DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

THRUST FAULT ZONES IN THE ALLEGHENY PLATEAU OF NORTH-CENTRAL PENNSYLVANIA

BY

H.A. POHN AND T.L. PURDY

Open File Report 79-1604

ABSTRACT

Field investigations in the Williamsport Valley to identify lineaments found on Landsat III images, have shown the presence of six discrete fault zones that strike subparallel to the trend of the Appalachian folds. These zones range from 0.5 to 1.75 km in width and from at least 10 km to more than 50 km in length. The individual thrust faults within each zone occur in "staircase-type" folds and are at a low angle to bedding. Although each individual fault may have only centimeters to displacement, many of these individual faults appear to exist within the six zones.

We believe that the stress that produced that Valley and Ridge folds to the south was largely dissipated in faulting in the Williamsport Valley. This dissipation of the stress would explain the presence of only broad open folds to the north on the Allegheny Plateau.

The extreme faulting in the Williamsport Valley along with the unique "staircase" and "reverse staircase" structures may result in fracture porosity traps at depth.

INTRODUCTION

The Williamsport Valley (fig. 1) lies between the northernmost anticlines of the Valley and Ridge (Bald Eagle Mountain) and the southernmost syncline of the Allegheny Plateau (Allegheny Ridge). The Valley occupies a unique position in that the area to the south is composed of tightly-folded extensively-faulted anticlines and synclines, whereas the area to the north is composed of broad open folds with little apparent faulting. However, analysis of Landsat images, field investigations, and subsurface data shows that the Allegheny Plateau contains numerous faults (see Pohn and Purdy, 1979).

The area under consideration includes the Cogan station, Montoursville North, and Huntersville 7 1/2-minute quadrangles which were mapped in part by Faill and others (1977). Faill and others interpreted the radical changes in dips as axes of synclines and anticlines. We believe that a different explanation, which will be discussed in the following section is more consistent with the observed changes in dips.

This report briefly describes the presence of six discrete zones of thrust-faulted "staircase-type" folds. These zones appear to be imprinted on a broad synclinal structure which occupies the Williamsport Valley.

FIELD INVESTIGATIONS

We were fiest led to investigate the Williamsport Valley as a result of some conspicuous lineaments seen on Landsat III RBV (Return-Beam Vidicon) images. These lineaments (fig. 2) were observed to be at a slight angle to the trend of both Bald Eagle Mountain and Allegheny Ridge. We suspected that the lineaments might represent fault zones on the ground.

Field investigations were conducted in August and September of 1979 in the Cogan Station, Montoursville North, and Huntersville quadrangles as part of an effort to understand the nature of possible faulting at the flexure point between synclines and adjacent anticlines (Pohn and Purdy, 1979). We first noticed the presence of nearly vertical beds in a roadcut 1 km east of Hepburnville (Cogan Station quadrangle). On further investigation, we found that these vertical beds generally occupied the riser portion of a staircase fold and that these staircase folds appeared in discrete zones at virtually every outcrop along the strike of the beds (fig. 3). Individual steps in a staircase ranges from 3 m high to folds in which the riser portions occupied zones of nearly vertical beds 0.25 km wide (the height of the riser is proportional to its outcrop width). Where these structures are sufficiently well exposed, it could be seen that the shoulder as well as the toe of the riser was cut by numerous thrust faults whose sense of movement was up the staircase (figs. 4a, b and 5). The shoulder of the staircase was fractured but no displacement was discerned (fig. 6). In one place (fig. 3 letter A), the structure defined a staircase descending to the north adjacent to a staircase descending to the south. This unique configuration when seen in its entirety is similar to a stile (fig. 7). The outside of each riser is a series of reverse faults.

The areas between the staircase zones are composed of gently to moderately dipping (5° - 30°) beds and no staircase folds are present. These gently dipping beds define a broad open syncline (the axis of which is coincident with Loyalsock Synclines of the geologic map of Faill and others, 1977), as above.

