Bedrock Geology of Lincoln Area, Vermont

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The Lincoln area, Vermont, is situated at the northernmost extent of Proterozoic Y-age basement in New England. These rocks are part of the Blue-Green-Long axis, and involve basement-cover relationships along the Lincoln anticline (a smaller satellite structure west of the Green Mountain anticlinorium). The basement is composed predominantly of granofels and metabasite of the Mt. Holly complex. These rocks are mantled by Late Precambrian through Lower Cambrian metasedimentary rocks and are divided into an eastern and western sequence. The eastern sequence consists of the schists and metabasite of the Hoosac and Underhill Formations, whereas the western sequence includes the Pinnacle, Fairfield Pond, and Cheshire Formations. Figure 1 correlates the results of this report with the previous interpretation of the stratigraphy as shown on the Geologic Map of Vermont (Doll and others, 1961).

The eastern half of the Lincoln area was previously mapped by Cady, Albee, and Murphy (1962) and was published at a scale of 1:62,500. They delineated the major units (including the Mt. Holly basement complex) and interpreted all contacts as depositional. Consequently, they were forced to correlate the Fairfield Pond with the Underhill Formation to the east. However, this work has demonstrated that a tectonic stratigraphy exists to the east, and recognizes the similarity of the western sequence of the Lincoln anticline with the Late Precambrian sequences described to the south along the western margin of the Green Mountain massif.

The map pattern is dominated by the major F1-structure, the Lincoln anticline, and its complementary syncline to the west. The anticline is recumbent and isoclinal at the core, with the units becoming only moderately overturned to the west. The axial planar F1-schistosity is the dominant foliation in the area.

Major thrust faults dominate the east limb of the Lincoln anticline and are responsible for the juxtaposition of the more distal, eugeoclinal rocks of the eastern sequence onto the basement complex and the rift clastics of the Pinnacle Formation. Slivers of Proterozoic Y-age material are found along these faults which are considered syn-to-post F1 in age.

Both the dominant schistosity and the tectonic contacts are folded by a second generation déformation (F2). This event was much less intense than F1, as its associated cleavage is relatively rare. F2 commonly exhibits broader, more open folds.

During F1, the major prograde metamorphism imprinted the biotite grade of the greenschist facies on the rocks to the west, and lower epidote-amphibolite facies to the east. During F2, a subsequent phase of chlorite-grade, greenschist facies metamorphism overprinted the entire area. The earlier event is considered to be associated with the Taconic orogeny whereas the second is thought to be Acadian based on radiometric data from the immediate area.

STRATIGRAPHY

The Mt. Holly Complex

The Mt. Holly complex consists predominantly of a tan-weathering, grey to buff, quartz-feldspar granofels/gneiss (Ymhg). This unit commonly has a granular (massive) texture, although many outcrops exhibit a faint compositional layering (referred to as the Grenvillian schistosity). This schistosity is nowhere present in the cover rocks and serves to distinguish the Mt. Holly in the field. The Ymhg unit commonly has a tabular-to-mylonitic fabric which is the result of lower Paleozoic overprinting. These feldspar rich rocks are among the most easily eroded in the area, and are best exposed along the New Haven River.

A sedimentary origin is suggested for a small part of the Mt. Holly interbedded with quartzite. The abundance of sodic plagioclase and its interlayered relationship with blue-green amphibole-rich metabasite, however, indicates an igneous origin for most of the basement complex.

The metabasite (Ymhm) is a massively textured, dark green epidote-amphibolite which can exhibit a prominent layering, usually parallel to the dominant schistosity (S1). The layers are light grey to green, plagioclase or epidote-rich horizons. Lighter green amphibolite gneiss is also included in this unit. The metabasite is seen interlayered and infolded with the granofels/gneiss unit on both small and large scales.

