Preliminary bedrock geologic map of part of Durham quadrangle, Connecticut

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Durham quadrangle, situated in Middlesex and New Haven Counties, central Connecticut, lies astride a faulted boundary between metamorphic rocks of the Eastern Highland, and sedimentary rocks with interbedded lava flows of the Connecticut Valley, or Triassic, Lowland. Bedrock formations of the Lowland are of Triassic age, and in Durham quadrangle their mapping began as a byproduct after study and detailed mapping of the surficial geology of the quadrangle had started (Simpson, 1968). Thus attitudes of and information regarding bedrock chiefly in the northern one-third of the map area are presently somewhat incomplete. This open-file report, therefore, is intended to make present data available until mapping of the quadrangle and publication are completed.

A widespread mantle of surficial deposits, mostly glacial in origin, generally hides the underlying bedrock. This is especially true of the sedimentary rocks in the northern half of the map area, where they are less prominently broken and deformed than to the south. The basaltic rocks, however, because of their hardness, dip, and jointing, consistently form prominent ridges that are generally marked by west-facing cliffs. Although most bedrock exposures measure only a few feet across, much can be inferred from the character of the rock visible as to the nature and origin of the formation it constitutes.

Note: (The name of each sedimentary unit and each basalt (lava-flow) unit could be added here, increasing length by 3 lines. I decided not to include them as they are apparent on the map explanation)

Stratigraphy.--The interbedded sedimentary strata and lava flows constitute a sequence of formations of alternating lithology. The sequence consists of four sedimentary units enclosing and separating three units composed of lava flows. Cross-bedding and imbrication indicate that the sedimentary formations were deposited in a non-marine environment by streams flowing westward from higher land to the east. The lava flows are composed of basalt, and probably came from fissures in central Connecticut. Only the upper three of the sedimentary formations, and the upper two of the basalt formations, are exposed in Durham quadrangle.

The three sedimentary formations exposed are lithologically similar to one another, and are composed mainly of shale, siltstone, sandstone, and conglomerate. The finer-grained beds, chiefly shale and siltstone, consist mainly of quartz, feldspar, and light-colored mica, whereas the coarser-grained strata, mostly sandstone and conglomerate, consist largely of rock fragments. Iron oxides, clay, clay-size particles, and some calcareous material cement these components together firmly. The principle exceptions to these common lithologies are scattered, small, moderately thin deposits of limestone, gray or black micaceous shale, and volcanic tuff. The petrology and history of the sedimentary formations in south-central Connecticut have been described by Krynine (1950).

In a general way the sedimentary formations are characterized by a gradational decrease in average particle size from east to west. Beds of siltstone, sandstone, and conglomerate are commonly current cross-bedded, mainly in a westerly direction, but some beds are massive. [The] A mudflow origin of a few beds is clearly indicated by their massive quality, lack of sorting, great range in particle size, and the angularity of some stones, and a similar origin may be inferred for other beds with less distinctive characteristics.

The most distinctive facies of the sedimentary rocks is boulder conglomerate, containing angular to subrounded stones as large as 20 inches in maximum diameter. These deposits originated as fanglomerates that accumulated at or very near the eastern boundary of the Lowland, and may? probably mark the apices? apex of alluvial fans built against a west-facing scarp by west-flowing streams. The deposits appear to grade longitudinally into progressively finer conglomerates, sandstones, and eventually siltstones, although there are not enough exposures to permit the actual tracing of an individual bed or fan deposit. The boulders are composed chiefly of rock types known nearby in the adjacent Eastern Highlands. Two excellent exposures of boulder conglomerate are mapped; one, in the west wall of Lake Quonnipaug, is of the East Berlin Formation, the other, just south of Durham Center, is of the Portland Arkose.

The three basalt formations each consist of a series of layers which are probably individual flows. The rock of each flow, although very similar in general appearance to the rock of other flows, differs in minor physical characteristics such as thickness or kind and spacing of joints, and possibly in chemical aspects such as the differing quantities of certain elements.

