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Late Triassic Volcanism in the Connecticut Valley and Related Structure

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Trip C-5

LATE TRIASSIC VOLCANISM IN THE CONNECTICUT VALLEY AND RELATED STRUCTURE

by

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The volcanic rocks in the Connecticut Valley consist of basalts with typically uniform composition. Because of the general homoclinal eastward dip of the Triassic Newark Formation, the basaltic flows are exposed in a north-trending zone in the center of the rift valley. The trend of this zone is locally interrupted by faulting and changed by folding. Three lava-flow units can be distinguished, from oldest to youngest respectively: the Talcott, the Holyoke, and the Hampden volcanic units. The complexity and thickness of the units increase from the north southward. This is best illustrated by the Talcott volcanic unit, which consists of four flows (total thickness, including intercalated sediments, about 500 feet) in the southern part of the rift valley and only one flow (thickness 50 feet) in the northern part.

As shown by Chapman's (1965) study of the Hampden volcanic flow unit, apparently massive flows have a complex texture. Chapman recognized eight distinctive sheets in the Hampden basalt, which could be correlated over some 20 miles from Berlin to Tariffville. The origin of these sheets is still obscure. They might have been formed by magmatic segregation during laminar flow of the lava.

Chemical analyses indicate that slight differences occur in the distribution of the major oxides. The silica-content of the Hampden flow(s) is less than that of the older volcanic units. The decrease in silica appears to be associated with an increase in total iron. Hanshaw and Barnett (1960) have shown significant differences in the distribution of trace elements. The boron content of the Hampden flow(s) averages much higher than that of the older basalts.

The intrusive masses occur dominantly along the western boundary of the valley and in its southern part. Because of the rather peculiar distribution of the intrusives, the New Haven Arkose (oldest sedimentary member of the Newark Formation) is usually the host rock. The intrusive basalts crop out either as massive dikes and sills, or as normally sized dikes. The latter are relatively rare in the valley. According to Mudge (1968), most larger concordant igneous masses that occur in relatively flat-lying sedimentary formations were intruded at depths ranging from 3000 to 7500 feet. These values are in good accordance with those estimated for the total stratigraphic thickness of the sediments overlying the sills in the Connecticut Valley.

So far it has not been possible to correlate the different lava-flow units and their intrusive counterparts by using petrologic methods. A paleomagnetic analysis of the basalts has shown that it is possible to differentiate and correlate different volcanic units by measuring their remanent magnetization. Four late Triassic-early Jurassic volcanic events can be distinguished paleomagnetically, from oldest to youngest respectively: the Talcott, the Holyoke, the Hampden, and the Higganum events. By means of their characteristic remanent magnetization it is possible to relate the following intrusive and effusive basalts (de Boer, 1968).

	Talcott event	Holyoke event	Hampden event	Higganum event
effusive	Talcott flow(s)	Holyoke flow(s)	Hampden flow(s)	---
intrusive	---	Mt. Carmel sill	Cheshire dikes	Higganum dike sy
		West Rock sill		Bridgeport dike system
		Barndoor sill		Foxon-Fair Haven dike system

Paleomagnetic correlation of these events with similar volcanic periods in the Appalachians indicates that the late Triassic volcanic activity was close to a one-phase event.

Most of the larger intrusives and the most massive flows were emplaced during the Holyoke volcanic event. The earlier Talcott event was restricted to New England and the later Hampden event was restricted to the Connecticut and Nova Scotia rift valleys. The Higganum volcanic event is represented by intrusive activity only. Dikes emplaced in this period crop out throughout the Appalachians from Georgia to Nova Scotia.

The Talcott, Holyoke, and Hampden volcanic events are separated from the Higganum event by a period of intensive tectonic activity. In this period longitudinal arching along the axis of the Appalachians caused the fracturing and tilting of the late Triassic formations. This period of regional uplift was followed by a period of deep-seated horizontal stress release. The dikes of the Higganum event were emplaced in tensional fractures that were the surficial expressions of these deep-seated movements. The fan-shaped arrangement of the dikes in the Appalachians suggests a southwestward decrease of the rotational component of the shear couple and a sinistral polarity of the shear movements. Both tectogenetic events are possibly related to the initial opening of the Atlantic Ocean.

