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OPERATION OF THE WILSON CYCLE IN WESTERN NEW ENGLAND DURING THE EARLY PALEOZOIC: WITH EMPHASIS ON THE STRATIGRAPHY, STRUCTURE, AND EMPLACEMENT OF THE TACONIC ALLOCHTHON

by

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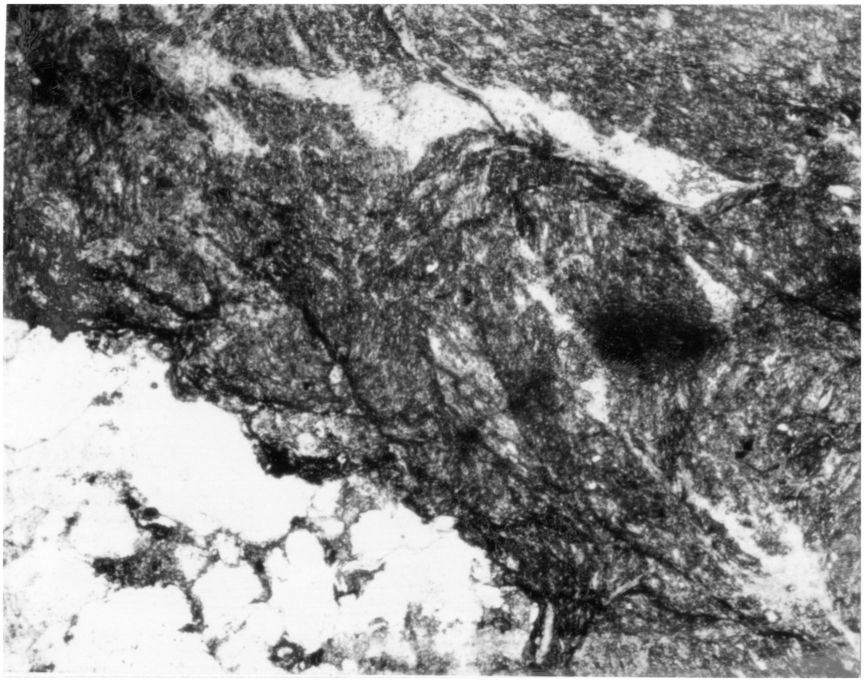

Figure 3.1. Photomicrograph of a pre-depositionally (?) foliated argillite clast in a medium to coarse grained Black Pond lithofacies arenite (light colored region in the lower left hand corner. The pre-depositional fabric is defined by folded and openly crenulated fine-grained micas and clay films that have an approximately vertically oriented enveloping surface. The clearly post-depositional fabric is defined by the anastamosing dark films that cross the field of view from the lower right to the upper left. The field of view is approximately 4mm across.

Figure 3.2a. Type locality of the West Castleton Member of the Hatch Hill Formation. White plaque is on a 75 cm thick lens of interbedded carbonate and black slate that lies within a predominantly dolomitic quartz arenite and black slate unit. Plaque is 10 cm on an edge. Roadcut is on Scotch Hill Road to the west of West Castleton.

Figure 3.2b. Type locality of the West Castleton showing dominant lithologies of thin interbeds of dolomitic quartz arenite and black slate.

Figure 3.3. Close-up of rotten-weathering dolomitic quartz arenite interbedded with fissile black slate at the West Castleton type locality.

Figure 3.4. 2 m thick channel-fill dolomitic quartz arenite with abundant arenite rip-up clasts, internal bedding laminations, and dish structures (Figure 3.7b). Along Poultney River on the east limb of the Mount Hamilton syncline.

Figure 3.5. Cross-cutting erosive base of a Hatch Hill dolomitic arenite along the Poultney River on the east limb of the Mount Hamilton syncline on the New York side. Note that the dominant lithology is thinly interbedded arenites and slates. White plaque is 10 cm on an edge.

Figure 3.6. Steep-sided channel filled with Hatch Hill conglomeratic arenite. Clasts are dominantly siliceous argillite and chert. From roadcut on Route 22A approximately 1.5 km north of intersection with Route 4.

Figure 3.7a. Thin, evenly bedded dolomitic quartz arenite, black slate, black siliceous slate, and black cherts exposed along the Poultney River on the Vermont side, on the east limb of the Mount Hamilton syncline. The thin beds of arenite are interpreted as levi, overbank deposits, possibly variably reworked by contour currents.

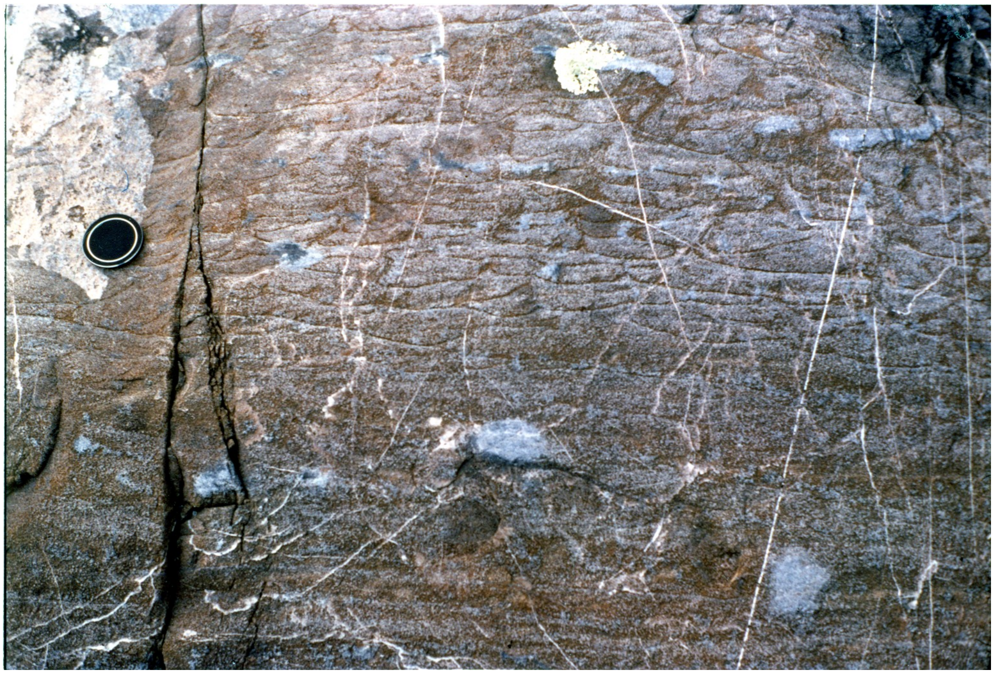

Figure 3.7b. Dish structures in thick dolomitic quartz arenite bed depicted in Figure 3.4. Lens cap approximately 5 cm in diameter.

Figure 3.8. Breccia in the Hatch Hill. Dominant clasts are indigenous internally laminated arenites of Hatch Hill type. Lens cap approximately 5 cm in diameter.

Figure 3.9. Hatch Hill breccia. Large tabular clasts suggest local derivation and deposition by debris flow processes.

