross-section is due to several causes.

1) The stream downstream from the school has been at or near its present level longer than it has upstream from the school.

2) The stream downstream from Chestnut Grove School is, for a considerable distance, working on weak Devonian rocks, while the segment upstream is cutting in the harder Mississippian rocks.

3) Perhaps, although it cannot be demonstrated, the possible east-west fault has weakened the rocks on which Shavers Fork downstream from the school is flowing.

The absence of any stream-cut terraces along Shavers Fork has already been discussed.

Plate 18 shows the syncline south from Bickle Knob. The position of the two ridges on either side of the syncline and the canyon of Shavers Fork along the axis of the fold are indicated. Alpena Gap and Collett Gap across Shavers Mountain are also indicated. The synclinal form of the entire area is clearly visible in the topography.

Collett Gap was mentioned previously in the discussion of the Upland Peneplain. As discussed previously, Collett Gap and the other gaps in Shavers Mountain are due either to headward working of opposing tributaries or to streams that formerly flowed off the Blackwater anticline. Therefore either no stream ever flowed through the gap or it was abandoned by the stream before completion of the Upland cycle. As seen on plate 18 it superficially appears to be a fairly recent windgap. Because of the importance that has been attached in this paper to the sparsity or absence of windgaps formed after the pre-Schooley (Upland) cycle it is important to demonstrate that Collett Gap has long since been abandoned by any stream that might have flowed through it.

The approximate section exposed in Collett Gap is as follows, from the top of Spruce Knob to the roadway east of the gap:

| | |
|---|---|
| Pottsville conglomerate and sandstone | about 25 feet |
| Mauch Chunk sandstones and shales (red) (about 75 % shale) | about 1000 feet |
| Greenbrier limestone | about 250 feet |
| Pocono (?) sandstone | 80 + feet |

The Pocono sandstone and overlying Greenbrier limestone make a bench at about 3000 feet A. T. (about 800 feet below the top of Spruce Knob). The slope from the floor of Collett Gap at about 3200 feet to the top of Spruce Knob is not uniform but averages about 15°. There is no evidence of faulting through the gap, but due to the poorness of exposures here this lack of evidence is not proof of the absence of faulting.

The evidence against the fairly recent presence of a stream through Collett Gap is as follows:

1) There is no alluvial material to be found in the floor of the gap today.

2) The floor of the gap is at about 3200 feet. There is however no gap at this elevation in Middle Mountain east of Collett Gap; hence if a stream did flow through the gap it must have been above the present level of Middle Mountain and not a recent east-west stream across the anticline. It is possible that Shavers Fork could have made Collett Gap. This stream might have originally turned east through the gap and then drained north through Glady Fork east of Shavers Mountain. Capture of Shavers Fork west of the gap would then have given the stream its present course. However a careful examination of the canyon of Shavers Fork upstream from Collett Gap Run reveals no sudden widening of the valley sides above 3200 feet, as would be expected if a stream had originally flowed through the gap at this elevation and then been suddenly lowered by capture. The upper part of the canyon walls are no wider above Collett Gap Run than they are below it, as would be expected if that part of Shavers Fork below this Run was younger than the course upstream from it. Actually the valley is wider downstream from Collett Gap Run (plate 24) than upstream as is to be expected if mass-wasting has been causing the retreat of the slopes longer farther downstream, since the retreating falls passed this spot. Along Glady Fork north of Gap Run the valley is no wider (actually less wide) below 3200 feet than it is south of Gap Run. The terraces along Glady Fork are found both upstream and downstream from Gap Run. Hence the evidence along Glady Fork indicates that no larger

stream flowed through its valley below 3200 feet elevation north of (downstream from) Collett Gap. These facts, together with the absence of terraces along Glady Fork above 3200 feet A. T. upstream from Gap Run also preclude the possibility that Glady Fork might have flowed westward through Collett Gap to Shavers Fork. If this latter case were true, terraces along Glady Fork on the Devonian beds should certainly have been developed behind the base level at Collett Gap.

