1-1-1982

Multistage Deformation of the Preston Gabbro, Eastern Connecticut, clinopyroxene, Lake Char fault

Dixon, H. Roberta

P8-1

MULTISTAGE DEFORMATION OF THE PRESTON GABBRO, EASTERN CONNECTICUT

H. Roberta Dixon
U. S. Geological Survey
Denver Federal Center
Denver, Colorado, 80225

INTRODUCTION

The Preston Gabbro is an irregular, but generally oval shaped body which underlies approximately 45 sq. km. in southeastern Connecticut. It is exposed in two areas; a larger northern one in the Jewett City quadrangle, and a smaller one to the south, mostly in the Old Mystic quadrangle, but with a small part along the southern border of the Jewett City quadrangle. The Preston Gabbro has been studied previously by Loughlin (1912) and Sclar (1958). From both field and geophysical studies, the Preston has been interpreted to be a west-dipping laccolithic pluton, 1200 to 1800 m. thick (Griscom and Bromery, 1968, p.426). This interpretation applies to the larger northern part of the pluton, as gabbro in the smaller southern part occurs in irregular fault blocks (Richard Goldsmith, written commun., 1980). The pluton consists largely of gabbro, much of which is hydrothermally altered, but a zone of diorite to quartz diorite about 300 m. thick occurs along the outer margins, in what is interpreted to be an upper shell over the gabbro. The pluton intruded the Quinebaug Formation on the north and west sides and is separated from the Plainfield Formation and Sterling Plutonic Group on the east by the Lake Char fault and on the south by its extension, the Honey Hill fault (Dixon and Lundgren, 1968). The pluton has been complexly faulted by both high-angle and thrust faults, especially in the southern part. In the northern part, numerous small faults and shear zones occur in gabbro exposures, but these could not be traced beyond a given outcrop, and only a few through going faults were recognized.

