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LATE NEWARK FAULT VERSUS PRE-NEWARK PENEPLAIN IN CONNECTICUT*

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ABSTRACT. Inferred structural features in south-central Connecticut previously presented in favor of a pre-Newark peneplain have not been confirmed by recent detailed geologic mapping. Part of the western boundary of the east-dipping Newark Group formerly interpreted as an unconformable contact now is known to be a fault of Late Newark or post-Newark age. The irregularity of the boundary near Bethany Mountain is the result of differential erosion where relief on the pre-Newark surface is moderately high. There is no evidence for the oblique faults formerly inferred there to offset a pre-Newark peneplain. An irregular diabase sheet near the base of the Newark Group in that area is clearly dikelike at Bethany Gap and cannot be used as a "marker bed" for recognizing concealed faults.

INTRODUCTION

Purpose.—A fault contact along the western boundary of the east-dipping Newark Group in central Connecticut recently was excavated at the unincorporated community of Mixville near West Cheshire, Connecticut (figs. 1 and 2) and at Marion. Connecticut (fig. 2). The contact, here called the Mixville fault, previously was interpreted as a tilted pre-Newark peneplain. The purposes of this paper are (1) to show that the pre-Newark peneplain hypothesis was based on inferred field relations, which have not been confirmed by recent detailed geologic mapping, and (2) to present a new interpretation of geologic structure in the area where the hypothesis was conceived.

Current geologic mapping.—New data presented here were collected in the course of detailed geologic mapping in the Mount Carmel and Southington quadrangles. Connecticut, from 1957 to 1960. The work was financed jointly by the U. S. Geological Survey and the Connecticut State Geological and Natural History Survey. Mapping was done at scale 1:24.000 on topographic base maps that have a 10-foot contour interval. Interpretation of geologic structure was facilitated by bedrock data obtained from numerous new water wells drilled near the contact between the Newark Group and older rocks.

Acknowledgments.—Mr. Peter S. Ely of Cheshire, Connecticut, helped the writer excavate the fault contacts found at Mixville and Marion, Connecticut. Permission to dig at Mixville was granted by Mr. Joseph Viviano, Vice-President. Consolidated Industries, Inc. Permission to dig at Marion was granted by Messrs. Ivan Schoonmaker. Clark Gould. and Royal J. Lacourciere for the Onlyx Club. Mr. Joseph Novarro, Chief Engineer, New Haven Water Company, gave the writer a copy of the profile of the dam at Lake Watrous in Mount Carmel quadrangle. from which figure 8 was made.

Previous geologic literature.—Numerous references to geologic literature concerning the pre-Newark topography of Connecticut or the interpretation of geologic structure along the western boundary of the Newark Group in the central part of the State are mentioned in the text. Others that might be of interest to the reader are Russell (1892), Tarr (1898) Hobbs (1901, 1902), Rice and Gregory (1906), Emerson (1917), and Reeside and others (1957).

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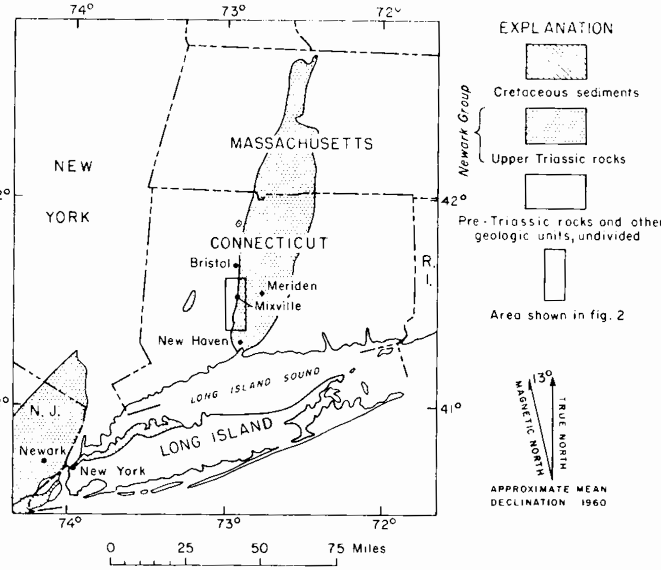

Fig. 1. Map showing the distribution of Upper Triassic rocks (Newark Group) and Cretaceous sedimentary deposits in and near southwestern New England, and the outline of the area shown in figure 2. Geology after Stose (1932) and Platt (1957).

GEOLOGIC SETTING

The Newark Group is a partly preserved, tilted and faulted sequence of continental sedimentary rocks, basaltic lava flows, and intrusive diabase of Late Triassic age. It was named by Redfield (1856, p. 357) for Newark, New Jersey (fig. 1). Isolated remnants of the strata have been found in several places in eastern North America (McKee and others, 1959, fig. 22). The latest consensus is that the sediments accumulated in several separate basins of deposition in a region characterized by moderate to high relief (McKee and others, 1959, p. 1, 13), but some remnants, such as those in central and western Connecticut (fig. 1) formerly were connected (Krynine, 1950, p. 119).