Figure 4.1. Roadcut along Route 22A approximately .4 km north of intersection with Route 4. Irregular lensing fabric of rocks adjacent to the white plaque is associated with slump folded and disrupted Bomoseen wackes, dirty arenites and micaceous slates.

Figure 4.2. Mesoscale fold of thin silty Bomoseen quartzite and argillite. Mesoscale folds have widely variable hinge line orientations, but are mostly reclined or steeply inclined on the superimposed regional slaty cleavage. These folds are interpreted to be of slump origin.

Figure 4.3. Large roadcut along Route 4 just east of the eastbound entrance ramp from Scotch Hill Road. Syn-depositional, slump repeated section of interbedded carbonates and medium to dark gray calcareous slates of the Browns Pond Formation. Note the truncations of bedding in the central lower part of the photograph, and the absence of veining along the zones of truncations. Sequence in the upper right hand portion of the photograph appears to be uneffected by this disruption.

Figure 4.4. Syn-depositional faults offsetting several layers of silty quartzites of the Poultney Formation. Faults are curved and appear to have somewhat variable offset of layers along their traces. New York side of the Poultney River near the core of the Mount Hamilton syncline.

Figure 4.5. Large water washed outcrop of the Poultney Formation showing prominent cross-cutting zone with lenses of gray weathering carbonate in the zone. Dominant lithology is interbedded silty quartzites and hard silty argillites. No demonstrably interbedded carbonate is present in the outcrop.

Figure 4.6a. Close-up of a portion of cross-cutting zone of Figure 4.5a. Note truncation of layering with a down the right (east) sense of 'drag'. Also the lens of carbonate along the fault surface. Examination of differently oriented sections of the fault indicate a pre-slaty cleavage, possibly syn-depositional age.

Figure 4.6b. Close-up of a carbonate lens along the fault. The carbonate lens clearly truncates bedding on either side.

Figure 4.7a. Small, approximately 15 cm diameter ring structure in thin silty quartzite and dark slate of the Poultney Formation. Outcrop along the Poultney River on the New York side, just east of the large outcrop with the cross-cutting pre-cleavage fault shown in Figures 4.5, 4.6a and 4.6b.

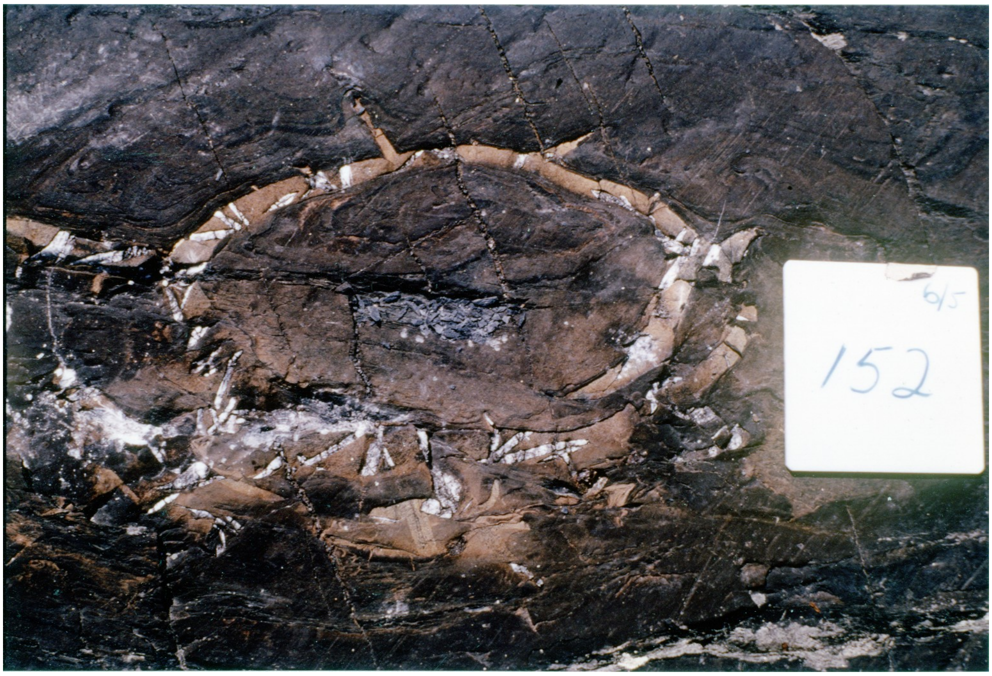

Figure 4.7b. Close-up of ring structure. White vein material in gypsum, and suggests the structure developed in association with radial expansion. Note small radially distributed dikelets of Poultney quartzite. Ring structure are believed to be comparable with ring dikes or cone sheets, and associated with loss of volatiles from the sediments. White plaque is 10 cm on an edge.

Figure 4.11a. Forbes Hill type pebbly mudstone adjacent to the Basal thrust of the Allochthon. Pebbles in the mudstone are mostly rounded quartzite and wacke comparable with the Black Pond lithofacies and the Bomoseen. Outscop is west of Moscow Road and approximately 1.1 km north of Black Pond.

Figure 4.11b. Isolated pebble of wacke in a dominantly argillite clast and argillite matrix facies of the Forbes Hill 'Conglomerate'. Wacke clast is 4 cm across. Roadcut just east of Bradlee School at the north end of the field area.

Figure 4.12. Exposure of the pre-slaty cleavage age 'Basal thrust' contact of allochthonous Bomoseen wacke and slate above and veined and fractured parautochthonous Providence Island carbonate below. Note that a thin zone of black slate invervenes between the carbonate and Bomoseen along the contact. Photograph from the west side of the window at William Miller Chapel, New York.