The above reasons indicate that Collett Gap is not a recent (post-Schooley) windgap, although no conclusion can be reached as to which of its two possible origins previously discussed is correct. The steep sides of the gap are possibly due to the presence of a thin but very resistant caprock (Pottsville conglomerate) overlying a thick, weak, shale sequence (upper part of the Mauch Chunk series). The flat floor of the gap is due to the presence of the hard, bench-forming, massive Princeton conglomerate (about 50 feet thick) near the middle of the Mauch Chunk series here. The combination of rock types in the gap is therefore apparently responsible for the steep-sided flat-floored appearance of the gap.

Plate 19 is a view north and northwest over the syncline from Bickle Knob Tower. The syncline in this northern view is broader and flatter than it is to the south because the Pottsville beds dip less steeply across the syncline in the north. The absolute control of the topographic expression of this syncline by the Pottsville is clearly shown in the views north and south from Bickle Knob.

All of the local high flat areas within the syncline that can be easily reached are found to be rock controlled.

Plate 25 is a stereo-oblique aerial photograph of Alpena Gap.

d.) Blackwater Anticline in Randolph County:

This fold is drained by Glady Fork and Laurel Fork which flow northward to Dry Fork of Cheat River. Despite the fact that Cheat River (and Dry Fork) at Parsons is about 300 feet lower than Tygart River at Elkins, the average topographic height of the center of the Blackwater anticline is over 1000 feet higher than the height of the center of the Deer Park anticline (Tygart Valley). No Devonian beds lower than the Chemung are exposed in the Blackwater anticline. The high elevation of the land in the Blackwater anticline is due to the former falls of Dry Fork, which have been previously discussed.

The positions of Glady and Laurel Forks are controlled by the weak beds of the Catskill series. The Catskill beds here are alternating sandstone and shale with a single 400 to 500 foot shale sequence just below the middle of the series. It is this thick shale sequence which appears to be the controlling factor in locating the streams on either side of the stripped crest of the anticline. The streams have locally developed floodplains about one half mile wide.

The meanders of these streams are ingrown (Rich, 1914).

Plate 25

Stereo aerial photographs looking westward toward Alpena Gap.

Plates 12 a and b are a vertical stereo pair and oblique aerial photograph respectively of the meanders of Glady Fork near Alpena. The presence of ingrown meanders cut into weak rocks by these streams is believed due to the slow downcutting of graded streams when the falls on Dry Fork was removed.

Two surfaces are found when descending from Shavers Mountain to Glady Creek and from Rich Mountain to Laurel Creek. The upper surface at about 2600 to 2800 feet is followed by the road paralleling Glady Fork on plate 11 and plate 26. This surface is the Pocono - Greenbrier bench. It is the "limestone lands" referred to by Reger (1931) as part of the Harrisburg peneplain. This bench slopes westward east of Shavers Mountain following the dip of the Pocono and Greenbrier series. It is therefore highest at its eastern edge (see plate 12 b). About 100 feet below this bench a surface is developed on the Catskill series. This surface is present in plate 11 on the tops of the long meander spurs. It is better developed on broad fairly flat areas southwest of Alpena around Evenwood.

Along Glady Fork these surfaces fall in height roughly 150 feet from south to north. Glady Fork (see fig. 2) from Evenwood to Panther Camp Run falls about the same vertical distance. From Panther Camp Run to its mouth at Gladwin, Glady Run falls much more steeply than it does from Evenwood to Panther Camp Run. In the part downstream from Panther Camp Run the meanders are much more steeply entrenched, yet the flats on top of the meander spurs are still preserved,

Plate 26

Looking northwest over Deer Park anticline north of Parsons.

Photograph taken from Backbone fire tower.

as is shown about one mile east of Kuntzville. The tops of the meander spurs were examined for alluvium. None was found on the sharp-crested spurs, but on the flat-topped spur east of Kuntzville rounded quartz pebbles are infrequently present. They are all about one half to one inch in diameter and it is possible that they are derived from weathering of the Pottsville high on the slope of Shavers Mountain. This appears to be less likely however than that they are Pottsville pebbles transported by Glady Fork when this stream was at the higher elevation.