INTERPRETATION

The sequence of structural events in the Williamsport Valley is interpreted as follows: Early in the Alleghian Orogeny, both the Valley and Ridge and the Allegheny Plateau were composed of broad open folds. The Williamsport Valley was a shallow, symmetric syncline whose steeper limb was to the south. As northwest-directed compression continued from the southeast (more from the south in the Williamsport area) and as the Valley and Ridge began to form the presently observed steep folds, the syncline at Williamsport began to form staircase folds which then failed by forward thrusting and more intense antithetic thrusting. These failures took place in a series of discrete zones (fig. 8). Continued compression in the Valley and Ridge manifested itself as an increase in fracture intensity in the Williamsport Valley until the present configuration was reached. It appears as though the thrusting in the Williamsport Valley might as well account for much of the dissipation of compressional forces that otherwise would have caused the Allegheny Plateau to be as steeply folded as the Valley and Ridge. This dissipation of forces would necessarily lead to a tectonic thickening of strati-graphuc section in the Williamsport Valley, a possibility which may be borne out by seismic investigation.

If the intensity of fracturing in these zones continues downward, the probability of fracture porosity traps at depth appears to be quite good.

FIGURES

Figure 1 Location map showing the position of Williamsport Valley.

Figure 2 Landsat III RBV (Return-Beam Vidicon) images of the Williamsport Valley showing Bald Eagle Mountain and Allegheny Ridge. Ends of lineaments are marked by arrows. A print can be ordered from the EROS Data Center, Sioux Falls, SD frame number 30243-15082C.

Figure 3 Location map of the six staircase-folded thrust-faulted zones in the Williamsport Valley. Heavy arrows indicate the down-staircase direction, light arrows indicate dip of the beds in intermediate zones. Dotted line indicates topographic front of Allegheny Ridge. Light dashed line indicates Loyalsock Syncline axis. Heavy dashed line indicates axis of stile-like double staircase (Letter A).

Figure 4a Photograph of steeply dipping portion of riser in a typical step fold. Arrows indicate thrust faults. Knife in lower center of photograph is 20 cm long.

Figure 4b Photograph of moderately dipping beds at toe of riser. Arrows indicate antithetic fault with approximately 1.5 m displacement. Hat in lower center of photograph is 30 cm along long axis.

Figure 5 Drawing of a typical step fold showing position of thrust faults. Step folds can be 10-300 m long. Morphology of a step fold is in inset.

Figure 6 Photograph of flexure in bedding at head of riser. Note fracture that breaks flexure shows no displacement. Numbers are approximately 10 cm high.

Figure 7 Stile-like double staircase such as seen in figure 3 letter A.

Figure 8 Schematic cross section of the transition zone between the Valley and Ridge and the Allegheny Plateau showing the position of the Williamsport Valley.

REFERENCES

Faill, R.T., Well, R.B., and Sevon, W.D., 1977, Geology and Mineral Resources of the Salladasburg and Cogan Station quadrangles, Lycoming County, Pennsylvania: Pennsylvania Geological Survey Atlas 133cd, p. 2 maps, scale 1:24,000.

Pohn, H.A., and Purdy, T.L., 1979, Décollement in the Southern Allegheny Plateau of Pennsylvania: U.S. Geological Survey open-file report 79-1321, 4 p., 6 figs.

