Figure 1. A small anticline in a post-glacial valley. Huidekoper's Ravine, Meadville, Pennsylvania.

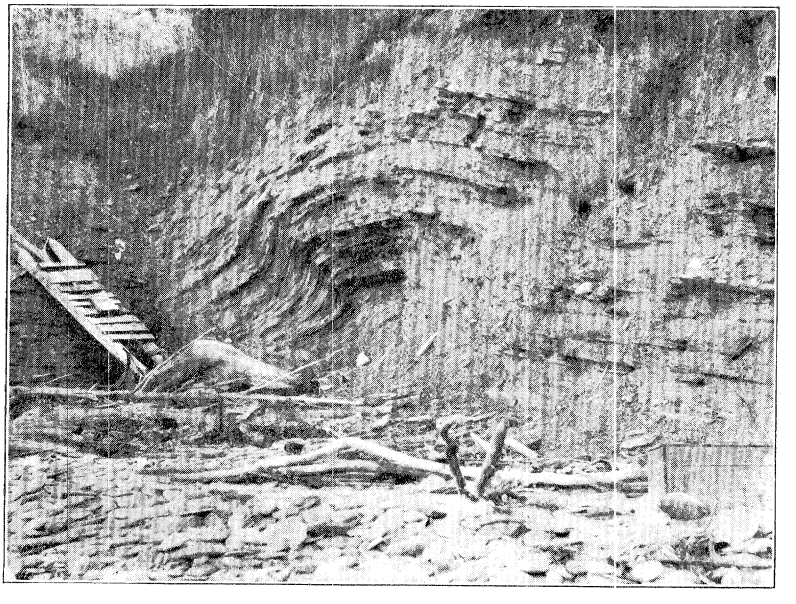

Figure 2. A fold in Portage Flaggs in lake cliff. Three miles east of Erie, Pennsylvania.

RECENT CRUSTAL MOVEMENTS IN THE EASTERN PART OF THE GREAT LAKES REGION

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INTRODUCTION

While in the region of the Great Lakes and along the Atlantic Coast, careful search has been made for even slight vertical movements in recent geological time, little attention has been given to recent tangential movements in either of these areas. The present study has been initiated in the eastern part of the Great Lakes Region to determine the age, distribution, extent, and significance of these tangential movements.

The rocks of northeastern Ohio and northwestern Pennsylvania and New York for the most part appear horizontal. However, a study of their distribution shows a gentle dip toward the southwest[1]. Exceptions to this gentle dip in the way of folds were noted early, and recent study is increasing the number of these exceptions very materially, especially between Cleveland, Ohio, and Westfield, New York.

PREVIOUS STUDY

Hall described and figured some folds in 1843 in northwestern New York[2], and in 1910 Van Horn described some small anticlines in the Chagrin shales near Cleveland, Ohio[3], but neither considered the edge of the folds. Gilbert[4] in 1886 recognized that some folds in northwestern New York were post-glacial, and presented a paper on "Some New Geologic Wrinkles." In 1903 Smallwood and Hopkins[5] described some small anticlines near Meadville, Pennsylvania. While these writers did not specially consider the age of the deformation, recency is implied by the origin assigned for the folds, landslides on the valley walls. However, most of these folds are in no way related to the landslides, and the few that are seem to have no causal relation with them, so an inference of recency because of such relation has little or no force.

AGE OF THE ROCKS

The rocks affected by the disturbances in the area under consideration range in age from Middle Devonian to Lower Mississippian[6].

1. I. C. White: Second Geol. Surv. of Pa., Report Q4, 1881, pp. 44-49.
2. Geol. of Fourth Dist., N. Y., pp. 295-298.
3. Bull. Geo. Soc. America, vol. 21, pp. 771-773.
4. Proc. Amer. Assoc. Adv. Sci., vol. 35, p. 227.
5. Bull. Syracuse Univ., Series IV. No. 1, pp. 18-24.
6. I. C. White, Second Geol. Surv. Pa., Report Q4. pp. 93-119.

CHARACTERISTICS OF THE ROCKS

Shales are the dominant rocks among those exposed in this area. Except for a few sandstones, they are nearly all shales with thin sandstone beds interspersed. The sandstone beds in the shales increase both in number and in thickness in the older formations, so that in the oldest formation, the Portage, flaggy sandstones constitute an important part of the rock, and some of the beds are a foot or more in thickness.

NATURE AND EXTENT OF DEFORMATION

The deformation includes folds and faults. Of the folds there are two types—those with longer axes parallel to the valleys and those with their axes transverse to valleys. These two types are found not together but in different areas. The faults, so far studied, are all thrusts, with possibly one slight exception.

FOLDS PARALLEL TO VALLEYS

The first type of folds noted above consists of small anticlines in the bottoms of valleys that trench the uplands (Fig. 1). These folds involve only a few feet of strata, and rarely affect the walls of the post-glacial valleys in which they are most commonly found. Some of these anticlines are narrow and close, while others are broad and open. They are variable also in length, ranging from a few feet in some instances to over 100 feet in others. While the axes of the folds vary somewhat in direction, most of them trend nearly with the valleys in which they occur. Though the folds seem to have been formed as the valleys developed, no definite evidence of age has been noted in connection with them, and they are small and unimportant when compared with many of the folds of the second type.