The flat-topped spurs and possibly the even-crested spurs within the meanders of Glady Fork may mark either a surface of mass-wasting or a former level of Glady Fork when the base level of Dry Fork was controlled by a waterfall where it crosses the Pottsville beds of the North Potomac - Georges Creek syncline southeast of Parsons. The latter hypothesis of origin is favored for the following reasons.

1) The general slope downstream of this bench is of course to be expected under either hypothesis of origin.

2) The presence of rounded quartz pebbles where their origin is most likely to be alluvium argues for the favored hypothesis of origin of the bench.

3) The elevation of the bottom of the Pottsville beds where Dry Fork crosses the axis of the North Potomac - Georges Creek syncline near Otter Creek School (fig. 2) is about 2500 feet. This height is in accord with the height of a base level of Glady Fork which would have caused this stream

to open a wide valley on the Catskill beds of the Blackwater anticline at 2600 to 2800 feet.

4) It seems unlikely that mass-wasting rather than stream action would have made the extensive and quite flat surfaces south of Evenwood. It is noticeable that the broadest of the flat-topped remnants are preserved well upstream from the mouth of Glady Fork. This is explicable by the fact that the stream is more deeply (and steeply) cut down near its mouth and hence mass-wasting is more vigorous and has been acting longer here on the valley sides than farther upstream. The retreat of the valley sides reduces the area of the flat-topped remnants. The steepness of the gradient of Glady Fork near its mouth indicates that this stream has not re-graded itself at a new and lower level throughout its length since the destruction of the waterfall along Dry Fork.

Exactly the same arguments apply to the levels along Laurel Fork on the east side of the Blackwater anticline.

e) Tucker County, including the area around Parsons, the Davis plateau and the Canaan Valley (see figs. 2 and 4).

This county may be split into two <u>major</u> divisions. The bifurcated Deer Park anticline on the west and the Davis plateau (North Potomac - Georges Creek syncline) on the east. The entire area is drained by Cheat River and its tributaries. Cheat River flows almost north while the folds trend northeast, so that the river cuts across the fold axes. As was previously discussed, Cheat River north of Parsons has wide meanders and a well developed floodplain upstream from the point where it crosses the axis of the Hannahsville syncline (fig. 2 and plate 15 a and b). Near Anvil is a cut-off meander. There are many terrace remnants along the valley sides at various levels and evidence of higher level meanders at various places. The terraces range in elevation from 1600 to 1900 feet and from 50 to about 300 feet above the stream. Reger (1923) discussed terraces of Cheat River and ascribed them to the five levels of the ice dam previously discussed. All of the comments previously made in this report concerning Tygart River terraces apply to Cheat River terraces. In the case of Cheat River however the local base level appears to have been the resistant rocks in the Hannahsville syncline. Terraces are not well developed across the Hannahsville syncline with the lone exception of a terrace remnant about 125 feet above the river near Hannahsville north of the synclinal axis. Two terrace remnants listed by Reger (1923, p. 80) near Bull Run in the Hannahsville syncline as a "rounded point" and "rounded gap" are rock controlled benches. Cheat River in Preston County, north of the Hannahsville syncline, has a much narrower floodplain and less well developed and less numerous terrace remnants.

Where the river crosses the axis of the syncline the base of the Pocono series is about 240 feet above the river and the base of the Pottsville about 1000 feet above the river. There are no terrace remnants 1000 feet above the river south of the syncline. Apparently lowering of the Devonian rocks of the Deer Park anticline since Cheat River was graded to the Pottsville as a local base level (as it must have been) has removed those remnants. On the eleven distinct terrace remnants along Cheat River upstream from the Hannahsville syncline listed by Reger (op. cit.) three are developed well above 240 feet above the present stream. The Catskill series around and north of Parsons is more resistant in general than the Chemung. It stands topographically higher. A typical section of Catskill beds southeast of Parsons is about 40 % sandstone while the Chemung rocks are about 20 % sandstone. It is probable therefore that the terrace remnants less than 240 feet above Cheat River south of St. George, which are developed on Chemung rocks, are due to the relatively slow downcutting of Cheat River through the Catskill rocks of the Hannahsville syncline.