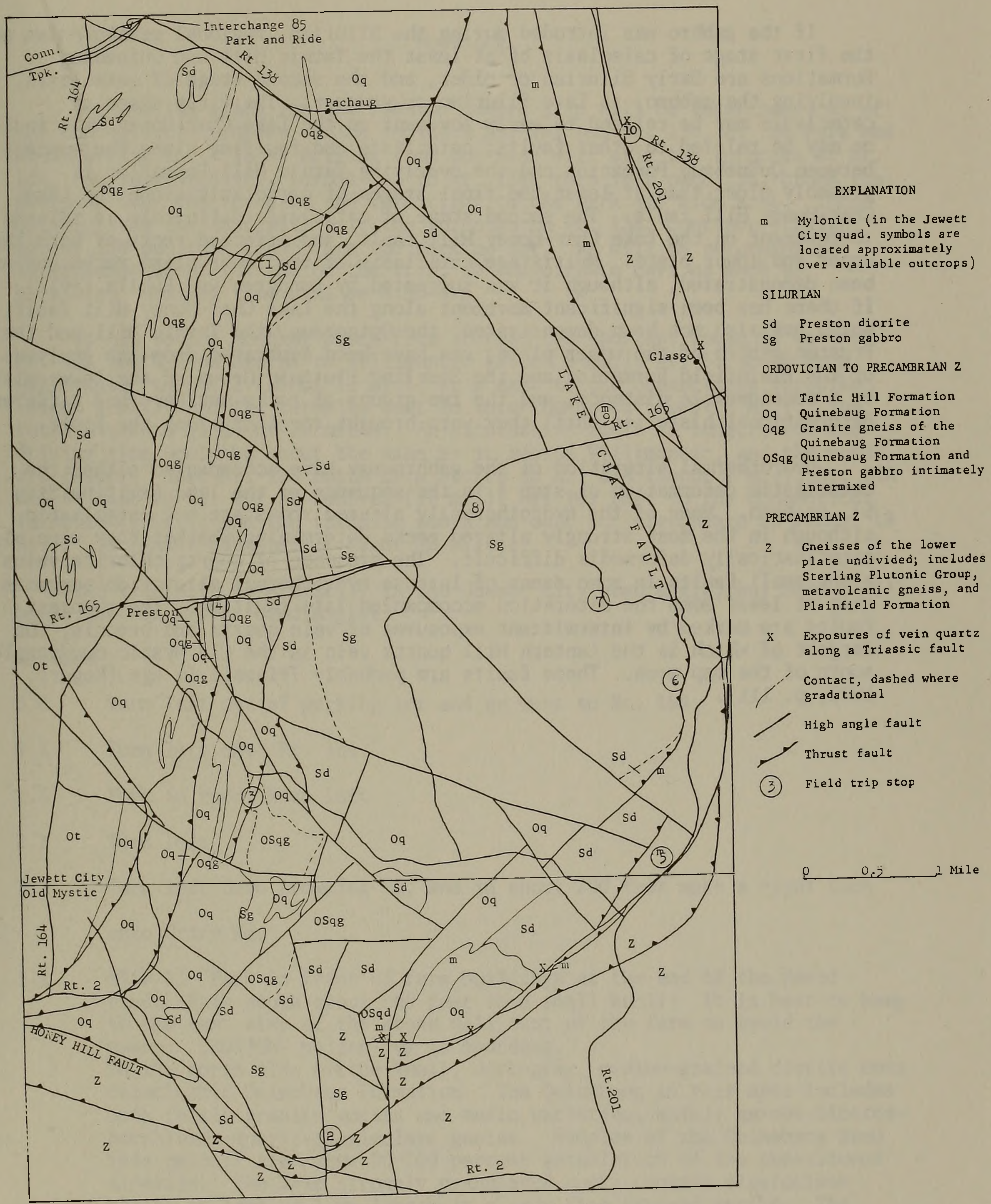
DESCRIPTION OF THE PRESTON GABBRO

The Preston Gabbro as now exposed apparently represents the upper part of a larger, differentiated pluton that has been cut off at the base by the Lake Char fault. Because of the extensive hydrothermal alteration, different compositions could be mapped in only a general way. Fresh gabbro is most common in the central core of the pluton. The gabbro is for the most part quite felsic, containing 50 percent or more labradorite. Clinopyroxene is the most abundant mafic mineral, and in many of the samples examined is the only mafic other than magnetite-ilmenite. Olivine or hypersthene may be present in small amounts, and locally either one may be the predominant mafic mineral. Gabbro containing less than 50 percent labradorite is present locally; Loughlin (1912) reported a sample containing 15 percent plagioclase and the remainder clinopyroxene and ilmenite. Gabbro as mafic as this is rare, however, and no true ultramafic rocks have been identified. If ultramafics formed they are not now exposed at the surface, and either they are buried at deeper levels within the pluton or they are beneath the Lake Char fault.

On the north, west, and less continuously the south, sides of the pluton, gabbro grades into an upper shell of diorite to quartz diorite. The diorite also may occur along the east side, and it is exposed along the southeast side, but much of the rock along the east side is so thoroughly mylonitized that its original composition cannot now be determined other than that it was mafic. The diorite consists of green hornblende, calcic andesine, and minor quartz and biotite. Much of the diorite is hydrothermally altered also, although fresh diorite is present locally, and in many areas alteration was not strong enough to destroy the original subophitic texture of the rocks. At least some of the hornblende apparently is pseudomorphic after clinopyroxene, as a few samples have a core of pyroxene preserved in the hornblende. More commonly, however, the hornblende replacing pyroxene is crowded with very fine grained opaque minerals, and is associated with small rounded blebs of quartz. Other hornblende is clear and without the small quartz blebs, and is probably an original magmatic mineral. Aside from the small quartz blebs, some diorite samples contain as much as 5 percent interstitial quartz, which also is considered to be a magmatic mineral.