The Newark Group of Connecticut (table 1) is believed to be generally equivalent to the Newark Group of northern New Jersey. The Newark in

TABLE 1

Stratigraphic sequence, Newark Group, Connecticut. Thicknesses are approximate and are based on current detailed geologic mapping as well as on previous geologic literature

	Thickness (feet)
Portland Arkose	4,000+
Hampden Basalt (lava)	200
East Berlin Formation	500
Holyoke Basalt (lava)	350
Shuttle Meadow Formation	100
Talcott Basalt (lava)	150
New Haven Arkose (includes intrusive sheet of nonporphyritic diabase as much as 700 feet thick)	10,000+

Connecticut contains strata younger than some of the Newark exposed farther south (McKee and others, 1959, table 1). The age of faults that offset the group in Connecticut, therefore, is Late Newark or post-Newark. It is believed that the faulting occurred in Late Triassic or perhaps Early Jurassic time.

Sedimentary rocks of the Newark Group in the Mount Carmel and Southington quadrangles are part of the New Haven Arkose, which consists of interbedded conglomerate arkose and arkosic siltstone. The sedimentary

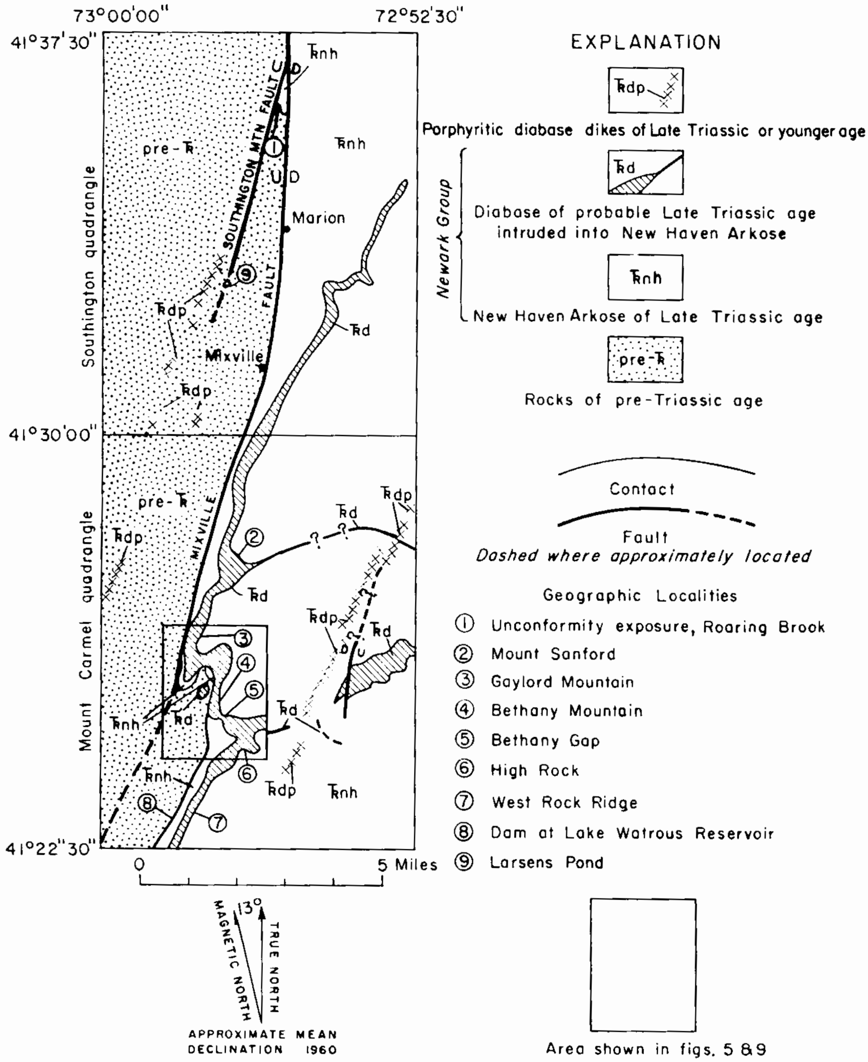

Fig. 2. Map of Mount Carmel and Southington quadrangles, Connecticut, showing generalized bedrock geology, the geographic localities mentioned in the text, and the outline of the area shown in figures 5 and 9. Based on detailed geologic mapping by C. E. Fritts, 1957-1960.