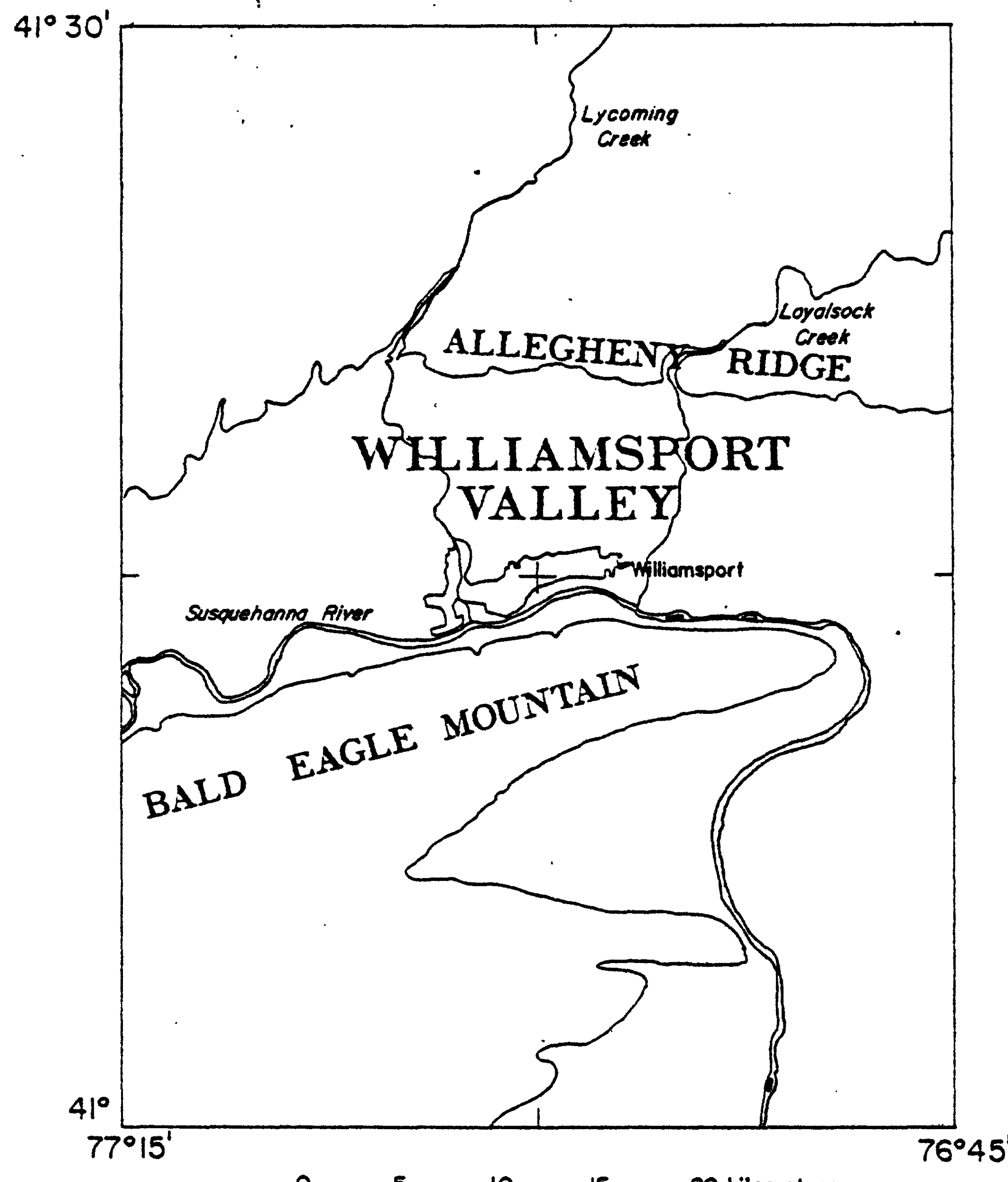

41° 30'
Lycoming Creek
Loyalsock Creek
ALLEGHENY RIDGE
WILLIAMSPORT VALLEY
Williamsport
Susquehanna River
BALD EAGLE MOUNTAIN
41°
77°15'
76°45'
0 5 10 15 20 kilometers