The source of the basaltic rocks has been discussed many times. Recent gravity data obtained by the U.S.G.S. have indicated that the regional gravity low of the Triassic valley is interrupted by positive anomalies. These anomalies are most probably caused by large dike-shaped masses with high density. Because these anomalies occur in areas with abundant intrusives, there is little doubt that they represent the original feeders. The lack of aeromagnetic anomalies over the feeders suggests that they are only present in the basement. The well defined parting surfaces in the Triassic sediments prevented a normal vertical ascent of the magma. The fluid continued its rise by following the bedding planes and by locally shifting to higher levels, using faults and joints. Locally the magma reached the surface and flowed out to form the Talcott, Holyoke and Hampden flow units (Fig. 1).

Figure 1 is a diagrammatic section of the Triassic rift valley of Connecticut during the Holyoke volcanic event, showing basement feeder, sills like those of West Rock and Mount Carmel, and lava flow. Basement configuration based on interpretation of gravity data by Chang (senior thesis, Wesleyan University).

The discontinuity and complexity of the lava-flow units suggest that several linear feeders may have existed. Not all feeders were simultaneously active. The Talcott flow unit in northern Connecticut, for instance, does not continue northward into Massachusetts despite its proximity to a possible feeder location east of the Barndoor Hills.

Intrusive volcanic activity is especially abundant in the southwestern part of central Connecticut. Most of the larger intrusives occur close to the western boundary of the rift valley and in the New Haven area. No large intrusives crop out in the eastern part of the rift valley. In view of the tectonic significance of the eastern boundary fault, this distribution appears to be anomalous. The eastern boundary fault extends to considerable depth and it must have formed an ideal pathway for ascending magma. Characteristic for the southeastern part of the rift valley is the peculiar distribution of the lava flows, which are folded into broad basins separated by narrow anticlines. These transverse folds have been attributed to differential movement of the Triassic deposits along the fault, caused by differences in the attitude of the fault plane. According to Wheeler (1939) anticlines formed opposite projections, and basins opposite reentrants in the border fault. The transverse folding can also be attributed to strike-slip movements along the boundary fault.

A microtectonic analysis of the fault zones has revealed that the latest movements along the north-trending segments of the fault were transcurrent. The polarity of the movements was sinistral. If the folding was due to sinistral shear along the boundary fault, NE-trending b-axes would be expected; instead, the fold axes of the transverse folds trend NW. A third possibility is that the basins are volcano-tectonic depressions, caused by collapse, following the removal of large quantities of magma from underground reservoirs. This possibility can only be checked by detailed geophysical analysis of the area. Gravity data obtained by the U.S.G.S. have shown the possible presence of a large feeder dike in the fault zone. Detailed geological field work in the Durham quadrangle has shown that many smaller intrusive masses occur in this zone. The most controversial of these is "Foye's volcano" (Stop #3).

<u>Stop #1</u> (23.22 N - 56.48 E) Cross Rock area, Mount Carmel quadrangle. Bedrock map: USGS GQ 199.

To reach Stop #1, follow Conn. Rte. 10 (Whitney Avenue) to the traffic light at Ives Corner, 0.8 miles N of Cheshire-Hamden town line. Turn east on Cook Hill Road, proceed 0.9 miles, turn left (north) on Halfmoon Road, proceed 0.4 miles, turn right (east) on Boulder Road, proceed 0.3 miles to second yellow house on north side of road.

<u>Stop #1A</u>: outcrop on north side of road close to house.