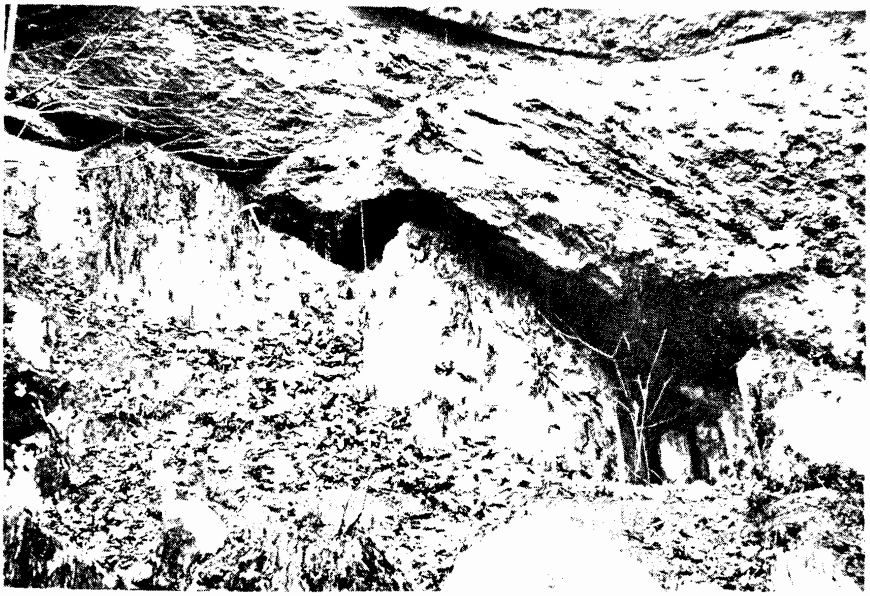

Fig. 3. Photograph of unconformity, north bank of Roaring Brook, Southington quadrangle, Connecticut. New Haven Arkose of Late Triassic age overlies fresh staurolite-bearing schist of pre-Triassic age. Hammer gives scale.

rocks were derived from the pre-Triassic rocks of eastern Connecticut, which were elevated relative to the Triassic strata by recurrent displacement along a fracture known as the Great fault (Krynine, 1950, p. 193). Bedding planes originally were gently inclined toward the west, but they now strike nearly northward and dip toward the east at 10° to 35° as the result of tilting and faulting during and after deposition.

The only igneous rocks younger than the New Haven Arkose in the Mount Carmel and Southington quadrangles are diabase intrusives. Nonporphyritic diabase forms an irregular sheet as much as 700 feet thick and several smaller bodies. The main sheet is sill-like in some places and dikelike in others. It is at least 15 miles long. Porphyritic diabase forms a system of widely spaced, discontinuous, nearly vertical dikes as much as 100 feet wide, which are younger than the bodies of nonporphyritic diabase (Hawes, 1875, p. 188). Some porphyritic dikes were intruded along faults that offset most, if not all, of the Newark strata in Connecticut.

Till of Pleistocene age and younger surficial deposits mantle Connecticut. Geologic units younger than the Newark Group and older than the till have not been found, although it is possible that sediments of Cretaceous and Tertiary ages once covered much of the State (Davis, 1898, p. 165).

Topography in the report area is only moderately rugged. Altitudes range from near sea level to a little more than 1000 feet. In general, relief is low in areas underlain by New Haven Arkose, and higher in areas underlain by large diabase intrusives or rocks of pre-Triassic age.

PRE-NEWARK PENEPLAIN AND RELATED STRUCTURAL INTERPRETATIONS

Origin of peneplain concept.—The peneplain concept originated with Davis (1889, p. 430; 1898, p. 20, 166; 1899, p. 216). Theoretically, a peneplain is a nearly flat surface of regional extent formed close to sealevel as a result of erosion mainly by running water. At the time of completion, a peneplain supposedly is characterized by (1) relief of perhaps several hundred feet in distances of fives or tens of miles, and (2) deep local soils, which grade into firm rock at depths of 30 to more than 50 feet. The theory was conceived in order to explain the apparent accordance of summits in eastern North America, which were interpreted as remnants of a peneplain formed in Cretaceous time. A pre-Triassic or pre-Newark peneplain was inferred by Davis and Loper (1891, p. 416), because the western boundary of the east-dipping Newark Group in central Connecticut is nearly straight, and an unconformity at the base of the Newark strata is exposed at Roaring Brook (figs. 2 and 3).

Structural interpretations by Davis.—Structural geology in central Connecticut first was studied systematically by W. M. Davis from 1885 to 1893, after reconnaissance in 1882. He was assisted by several men, including J. A. Merrill from 1889 to 1891 and L. S. Griswold from 1891 to 1893 (Gregory and Robinson, 1907, p. 23, 24). Both studied the western boundary of the Newark Group. Merrill discovered the unconformable contact at Roaring Brook (Davis, 1898, p. 19), and Griswold mapped the area between Gaylord Mountain and High Rock (Davis, 1898, p. 17, 185).