At least four flows appear to compose the Holyoke Basalt, and at least two form the Hampden Basalt. Topographic expression of individual flows in each formation ranges from low, step-like risers, as apparent on the south slope of Totocket Mountain on the topographic base map, to prominent cliffs, as near the southern end of Quonnipaug Mountain. The cliffs are generally perpendicular to flow contacts, and the height and prominence of these faces ordinarily is related directly to the total thickness of the flows. As no sedimentary deposits are known locally between the individual flows that constitute either the Holyoke or Hampden Basalts, the time lapse indicated by the flow contacts is inferred to be insignificant in this quadrangle [here], and the flows of one formation may represent one period of eruption. That the two formations may represent separate eruptions is suggested by the intervening thick sequence of strata of the East Berlin Formation, and by chemical differences in the two formations elsewhere in central Connecticut (Hanshaw, 1960).

Thicknesses of the several Triassic formations in Durham quadrangle are not well known, especially in the northern two-thirds of the map area. Here exposures of the sedimentary formations are widely scattered, and contacts with the basalt formations are generally covered. Moreover, drill-hole data is commonly unavailable or undependable; one water well penetrates most of the Hampden Basalt, but an unknown amount of rock has been eroded from the surface. Formation thicknesses given are based on a series of 43 cross sections prepared with a vertical exaggeration 10 times the horizontal scale of 1:24,000. In these cross sections, minimal thicknesses used give a consistent picture across the map. This has the advantages of requiring fewer faults, and less vertical displacement along the major faults mapped. Thicknesses from 100 to 200 feet greater can be used locally but require changes in thickness over short distances for which no evidence was observed.

Correlation.--The basalt units in this quadrangle are parts of formations of great extent, and were traced from areas where the standard stratigraphic sequence is clearly established. Within Durham quadrangle local correlation is dependant mainly on the lithologic contrast and physical relations of the basalt units and sedimentary units. Where exposures of basalt are widely spaced, or where fault displacement is great, correlation between areas of basalt may be somewhat tenuous; and is based on the sequence of physical characteristics of the various flows in a formation. Where exposures are isolated, small, and glacially smoothed, correlation is sometimes difficult, and occasionally? rarely may be impossible. Because the sedimentary rocks are so similar lithologically and generally are even more poorly exposed than the basalt formations, they commonly are of little help in correlation.

The alternation of sedimentary rocks and basalt flows is characteristic of the Triassic sequence in central Connecticut, and readily permits correlation with the stratigraphic sequences first established by Krynine (1950) and later by Lehmann (1959). The New Haven Arkose, oldest of the four sedimentary formations, is not exposed in the quadrangle, nor is it known from drill-hole logs; its presence is inferred solely from exposures in adjacent quadrangles. The Talcott Basalt, the oldest of the three basalt formations, is not exposed either. However, it is believed to underlie surficial deposits in the area west of North Branford Road and south of Pine Lake, along the west edge of the quadrangle, where basalt is reported in two drill-holes [by property owners]. The proximity and trend of ridges underlain by Talcott Basalt just west of the quadrangle boundary justify the tentative correlation, although the rock in Durham quadrangle might be an intrusive body of basalt, or conceivably a bed of hard gray or black shale. Black shale has been reported as "basalt" in some drillers' logs, and a similar error could exist in the well logs upon which this interpretation is partly based.

Correlation of the basalt in the area just northeast of Totocket Mountain with the Hampden Basalt is based largely on the similarity of physical characteristics and adjacent stratigraphic features. Davis (1898) mapped this rock as part of the Anterior Lava Flow (the Talcott Basalt of Krynine, 1950, and Lehman, 1959), but Digman (Mikami and Digman, 1957) assigned it to the Holyoke Basalt. I tentatively correlate the rock with the Hampden Basalt because of: (1) the absence from at or near its basal contact of the two tuff-like beds exposed at the base of the Holyoke Basalt in the quarry at Reeds Gap; (2) absence of basal, prominent but crude, columnar jointing of considerable height, characteristic of the Holyoke Basalt; (3) presence of large curved joint surfaces in a flow topographically and stratigraphically below a flow several feet thick characterized by crude columnar jointing, characteristic of the Hampden Basalt; (4) presence of closely spaced irregular jointing in the upper part of the unit, characteristic of the Hampden Basalt; (5) presence of little or no thermal alteration of the immediately underlying sedimentary rock, more nearly characteristic of the Hampden Basalt; (6) similarity of existing thickness to that [the known thickness] of the Hampden basalt; and (7) the absence of high cliffs characteristic of the Holyoke Basalt. The possibility that only the uppermost, thinner flows of the Holyoke Basalt are present in this area has not yet been disproven, although it is considered very unlikely. The character of the Hampden Basalt in central Connecticut has been described in detail by Chapman (1965).