The volcanic rocks exposed in the Mount Carmel quadrangle are characteristic for the Triassic volcanic activity in the southern part of the Connecticut rift valley. Three types of intrusives can be distinguished: the West Rock sill, the Mount Carmel sill-dike, and the Cross Rock dikes. All igneous masses were emplaced in the New Haven Arkose. Paleomagnetic

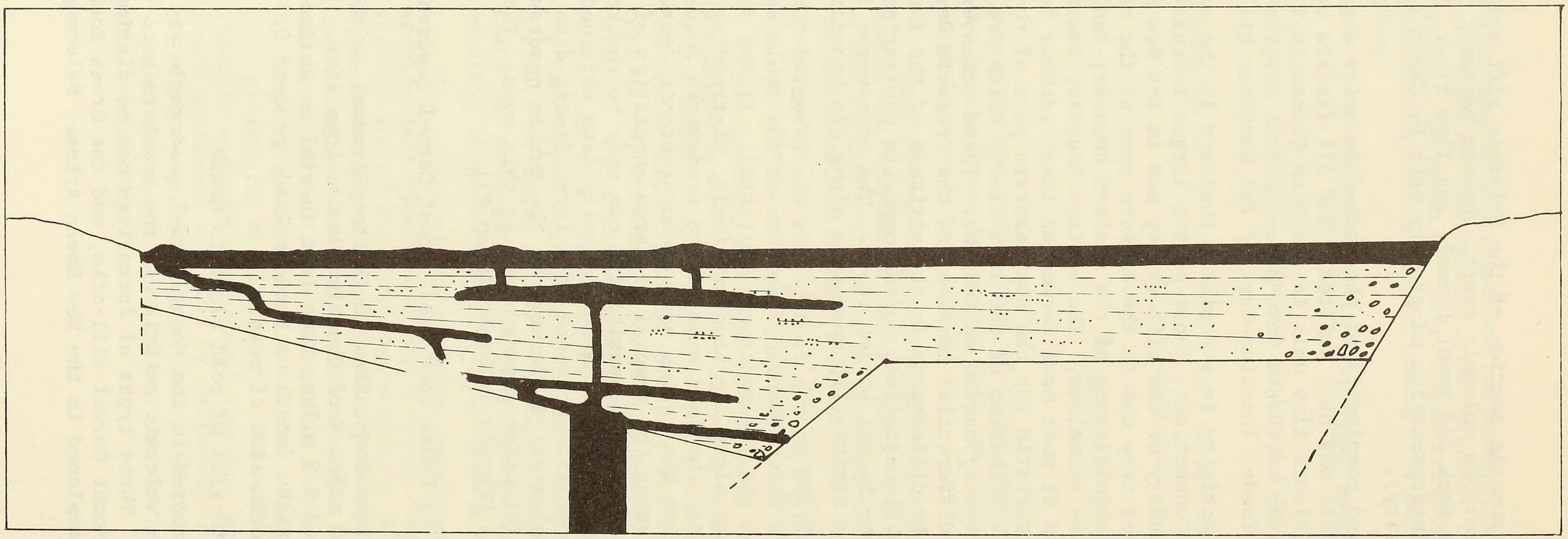

Figure 1. Diagrammatic section of the Triassic rift valley of Connecticut during the Holyoke volcanic event, showing basement feeder, sills like those of West Rock and Mount Carmel, and lava flow. Basement configuration based on interpretation of gravity data by Chang (senior thesis, Wesleyan University).

evidence suggests that the larger intrusives can be correlated with the Holyoke volcanic event. The Cross Rock intrusives consist of a NNE-trending sill (dip 20° to 30° E) and a WNW-trending dike (dip 45° to 60° S). The attitudes of the sill and dike were established by Barringer magnetometer surveys. At Stop #1, it can be observed how the magma, which elsewhere formed a sill, continued upward by using an en echelon set of subvertical faults.

Fritts (1963), who mapped the Mount Carmel quadrangle, assumed that an age difference exists between the Cross Rock sill and the dike. He distinguished the Buttress diabase (NNE-trending sill) from the West Rock diabase (WNW-trending dike). He considered that the latter was intruded contemporaneously with the large West Rock sill to the west and that the former was intruded along a fault that cuts and offsets both the Mount Carmel sill and the WNW dike. Geological evidence supports an age difference between these intrusives, but their paleomagnetic directions indicate that both the younger sill and the older dike intruded contemporaneously with the effusion of the Hampden flow unit.