Age of the Mt. Holly Complex: A Precambrian age is assigned to the basement complex due to contact relationships and internal structure. A profound angular unconformity separates basement from the Late Precambrian to Lower Cambrian cover rocks as the overlying unit truncates mappable units within the Mt. Holly. Furthermore, the Grenvillian schistosity is confined to the Mt. Holly and is always cut by the early Paleozoic dominant schistosity (S1).

THE EASTERN SEQUENCE

The Hoosac Formation

The Hoosac Formation is considered to be both autocthonous (CZhs) and allochthonous (CZhg). The two units are separated by the Underhill thrust. The depositional contact between the Hoosac and Mt. Holly basement is only exposed in the fault slice at South Lincoln (map location P-9). Surficial material covers the mapped contact, and the possibility that the Hoosac is fault-bounded cannot be ruled out.

CZhs and CZhg are very similar in aspect, both being biotite-rich, medium-grained schists, in general. The "lower" unit (CZhs), however, is a predominantly coarser grained schist with well-developed 1/4 inch laminations of the F1-schistosity. The units on the upper plate of the Underhill thrust (CZhg) are coarsest near the fault, where they grade out from highly deformed mylonitic rocks at the contact. To the east, this unit becomes much more micaceous, and locally, a mica schist with distinctive rusty-to-silvery foliation surfaces is common. Both units are strongly affected by small-scale F2 folds of the dominant schistosity.

The Underhill Formation

This formation has been divided into two major groups on the basis of the imbricate nature of the Lincoln anticline's eastern limb. A distinctive quartz-laminated schist (CZuql) comprises the rocks of the Jerusalem slice, and two units (CZums and CZund) are found in the Underhill slice.

Quartz-laminated Schist (CZuql): The quartz-laminated schist of the Jerusalem slice is easily recognized in the field by the profuse, closely-spaced, quartz-rich laminations which are intercalated with the finer grained, more micaceous matrix. The laminations are commonly up to 1/4 inch thick, giving the rock a distinctive pinstriped appearance. The laminations are parallel to S1 (the dominant schistosity), and are clearly deformed into small-scale, sinuous, F2-folds.

The unit is bordered by faults and consequently its stratigraphic position is not precisely known. The presence of stretched cobble conglomerates, and a general similarity to other basal units of the cover rocks, however, suggest a correlation with lowermost Pinnacle/ Hoosac /Tyson Formations.

Rocks of the Underhill slice

The Underhill slice contains the CZhg unit of the Hoosac Formation, and the mica schist (CZums) and undifferentiated (CZund) rocks of the Underhill Formation. Further subunits of the slice were not mapped due to time considerations.

(CZums): The mica schist unit is found exclusively to the south, near S. Lincoln, where it is in gradational contact with Hoosac biotite greywacke and mica schists (CZhg). It is distinguished by its greater chlorite content compared to the underlying schist, and by the presence of pre-F2 stringers and veinlets of quartz. In outcrop, it strongly resembles the quartz- laminated schist (CZuql), but is more micaceous and less quartz-rich.

(CZund): The rocks that make up the undifferentiated CZund unit can be separated into three main groups. In order of abundance, they are: 1) garnetiferous schist; 2) foliated tan-to-grey quartzite; and 3) massive, dark green metabasite. In general, the quartzite is found to the west of the schist, but is absent in the southern part of the field area. The metabasite is rare, and is found along the Underhill thrust contact in two places (outcrops are circled on the map).

The garnetiferous schist resembles higher grade analogs of the lower Pinnacle Formation. It exhibits the well-developed 1/4 inch lamination of the S1 schistosity with some areas having a high proportion of quartz stringers, veinlets, and "knots". The rocks have a characteristic rusty weathering. Large (3/8 inch), subhedral F1 garnets (locally altered to chlorite) are common. In the northern part of the field area, the garnet isograd coincides with the foliated quartzite/garnetiferous schist contact.

Underhill metabasite is a rare but distinctive dark green, medium to fine grained, massively textured rock with large euhedral magnetite porphyroblasts. It is distinguished from Mt. Holly metabasite by its smaller grain size, lighter color, and lack of associated Mt. Holly quartzite and granofels.