Small trondhjemite dikes, rarely more than a meter thick, cut the diorite and the adjacent Quinebaug Formation and form a late felsic differentiate in the upper part of the pluton. The trondhjemite contains oligoclase, quartz, minor biotite and microcline, and as much as 1 percent zircon. Most trondhjemite is moderately to strongly cataclastic. One dike which is slightly altered, but which is not cataclastic, cuts the diorite-Quinebaug contact near the northeast corner of the pluton; the Quinebaug of this area is strongly cataclastic. A U-Th-Pb zircon age of 424±5 m.y. (R. Zartman, written commun., 1980) was determined from a sample of this dike and indicates a Silurian age for intrusion of the gabbro.

The time of intrusion of the gabbro relative to the metamorphism and deformation of the adjacent rocks has been the subject of some discussion. Loughlin (1912, p. 38-40) interpreted the inclusions in the diorite to be hornfels, and on this basis, as well as the presence of foliated rocks near the edges of the pluton, concluded that the gabbro was intruded prior to regional metamorphism. Sclar (1958), on the other hand, concluded that the gabbro was emplaced after regional metamorphism but prior to cataclastic deformation. My work on the Preston Gabbro confirms Sclar's interpretation with the exception that cataclasis preceded as well as succeeded gabbro intrusion. Loughlin's hornfels inclusions are, for the most part, inclusions of cataclastic Quinebaug, many of which are present in undeformed diorite. The intensity of cataclasis of the inclusions is variable, and in some the original metamorphic gneissosity is still apparent. Foliated gabbro and diorite are as common within the pluton as they are near the edges, and this foliation is the result of cataclasis rather than of regional metamorphism. In places, especially along the Lake Char fault on the eastern margin of the pluton, and locally elsewhere, cataclasis is intense and the gabbro has been converted to mylonite. Thus, the sequence of deformation and intrusion is: (1) regional metamorphism of the area, including the Tatnic Hill and Quinebaug Formations and probably the rocks of the lower plate of the Lake Char-Honey Hill fault; (2) cataclastic deformation of at least the Tatnic Hill and Quinebaug Formations; (3) gabbro intrusion; (4) continued cataclastic deformation and mylonitization of gabbro and adjacent rocks along the Lake Char-Honey Hill fault; (5) late faulting, at least in part high angle, offsetting the mylonites.



Generalized geologic map of the Preston Gabbro, Connecticut
(Old Mystic quadrangle from R. Goldsmith, written comm., 1980)

If the gabbro was intruded during the Silurian, regional metamorphism and the first stage of calaclasis of at least the Tatnic Hill and Quinebaug Formations are Early Silurian or older, and the second stage of cataclasis, involving the gabbro, is Late Silurian or younger. The first stage of cataclasis may be related to early movement on the Lake Char-Honey Hill fault, or may be related to other faults; cataclasis and faulting along the contact between Quinebaug Formation and the overlying Tatnic Hill Formation is probably older than at least the final stages of cataclasis along the Lake Char-Honey Hill fault. The second stage of cataclasis definitely is related to movement on the Lake Char-Honey Hill fault, and affected rocks of both the upper and lower plate. Multistage cataclasis of the lower plate rocks has not been demonstrated, although it was suggested by Lundgren and Ebblin (1972). If there has been significant movement along the Lake Char-Honey Hill fault, which has also not been demonstrated, the Quinebaug, the Tatnic Hill and the Preston gabbro of the upper plate, may have been separated from the gneisses of the Plainfield Formation and the Sterling Plutonic Group of the lower plate by a considerable distance, and the two groups of rocks may have had different deformational histories until they were brought together along the fault.