FOLDS TRANSVERSE TO VALLEYS

In the second type of folds the axes are chiefly transverse to the valleys, and they affect not only flood-plains, terraces, and walls of valleys, but they occur also in the lake cliffs east of Erie, Pennsylvania. (Fig. 2). Some anticlines occur alone, but frequently several are associated with synclines in a series. These folds commonly involve from 10 to 20 feet, and in some instances 60 to 80 feet, of strata exposed above the stream bed and an unknown amount below it. The folds vary in width from a few feet to over 500 feet. Many folds may be seen distinctly on both sides of a stream.

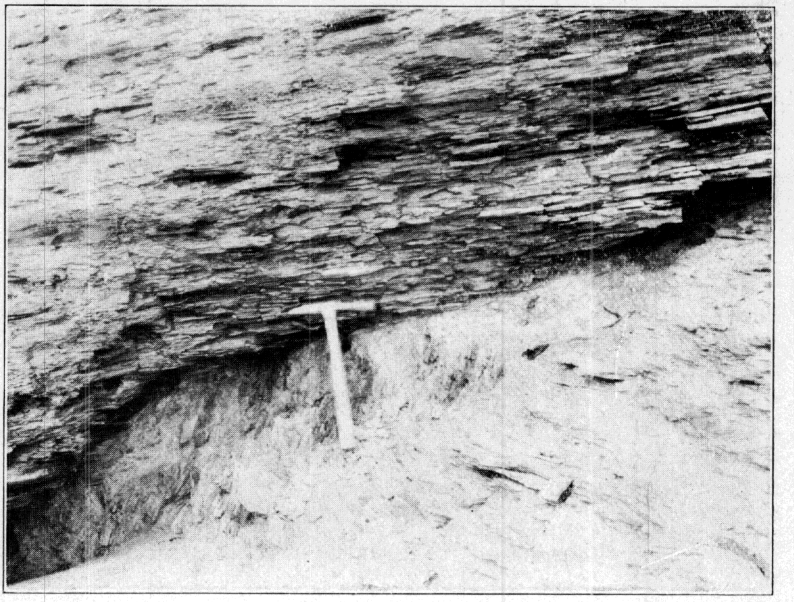

Figure 3. A fault showing brecciated zone with upturned beds still attached to downthrown side. A mile south of Girard, Pennsylvania.

Figure 4. An asymmetrical fold deforming the surface of a forty-foot terrace. A fault below grades into this fold above. Little Elk Creek, five miles south of Girard, Pennsylvania.

THRUST FAULTS

Many of the transverse folds are accompanied by thrust faults. Some faults occur in the middle of an anticline and others at the edge next a syncline. Some faults grade into folds above, others feather out in the loose upper shales, while still others break clear across the strata. Though the displacement of beds is generally less than ten feet, and may be less than a foot, many of the fault planes are marked by distinct brecciated zones. The evidence of overthrust in one of these faults seems very decisive, for the upturned edges of the soft shales are still attached to the ends of the downthrown beds, while the downturned ends on the upthrow side have been broken off and ground fine by the movement of the upthrown rocks over them (Fig 3).

AGE OF FOLDS AND FAULTS

The rocks themselves fix the age of the folds and faults only as later than Devonian or Mississippian, but the relations of these movements to glaciated surfaces, glacial deposits, terraces, and flood-plains, show that many of them are not only post-glacial, but that they are later than the low stream terraces, and that a few of them are even later than the present flood-plains.

The evidence of recency is seen in the rise of the loose top of a fold distinctly above glaciated surfaces on either side (Fig. 2), and in the deformation of glacial deposits above the fold in such a manner that surface drainage has been affected and a recent gully started along the fold parallel to the axis.

Other evidences of recency are found in the deformation of the surface of a terrace by a fold or fault, and in the uneroded condition of the top of fold or fault in a terrace (Fig. 4).

In like manner, the deformation of the surface of a flood-plain by a fold or fault, or the uneroded top of fold or fault in the flood-plain, shows that it is more recent than the flood-plain.

Though not so definite as to time, other evidences of recency are seen in the freshness of the brecciated fault zones and in the unweathered condition of joints near the surface.

CONCLUSIONS

A reconnaisance was made by the writer of parts of the larger streams flowing into Lake Erie from Sandusky, Ohio,

eastward to Westfield, New York. While distinct folds of considerable size were found particularly along the Vermilion and Black rivers in northern Ohio, no evidence of recency was found in connection with any of the folds until in the vicinity of Cleveland. From there eastward through northeastern Ohio and northwestern Pennsylvania and New York the rocks have suffered recent deformation in a manner not duplicated in those in adjacent glaciated areas.

Though these movements have not been studied eastward, there is evidence that they extend much farther in that direction, and some of them have been noted on the north side of the lakes as well.