Davis' work was important for two main reasons. He recognized that (1) the Newark Group contains three extrusive igneous units, which facilitate structural interpretations, and (2) the stratigraphic succession, especially near Meriden, Connecticut (fig. 1), is repeated by high angle faults of general northeast trend, which underlie valleys between prominent ridges of tilted lava. Interpretation of field relations along the western boundary of the Newark Group was based partly on the inference that high-angle faults also underlie valleys between ridges formed by nonporphyritic diabase intruded into the lower part of the New Haven Arkose.

In 1887 Davis (1888, pl. 52) compiled a generalized geologic map of central Connecticut based in part on remarkably detailed mapping by Percival (1842). The entire western limit of the Newark Group was shown as an unconformable contact, but Davis (1888, p. 463) emphasized that field relations north of West Rock Ridge (fig. 2) had not been studied carefully. He may have been unaware that Richardson (1854) and Silliman and Whitney (1855) already had described field relations at the Bristol Copper Mine near Bristol, Connecticut (fig. 1), where the contact between the Newark Group and older rocks could be interpreted as a fault.

Near the middle of the Mount Carmel quadrangle the western boundary of the Newark Group is not straight (fig. 2). The irregularity of the boundary in the area between Gaylord Mountain and High Rock was attributed to faulting (Davis and Griswold, 1894, fig. 1, p. 525, 527; Davis, 1898, p. 123, 124). Two principal high-angle, oblique faults of northeast trend, about a mile apart, were inferred to offset the pre-Triassic peneplain proposed by Davis and Loper (1891, p. 416). On the basis of indirect evidence, the faults were "traced" 35 to 40 miles across central Connecticut. The inferred structure was called the Lamentation block (fig. 4), named for Lamentation Mountain near its geographic center. The estimated throw on the northern fault was 2000 to 3000 feet, and the estimated throw on the southern one was 1300 to 2000 feet.

This interpretation of geologic structure was shown by Davis (1898, pl. 19) on his final map of central Connecticut at scale 1:126,720. The possibility that the relatively straight western limit of the Newark Group north and south of Roaring Brook is a fault was rejected (Davis, 1898, p. 25). An enlargement of the area between Gaylord Mountain and High Rock (Davis, 1898, fig. 33) showed an unconformable contact (tilted pre-Newark peneplain) offset by the two faults inferred earlier and several others of similar trend but smaller throw (fig. 5).

Interpretations by others.—The concept of a pre-Triassic or pre-Newark peneplain in Connecticut was accepted by several subsequent workers. The " . . . straightness and planeness . . . " of the tilted pre-Newark surface was mentioned by Barrell (1915, p. 32), and the peneplain was mentioned specifically by Foye (1922, p. 691) and Krynine (1950, p. 52). Wheeler (1937, p. 52) proposed that the peneplain formerly extended 1200 miles or more from South Carolina to Nova Scotia.

Except for the Lamentation block (fig. 4), many of the faults inferred by Davis and Griswold (1894) and Davis (1898) also were accepted by subsequent workers. Oblique faults were inferred in the area between Gaylord Mountain and High Rock on maps by Longwell and Dana (1932, pl. 1), Longwell (1933a, pl. 15), Wheeler (1937, pl. 1), Krynine (1950, map in pock-

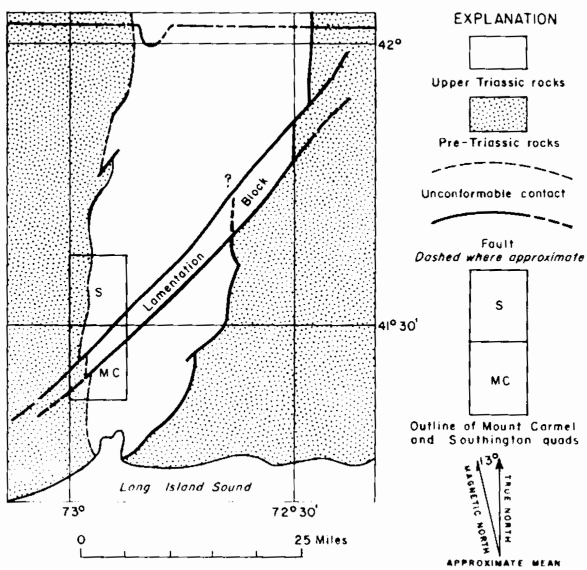

Fig. 4. Simplified geologic map of central Connecticut showing Lamentation block inferred by Davis and Griswold (after Davis, 1898, fig. 25, p. 123). Outline of Mount Carmel and Southington quadrangles also indicated.