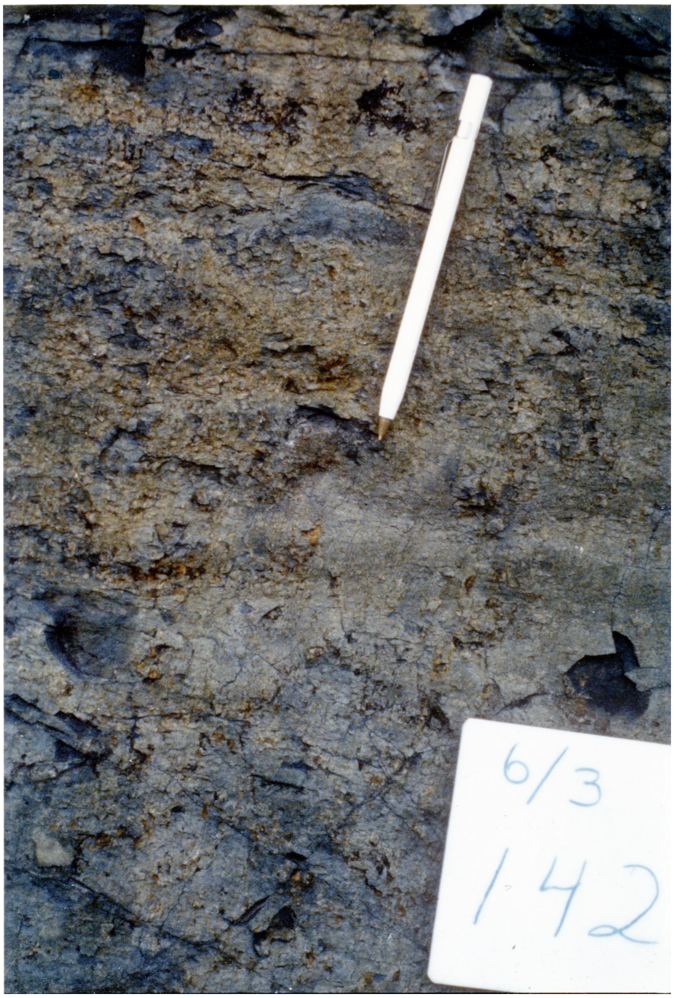

Figure 4.13. Very faint, thin layer of slickensides on a bedding parallel surface in the Poultney Formation. Slickensides parallel the pen and pre-date the slaty cleavage that produces an intersection lineation running horizontally across the photograph. Pen is approximately 15 cm long.

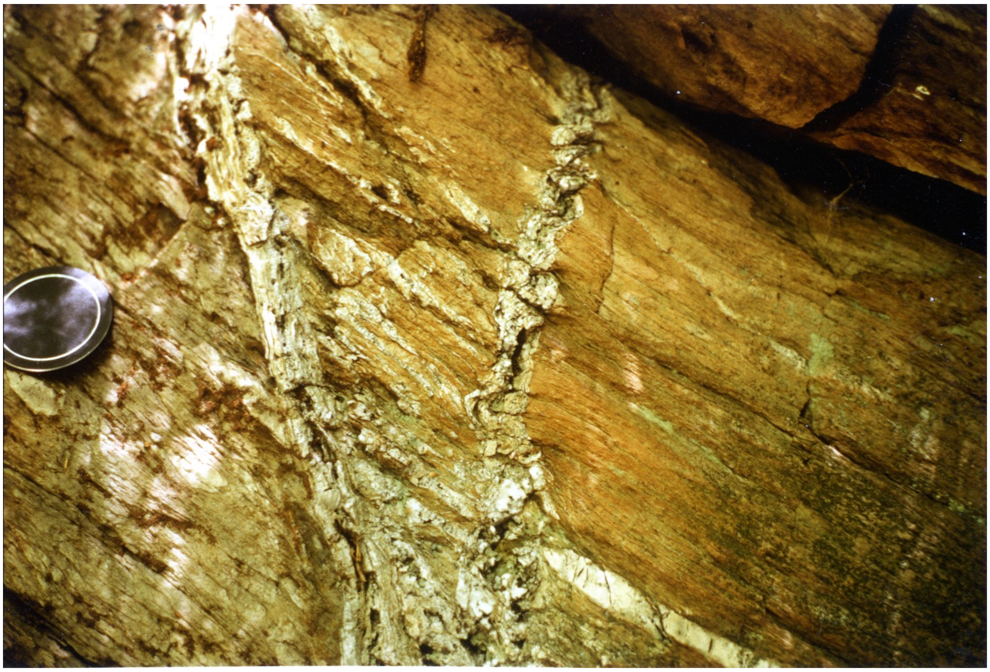

Figure 4.14. Two pre-slaty cleavage laminated shear zones from the east limb of the Porcupine Ridge anticline, 0.5 km south of Moscow Pond.

Figure 4.15. Slickensided laminated shear zone along the base of a 35 cm thick Hatch Hill dolomitic quartz arenite. Bedding is vertical and the slickenside striations plunge down dip. Outcrop along the Poultney River on the New York side on the east limb of the Mount Hamilton syncline.

Figure 4.16. Same outcrop as 4.15 showing region where fault cross-cuts bedding and is associated with folding and disruption of bedding as well as extensive veining shown in Figure 4.17. White plaque is 10 cm on an edge.

Figure 4.17. Close-up of a region where the fault surface obliquely intersects thicker dolomitic quartz arenite layer. Note the development of net veining in the arenite.

Figure 4.18. Detailed view of a pre-slaty cleavage laminated vein from a roadcut of the White Creek Member of the Hatch Hill Formation along Route 4, 2.7 km west of the New York-Vermont state border. Photograph courtesy of Bill Bosworth.

Figure 4.19a. Veined and partially 'necked' pull-apart zone connecting two pre-slaty cleavage laminated shear zones. The relative motion was upper right over lower left. Total amount of motion along the lower fault is equal to the amount of extension represented by the veining. Southeast side of Route 4 (see Plate 3).

Figure 4.19b. Thin bedding and shear zone parallel exposure of pre-slaty cleavage slickensided surface. Slickensides are oriented from left to right across the photograph, whereas the superimposed slaty cleavage-shear zone intersection lineation crosses the photograph from top to bottom. Location same as Figure 4.19a.

Figure 4.20. Pre-slaty cleavage laminated shear zone in Middle Granville slates exposed along Route 4 and shown on Plate 3, thrust sheet 2. Note plications of the laminae and the offset of the thin vein on the left side of the photograph. Quarter for scale.

Figure 4.23a. Large mesoscopic fold of thin Poultney quartzites and silty argillites. Note the nearly horizontal upper limb, nearly vertical lower limb, and the narrowness of t the hinge region. Outcrop on the New York side of the Poultney River. Same outcrop as depicted in Figure 4. White plaque is 10 cm on an edge.

Figure 4.23b. Oblique section through fold shown above illustrating rounded hinge, approximately 2 times thickness increase parallel with slaty cleavage, and small scale disruption of bedding.

Figure 4.23c. Mesoscopic fold of a 35 cm thick bed of Hatch Hill dolomitic quartz arenite. Note the apparent absence of thickening of the arenite in the hinge of the fold. Outcrop is adjacent to the Poultney River on the New York side, on the lower, west limb of the Mount Hamilton syncline.

Figure 4.23d. Mesoscopic fold profile of folded Hatch Hill arenite. In contrast to the fold shown above this fold shows a marked thickening of bedding in the hinge region of the fold. Same outcrop as above.

Figure 4.27. Photograph of the hinge region of the Scotch Hill syncline as exposed at West Castleton immediately east of Glen Lake. The rocks belong to the Poultney Formation.

Figure 4.28. Profile and hinge line-parallel exposure of the Cedar Mountain syncline in the large abandoned quarry on Cedar Mountain near the north end of Lake Bomoseen. Rocks belong to the Middle Granville Slate and consist of interbedded purple and green slates. The wall with the fold profile is about 10 meters high.