Figure 1

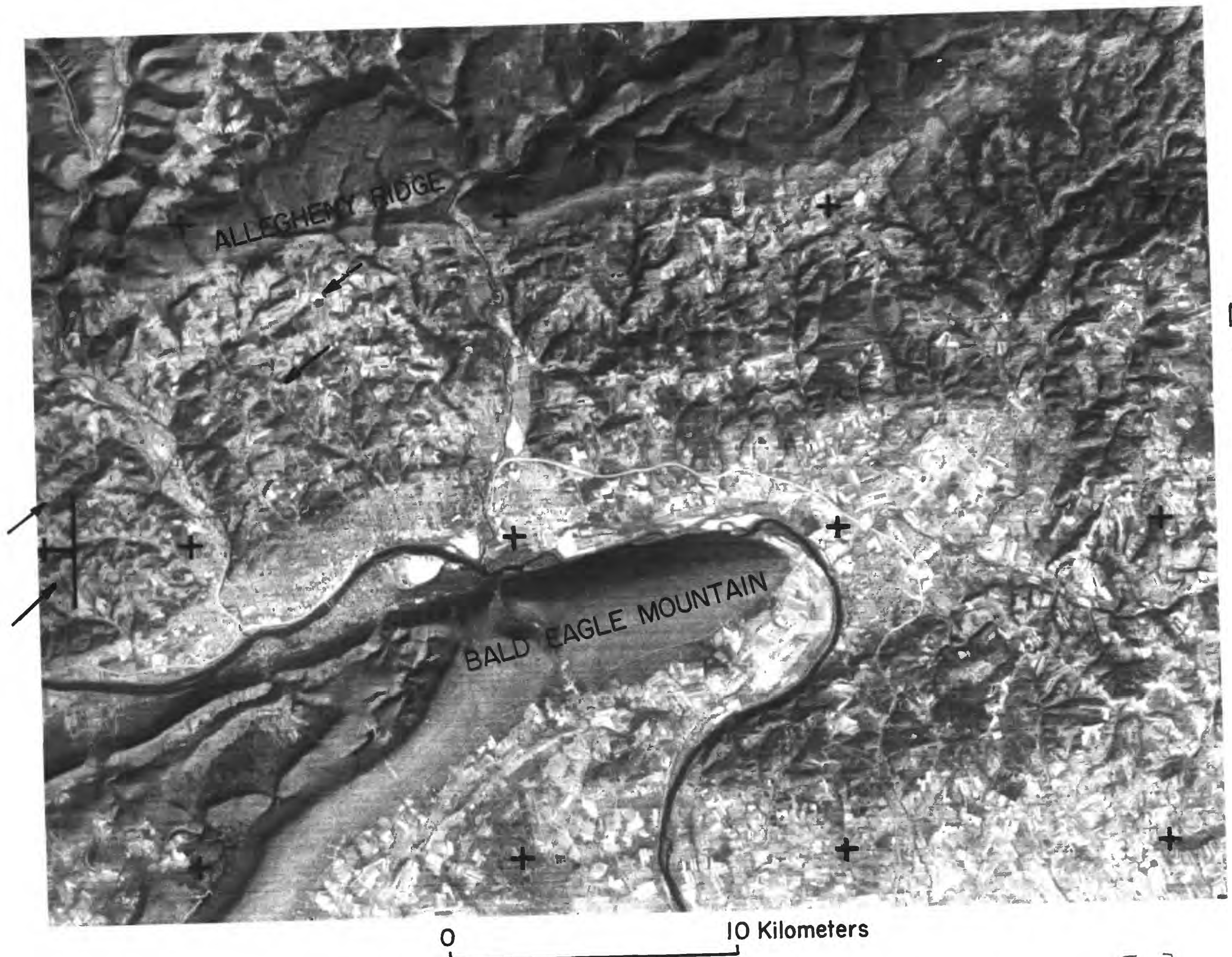