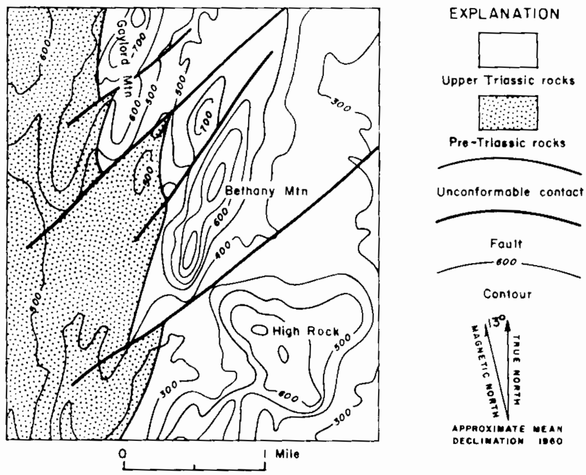

Fig. 5. Generalized geologic map of area between Gaylord Mountain and High Rock, Mount Carmel quadrangle, Connecticut, showing faults inferred by Davis and Griswold (after Davis, 1898, fig. 33, p. 132).

et). R. J. Ross, Jr. (1950, written communication), and Rodgers, Gates, and Rosenfeld (1959). The Lamentation block, however, was shown only by dashed lines on the first three maps, and it was not shown completely on the last three.

The first significant change in the interpretation of geologic structure along the western boundary of the Newark Group in central Connecticut was discussed by Longwell (1933b, p. 112). He proposed that the New Haven Arkose and rocks of pre-Triassic age are in fault contact a few hundred feet west of the unconformity exposure at Roaring Brook. He showed a fault as the western boundary of the Newark Group from the vicinity of Bristol, Connecticut (fig. 1) to a point about 3 miles south of Roaring Brook (Longwell and Dana, 1932, pl. 1; Longwell, 1933a, pl. 15).

Wheeler (1937, p. 18-28, pl. 1) was influenced strongly by Longwell's interpretation, and he extended the fault southward to a point about one mile north of Mixville, Connecticut, where he showed an unconformable contact at the base of the Newark Group diverging toward the south-southwest away from the fault. From that point southward to New Haven the western boundary of the Newark Group was interpreted as a tilted pre-Newark peneplain, except where offset by inferred diagonal or oblique faults. His conclusions were discussed briefly by Longwell (1938).

Field relations in the vicinity of Roaring Brook were studied next in 1950 in preparation for the 1956 preliminary geologic map of Connecticut (Rodgers, Gates, Rosenfeld, 1959). At that time, the western limit of the Triassic rocks of central Connecticut was studied briefly by Reuben J. Ross, Jr. (written communication), then of Wesleyan University. He was accompanied in the field by Chester R. Longwell. They showed that the fault west of the unconformity exposure at Roaring Brook trends toward the south-southwest (parallel to a fault-line scarp) rather than southward. Thus, it cannot be the western limit of the Newark Group south of Roaring Brook. Once again, in the absence of a similar fault-line scarp and exposures of a fault contact along the western boundary of the Triassic rocks south of Roaring Brook, the boundary from Roaring Brook to New Haven was interpreted as an unconformable contact offset in some places by inferred diagonal faults.

NEW DATA

Mixville fault.—The Mixville fault was uncovered in July 1959 on the north bank of Ten Mile River about 700 feet northeast of the intersection of Mixville and Marion Roads at Mixville, Connecticut (fig. 2). Previously granodiorite gneiss of pre-Triassic age and New Haven Arkose cropped out about 17 feet apart, but the exposures had not been mentioned in geologic literature. The fault is immediately west of the arkose outcrop (fig. 6). Local strike of the contact is about N 20° E. but the regional trend here is closer to N 10° E. The fault is nearly vertical where exposed, but the dip at depth is uncertain. Nearly vertical striations on a slickensided joint in the arkose near the fault (fig. 6) suggest nearly vertical displacement, but they are considered inconclusive evidence. Similar slickensided joints are common in the arkose away from the fault. Where exposed, the fault lacks striations.

The fault zone here is characterized by well indurated arkose, as much as 10 inches of gouge, and about 16 feet of altered gneiss. The gneiss is so thor-

Fig. 6. Photograph of excavation, north bank of Ten Mile River, Southington quadrangle, Connecticut. Granodiorite gneiss on left is in fault contact with New Haven Arkose on right. The contact is nearly vertical but seems to dip steeply westward in photograph because of slope of stream bank. Notice altered gneiss (light gray, above trenching shovel) slumped over well indurated arkose. Nearly vertical striations on slickensided joint in arkose can be seen east of pail. Hunting knife and prospecting pick have been driven into thoroughly altered gneiss. One-foot rule below and to right of pick handle rests on altered gneiss near gouge.

oughly altered that a shovel or knife blade can be passed through it easily. For about 1½ feet west of the gouge, foliation in the gneiss has been destroyed by brecciation, alteration, and shearing. East of the fault, altered gneiss and overlying unconsolidated materials of Pleistocene and Recent ages are slumped over arkose (fig. 6), indicating that the fault is oblique to the streambank or is slightly offset along another fracture parallel to the joint shown in figure 6.