The Catskill beds of the Deer Park anticline at and north of Parsons stand distinctly higher than the Chemung beds. The topography is closely controlled by lithology.

Plate 26 is a general view northwest over the Deer Park anticline just north of Parsons.

The Davis plateau stands about 2000 feet above and to the east of Cheat River (Deer Park anticline) in Tucker County (plate 27). The plateau is the northern continuation of the North Potomac - Georges Creek syncline. The rocks underlying the plateau are almost horizontal, the dips toward the synclinal axis being from 2 to 4 degrees. As discussed

Plate 27

Davis plateau as seen from Backbone fire tower.

Upper photograph: Looking northeast over plateau. Canaan Mountain forms the horizon.

Lower photograph: Looking southeast over plateau. Blackwater Canyon is in the middle distance.

previously, the Pottsville rocks holding up the plateau have probably been lowered little since the pre-Schooley peneplain. They stand about 700 to 1000 feet above the more steeply dipping Pottsville rocks supporting Laurel Ridge to the west.

The Davis plateau is drained by Blackwater River which flows across it from east to west. Near Davis, this river spills over Blackwater Falls into narrow, steep, deep Blackwater Canyon. Plate 11 is an aerial view of Blackwater Canyon in which the Pottsville beds of the canyon rim are visible.

Blackwater Falls has been retreating into the Davis plateau since the end of the pre-Schooley cycle and has gone back about 9 miles. As long as the weak Mauch Chunk shales were exposed beneath the Pottsville rocks in the fall, it retreated as a caprock fall, with the elevation of the lip of the fall probably not far below that of the top of the Pottsville. Several hundred yards downstream from the present position of Blackwater Falls, the Mauch Chunk beds dip below the gradient line of Blackwater River (downstream from the fall). From the time the fall retreated past this point, the caprock action of the Pottsville ceased because weak underlying rock was no longer present. The stream today is cutting slowly through the Pottsville as is evidenced by a steep-sided gorge about fifty feet deep cut into the Pottsville immediately above the fall. This gorge disappears upstream and at Davis the stream has a floodplain at the level of the plateau.

Evidence that the falls maintained itself at or very close to the general plateau level for most of its retreat is given by the north side tributaries of Blackwater River. These streams are hanging tributaries. Those far downstream, such as Big Run, have cut back their lips considerably since the falls passed their mouths. Farther upstream, Pendleton Run, a fairly large tributary, with a small floodplain, has cut back its lip at the canyon edge very little. This is explicable by the fact that the falls has only recently retreated past the mouth of Pendleton Run. This consistent picture of tributaries cutting back their lips in proportion to the length of time since they were left hanging is evidence that the falls maintained full or almost full height during their retreat until recently. If the falls had been lowering ever since their retreat then a tributary, such as Pendleton Run, would have been left hanging and hence cutting back its lip for a considerable time. In other words, if the falls had been lowering steadily since their retreat Pendleton Run would not now be a hanging tributary which has barely cut down its lip.

The short retreat concomitant with the lowering of the falls, since the Mauch Chunk shales were no longer present, is due to slight inhomogeneity within the Pottsville series. The present Blackwater Falls (plate10) is a caprock falls. This caprock consists of a bed of quartz pebble conglomerate underlain by somewhat weaker beds of sandstone. The slight difference of resistance of the conglomerate and the sandstone is undoubtedly emphasized by the plunge pool action and the mist and spray near the foot of the falls which keep the rocks behind the falls wet and hence promote weathering. The inhomogeneity of the Pottsville rocks is apparent in the step-like pattern of the falls (plate 10).