Fig 2

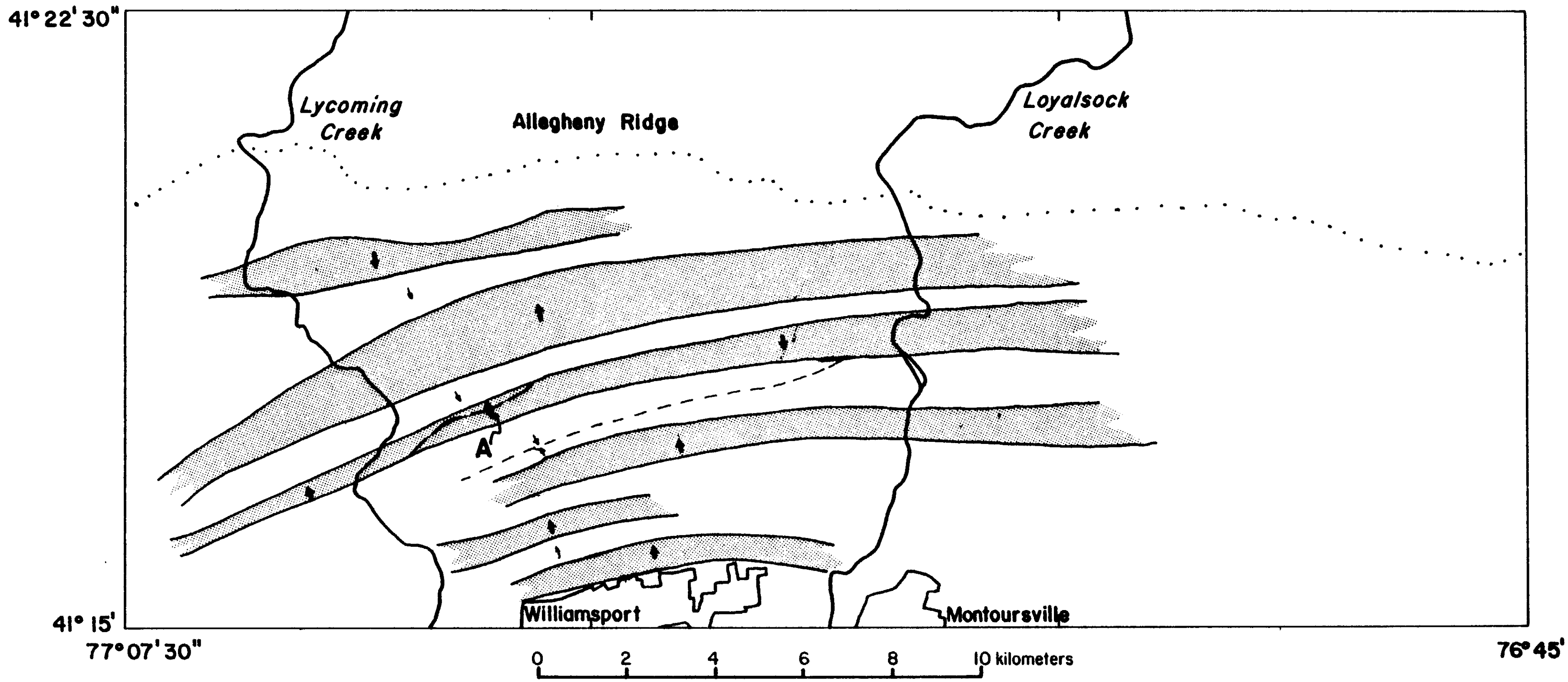