Alteration of the gneiss is the result of hydrothermal activity rather than weathering. The fresh gneiss is medium grained and is composed mainly of calcic oligoclase, quartz, biotite, and microcline in the approximate ratio 9:5:4:1. Sphene, garnet, apatite, and zircon are accessory minerals. Where the rock is most thoroughly altered, however, the following changes have occurred: (1) oligoclase has been converted to a mixed-layered mica-montmorillonite composed of iron muscovite and montmorillonite in the approximate ratio 8:2 (Theodore Botinelly, U. S. Geological Survey, oral communication); (2) tiny hematite crystals have formed in biotite; (3) chalcedony occupies spaces between parts of broken biotite crystals, but medium-grained quartz is absent; (4) sphene is partly altered and is much less abundant than in the fresh rock; (5) garnet and apatite are broken, but still can be identified optically; (6) zircon is euhedral, but contains unidentified dark inclusions.

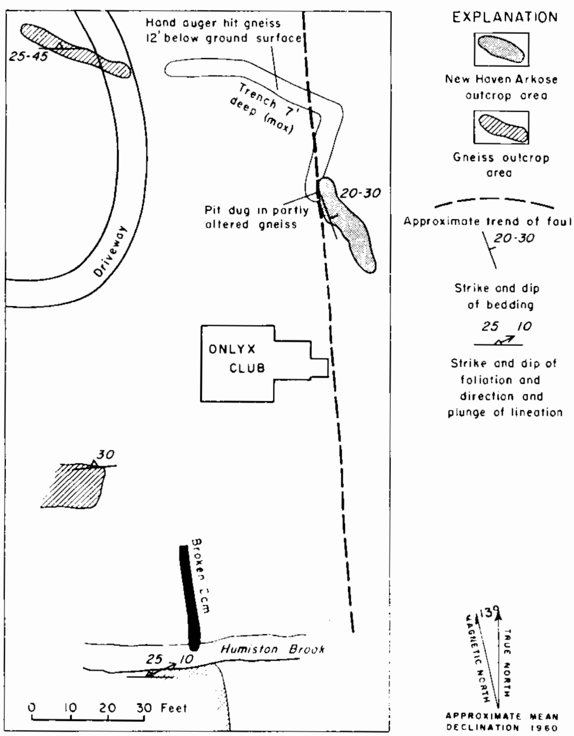

Fig. 7. **Sketch map showing geologic relations and excavation** near Onlyx Club cabin, north bank of Humiston Brook, Marion, Connecticut, 1959.

The Mixville fault was observed also in August 1959 at Marion, Connecticut (fig. 2). but the excavations there (fig. 7) have been filled. Gneiss and arkose crop out about 60 feet apart approximately 100 feet north of Humiston Brook and 250 feet east of the Defashion Street Bridge. A trench on a wooded knoll between the exposures reached bedrock only near the gneiss outcrop. but the fault was exposed in a pit dug through blocky till and tree roots immediately west of the arkose outcrop. Where observed. the fault strikes about N 5° W but the regional trend here is N 0° to 5° E. The contact dips about 35° E. but it was exposed for only 2½ feet along strike and 2 or 3 feet downdip. The dip at depth is unknown. but the fault is believed to be normal.

The fault zone at Marion is characterized by well indurated arkose. as much as 1½ inches of gouge. and several feet of altered gneiss. Alteration here was similar to but less complete than alteration at Mixville. Nevertheless. the gneiss exposed in the pit was penetrated easily by a hand auger to a depth of at least 2¼ feet. Randomly oriented slickensided joints in the altered rock could be traced for only a few inches and gave inconclusive evidence of displacement. The gouge was slickensided but lacked striations or grooves that might have indicated the direction of displacement.

The Mixville fault apparently passes about 1000 feet east of the unconformity exposure at Roaring Brook (fig. 2) and may continue northward at least as far as the abandoned Bristol Copper Mine a few miles north of Bristol. Connecticut (fig. 1), although it may join. offset. or be offset by other faults. The contact between the New Haven Arkose and older rocks at the mine is a normal fault. which Bateman (1923. p. 128) called the Bristol fault. The contact strikes toward the north northeast. and mine records dated 1895 indicate that it dips eastward at about 68° (Bateman. 1923. fig. 26. p. 129). The fault zone is characterized by indurated arkose, clayey gouge. and from 27 to more than 50 feet of altered schist and gneiss so soft that it could be removed without blasting (Silliman and Whitney, 1855, p. 364. 366). In addition to chalco-