In the outcrop along the road, an alternating sequence of basaltic breccias, basalts and hornfelses can be seen. Clearly three types of basalt can be distinguished: the basaltic fragments of the breccia, the basaltic matrix of the breccia and the NNE-trending basaltic dikes. The presence of hornfels fragments in the breccia suggests that the metamorphism of the arkose preceded the first two intrusive events.

The following sequence of volcanic events can be deduced from the observations in the Cross Rock area.

<u>Holyoke volcanic event</u> (late Triassic)

(a) Large-scale intrusive volcanic activity, which resulted in the emplacement of large sills (Mount Carmel, West Rock, etc.) in the New Haven Formation.

(b) Regional faulting, generally in north-northeast and east-west directions. These directions are respectively parallel and at right angles to the deep-seated intrusive indicated by gravity. The fractures are therefore thought to be tensional and caused by local arching following the intrusive activity.

(c) General silicification of the wall rock of the fractures by hydrothermal solutions. The quartz influx resulted in relatively extensive hornfelses.

(d) Explosive volcanic activity. Local formation of coarse breccias composed of fragments of sediments (arkoses, siltstones) and Holyoke-type basalts. The explosive volcanic activity was followed by widespread mineralization of the brecciated zones. The main minerals emplaced were barite and quartz.

<u>Hampden volcanic event</u> (late Triassic)

(e) Continued faulting along the east-west fractures and subsequent intrusion of basalt. This basalt forms locally the matrix for a volcanic breccia (Stop #1A).

(f) Continued faulting along the north-northeast fractures and subsequent intrusion of basalt in these fractures. The magma emplaced during this period dominantly followed the bedding planes, but locally it shifted to higher levels by using faults and joints.

Higganum volcanic event (early Jurassic)

(g) Regional faulting along northeast-southwest fractures. One such fracture cuts the Cross Rock intrusives more or less at their intersection. Dikes were emplaced along these faults in the Eastern and Western Highlands, and in the Gaillard area.

Stop #1B: pits on south side of road about 80 yards west of Stop #1A.

The Cross Rock area is part of the Cheshire barite district, well known for its mineralization. Several attempts have been made to mine the copper and barite minerals. The concentrations, however, were insufficient and the attempts were stopped. Old pits and prospect trenches can be found throughout the area. Behind the rock wall a prospect trench can be seen, which was started for copper in 1710 by John Parker of Wallingford (Fritts, 1962). The trench was recurrently deepened until 1901, the main purpose being stock promotion for the Cheshire barite mines. The arkose mined in the trench contains barite, bornite, chalcocite, malachite, cuprite, and chrysocolla. The copper minerals must have especially attracted investors. A nice piece of arkose with barite and bornite is exposed between the roots on the south side of the large old birch that grows on the north wall of the trench. Smelter marks on this piece suggest that it was brought here from the main plant in Cheshire and that it was probably used to salt the area. The mineralized zone occurs between two east-west dikes. The southern dike is well exposed. One outcrop of basalt in the trench suggests the presence of the northern dike. Magnetometer surveys indicate that the latter intrusion is much smaller and that it pinches out over a distance of a few hundred yards. This dike continues below outcrop 1A.

Supplementary notes on the Jinny Hill barite area (to find the mines, use the bedrock map of the Mount Carmel quadrangle — Fritts, 1963).

The Jinny Hill mines were probably the earliest barite mines in the United States. About 160,000 tons of barite were mined here in the general period from 1838 to 1877. The barite was processed in New Haven and was mainly used by the paint industries of New York City (Fritts, 1962). The mineralization of the Jinny Hill area occurred in three E-W trending zones. This is not the only direction in which mineralization zones occur in the Cheshire area. NNE-trending zones occur east of the West Rock intrusion and parallel to the Cross Rock sill (Tallman mine). The main barite vein in the Jinny Hill zone was about 3 feet wide and extended over 3/4 of a mile (Fritts, 1962). Most barite occurs in lenses which are only a few inches wide. The minerals were emplaced in the cavities of a very coarse breccia, which has been called a fault breccia. Several observations, however, appear to indicate that we may be dealing with a volcanic explosion breccia. The pressure was released along faults which opened up parallel and at right angles to the large deep-seated intrusives.