In summary, Blackwater Falls retreated at or slightly below the elevation of the top of the Pottsville (the general level of the plateau) as long as the weak Mauch Chunk shales underlay the caprock Pottsville rocks. At or near the point where the Mauch Chunk rocks dipped under the stream bed the falls started to lower its lip relatively rapidly. During this lowering it continued to retreat because of inhomogeneity within the Pottsville series. As a result of this lowering, Blackwater River just above the falls is in a shallow gorge.

On the eastern edge of the plateau where the river passes between Canaan Mountain and Brown Mountain east of Davis, the Pottsville and Mauch Chunk series are present but there is no waterfall because the rocks are dipping downstream and hence no caprock action by the Pottsville beds can develop.

The entire Davis plateau shows a broad synclinal form with the two Pottsville ridges bounding it on the east and west.

East of the Davis plateau lies the Canaan Valley (fig. 2), the northeastward extension of the Blackwater anticline. The valley is about 13 miles long. It has a complete, doubly plunging anticlinal form. Pottsville ridges bound it on east and west. Inside the Pottsville ridges is a broad area of very low relief, which has an annular elliptical shape, wider on the west than on the east. This lowland is developed on, and exactly coincides with, the Greenbrier limestone. In the center of the valley is a low but distinct anticlinal range of hills or "turtleback" on the Pocono series, which is the lowest exposed in the anticline. The topography of the whole Canaan Valley is clearly dependent on rock type. The high elevation of its floor (3150 feet A.T.) is due to the temporary base level at Blackwater Falls.

The streams draining the valley are Blackwater River and its tributaries, which are subsequent streams generally following the strike of the rocks. Blackwater River in the Canaan Valley flows down the middle of the "turtleback" in the Pocono beds rather than following the lowland developed on the Greenbrier. In the Pocono beds its floodplain is not so well developed as on the limestones. Upstream (south) from the point where Blackwater River starts to cross the Pocono it has a well developed, marshy, poorly drained floodplain apparently due to the Pocono sandstones forming a temporary base level. It is probable that the course of Blackwater River on the Pocono beds is due to superposition from the limestones that once arched over them. As the anticline was eroded down and the Pottsville ridges retreated on either side, the Greenbrier limestone would first appear in the center of the anticline and perhaps localize the drainage there. From this position the drainage might well have been superposed on the Pocono.

The streams on the limestone lowlands show no trenching or downcutting propensities attesting to the fact that Blackwater Falls has served as a base level. The recent tendency toward lowering of the fall has not yet been felt this far upstream.

Red Run in the southern tip of the Canaan Valley is working back to capture the headwaters of Blackwater River. This capture has not occurred previously in the long erosional history of the region because of the former waterfall on Dry Fork of which Red Run is a tributary. With the destruction of this fall and subsequent rapid downcutting of Dry Fork, Red Run became eligible to capture Blackwater River headwaters.

East of Canaan Valley is the wild uninhabited area of the Stony River syncline, whose western ridge, Cabin Mountain, is the eastern ridge of Canaan Valley; and whose eastern ridge is the Allegheny Front. Plate 28 is a stereo view over this synclinal area from the Allegheny Front.