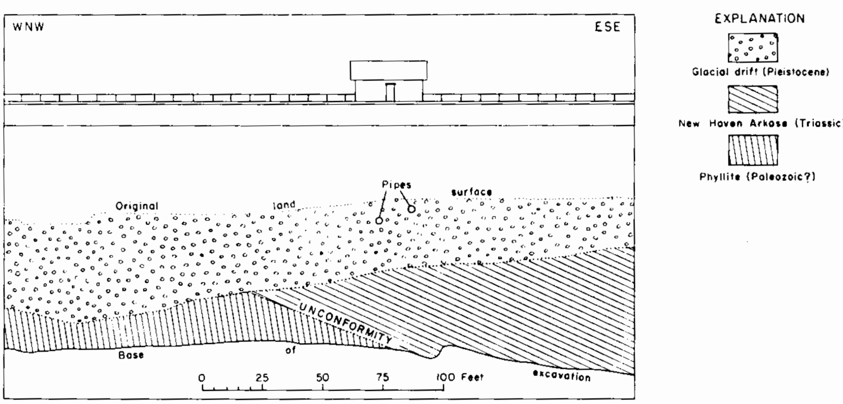

Fig. 8. Partial profile, Lake Watrous dam, Mount Carmel quadrangle, Connecticut, showing materials excavated and attitude of unconformity beneath New Haven Arkose. Modified from profile by engineers of the New Haven Water Company, dated January 1915. Ruled lines indicate approximate attitude of bedding planes in arkose and foliation planes in underlying phyllite, based on geologic mapping by C. E. Fritts, 1957.

cite. which probably was deposited after most of the faulting. garnet and tourmaline are the only minerals in the soft material that were not altered.

The throw or vertical component of displacement on the Mixville fault could be measured most accurately by means of drilling or seismic surveys near the unconformity exposure at Roaring Brook. because New Haven Arkose lies on both sides of the fault in that area. So far this kind of measurement has not been attempted. but reconnaissance gravity surveys by Martin F. Kane and Donald L. Peterson of the U. S. Geological Survey were made in June 1960 near Mount Sanford and Marion. Connecticut (fig. 2). and in two places near Bristol. Connecticut (fig. 1). The data collected indicate that the throw probably is several hundred feet rather than several thousand. Mine records indicate a minimum throw of 360 feet on the fault at the Bristol Copper Mine (Bateman. 1923. fig. 26. p. 129).

Southington Mountain fault.—The fault west of the unconformity exposure at Roaring Brook (fig. 2) is referred to here as the Southington Mountain fault. because the fault-line scarp near it forms the eastern face of Southington Mountain. This fault has been mapped by the author south-southwestward for at least five miles. It probably is either continuous with or nearly parallel to a fault exposed in 1960 in a new roadcut on Interstate Route 84 just south of Larsens Pond in Southington quadrangle. The exposed fault dips eastward at about 60° and is normal. For about three-fourths of a mile north of Roaring Brook the Southington Mountain fault is the western boundary of the Newark Group (fig. 2), but it is uncertain whether this fault joins. cuts. or is cut by the Mixville fault north of Roaring Brook.

Unconformity near New Haven. Connecticut.—For approximately 11 miles north of Long Island Sound near New Haven. Connecticut. the western boundary of the Newark Group is an unconformable contact. It was excavated in the 1880's at a dam site at Dawson Lake about one-half mile south of Mount Carmel quadrangle (Wheeler. 1937, p. 15), but written records of the field relations uncovered are not available. The contact was excavated again in 1914 at a dam site at Lake Watrous (fig. 2). A profile of the younger dam (fig. 8) indicates that the unconformity there dips toward the east-southeast at about $21\frac{1}{2}°$. but it was exposed for only 60 to 65 feet downdip. The profile and written descriptions of the excavation in the New Haven Water Company's reports give no indication of deep weathering on the pre-Newark surface. but the descriptive material is incomplete from the geologic point of view.

Relief on pre-Newark surface.—In the area between Gaylord Mountain and High Rock (fig. 9) the oblique faults inferred by previous authors are unnecessary for a reasonable interpretation of field relations. and direct evidence for the faults has not been found. Diabase cuts across bedding in the New Haven Arkose at Bethany Gap and obviously is dikelike rather than sill-like. Thus. if the intrusive is known to change stratigraphic position. it cannot be used as a marker bed for the purpose of recognizing concealed faults. The small masses of diabase between Gaylord and Bethany Mountains are medium grained at their summits and fine grained below. They rest on phyllite of pre-Triassic age and can be interpreted as remnants of a diabase sheet that former-