The sequence of mineral deposition is as follows:

Primary minerals:
(a) quartz (silicification of wall rock)
(b) granular barite, anhedral barite and chalcocite (often intergrown)
(c) euhedral barite (large crystals)
(d) euhedral quartz (very clear crystals)

Secondary minerals:
(e) hematite, malachite, azurite, chrysocolla
(f) limonite, hematite

Three shafts were used to mine the Jinny Hill zone. These shafts were reported to have gone to depths of 500 and 600 feet (Fritts, 1962). The holes have been filled in and only the dumps remain. Most of these are located on privately owned land. Please obtain the permission of the owners before visiting the dumps.

Stop #2 (26.35 N - 57.65 E) East Peak of Hanging Hills of Meriden, Meriden quadrangle. Bedrock map: USGS GQ 738. Description of stop by John Rodgers.

To reach Stop #2, turn north off Connecticut Rte. 66 into Hubbard Park in the western part of Meriden (this is a particularly blind corner coming from the east). Proceed straight north 1.3 miles, through the park, up the hill (through the Talcott flow) to Lake Merimere, and along its east side to its north end, turn left and follow narrow, poorly paved road (up dip slope of Holyoke flow — note great irregularity of upper surface, probably the result of numerous small faults) 1.5 miles to fork near top of hill. Follow left fork to parking place below stone tower on East Peak (right fork leads to steel fire tower and television installation on West Peak). Walk to stone tower.

At the tower, we are standing at about 950 feet above sea level, approximately on the upper surface of the Holyoke lava flow, which holds up all the highest hills in the Connecticut Valley except those on the West Rock, Mount Carmel, and Barndoor sills. The characteristic double jointing in the Holyoke flow is particularly well displayed here. The older columnar joints show narrow altered (silicified?) selvages, which weather in slight relief above both the normal rock and the joint itself; the younger systematic joints cut undeflected across the columnar joints, implying that they had been entirely healed. According to de Boer, the systematic joints here belong to one of two conjugate sets that intersect at a low angle, this one trending about N.35° E, the other about N 5° E. The faults of the region show the same trends; possibly this is an argument for dominant strike slip along many of them. Large boulders of this rock showing the characteristic jointing pattern are scattered over the countryside from here to Long Island Sound. The well known "Judges Cave" on West Rock in New Haven is a group of such boulders so placed as to provide some shelter.

The Talcott flow forms the bench at our feet, between us and the lake in Hubbard Park. The Hampden flow forms low ridges in the country to the northeast, beyond the dip slope on the Holyoke flow, but they are not clearly seen from here. The city of Meriden, spread out before us to the southeast, and all the country to the south is underlain by the New Haven Arkose, drained by the Quinnipiac River to Long Island Sound at New Haven Harbor.

In the Hanging Hills, the Holyoke flow and the beds above and below strike nearly east-west and dip gently north, in strong contrast to their normal north-south strike and moderate east dip; the change is evidently associated with the particularly intense faulting in the Meriden region (see USGS GQ 738, 494; CG&NHS QR 8) and especially with the large sinistral offset in map pattern caused by the largest of these faults (sinistral offset does not <u>prove</u> sinistral strike slip, of course).

To the east across Lake Merimere is South Mountain, Holyoke lava displaced only a little to the left from what we are standing on; half hidden behind it is Cathole Mountain, displaced somewhat more. The largest fault (or group of faults) then offsets the Holyoke flow 8 miles to the northeast, to the north end of Lamentation Mountain, the northernmost of the north-south mountains in the middle distance to the east, in which the Holyoke flow resumes its normal strike and dip. The main Hartford line of the New Haven Railroad and the Berlin Turnpike (visible at the foot of the mountain) go through the gap between, the lowest divide into the Connecticut River drainage (175 feet). Chauncey Peak, the south end of Lamentation Mountain, is slightly offset from the rest. Another fault then displaces the flow another 5 miles to the northeast, to the north end of Higby Mountain; Rte. I-91 goes through this gap. Smaller gaps are visible in the ridge from Higby Mountain south, each caused by a smaller offset along a similar fault; Rte. 66 and the old Air Line of the New Haven follow two of these gaps toward Middletown. From here it is not easy to pick out the larger gaps between Pistapaug Mountain (at the south end of the Higby Mountain ridge) and Totoket Mountain (gap used by Rte. 17) or between Totoket Mountain and Saltonstall Ridge (used by Rte. 80); the latter gap is not caused by faulting within the Triassic but by a transverse anticline that abuts southeastward against the eastern border fault, interrupting the outcrop of the Holyoke flow.