The Underhill metabasite helps define the trace of the Underhill thrust, especially north of the field area where it is more abundant. It forms discontinuous lenses or slivers along the thrust.

THE WESTERN SEQUENCE

Figure 2 is a stratigraphic column for the western sequence of the Lincoln anticline. Thicknesses are taken from the cross-sections and must be considered first order approximations due to intense folding in the lower part of the column and a shear zone along the Fairfield Pond/Cheshire contact.

The western sequence includes the Late Precambrian Pinnacle and Fairfield Pond Formations and the Lower Cambrian Cheshire Formation. No fossils have been found in the field area, but the stratigraphy is correlated with similar sequences west of the Green Mountain massif on the basis of lithology and stratigraphic position.

The Pinnacle Formation

The oldest formation of the western sequence is the Pinnacle. The lower part is characterized by a basal conglomerate (CZpbc), and by muscovite and/or biotite-rich schist and pebble conglomerate (CZpcm; CZpbg; CZpm). The upper Pinnacle is a distinctive chlorite and dolarenite-rich assemblage (CZpcl and CZpfd).

The lower Pinnacle Formation

The Basal Conglomerate (CZpbc): The western margin of the Mt. Holly complex is unconformably overlain by the Pinnacle Formation. The contact is best exposed at Elder Hill (map location H/J-8) and Crash Bridge (map location L-8). The basal unit of the cover sequence consists predominantly of magnetiferous quartz-albite schist, pebble conglomerate, and locally cobble and boulder conglomerate.

The Elder Hill locality is important because it is the only locality where the unconformity is found on the eastern margin of the Mt. Holly. A short distance to the south it is overlain by major thrust slices. The contact is best exposed on the western side of the hill where bedding in the Mt. Holly truncates against chlorite-magnetite schist of the Pinnacle.

Figure 3 is an interpretive map of the outcrop at Crash Bridge on the New Haven River. Here, metabasite and granofels of the Mt. Holly complex are in sharp contact with schist and cobble conglomerate of the Pinnacle Formation. The conglomerate is confined to many lenticular, composite paleochannels. It is clast-supported with little or no matrix between the clasts. This contrasts strongly with the finer grained schist which envelopes the channels. Several channels exhibit downcutting relationships into the schist and normal grading of quartzose beds is also observed.

Large blocks or boulders of Mt. Holly granofels are common in the basal unit. They are difficult to recognize in areas where later deformation is intense. The composition of the blocks, cobbles, and sands of the basal Pinnacle indicate that the immediately adjacent sodic-plagioclase rich Mt. Holly basement is the source. The morphology of the channels and the presence of the blocks indicates a proximal fluvial environment, most likely on an alluvial fan, for the basal Pinnacle.

Muscovite Schists (CZpcm and CZpm): The lower Pinnacle Formation contains two very similar, muscovite-rich units separated by a thick sequence of biotite-rich greywacke. The lower unit (CZpcm), however, has a distinctive brown mottling of carbonate. Both units are very uniform, grey schists, with either a silvery luster, or slight rusty weathering, due to the mica. The schistosity is the typical 1/4 inch wide lamination. The rocks commonly show the effects of F2 as a small-scale, sinuous folding of the dominant schistosity.

The contacts of these units with the biotite greywacke (CZpbg) are locally sharp. The upper contact of the upper muscovite schist (CZpm), however, is gradational with the chlorite and magnetite schists of the upper Pinnacle.

Biotite Greywacke (CZpbg): The thickest unit of the lower Pinnacle is the massive, coarse-grained, thick-bedded (< 3 feet) biotite greywacke. These rocks are commonly pebbly, with local conglomeratic horizons having clasts up to 2 inches in length and showing weakly developed normal grading. Beds are laterally extensive, with sharp, planar, contacts. Many beds also exhibit "dish" or dewatering structures.