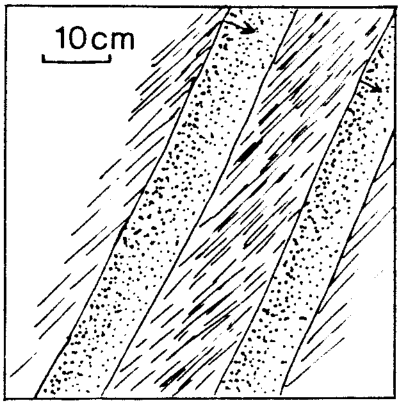

Figure 4.32. Outcrop sketch of thin bedded Hatch Hill dolomitic quartz arenite and black slates from the Cossayuna area. Sketch shows east-dipping, westward younging arenites and more steeply east-dipping slaty cleavage. Projection of the bedding younging direction on the slaty cleavage suggests a downward facing antiformal syncline geometry. This geometry does not appear to be substantiated by the regional mapping of Platt (1960) and Pindell (pers. comm., 1980).

Figure 4.33. Inadvertently omitted.

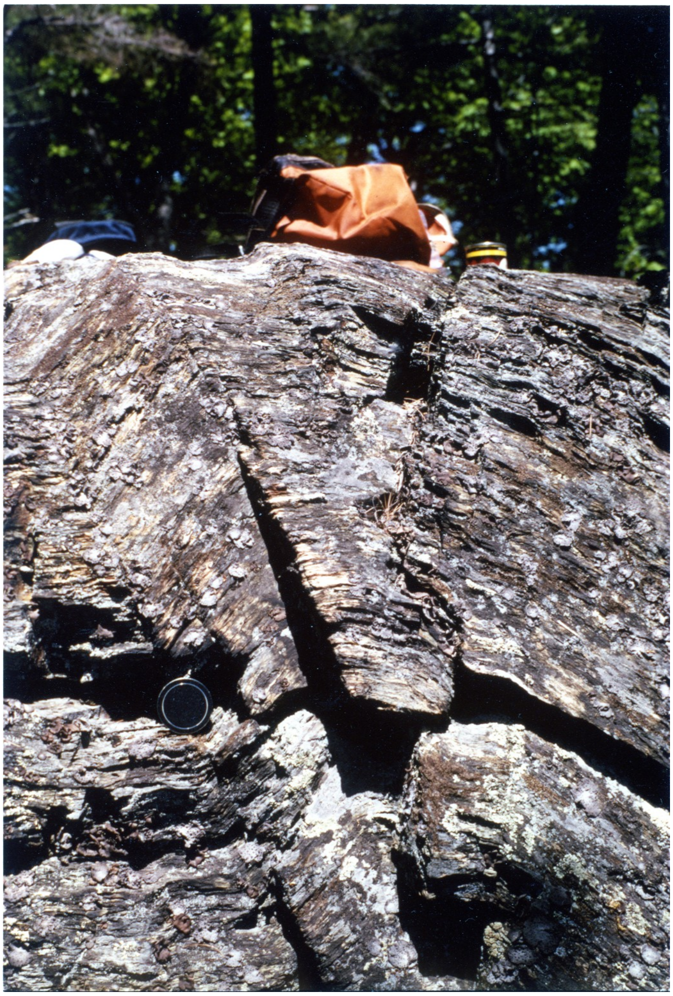

Figure 4.34. Asymmetric conjugate box fold geometry of a mesoscopic F_3 fold. Hinge line is nearly horizontal and the photograph was taken looking north. East limb of the Porcupine Ridge anticline, west of the north end of Glen Lake.

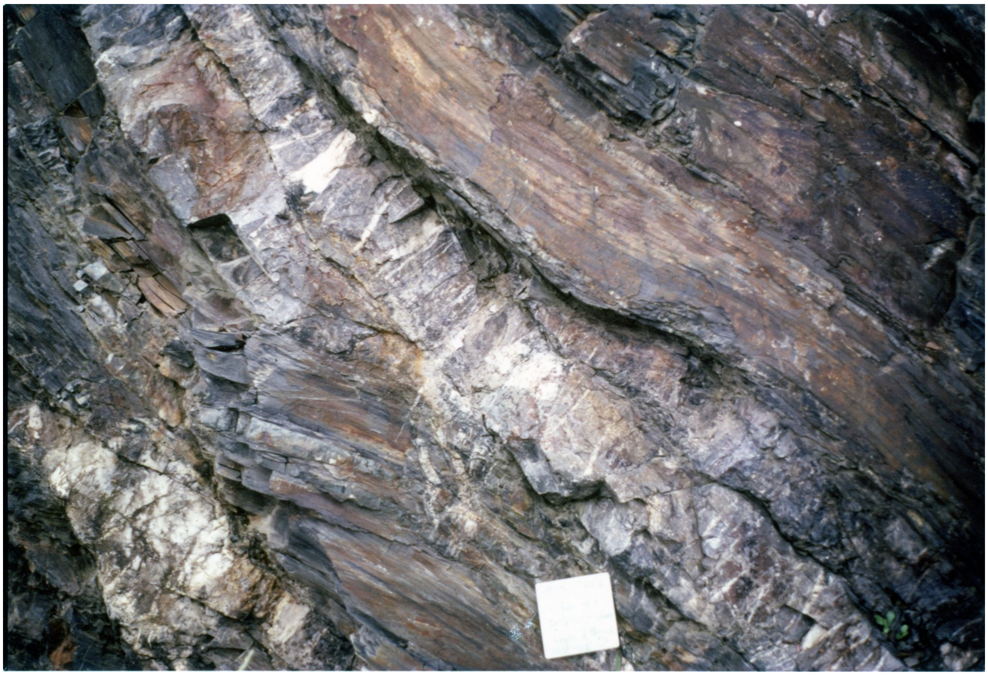

Figure 4.36. Thrust replicated quartzite in the Bull Formation. Quartzite contains pre-existing fibrous extension veins. Roadcut on Route 22 A, 0.4 km north of intersection with Route 4. White plaque is 10 cm on an edge.

Figure 4.37. Narrow zone of crenulation cleavage development along the extension of one of the faults that repeat the quartzite bed shown above. Outcrop location same as above.

Figure 4.38. Interbedded carbonate and dark slates of the Browns Pond Formation. Carbonate beds are extensively veined by both fibrous and massive carbonate and carbonate plus quartz veins. Roadcut shows the hinge region of the Scotch Hill syncline where bedding-parallel extension is not expected. Note that veins occur around the hinges of the smaller folds as well. Road-cut on south side of Route 4 immediately east of the eastbound entrance ramp from Scotch Hill Road.

Figure 4.39. Close-up of quartzite shown in Figure 4.36 showing details of the fibrous vein-filled extension fractures. Note that fiber are parallel bedding irrespective of orientation of the vein. Bed is about 10 cm thick. Roadcut Route 22A, 0.4 km north of Route 4.