Off to the north of Lamentation Mountain is Cedar Mountain, again upheld by the Holyoke flow brought up along a northern branch of the fault behind Cathole Mountain. The Hampden flow east of Cedar Mountain can be traced onto the Trinity College campus in Hartford. On a good day, the insurance towers of Hartford can be seen behind Cedar Mountain.

Behind Higby and Lamentation mountains and off to the northeast are the Eastern Highlands, metamorphic rocks separated from the Triassic rift valley by the eastern border fault and the chief source of the Triassic sediments. Due east of us, one can make out the break in the Highlands at Middletown, where the Connecticut River turns away from the valley to find its way through the Highlands to the Sound.

In the opposite direction, the Holyoke flow extends west to West Peak (1,024 feet above sea level) and then turns abruptly north, resuming its normal strike and dip. Thence it extends north for many miles, though broken and somewhat offset by faults, forming Talcott Mountain west of Hartford and reaching Mt. Tom and Mt. Holyoke, on the opposite side of the Connecticut River in central Massachusetts — these can be seen from here on a very clear day.

Beyond West Peak is the valley underlain by the New Haven Arkose, and behind that the Western Highlands, underlain by metamorphic rocks; the contact here is mostly a fault. To the south, however, the West Rock sill appears, first as low hills within the valley, then higher and higher in front of the Western Highlands until Mount Sanford reaches the skyline and hides them. Out in the valley southwest of Mount Sanford is the large mass of Mount Carmel or the Sleeping Giant, an irregular sill or stock higher in the New Haven Arkose than the West Rock sill and probably nearly above the main basement feeder dike.

Just to the left of and behind Mount Carmel, on a clear day one can see the Civil War monument on top of East Rock in New Haven and behind that the waters of Long Island Sound and Long Island. Thus one can see entirely across the 55-mile width of Connecticut, to points in Massachusetts and New York State 95 miles apart.

From the latitude of the Hanging Hills south, the hills upheld by the Holyoke lava and the Mount Carmel and West Rock sills reach to heights that decline steadily southward, reaching sea level around New Haven Harbor; the slope is about 45 feet per mile (8 meters per kilometer). From the Hanging Hills north, however, no peaks on the Holyoke flow reach 1,000 feet until Mt. Tom (1,200 ft.) and the Holyoke Range; the slope from West Peak to Mt. Tom would be only about 4 feet per mile (less than a meter per kilometer). The sloping hill-top surface to the south is continuous with the surface beneath the Cretaceous rocks on Long Island — for this reason, from the Hanging Hills Long Island Sound and Long Island appear higher than any of the hills between — and it therefore represents the Fall Zone surface or facet (Flint, 1963); even the highest hills to the north have been reduced by erosion well below this surface. One can therefore imagine that when that erosion was going on, Cretaceous rocks still reached inland as far as Meriden. As Barrell pointed out long ago, it is probably no coincidence that the Connecticut River deserts the Connecticut Valley just at this latitude.

Stop #3 (22.49 N - 61.82 E) "Foye's Volcano," Durham quadrangle.

To reach Stop #3, follow Conn. Rte. 77 to a point 0.9 miles south of its intersection with Rte. 17 south of Durham, or 1.4 miles north of the Durham-Guilford town line. Walk west across field to old quarry in low hill (north end of group of hills) beyond stream.