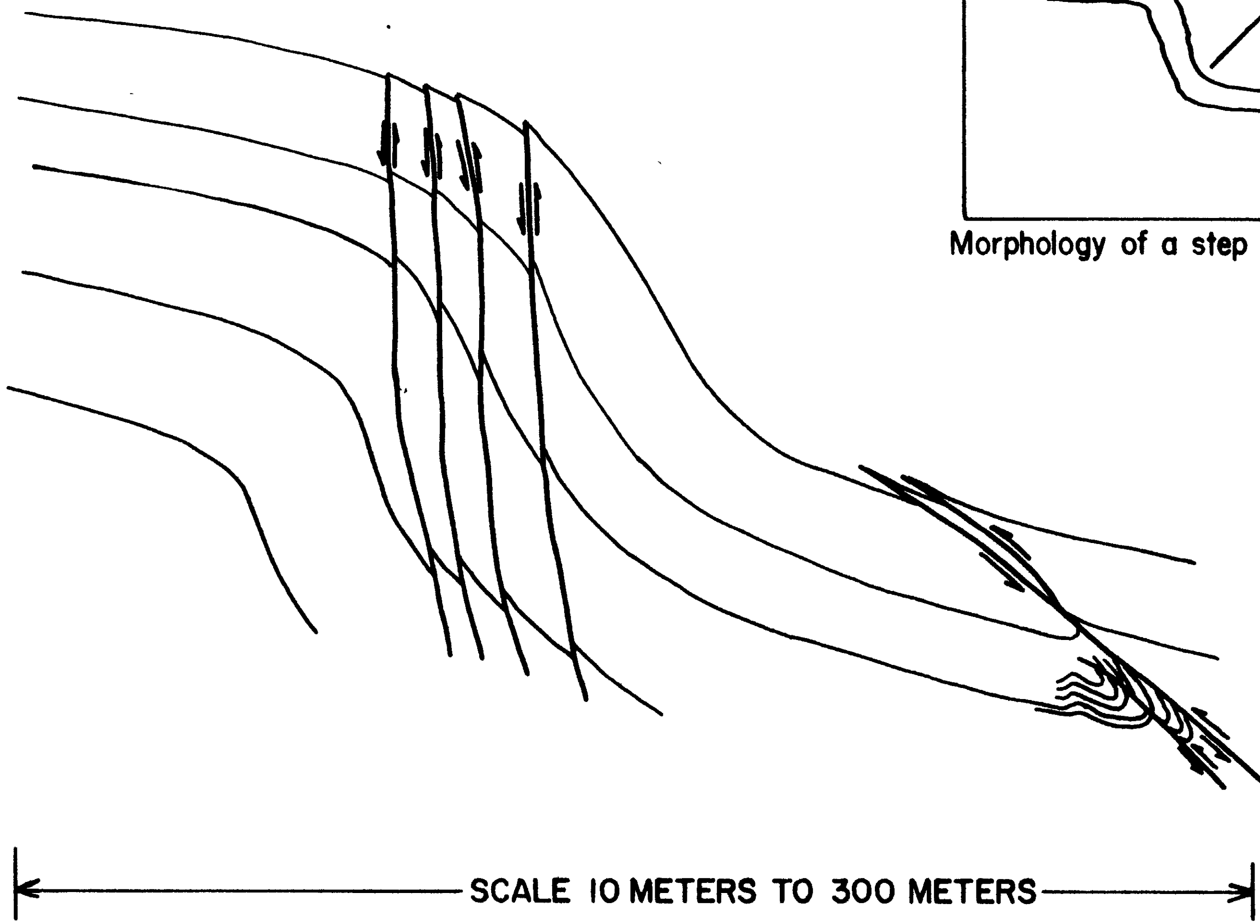