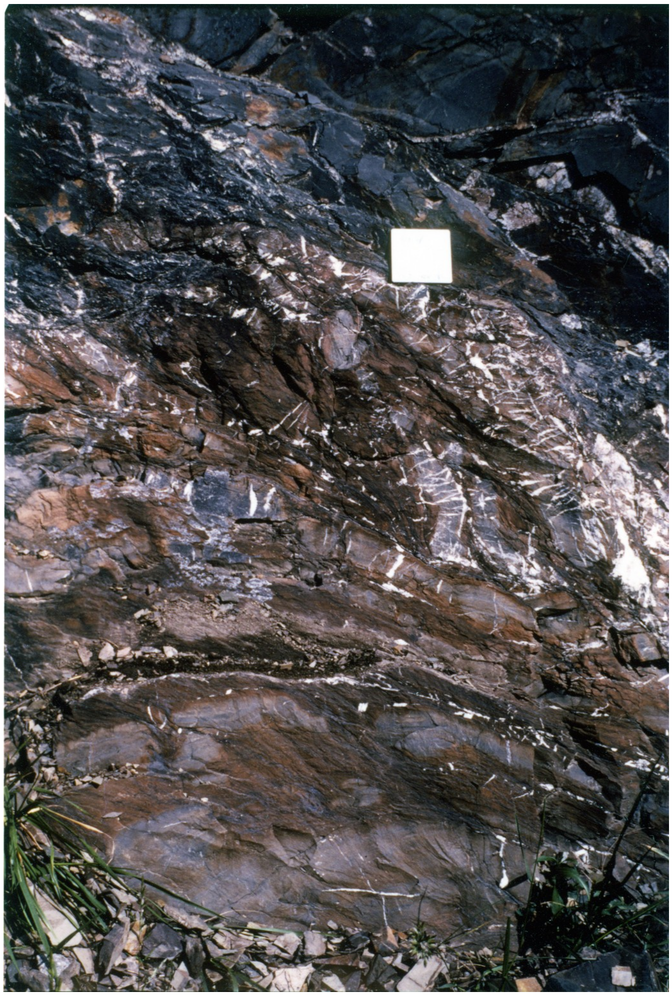

Figure 4.40. Route 4 roadcut (plate 3, thrust sheet 1). Hatch Hill dolomitic quartz arenites and black slates showing varying degrees of disruption and veining. Note region at the base of outcrop with almost completely undisrupted layering below a narrow layer-parallel laminated shear zone.

Figure 4.41. Small rootles fold hinge of carbonate in phacoidally cleaved black slates of the Hatch Hill Formation, 5 meters west of Figure 4.40, in thrust sheet 1.

Figure 4.43. Close-up photograph of details of disruption of Hatch Hill arenites adjacent to the thrust contact with sheet 2.

Figure 4.44. Sealed fault gouge along the thrust contact between thrust sheets 1 and 2 near 36.5 on Plate 3. Note the subangular and angular clasts of slate within the gouge, and the association with veining in the adjacent rocks.

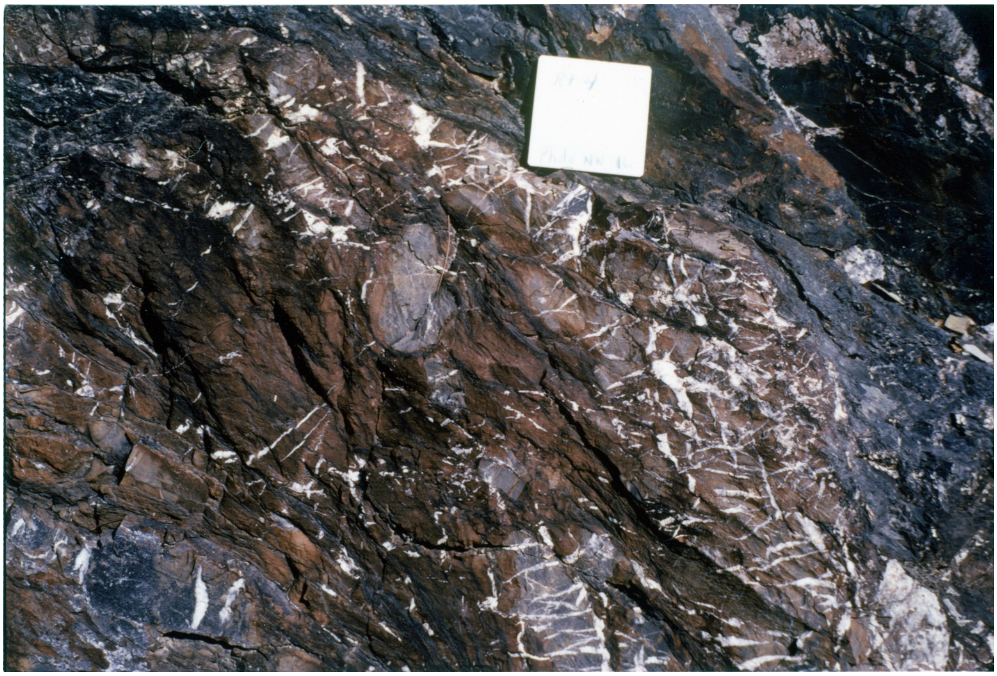

Figure 4.45. Photograph showing the extensive veining particularly of the dolomitic arenites of the Hatch Hill immediately below the thrust contact of sheet 1 with sheet 2. White plaque rests on the thrust contact. Note that the veining does not effect the overlying Middle Granville slates of sheet 2.

Figure 4.46. Photograph of sheet 1 from the southeast side of Route 4. The dominant lithology is interlayered carbonate and dark calcareous slates. Note folded laminated shear zone marked by pen, pencil and blue erasure that extends from the top left to bottom right of the photograph.

Figure 4.47. Clastic dike of silty quartose carbonate cross-cutting bedding and oriented approximately parallel with slaty cleavage, at least in two dimensions. Quarter for scale. Southeast side of Route 4 roadcut.

Figure 4.48. Large irregular mass of 'intrusive' carbonate in thrust sheet 1 on the southeast side of Route 4.

Figure 4.49. Fault contacts bounding the western edge of sheet 1 from the southeast side of Route 4. Note the truncation of fold by the fault at the lower right and thick slickensided vein along the fault contact. Both faults are sharp and planar.

Figure 4.50. Close up of upper fault contact between sheets 1 and 2 on the southeast side of Route 4. Note the truncation of layering in sheet 1 by the fault contact. In addition the vein in sheet 2 is also truncated by the fault. Quarter for scale.

Figure 4.51. Fault surface separating sheets 1 and 2 on the southeast side of Route 4. The prominent lineation on the surface results from both color streaking in the argillaceous material and from slickensided vein surfaces. The lineation trends east-west. Weaker lineation running horizontally across the photograph is an intersection lineation with the regional slaty cleavage. This intersection lineation post-dates the color streaking and slickenside lineation.

Figure 4.52. Middle Granville slates with interlayered micritic to calcisiltitic limestones and darker color banded slates. Note the difference in fold form of the different lithologies. Sheet 2, southeast side of Route 4.

Figure 4.53. Graded beds of silty to fine grained slates in the Middle Granville Slate of sheet 2 on the northwest side of Route 4, and shown on Plate 3. Note the erosive nature of the bases of several of these mud turbidites. Lens cap is approximately 5.0 cm in diameter.

Figure 4.54. Lower thrust contact separating sheets 2 and 3. Note plicated laminations and refraction? of the slaty cleavage across the laminated shear zone.