Wilbur G. Foye, late Professor of Geology at Wesleyan University, published a paper in 1930 on the possible existence of a late Triassic volcanic vent in the Durham area. The volcano was opened up in a quarry west of Rte. 77. It forms part of a basaltic mass that can be traced westward to a fault contact with the Hampden flow unit. Because of the agglomeratic texture of the basalt in the vent, Davis attributed this intrusion to the Talcott volcanic event. However, paleomagnetic data indicate that the basalt which forms the matrix of this agglomerate cooled during the Hampden volcanic event.

Facing west into the quarry, the following units can be distinguished from north to south:

(1) unmetamorphosed red sandstones (dip ±30° NE)

(2) contact metamorphosed sandstone (3 to 5 feet thick)

(3) irregular contact zone containing detached blocks of basalt

(4) agglomeratic basalt

Magnetite, biotite, muscovite and garnet have grown as new minerals in the contact metamorphosed rock. The formation of the magnetite at the expense of hematite caused a change in the color of the sediments from red to dark gray-green. The biotite and muscovite formed at the expense of the sericite and chlorite. The new micas have grown across the original bedding, resulting in a total loss of fissility for the rock. Locally, recrystallized tourmalines can be found.

Foye was of the opinion that the basalt intruded by stoping and that the eruption occurred quietly without explosive violence. The occurrence of large tuffaceous blocks in certain horizons of the conglomerates exposed to the north, however, appears to indicate that some explosive activity may have taken place in the area.

Stop #4 (20.59 N - 61.41 E) Outcrop of metamorphic rock west of eastern border faults, Durham quadrangle.

To reach Stop #4, follow Conn. Rte. 77 to north end of Lake Quonnipaug, 4 miles south of Stop #3. Park by first houses southwest of bridge over inlet to lake, and walk up private road to west.

This outcrop of metamorphic rock is located on the wrong side of the eastern border fault. The eastern border fault, which separates the basement from the late Triassic deposits, runs through Lake Quonnipaug, more or less parallel to Conn. Rte. 77. The metamorphic rocks are overlain by coarse breccias, which grade upward into arkosic agglomerates and conglomerates. The metamorphic rocks in turn overlie an intrusive mass of basalt, which crops out in the valley north of the exposure. There is no doubt that the basalt is Triassic, so that the metamorphic rocks appear to be completely surrounded by Triassic sediments and igneous rocks.

The metamorphic rocks consist dominantly of cataclastic and mylonitic gneisses, which occasionally contain anthophyllite. This indicates that they belong to the Middletown Formation, which is exposed on the east side of Lake Quonnipaug. Judging by the amphibolite gneisses and schists found on top of the hill at Stop #4, the metamorphic rocks most probably belong to the uppermost part of this formation. Their cataclastic and mylonitic appearance suggests that significant faulting occurred in this area before the metamorphic rocks were emplaced in their present position. The foliation in the gneiss trends from N to NE; the dip varies from 10° W to 70° E. In the exposure in the small road, the foliation dips steeply to the east, whereas on top of the hill the foliation is generally much less steep. These attitudes contrast sharply with those of the metamorphic rocks east of the fault which trend N to NE, but dip about 60° W. It seems therefore that the steeply dipping beds are overturned (cascade folding). A thrust plane (N 50° E - 15° W) is exposed in the cliff on top of the hill. The structure of the mass suggests that we are dealing here with a large landslide (Fig. 2).

Figure 2 is a cross-section at Stop #4, showing interpretation of metamorphic rocks west of eastern border fault as a landslide. Patterns (left to right): sediments grading into fanglomerate, basalt, pegmatite, gneiss of Middletown Formation.

There seems to be little doubt that this landslide was related to movements along the border fault. The sliding occurred after the emplacement of the Holyoke and before the emplacement of the Hampden flow units. It appears as if the mass may have blocked a major stream because it was strongly eroded after emplacement. A walk southward along Rte. 77 shows that the very angular breccias that overlie the metamorphic rocks gradually go over into agglomerates and then into red arkosic sandstones (Stop #9 of Trip C-1).