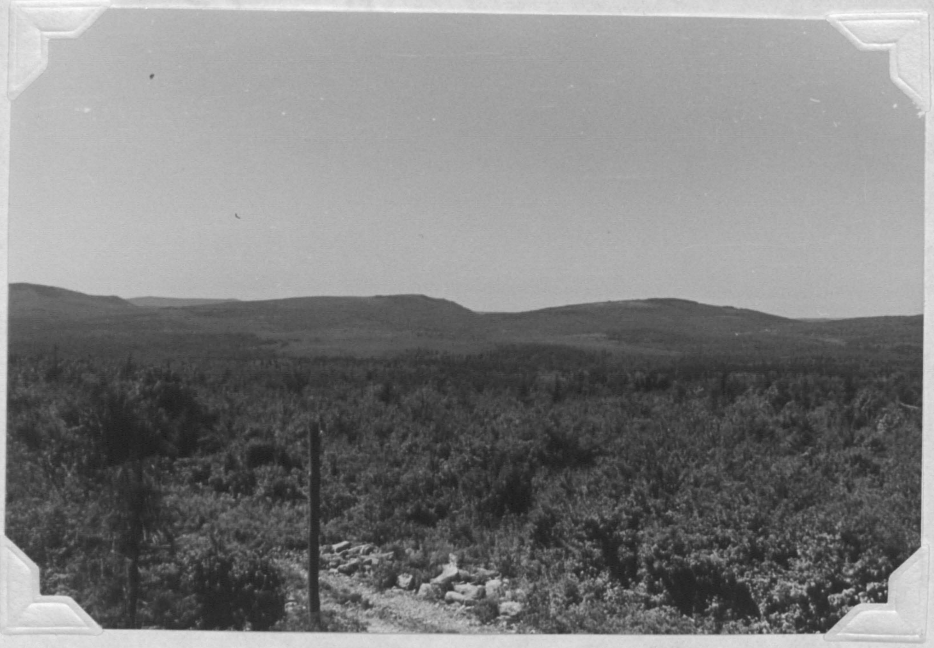
f) Area east from Blackwater Anticline to Allegheny Front:

This area in Randolph and Pendleton counties has been studied only in reconnaissance fashion.

Going east from the Blackwater anticline one crosses successively the Job syncline, the Horton anticline and the Stony River syncline. The eastern limb of the last mentioned fold is the Allegheny Front. The Job syncline and the Horton anticline die out northward before reaching Tucker County so

Plate 28

Stereo photographs looking westward over Stony River syncline from Dolly Sodds fire tower on the Allegheny Front. Cabin Mountain forms the horizon.



that here the Blackwater anticline (Canaan Valley) is adjacent to the Stony River syncline.

Various high flat areas observed in this region are rock controlled in the same fashion as those described from further west.

The Job syncline and the west side of the Horton anticline are drained by Dry Fork and its tributary Gandy Creek. The east side of the Horton anticline and the Stony River syncline drain eastward via Seneca Creek and eventually to Potomac River.

There is nothing in this region that contradicts any of the observations made previously. The position and attitude of the Pottsville beds exerts the controlling influence on the topography. Wherever they are present the area is high. Where they have a low dip or are flat, such as at Roaring Plains, the area underlain stands very high and has low relief. The Horton anticline is topographically similar to the Blackwater anticline in that it is topographically low on the Catskill beds on either side, where the streams are developed, and high on the Chemung beds in the center. The anticline narrows suddenly just north of the point where Gandy Creek crosses over into the Job syncline (fig. 2). The Pocono and higher beds are present across the anticline (fig. 4). North of this Pocono projection a dome in the anticline brings the Devonian beds back to the surface. It is through this dome that Seneca Creek enters the anticline. It is possible that the location of the place where Gandy Creek leaves the anticline is controlled by the resistant Pocono "projection", for the creek leaves the anticline just south of this point.

Summary of factors controlling general physiography of region:

1. The Allegheny Ridges in east-central West Virginia were imperfectly peneplained in pre-Schooley time.

2. Since uplift of the pre-Schooley surface no external base level has affected this region. In other words, no peneplains controlled by a base level outside the area have developed since pre-Schooley time. The region has been lowered by differential mass-wasting ever since this uplift.

3. The resistance to erosion of the various rocks has exerted the dominating influence in control of topography. The topographic height is a direct function of rock type and attitude. The resistant rocks stand topographically above adjacent weak rocks. Local flat areas are developed on flat lying rocks. Homogeneous groups of tilted rocks, especially around Elkins, have been lowered uniformly by mass-wasting, so that today they form low relief surfaces at various levels unrelated to regional base levels.

4. The general level of the rocks in the anticlines is controlled in detail by rock type but in gross elevation by the levels of the streams draining these folds (below which mass-wasting cannot work). Retreat of caprock falls without loss of height has therefore resulted in local topographically high areas on weak rock above the caprocks.

5. The various terrace remnants along the larger streams of this region are not related to any external, single base level but are the result of the streams' slowly cutting down at grade through local, hard rock base levels.

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