The source or sources of the several basalt flows in central Connecticut are not known, but the source of the basal flow of the Hampden Basalt in Durham quadrangle is suggested by the orientation of 24 elongate, or "stretched" vesicles observed near the southern end of Quonnipaug Mountains. These vesicles were originally gas bubbles in the then fluid basalt; the sense of movement interpreted from their direction of elongation implies the flow moved toward the northwest at that locality. This suggests the flow may have been fed either from a dike located about half a mile southeast of the vesicle locality and within the metamorphic rocks of the Eastern Highland, or possibly by eruption through an adjacent fault marking the eastern boundary of the Triassic Lowland.

Exposures of metamorphic rock typical of rocks [those known] in the Eastern Highlands are rare west of the boundary fault. Two such localities are mapped in Durham quadrangle. One locality, which forms the eastern of two small knolls on the northeast flank of Quonnipaug Mountain, is a block that was downdropped against the Eastern Boundary Fault along small subsidiary faults. The rock is a thoroughly brecciated, very fine-grained, biotite-feldspar-quartz gneiss, faintly schistose and moderately well laminated, tentatively correlated with the Brimfield Schist of Early Paleozoic age--an adjacent formation of the Eastern Highlands. The second locality is poorly exposed in a borrow pit on the west side of State Route 77, some 900 feet north of Bluff Head Cemetery. Here gneiss similar to that described above contains a dike of basalt 4 to 6 inches thick. The area of gneiss exposed is about 2 1/2 by 3 feet in size, and is oriented diagonally in the west wall of the pit near its floor level. The gneiss [It] is enclosed by Holyoke basalt on the upper left side, upper right end, and lower right side; the lower left end is buried beneath debris. Thus the gneiss may well be a xenolith in the basalt, but the lack of attachment has not been proven. Presence of the gneiss suggests that at this locality Holyoke Basalt may have erupted to the surface through the Eastern Boundary Fault.

A possible third locality is a glaciated knoll, chiefly underlain by pegmatite, very near the southern boundry of the quadrangle. The rock is tentatively thought to be a small down-faulted block between two subparallel branches of the Eastern Boundary Fault of the Triassic Lowland.

Structural geology.--Faults, folds, and joints constitute the major structural features of the quadrangle. Faults are the dominant features, and are primarily responsible for the pattern formed by the segments of basalt ridges and intervening sedimentary formations. The principal sets of faults strike northeast, and north; lesser sets strike approximately northwest, and west. The distinctive pattern of Totocket and Quonnipaug Mountains, and the eastward trend of the Hampden Basalt south of Durham Meadows, are indicative of synclinal folds; they are separated by a broken anticlinal fold, and all are more or less transverse to the regional [general] strike of the strata. A small chevron-like syncline is present in the Portland Arkose near the northeast corner of the quadrangle. Joints, some formed as the result of tectonic stress, and others as a result of cooling of the basaltic lava, are common. Those caused by tectonic stress together with the strikes and dips of fault-tilted and deformed strata offer substantiating evidence for tectonic inferences.

For many years geologists have described the eastern boundary of the Triassic Lowland as a sinuous normal fault trending north-northeast and downthrown on the west; it is generally known as the Eastern Boundary Fault. I believe the sinuous character of the boundary fault to be the result of the intersection of faults representing two sets of moderately high angle, westward-dipping, normal faults, one trending northeast, the other trending north. The same sets of faults may be present elsewhere along the boundary as well. For simplicity these faults are referred to together in this report as the Eastern Boundary Fault.