Hydrothermal alteration of the gabbro may have accompanied either the cataclastic deformation of step 4 in the sequence or the late faulting(Step 5), or both. Many of the hydrothermally altered rocks are not cataclastic, although in the most strongly altered rocks determining whether they were also cataclastically deformedis difficult. The presence of quartz-chlorite veins along small faults in some areas of intense hydrothermal alteration suggests that at least some the alteration accompanied late faulting. The youngest faults are marked by intermittent exposures of vein quartz and breccia, the largest of which is the Lantern Hill quartz vein in the Old Mystic quadrangle, south of the map area. These faults are probably Triassic in age (Rogers, 1970, p. 111).

Road Log

The meeting place for the Preston Gabbro trip will be Interchange 85 of the Connecticut Turnpike, which includes Rt. 164 and Rt. 138, at the Park and Ride parking lot. Those driving from the west will exit the turnpike at Rt. 164, continue straight, across 164 to Rt. 138; turn left onto 138, cross the overpass over the turnpike and turn right to the Park and Ride area. Those driving from the east will exit the turnpike on Rt. 138, continue straight across 138 and turn right into the parking lot. We will be returning to Interchange 85 at the end of the trip, so consolidate cars as much as possible. Meeting time will be 8:30 a.m.

To get to the meeting place from Storrs, the shortest route is to take Rt. 195 south from Storrs to Willimantic (about 8 mi.); Rt. 32 south from Willimantic to Rt. 2 (about 12 mi.); Rt 2 east to the Connecticut Turnpike (about 1 mi.); and the turnpike east to Interchange 85 (about 8 mi.). The total distance is about 30 miles. An alternative route is longer, but the driving time would be about the same as it avoids Willimantic, and the roads are faster. Take Rt. 195 north from Storrs to Rt. 44A (about 1 mi.); Rt. 44A and 44 east to Rt. 101 at Pomfret (17 mi.); Rt. 101 east to the Connecticut Turnpike (5 mi.); and the turnpike south and east to Interchange 85 (about 18 mi.). The total distance is about 40 miles.

The trip will be primarily in the Jewett City quadrangle, but Stop 2 will be in the Old Mystic quadrangle.

Mileage

0.0 Turn left out of parking lot and go west to Rt. 164.

0.2 Turn left onto Rt. 164.

1.3 Fork in road; keep left

2.1 Turn left.

2.7 Turn left onto Browning Rd, and in about 200 feet make a right turn onto Crary Rd.

3.1 STOP 1. Park in front of farm buildings at the end of the paved road. Walk south about 800 feet to a small knoll; it is best to keep to the east side of the stone wall east of the farm to avoid the swamp. CAUTION--poison ivy is abundant.
On the north side of the knoll, dark-gray, medium-grained diorite cuts cataclastic Quinebaug Formation. The Quinebaug in this area includes both felsic granite gneiss and mafic varieties, mainly garnet-biotite-hornblende-quartz-plagioclase gneiss. Samples of the Quinebaug from this general area show 50-100 percent granulation of the constituent minerals. The less strongly granulated rocks contain plagioclase clasts as long as 1 mm length in a very fine grained matrix. The diorite is subophitic, and contains green hornblende, andesine, and minor biotite and quartz. Quartz occurs both as rounded blebs

associated with the green hornblende and as irregular interstitial, grains. The rounded blebs of quartz are residual silica from the hornblendization of pyroxene. The diorite here is not cataclastically deformed. One the south side of the knoll is a trondhjemite dike, apparently cutting the Quinebaug-diorite contact. The rock is light gray, medium grained, and contains 75 percent oligoclase, 11 percent quartz, 7 percent biotite (partly chloritized), 4 percent hematite, and about 1 percent zircon. The thin section of the trondhjemite shows minor granulation along grain boundaries, and minor alteration, but the rock is not cataclastic. Zircons from this rock gave a 424±5 m.y. age. Deposition, metamorphism and cataclastic deformation of the Quinebaug Formation must be older than 424 m.y.

Turn the cars around and return to Browning Rd.