Figure 4.55. Complex fault relationships adjacent to the thrust sheet 3 and 4 contact between 44 and 45 on Plate 3. Fault diverges around lens of color laminated Middle Granville slate. Fault zones are marked by black irregularly foliated slates. Note possible intensification of the slaty cleavage where the faults diverge.

Figure 4.56. Photograph showing block-like behavior of Middle Granville slates in sheet 5, near 58.4 on Plate 3. Note that the sense of overlap of comparable lithologies reflects approximately layer-parallel shortening prior to D_2 folding and slaty cleavage development. Faults are delineated by thin veins.

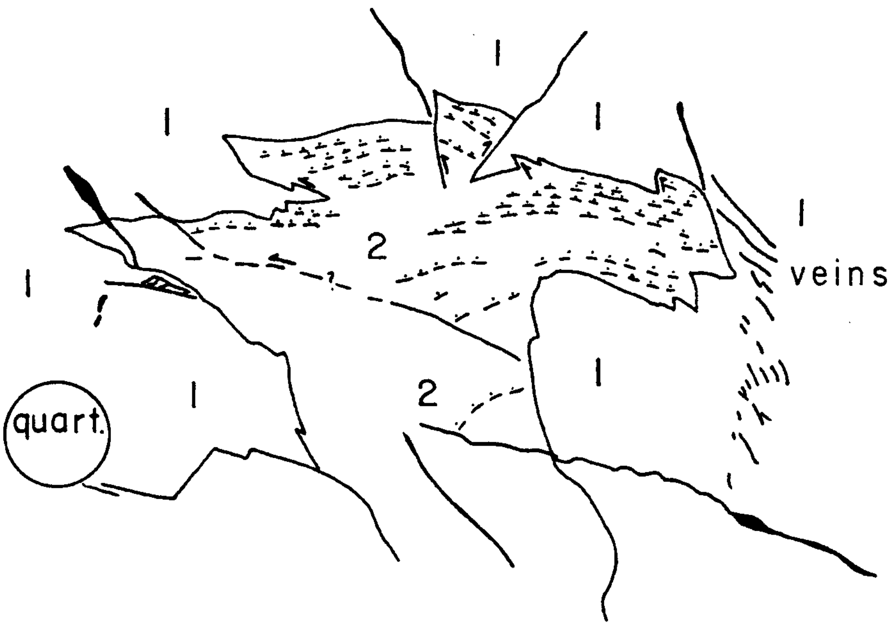

Figure 4.57. Sketch from a photograph of a small example of the block-like behavior of the slates, and the clear evidence for layer-parallel shortening. Quarter for scale. Lithologies: 1 - homogeneous gray-green slates; 2 - darker color and compositionally laminated slates with calcisiltite laminae.

Figure 4.58. Mesoscale, approximately slaty cleavage-parallel thrust fault with about 30 cm of east-over-west motion. Note bending and associated block faulting of layering as the fault is approached. Top of roadcut in sheet 5.

Figure 4.59. Photograph showing the complex fault-bounded lens of Middle Granville slates adjacent to the sheet 5-6 thrust contact. Actual contact defines the upper surface of the prominent lens of color laminated slates (see Figure 4.60) in lower middle part of the photograph. Location near 61 on Plate 3.

Figure 4.62. Melange along the vertical to overturned thrust contact between thrust sheets 6 and 7. Sheet 6 to the right is characterized by lithologies that are transitional from Middle Granville the Hatch Hill. Sheet 7 consists entirely of variably disrupted Hatch Hill arenites and black slates. Note the complex fold profile of the thick arenite at the top of the roadcut. Note also the sharpness of the contact from undisrupted Middle Granville slates to Hatch Hill lithologies that could be appropriately described as varying from a 'broken formation' to a melange.

Figure 4.63. Photograph showing almost entire width of sheet 7 and its characteristic disrupted character. It essentially constitutes a disrupted fault zone between relatively more coherent sheets 6 and 8. Six-inch ruler for scale.

Figure 4.64. Overturned thrust contact between thrust sheets 7 and 8. Contact is sharp and marked by the relatively more coherent nature of bedding in sheet 8 as opposed to the broken character of sheet 7. Six-inch ruler for scale.

Figure 4.65. Complex, multiply folded character of thrust sheet 8 immediately to the west of the thrust contact with sheet 7. See Figure 4.66 for details of the geometry of the folds.

Figure 4.67a. Thrust contact between sheets 8 and 9. The eastern portion of sheet 9 is characterized by interlayed black slates and gray weathering carbonates of the West Castleton Member of the Hatch Hill Formation. The thrust contact is sharp and marked by sharp truncation of layering in sheet 9. The western edge of sheet 8 is characterized by a narrow zone of melange. Contact pre-dates F_2 folding and is overturned.

Figure 4.67b. Interbedded carbonates and black slates of the West Castleton Member. Rare sedimentary structures, such as cross-laminations suggest bedding is overturned.

Figure 4.68a. Thin bed of intraformational conglomerate characterized by clasts of black chert or phosphate in a quartz and pyrite matrix.

Figure 4.68b. Thicker bed of chert and/or phosphate pebble conglomerate from thrust sheet 9. Matrix of the conglomerate consists of quartz, carbonate (dolomite?), and pyrite. Clast-size grading suggests bedding is overturned. Note slickenside striation of surface below the conglomerate. Quarter for scale.

Figure 4.69. Narrow shear zone in sheet 9 (see Plate 3) near 83.3. Fault dips vertically to steeply to the east and 'drag' structures suggest east-side down relative motion. Note quartz veining and also possible argillite 'dikelets' in the arenites.