The Eastern Boundary Fault is not presently visible anywhere within this quadrangle. However, its position is closely defined at two localities south of Huber Pond, although at both places it is presently concealed beneath a veneer of rubble and other debris. The best known locality is in an excavation on the east flank of the ridge on which Bluff Head Cemetery is situated. The fault formerly was well exposed in this pit, and was described in detail by Digman (Mikami and Digman, 1957, p. 70-72) at the time of excavation. He found the strike of the fault to be uniformly north 5 degrees east, and its dip to be about 55 degrees west. I found the nearest exposure of nonbrecciated basalt (Holyoke Basalt) west of the fault gouge is about 700 feet distant, but other fault surfaces probably intervene.

The other near-exposure of the fault is in a borrow pit about 900 feet north of Bluff Head Cemetery, where State Route 77 passes through a narrow gap. In this gap, brecciated metamorphic rock--and unbrecciated pegmatite--is exposed in the roadcut on the east side of the road, whereas brecciated basalt is exposed about 50 feet west in the west wall of the small, long-unused borrow pit. The fault trace must lie between, buried by broken rock and other debris.

Elsewhere in the quadrangle the fault lies between outcrops of metamorphic rocks to the east and sedimentary rock or basalt to the west, and can be located by following in-line topographic lows through areas lacking exposures. In general this technique probably results in placing the principal fault plane within about 500 feet of its actual position. Locally, however, as in a small stream valley about one-quarter mile south of the northern boundary of the quadrangle, the position is narrowed to within a breadth of about 150 feet.

In general, evidence suggests that the principal fault zone of the Eastern Boundary Fault is generally less than 1,000 feet wide, and locally may be as little as about 75 feet wide in this quadrangle. Furthermore, the limited evidence available suggests that the zones associated with faults of the set that trends northeast are generally narrower than the zones of faults associated with the set that trends north.

Very likely the Eastern Boundary Fault in many places is actually a fault zone consisting of multiple fault surfaces. This is indicated by the distribution of brecciation and topographic features, notably the character of Broomstick Ledges located just southeast of Huber Pond. Certainly minor faults of the same set are more numerous within a few hundred feet of the main fault than farther away.

The branching character of the Eastern Boundary Fault at the southern margin of the map is not supported by direct evidence in Durham quadrangle. Certainly one fault is present, and if there is only one, it is the more northwesterly of the two shown. Digman (Mikami and Digman, 1959) mapped both, but neither the map nor text indicate the nature of the evidence. Both faults are shown here, one tentatively, largely on geomorphic reasoning. A prominent glaciated knoll chiefly underlain by pegmatite is tentatively mapped as a small downdropped block of Eastern Highland character, flanked within the wedge by rocks of Triassic age. Because there are no exposures within the wedge other than those on the knoll, the flanking rocks are inferred to be significantly less resistant to erosion than those in the knoll. As the metamorphic rocks are more resistant to erosion than the sedimentary Triassic rocks, the absence of exposures suggests the rocks in the wedge are Triassic in age, and the southeasterly fault of the two mapped is the Eastern Border Fault. If the flanking rocks in the wedge are metamorphic, the southeasterly fault may be present but need not be; in either case the northwesterly fault of the pair would be the Eastern Border Fault.

A variety of drag effects are indicated by attitudes of bedding adjacent to the Eastern Boundary Fault. In the northern part of the map area, measured dips are 25 to 35 degrees southeast. This is several degrees steeper than the regional dip of 10 to 15 degrees, and thus suggests reverse drag. A dip of about 2 degrees southeast, which suggests [normal] drag, characterizes the single exposure of sedimentary rock in the flat-lying fault block capped by Hampden Basalt near the middle of the quadrangle. No drag was observed along the west side of Quonnipaug Lake, but between the southern end of the lake and Menuckatuck Reservoir, the changing strike of bedding indicates a horizontal component of motion, with the northwest block having moved northeast.