3.5 Turn left onto Browning Rd.

5.1 Intersection with Rt. 164; take left fork onto Rt. 164.

6.3 Town of Preston; continue south on Rt. 164.

8.6 Enter Old Mystic quadrangle.

9.3 Intersection with Rt. 2; turn left onto Rt. 2.

10.3 Outcrops of Quinebaug Formation on the left.

11.3 Outcrops of Preston Gabbro on the left.

11.8 Turn left onto Old Rt. 2.

12.1 STOP 2. Pull cars off on the right side of the road. A road cut on the north side of the road exposes mylonitized gabbro. Sclar (1958, p. 70-74) gives a detailed petrographic description of the rocks in this exposure. The intensity of cataclasis increases from west to east in this exposure, and the mylonite on the southeast side is ultrafine grained and well layered, whereas that on the northwest side is not quite so strongly cataclastic, and is massive. The layered mylonites are so thoroughly granulated that identification of the constituent minerals is difficult, except for a few fine clasts of hornblende and plagioclase. The light-colored laminae may be thoroughly granulated and attenuated grains of plagioclase, or they may have been small felsic dikes that are completely granulated. Sclar (1958) interpeted some of the mylonite in this exposure to have been originally an amphibole gneiss associated with the metamorphic complex, and the rest to have been gabbro. The rocks are so thoroughly granulated it is impossible to be sure what the original rock was, but more likely all of the mylonite in this exposure was originally gabbro. Deformation of the gabbro must have been younger than 424 m.y.

Proceed east on Old Rt. 2.

12.3 Turn right onto Rt. 2.

13.5 Turn right onto Wattson Rd.

14.5 Enter the Jewett City quadrangle.

15.1 Intersection with Hollowell Rd.; keep to the right.

15.9 Turn right onto Preston-N. Stonington Rd. (Road names in local usage do not agree with those on the topographic map. The map usage is followed here.)

16.4 STOP 3. Take a right fork onto a dirt trail and park the cars near the small house left of the trail. Walk south along the trail about 800 feet. Exposures along the trail are of cataclastic Quinebaug Formation, mostly the felsic granite gneiss, though with some interlayered mafic gneiss. The felsic gneiss is light colored, and very fine grained, and is composed mainly of oligoclase and quartz with lesser amounts of biotite-chlorite and epidote. The mafic rocks are composed of varying proportions of plagioclase, hornblende, quartz, chlorite and epidote. About 60-100 percent of the constituent minerals are granulated. East of the trail are numerous exposures of cataclastic Quinebaug and of massive, coarse- to medium-grained diorite which is altered but not cataclastic. The less strongly altered diorite is composed primarily of green hornblende, and andesine, minor opaque minerals, biotite, and quartz and varying amounts of chlorite and epidote. A subophitic texture is apparent in diorite which is not thoroughly altered. The diorite contains inclusions of strongly cataclastic Quinebaug, both the felsic and mafic varieties. Where locally sheared in this area, the diorite is difficult to distinguish from the Quinebaug. The cataclasis of the Quinebaug was older than intrustion of the gabbro-diorite, and thus was older than 424 m.y.; shearing of the diorite is younger than 424 m.y.

Return to the cars, turn left on North Stonington Rd.

18.0 Turn right onto 164.

18.2 Stop light at Preston City, turn right onto Rt. 165.

18.8 STOP 4; LUNCH. Turn right into Folly Worke Brook roadside park. Intermittent exposures for about 1600 ft. (500 m) along Rt. 165, from the roadside park east, cross the Quinebaug-Preston contact. Road cuts at the park are moderately cataclastic granite gneiss of the Quinebaug Formation. The foliation is defined by a biotite streaking, which forms a faint lamination. Several small faults are recognized by slicked surfaces, which are diverse in attitude, and the plunge of the slickensides ranges from horizontal to vertical. To the east along the road are low-lying exposures of amphibolite, hornblende gniess, and granite gneiss. A high-angle fault, approximately paralleling the road, cuts the exposures on the south side of the road. East of the farm road (Strawberry Camp Grounds) are exposures of mylonitic Quinebaug. The rocks are of various phases of the