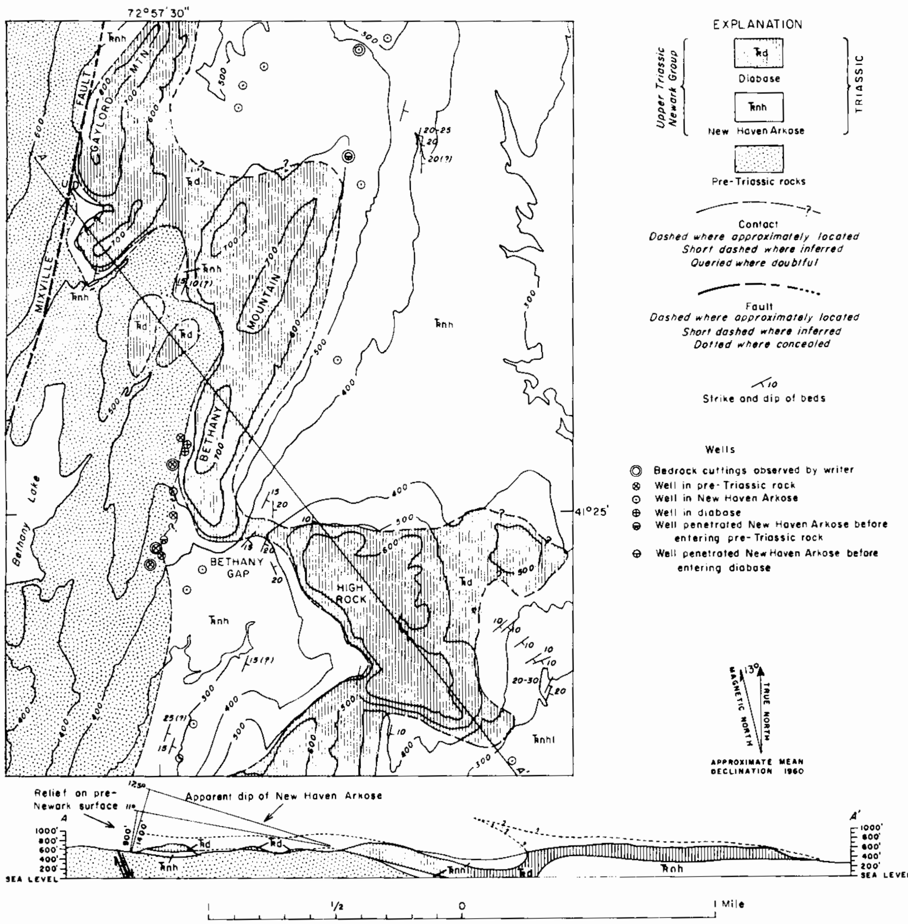

Fig. 9. Simplified geologic map and cross section of area between Gaylord Mountain and High Rock, Mount Carmel quadrangle, Connecticut, based on detailed geologic mapping by C. E. Fritts, 1957 and 1958.

ly extended across the area between the two mountains (Percival, 1842, p. 20, 402, 403). A cross section (fig. 9) shows that a single sheet of diabase can be projected from Gaylord Mountain to High Rock without the need for faults in valleys between ridges on which diabase is exposed.

Relief on the pre-Newark surface west of Bethany Mountain is approximately 1,000 feet in a distance of a little less than 1 mile, according to the cross section (fig. 9). This estimate is based on the assumption that the plane of section is approximately 45° to 60° from the strike of bedding in the New Haven Arkose. The most reliable measurements made in the field indicate that the average dip of the bedding is 15° to 20°. The best estimate of apparent dip, therefore, is 11° to 17.5°, for which the cross section indicates that relief on the pre-Newark surface is 900 to 1400 feet.

CONCLUSIONS

On the basis of current geologic mapping in south-central Connecticut the following conclusions are justified:

(1) Indisputable evidence of a pre-Newark peneplain is lacking in Connecticut.

(2) Relief on the pre-Newark surface near Bethany Mountain is higher than that proposed by advocates of the peneplain hypothesis.

(3) Recognition of moderately high relief on the pre-Newark surface will affect measurements of the thickness of the New Haven Arkose as well as the interpretation of the original regional distribution of the formation.

(4) Part of the western boundary of the Newark Group in south-central Connecticut is formed by faults of late Newark or post-Newark age.

(5) All parts of the western boundary of the Newark Group in central Connecticut formerly interpreted as the trace of a tilted pre-Newark peneplain should be reexamined.

(6) The unconformable contact at the base of the New Haven Arkose at Roaring Brook is the western boundary of the Newark Group for only about three-fourths of a mile in that area, but a similar contact probably extends from Bethany Mountain 11 miles southward to Long Island Sound.

(7) Further geophysical work is warranted in order to obtain more information about throw along faults in central Connecticut.

(8) Copper mineralization similar to that at the Bristol Copper Mine may have occurred elsewhere along the Mixville fault.

(9) Faults should not be inferred in valleys between ridges of intrusive diabase unless the stratigraphic position of the diabase is known to be constant. or unless it can be proved that contacts have been offset.

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