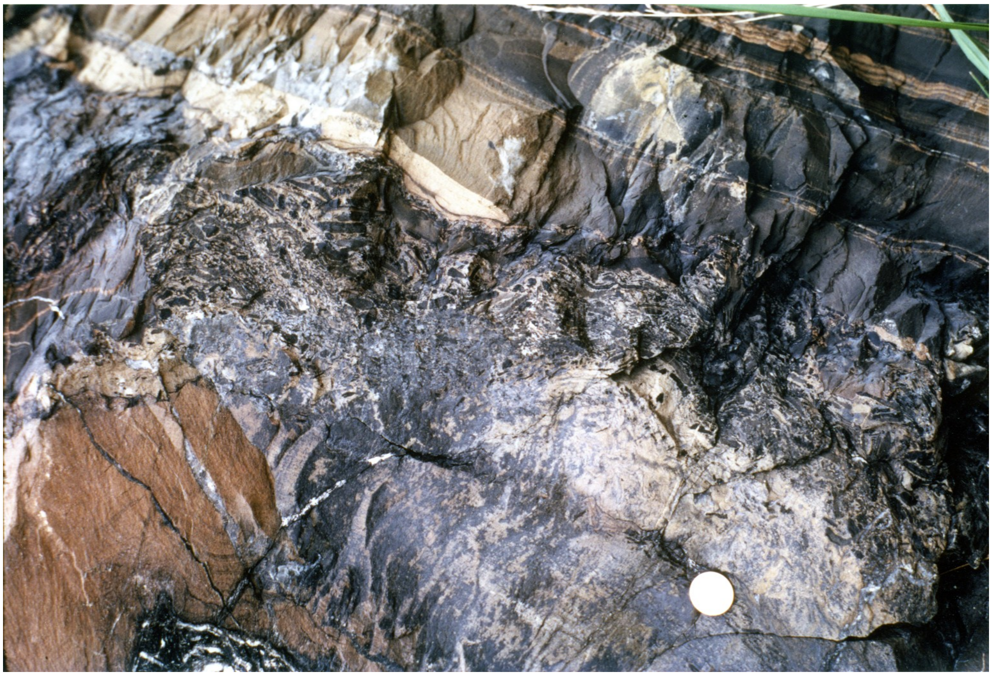

Figure 4.70. Thick arenite bed of Hatch Hill with atypical conglomeratic base. Note the erosive character of the base of the bed and the brown weathering of the adjacent arenite layer which is characteristic of this section.

Figure 4.71. Thick arenite bed with conglomeratic base (Figure 4.70) has a well developed laminated shear zone along its upper surfaces that is folded about the hinge of F_2 hinge in this region. This demonstrates that the laminated shear zone predates folding.

Figure 4.72a. Large rounded block of quartzose carbonate in a melange zone separating sheets 9 and 10. Carbonate block is extensively veined and lies within a phacoidally cleaved argillite matrix. Lens cap is approximately 5.0 cm in diameter.

Figure 4.72b. Photograph shows the wide variety of lithic types that comprise the blocks within the melange between sheets 9 and 10. Note also the thin deformed veins within the matrix argillite.

Figure 4.73. Photograph showing well exposed internal bedding laminations in Hatch Hill arenite at the southwestern end of the Route 4 outcrop shown on Plate 3. Note also the abundant thin vein-filled fractures that strike approximately east-west along this segment of the roadcut. Quarter for scale.

Figure 4.74. Photograph of the rounded hinge of large nearly recumbent F_2 syncline that effects at least sheets 8, 9, and 10. Note the mullioning of the thicker arenites in the hinge, axial surface parallel nature of the slaty cleavage in the hinge, but on the lower limb it defines a convergent fan. Six-inch ruler for scale.

Figure 4.75. Photograph looking down on the top surface of the road cut on the vertically dipping bedding in the hinge of the fold shown in Figure 4.74. Narrow zones of carbonate + quartz vein material with abundant clasts of slate and arenites from the adjacent lithologies. Slaty cleavage in argillite clasts all appear to be parallel, suggesting that these zones pre-date D_2.

Figure 4.77. Photograph of structural contacts between the Middle Granville Slate and West Castleton Member of the Hatch Hill Formation. Early thrust contact below the West Castleton has subsequently been imbricated along a moderately west-dipping thrust contact along its eastern edge.

Figure 4.78a. Highly folded and dismembered thin bedded dolomitic quartz arenites and black slates of the Hatch Hill Formation structurally below West Castleton carbonates shown in Figure 4.77.

Figure 4.78b. Detailed view of the dismemberment of arenite layers during melange development. Note angular to subangular shapes of many of the bedding fragments.

Figure 4.79a. Complex fold and fault geometry exposed at the very southwestern end of southeast side of the Route 4 roadcut. Note the exceedingly complex cross-cutting relationships between folds and faults.

Figure 4.79b. Same outcrop as above, but looking east-northeast parallel with the plane of the slaty cleavage. No attempt has been made to reconstruct the original geometry of this outcrop.

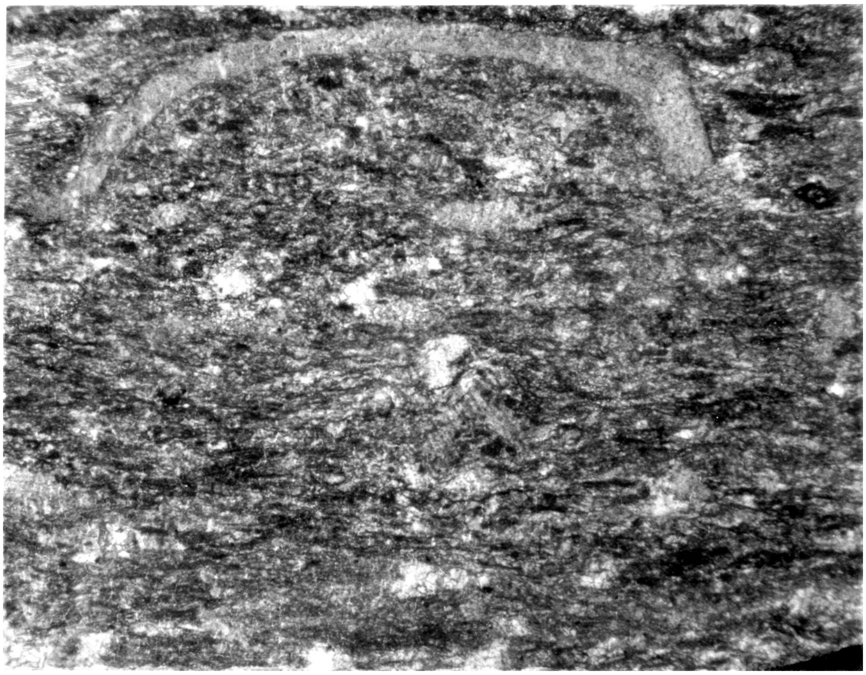

Figure 4.80. Photomicrograph of parautochthonous carbonate sliver from the 900 foot high hill east of Black Pond shown on Figure 4.10. Note well developed cleavage, fossil fragments, including bivalves and crinoids. Field of view approximate 1.0 cm across.

Figure 4.81. Roadcut of fine grained mudchip conglomerate in the Hortonville near Bradlee School showing well developed slaty cleavage and spaced crenulation cleavage. Pen is approximately 15 cm long.

Figure 4.82. North-facing wall at the entrance to Bos Hogs Quarry, West Haven, Vermont. Synclinal fold of Providence Island Formation with moderate to well developed axial surface parallel solution cleavage and approximately 2 times increase in thickness of beds in the hinge of the fold.

Figure 4.83. Roadcut on Route 22A showing multiply repeated sections of the upper part of the parautochthonous shelf sequence including Isle La Motte, Glens Falls, Snake Hill, and Forbes Hill lithologies. Frontal thrust of the Allochthon is just to the east of the roadcut.

Figure 4.84. Detailed view of one of the structural contacts within the thrust repeated section shown in Figure 4.83. Glens Falls Formation, which consists of interbedded carbonates and shales is thrust over Glens Falls with a narrow zone of black phacoidally cleaved shales and pebbly mudstones along the contact.

Figure 4.85. Photograph showing irregularly cleaved Forbes Hill type pebbly mudstone along one of the structural contacts exposed in roadcut pictured in Figure 4.83.