Quinebaug; all are about 100 percent granulated, and locally there is healed breccia. Small dikelets of ultramylonite are present. East of the mylonite is about 600 feet of no exposure, and then low lying exposures of Preston diorite on the north side of the road. The diorite is medium grained and is composed of green hornblende, andesine, and about 5 percent quartz, both as rounded blebs associated with hornblende, and as irregular interstitial grains. The diorite is not cataclastic; thus cataclasis of the Quinebaug Formation in these exposures must be older than 424 m.y.

Return to the cars and turn right onto Rt. 165.

20.4 Turn right onto Northwest Corner Rd.

22.9 Turn left onto N. Stonington Rd.

23.6 Fork in road; keep right

23.7 Enter Old Mystic quadrangle

24.3 Intersection with Rt. 201; turn left onto Rt. 201.

24.7 Enter Jewett City Quadrangle.

25.0 STOP 5. Pull onto the wide grassy area on the left (west) side of the road. Walk into the woods on the west side of the road. Several low cliffs are of mylonite, and were described and illustrated by Lundgren and Ebblin (1972). The rocks here are so thoroughly granulated that identification of the original rockis not possible, although it probably is from the lower plate of the Lake Char fault. Both felsic and mafic mylonite are exposed, and the felsic mylonite is probably Hope Valley Alaskite Gneiss, and the mafic mylonite is probably metavolcanic rock, which is exposed east of the Rt. 201 where it is not so strongly cataclastic. For the most part, the mylonites here are too fine grained to identify the constituent minerals with the microscope. Various stages of folding are seen from irregular open folds, to tight isoclinal folds of layers about 5 mm thick. A general N30^{o}W cataclastic lineation is axial to the tight isoclinal folds. Cataclasis here is associated with the Lake Char fault and is younger than 424 m.y.

Turn back onto Rt. 201 and continue north.

26.2 STOP 6. Turn left onto a farm road, and drive up to the house. Park the cars by the house, and walk through the animal pens to the cliff exposures behind the pens. Be sure to KEEP THE GATE CLOSED, so the geese will not get out. The rock in the cliffs is mylonitic gabbro on the extreme east side of the Preston pluton. Mylonite here is massive and unlayered, although along the hill slope both north and south local areas of layered mylonite are exposed. Probably the layering occurs in areas containing felsic dikes, which are more readily granulated and attenuated than is the gabbro. Strong cataclasis of the gabbro is apparent in only a narrow zone immediately adjacent to the fault; in the upper part of the cliff, the intensity of cataclasis has decreased to the point where some consituent minerals of the gabbro are recognizable in the hand sample. Proximity to the Lake Char fault is indicated by felsic mylonite from the lower plate on the sides of the small gulley just east of the cliff; the felsic mylonite may be boulders rather than outcrop, but, if so, the boulders cannot have moved far. Cataclasis here is associated with the Lake Char fault and is younger than 424 m.y.

Return to Rt. 201.

26.5 Turn left onto Rt. 201.

26.7 Turn left onto unnamed road.

27.3 Turn left onto Youngs Rd.

27.9 STOP 7. Go straight onto the dead end road, and park cars by the side of the road just west of the bend in Youngs Road. Numerous low-lying exposures of gabbro occur on both sides of the road. Much of the gabbro is hydrothermally altered, but fresh gabbro is exposed in a small area on the south side of the road. No thin section is available from the gabbro right here, but thin sections from nearby exposures indicate that the rock of the general area is a clinopyroxene-olivine gabbro. The gabbro here is not cataclastic, although there are small local zones of foliated gabbro.

Turn around and continue north on Youngs Road.