41° 22' 30"
Lycoming
Creek
Allegheny Ridge
Loyalsock
Creek
A
Williamsport
Montoursville
41° 15'
77° 07' 30"
76° 45'
0
2
4
6
8
10 kilometers

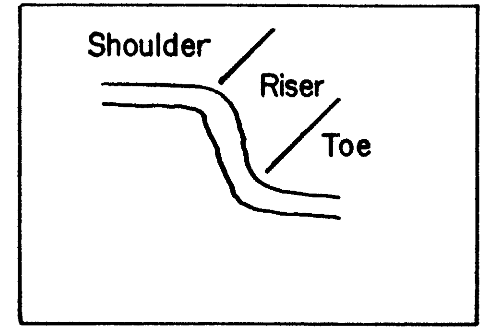
Figure 3

a

Fig 4/a

Fig 4b





Morphology of a step fold

Figure 5

Fig 6

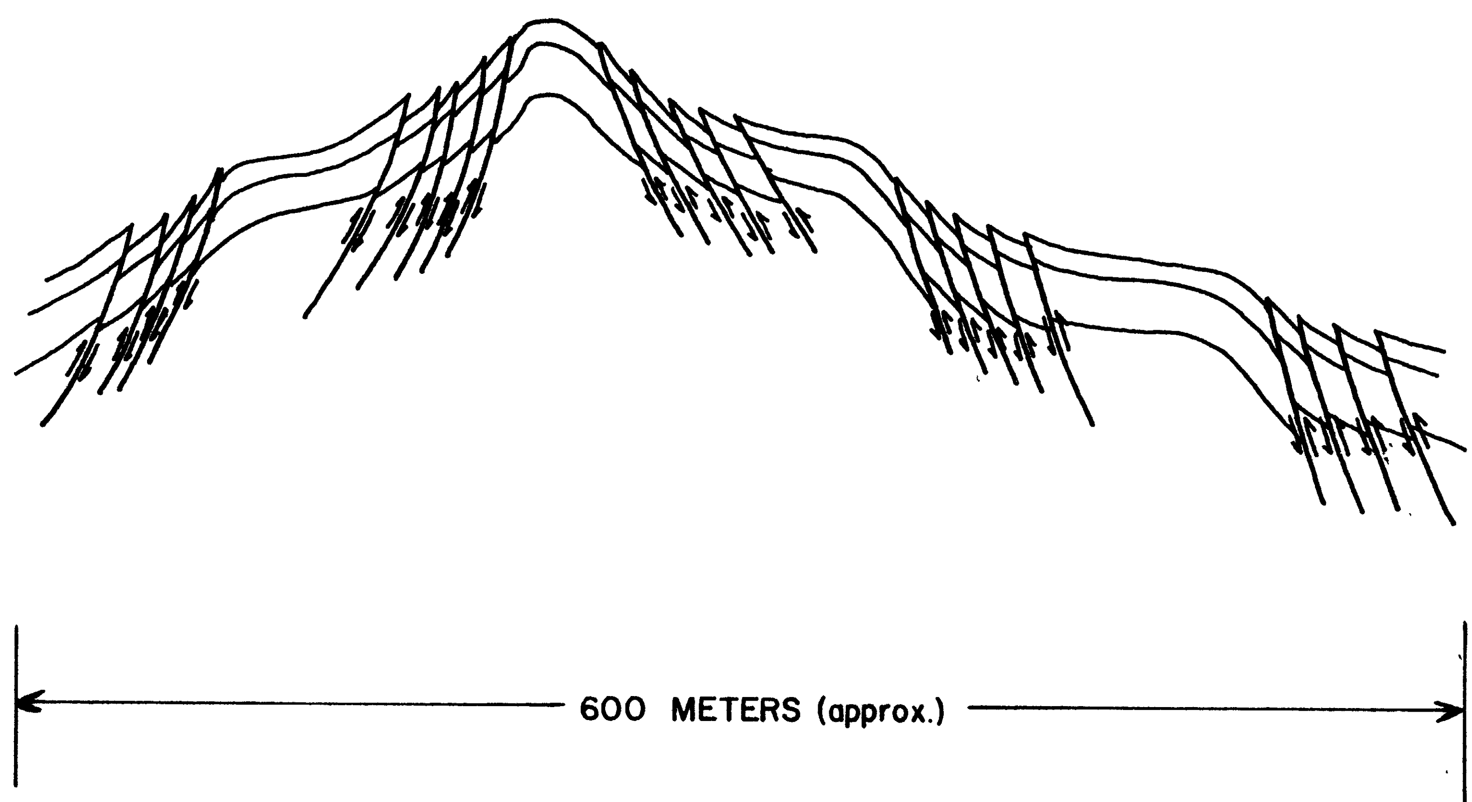
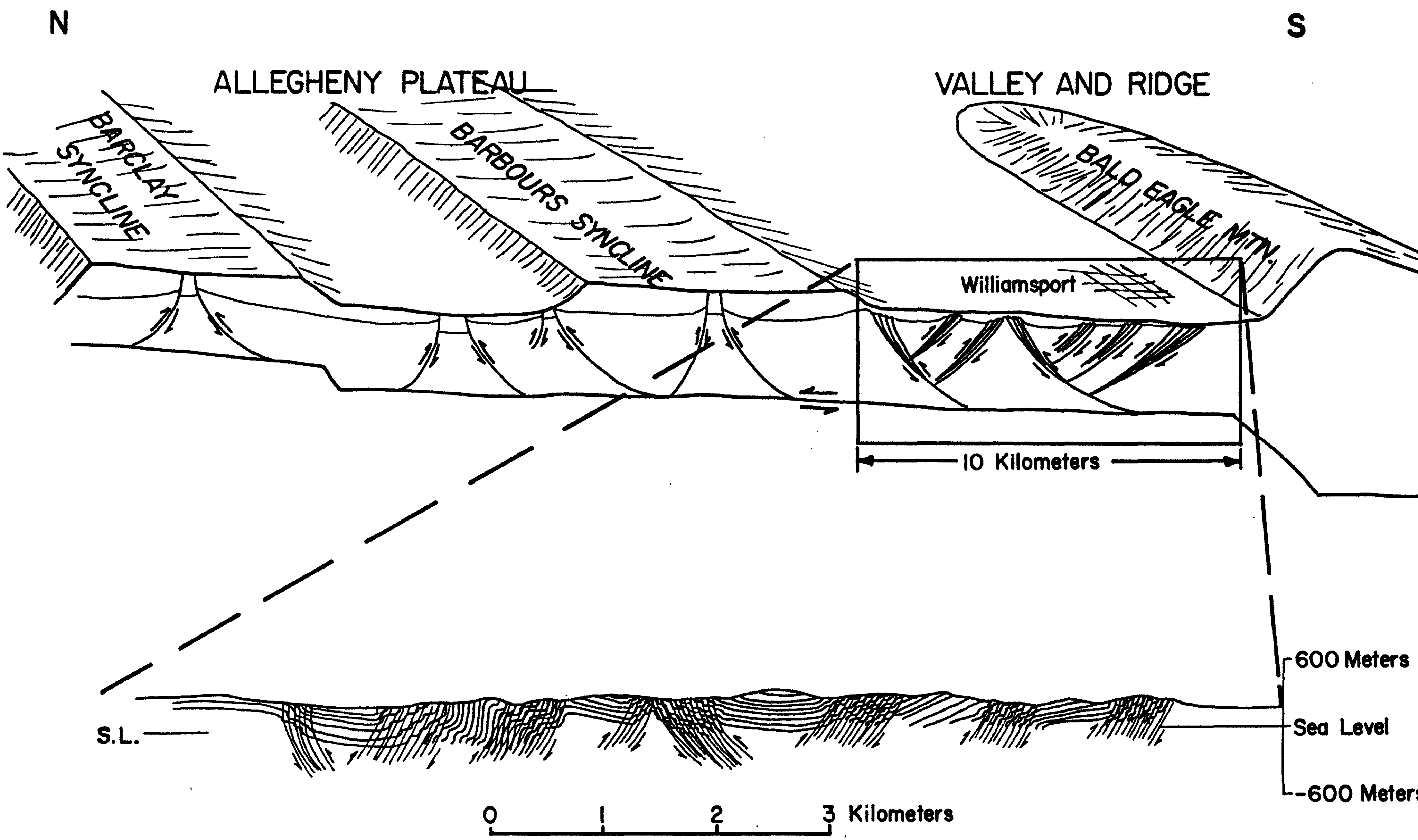


Figure 7


N
S
ALLEGHENY PLATEAU
VALLEY AND RIDGE
BARCLAY SYNCLINE
BARBOURS SYNCLINE
BALD EAGLE MTN.
Williamsport
10 Kilometers
600 Meters
Sea Level
-600 Meters
S.L.
0
1
2
3 Kilometers