Figure 4.86. Roadcut southwest of Harlow School on the Thorn Hill 7-1/2 minute quadrangle. Planar thrust contact between Isle La Motte carbonate (above, east) and Snake Hill shales and wackes (below, west). Note multiple faults in the carbonate that appear to sole into the main detachment surface. Note also the small wedge of shales in a remnant ramp structure above the main detachment.

Figure 4.87. Close-up of region just to the west of the preserved ramp shown above. The prominent foliation in the slates below the detachment, which is the regional slaty cleavage is folded into parallelism with the fault and has a second phacoidal fabric superimposed on top of it. Note also the detached slab of carbonate from the hanging wall within the argillites of the fault zone.

Figure 4.88. Photograph of Champlain Thrust as exposed at Lone Rock Point north of Burlington, Vermont. The Champlain Thrust juxtaposes early Cambrian Dunham Dolomites with medial Ordovician shales and interbedded carbonate turbidites of the Iberville Formation.

Figure 4.89. Irregularly foliated dark slates of the Iberville with abundant, complexly folded laminated shear zones exposed immediately below the Champlain Thrust at Lone Rock Point.

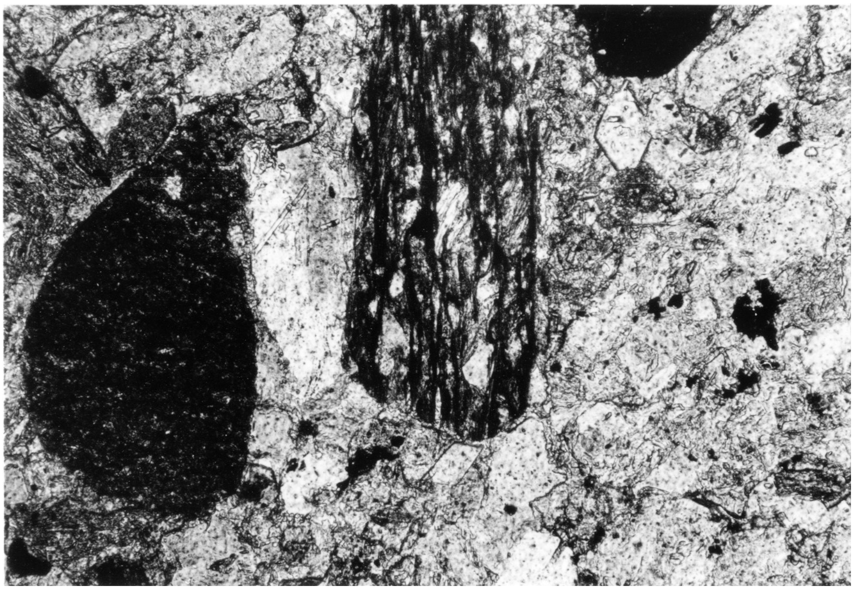

Figure 6.3a. Pre-depositionally deformed and metamorphosed muscovite-chlorite-quartz schist. Pre-depositional cleavage is crenulated by the 'regional' slaty cleavage of the greywacke. Field of view 0.7 mm, 10 X magnification. Pawlet Formation.

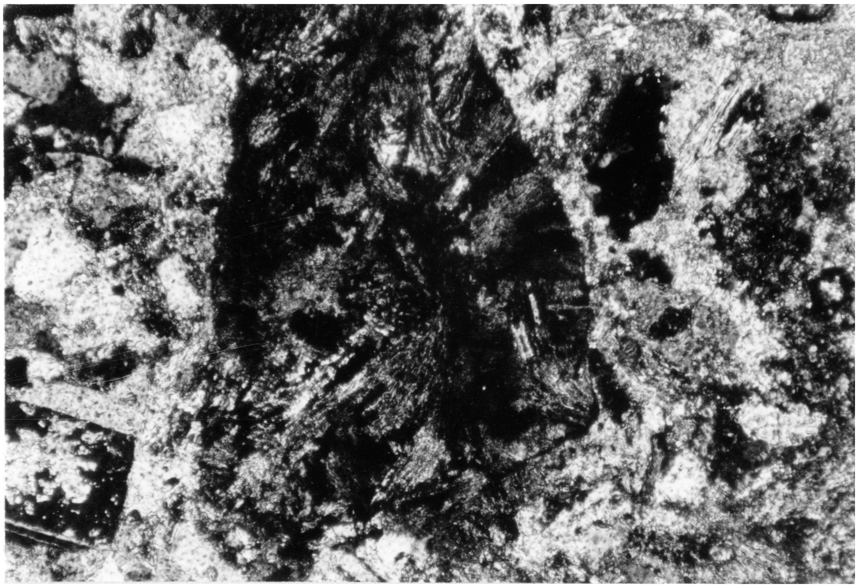

Figure 6.3b. Subrounded volcanic fragment. Clast consists of altered volcanic glass, plagioclase and chlorite with a pilotaxitic texture. Altered plagioclase grain is adjacent to volcanic fragment. 0.7 mm field of view, 10 X magnification. Pawlet Formation.

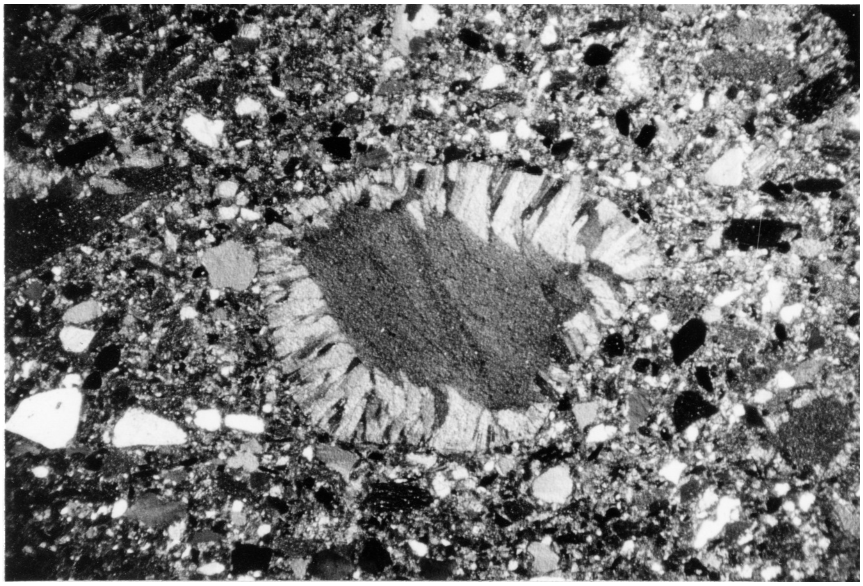

Figure 6.3c. Pre-depositionally deformed and slightly metamorphosed clast from parautochthonous conglomeratic greywacke with diagenetic rim of carbonate. Several sand and silt-size lithic fragments are within field of view along with quartz, feldspar, muscovite, chlorite, and opaques. Texture is typical of the greywackes. 1.8 mm field of view; 4 X magnification. Austin Glen Greywacke.