29.0 Turn left onto Rt. 165.

29.8 STOP 8. Pull off the road onto the wide shoulder on the right. On the east side of the road are exposures of porphyritic gabbro. The gabbro is hydrothermally altered so that none of the original mafic minerals are still present in the rock, but labradorite is still fairly fresh. Hornblendized pyroxene, as much as 10 cm in diameter, is unusually large in this exposure. Porphyritic gabbro is common in the central part of the pluton, but the pyroxene, or hornblendized pyroxene grains, are commonly 0.5-1.5 cm in diameter. Symplectite coronas of actinolite, opaque minerals and chlorite surround alteration masses of amphibole and suggest that originally the rock contained olivine. At the east end of the exposures the gabbro is thoroughly altered so that only minor plagioclase is left, and the rock consits mainly of epidote, chlorite and pale green amphibole.

Turn cars around and return east on Rt. 165

30.8 Turn left onto a dirt road called Burdic Lane

31.2 STOP 9. Pull cars off the road on the left. Exposures of mylonite on the top and east side of the knoll (note that the topographic map locates the top of the knoll about 200 ft. west of the road, whereas it is actually just uphill from the road). Again, the rock is so thoroughly granulated that the original rock cannot be identified with any certainty. Just above the road is a rusty weathering mafic mylonite that was probably mafic metavolcanic rocks of the lower plate. The mafic mylonite has a slatey cleavage and a crinkle lineation on the cleavage surfaces, but folding has not been observed. The mylonite on the top of the knoll is granitic in composition, and much is strongly epidoitized; it probably is Hope Valley Alaskite Gneiss. Mylonite here is lineated and folded, but the prominent cataclastic lineation is folded around the axis of the main visible folds and thus is not axial to them. The tight isoclinal folding observed at Stop 5 has not been seen here. Cataclasis is associated with the Lake Char fault and is younger than 424 m.y.

Turn cars around and return to Rt. 165

31.6 Turn left onto Rt. 165

32.7 Turn left onto Rt. 201

34.9 Turn right onto Rt. 138, and in less than 0.1 mile turn left into the old road alignment of Rt. 138.

STOP 10 Vein quartz, somewhat brecciated, along a north-trending fault. This is one of a series of intermittent exposures of vein quartz that occur along a line from the town of Glasgo north into the Plainfield quadrangle to the north, and mark the trace of a late, high-angle fault. At stop, 10 nothing much is visible but the quartz, but in some exposures the vein quartz is associated with silicified, but recognizable Hope Valley Alaskite Gneiss. This fault is interpreted to be related to the faulting that resulted in the large vein quartz at Lantern Hill in the Old Mystic quadrangle to the south, although they are not on line, and is thought to be Triassic in age.

Turn the cars around and turn right onto Rt. 138 and return to the Connecticut Turnpike. Interchange 85 is about 4 miles west.

REFERENCES CITED

Dixon, H. R., and Lundgren, L. W., Jr., 1968, Structure of eastern Connecticut, in Zen, E-an and others, eds., Studies of Appalachian geology--Northern and maritime: New York, Interscience Publishers, p. 219-229.

Griscom, Andrew, and Bromery, R. W., 1968, Geologic interpretation of aeromagnetic data for New England, In Zen, E-an and others, eds., Studies of Appalachian geology--Northern and maritime: New York, Interscience Publishers, p. 425-436.

Loughlin, G. F., 1912, The gabbros and associated rocks at Preston, Connecticut: U. S. Geological Survey Bulletin 492, 158 p.

Lundgren, Lawrence, and Ebblin, Claude, 1972, Honey Hill fault in eastern Connecticut; regional relations: Geological Society of America Bulletin, v. 83, p. 2773-2794.

Rodgers, John, 1970, The tectonics of the Appalachians: New York, Wiley-Interscience, 271 p.

Sclar, C. B., 1958, The Preston gabbro and the associated metamorphic gneisses, New London County, Connecticut: State of Connecticut Geological and Natural History Survey Bulletin 88, 131 p.