It has long been recognized that relative downward movement on the west side of this boundary fault brought about deposition of the Triassic formations, and that this movement continued during the [that] period of accumulation (Barrell, 1915). In Durham quadrangle, the very coarse nature of material locally, the presence of mudflows, and the alluvial-fan nature of the deposits that constitute the East Berlin Formation and the Portland Arkose, together with evidence that basaltic magma may have flowed from the fault in places to form the Holyoke and Hampden Basalt formations, show this conclusion to be correct, at least from Holyoke time on during the Triassic.

Faults trending across the Triassic area belong to several major sets. Two of the sets parallel the boundary faults, and trend northeast and north, respectively. Two other sets are cross-faults and trend north-northeast and northwest; a fifth set appears to trend about east-northeast. Of the five sets the northeast and the northwest sets are dominant in terms of influence on the outcrop pattern, and thus on the topography of the quadrangle.

Mapping of major faults within the Triassic area is based mainly on the areal distribution of the basalt formations; linearity of topographically low areas; and brecciation of rock. At two localities breccia about two feet thick is exposed. One is in the roadcut on Whirlwind Hill Road at the north end of Pistapaug Pond, the other is in the west wall of the Coginchaug River valley at the Middlesex-New Haven County line; both zones strike northeast, and dip vertically. Fault-shattered rock is also exposed in borrow pits at the east end of Pistapaug Mountain, but dependable measurements of the attitudes [were not available] of the fault surfaces could not be made.

Minor faults, mostly believed to approximately parallel major faults, are exposed at several places. Most of these minor faults are fractures bordered by distinct brecciated zones; in some, fragment surfaces show slickensides. Actual displacement was measurable along few of these fractures, but in the absence of more useful data, they were mapped as faults. In about three-fourths of them the fractures dip 75 degrees or more, and the minimum dip observed was 35 degrees. The plunge of slickensides in the few cases found ranged from horizontal to 90 degrees; as it is commonly more than 70 degrees, vertical relative stratigraphic displacement has been assumed in the construction of cross sections. Numerous fractures bordered by thin zones of broken rock may represent faults, but were not mapped as such. Together the brecciated fractures suggest that minor faults provided within the formations a considerable amount of adjustment to tectonic stress.

With one exception, the vertical displacement of major faults must be approximated from the cross sections. The exception is the fault traced through Reeds Gap; in the Gap the throw is calculated from the attitude and altitude of the basal contact of the Holyoke Basalt as exposed in the adjacent quarry, together with a water-well log at a house on the north side of the Gap as reported by the quarry superintendent (1964). These data indicate a vertical displacement of about 125 feet. Apparent vertical displacements for other faults as measured on the cross sections include: (1) a total of about 400 feet for the faults through and just north of Pistapaug Pond, (2) about 75 feet for the fault at the north end of Fowler Mountain, (3) about 800 feet for the fault northwest of Totocket Mountain, (4) about 1,375 feet for the fault northeast of Totocket Mountain, and (5) about 125 feet for the fault parallel and next northeast. The amounts of these displacements may change along the strike of the faults.

Some linear, topographically low areas are presumed to have been cut by stream erosion during preglacial time along relatively weak zones in the rock that were caused by faulting. These valleys were modified by glaciers during Pleistocene time, but remain topographically low. Such topographic lineaments are interpreted to be faults only where substantiating data in the form of bedrock displacement and brecciation is known. Elsewhere they are simply shown as lineaments by dotted lines. Although the lineaments mapped all may be the result of faulting, some may be the product of differences in lithology. Minor faults mapped show little or no topographic expression.

Distinct topographic lineaments are apparent in the unmapped part of the quadrangle, which is underlain almost wholly by metamorphosed sediments and mantled by a very thin veneer of glacial deposits. In general these lineaments appear to constitute sets similar in orientation to those of faults in that part of the map underlain by sedimentary rocks of Triassic age. If the lineaments in the unmapped part of the quadrangle are also caused by faults, the position and strike of the Eastern Boundary Fault and other faults within the Triassic Lowland may have been caused during Triassic time either by recurring movement along faults of Pre-Triassic age, or by the development of new faults that broke not only the Triassic rocks as they accumulated, but also the ancient metamorphic rocks that lie ~~lay~~ beneath them and form the adjacent Eastern Highlands. One lineament in the unmapped area may continue beneath the floor of Durham Meadows, and may have been a factor in its origin.