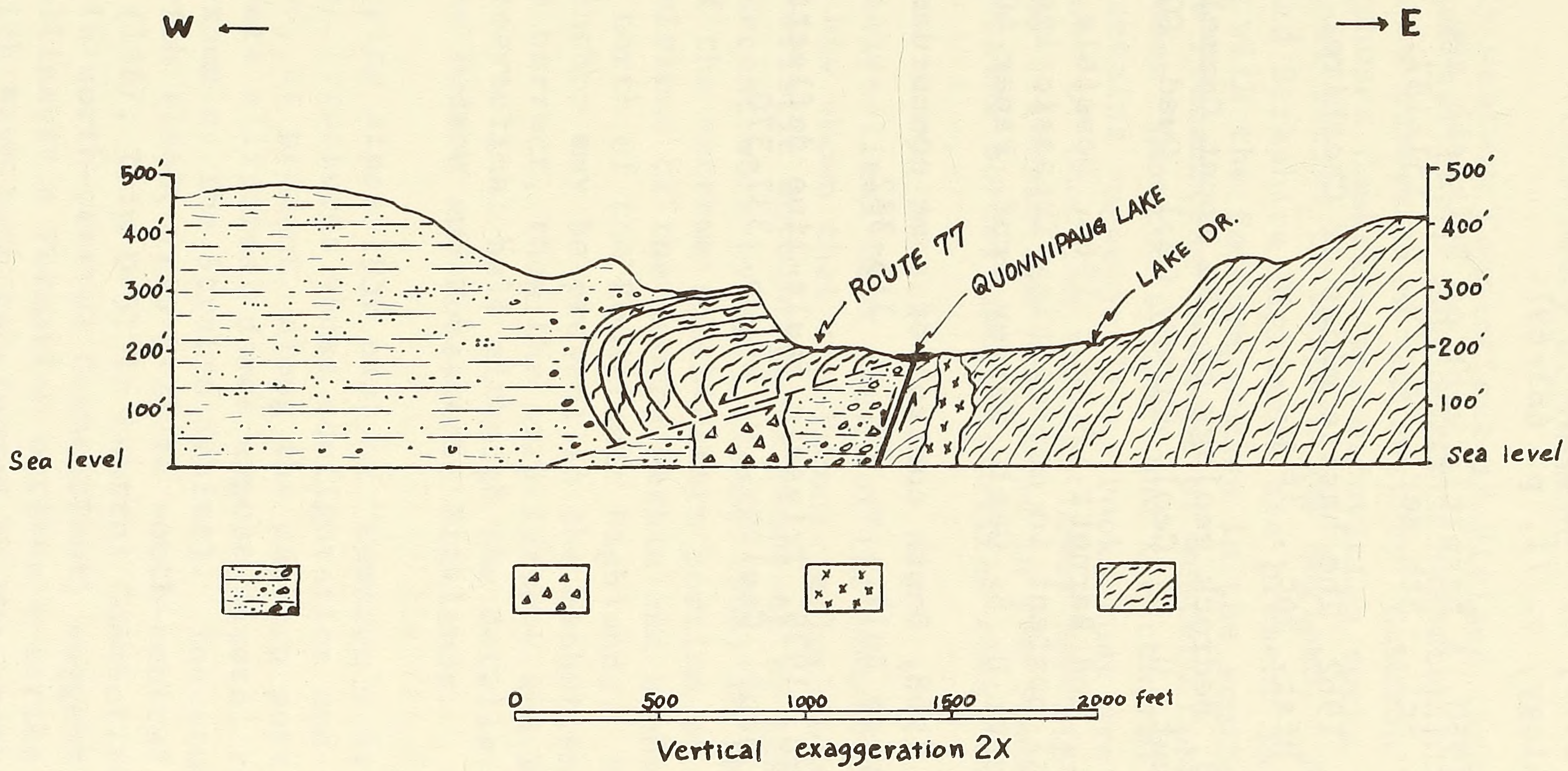

Figure 2. Cross-section at Stop #4, showing interpretation of metamorphic rocks west of eastern border fault as a landslide. Patterns (left to right): sediments grading into fanglomerate, basalt, pegmatite, gneiss of Middletown Formation.

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