Most joints observed in the Triassic rocks were caused by cooling or tectonic stresses. In the basalt formations, joints represent both kinds of stresses, and are generally distinct, especially those caused by shear. [There are, of course, no joints caused by cooling] in the sedimentary formations [here most joints were ~~are~~ caused by tectonic stresses, though some may be caused by compaction or physio-chemical stresses.

Joints present in the basalt formations that are caused by reduction of volume on cooling are of three principal types: prismatic, columnar, and irregular. The most obvious are the distinctive prismatic joints which form discrete, generally three-sided prisms a few to several inches wide and from 10 to 30 inches long. Good prisms were observed in the basal part of the Holyoke Basalt, but they are believed to be present also in the middle part of the Hampden Basalt. Locally present but less well developed are columnar joints which yield crude columns that are commonly six-sided but that have as few as four and as many as eight sides. The columns range from about 1 to 3 feet in diameter, and from about 5 to more than 50 feet long. The largest are found in the middle part of the Holyoke Basalt, but smaller ones are found in the Hampden Basalt. Small [illegible] fractures a few inches long but without apparent pattern break some basalt into irregular ~~rough~~ chunks; these are most common in the upper part of the Hampden Basalt but may be present also in the upper part of the Holyoke Basalt. Some more or less horizontal fractures of small lateral extent and generally associated with vesicular zones in the basalt, represent flow contacts.

Joints that are generally planar, near-parallel, and of considerable extent both laterally and vertically are believed to be the result of shear stresses caused by tectonic forces. This is indicated by the similarity of attitudes among the sets of joints and the sets of faults. Like the faults, these joints generally dip steeply: dips are generally more greater than 60 degrees, and many dip ~~are~~ from 80 to 90 degrees. A few of the joints are broadly curved. In the sedimentary formations tectonic joints are more common and more distinct in the more massive beds of sandstone and conglomerate; in relatively weaker beds of shale and siltstone the joints are less open, more closely spaced, very irregular in both cross section and plan, commonly branch and pinch out in a complex manner, and are more closely spaced. A few more or less horizontal fractures observed may have been caused by stress relief removal of formerly overlying rock by erosion.

Economic geology.--Basalt is the only bedrock resource currently exploited in Durham quadrangle. Quarry No. 1 of the New Haven Trap Rock Company is situated on the south side of Reed Gap, and yields crushed rock from a face about 250 feet high. Two borrow pits in thoroughly fragmented rock of the Holyoke Basalt are situated at the east end of Pistapaug Mountain, a third is on the east side of the hill on which Bluff Head Cemetery is located, and a fourth is on the west side of State Route 77 some 900 feet north of the cemetery. The rock is used for fill, and is excavated from time to time as needed.

Blocks of basalt from six inches to ten feet across are a major component of talus slopes beneath high bluffs of the Holyoke Basalt. This rock is a potential source of riprap.

Limestone was produced until 1946 from the small quarry about one mile southeast of Pistapaug Pond, in North Branford. The quarry, which is now gradually being filled with trash, exposed a face about 18 feet high in a bed that reportedly (R. S. Coe, in Mikami and Digman, 1957, p. 63) extends 1,250 feet along strike, and yielded rock with a CaO content of 48 to 52 percent, and MgO content of 2 to 3 percent. Most of the rock was ground and used as agricultural limestone, but originally some was calcined, some was ~~or~~ cut for use in construction, as in The Old Stone House, Guilford, Connecticut (W. S. Coe, oral communication, 1964).

Two localities reported both by Carl Otte and by F. F. Bailey (oral communications, 1964) are of possible historical interest. These are a "coal mine" and an "oil well", the approximate locations of which are shown on the geologic map. No surface indication of either was found during mapping, and no record of coal production is known; the "oil well" is inferred to have been an oil test, [possibly of promotional nature.]

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