Significantly, this unit north of the field area contains polymictic matrix and clast supported conglomerates containing intrabasinal sedimentary clasts as well as basement material. The CZpbg unit, then, may represent an influx of coarse material during lower Pinnacle time, most likely of sub-aqueous fan origin.

The upper Pinnacle Formation

The upper Pinnacle consists of two main rock types: chloritic schist and "greenwacke" (CZpcl); and a sandy dolarenite (CZpfD) commonly known as the Forestdale Marble.

(CZpcl): The chloritic schists are easily recognized by their dark green color. The distinct change from the muscovite/biotite rich schists of the lower Pinnacle is a reflection of a compositional change (decrease in potassium?) in the original sediments. The "greenwacke" is very similar to the muscovite schists of the lower Pinnacle except for the color and the abundance of quartz pebbles. The fine-grained schist is characterized by abundant quartz stringers and veins parallel to early schistosity. Associated with the quartz are "clots" of chlorite with a metallic green luster. The schist commonly has many large (> 1/4 inch) euhedral porphyroblasts of magnetite.

(CZpfd): The Forestdale is a tan-to-buff weathering sandy dolarenite. The main part of the Forestdale is a thick-bedded, massive sandy dolarenite. Many beds within this facies exhibit a well-developed normal grading of their siliciclastic grains. Bedding plane stylolites and pressure solution fracture cleavages are common. The most abundant rock type is the transitional facies, which is a thin-bedded (< 6 inches) intercalation of sandy dolarenite and typical CZpcl chlorite schist, found at both the upper and lower contacts of the Forestdale. These relations indicate that the Forestdale in this area represents an influx of carbonate and quartz/feldspar rich detritus during upper Pinnacle time. The carbonate may have been derived from the erosion of small carbonate banks on local basement highs.

A resedimented origin for the entire upper Pinnacle is suggested by the presence of laterally extensive sandstone/phyllite couplets of CZpcl rocks immediately below the Forestdale, by the gradational nature of the Forestdale contacts, and by the presence of intraformational pebble conglomerates above the Forestdale.

The Fairfield Pond Formation

(CZfp): The grey phyllite of the Fairfield Pond Formation is gradational with magnetiferous chlorite schist of the upper Pinnacle. These rocks locally are pinstriped or banded with lighter grey, quartz-rich laminations. Although the laminations are parallel to the early foliation, they are not considered false bedding as they vary up to 1 inch in thickness locally. The phyllite is intensely deformed by a well-developed slip-cleavage that clearly cuts bedding and the early schistosity.

The contact with the overlying Cheshire Formation is gradational and is marked by an increase in detrital quartz and feldspar. In many places it is severely affected by a major shear zone oriented nearly parallel to the contact. The Fairfield Pond thins to the north as strain along the Hinesburg fault zone increases.

The Cheshire Formation

The western sequence is capped by the highly bioturbated, argillaceous rocks of the lower Cheshire (Cca) and the grey-to-pink massive quartzites of the upper Cheshire (Ccm).

(Cca): The lower unit of the Cheshire consists of two facies which are interbedded in various proportions: a grey, highly bioturbated quartz-feldspar rich arenite; and thin-bedded (< 6 inches), grey-to-white quartzites which have a distinctive brown carbonate mottling. An outcrop belongs to the thin-bedded facies when the number of thin mottled white interbeds exceeds that of the bioturbated beds.

Most of the thin mottled white beds are rippled, with mud drapes found in the intercrest areas. Vertical U-shaped burrows are common in thin bedded facies. These features indicate a shallow-water marine environment for the lower Cheshire.

Locally, the lower Cheshire displays two additional types of quartzites. First is a laterally extensive, tabular bedded, grey vitreous quartzite. These beds are commonly less than 1 foot thick, and have sharp, planar-to-convolute contacts with the adjacent arenites. Second, small (3 feet in diameter), lenticular pink quartzites downcut into the bioturbated facies. Both types of quartzite represent the highest energy conditions within the lower Cheshire.

(Ccm): In contrast, the massive quartzite of the upper Cheshire is so uniform that bedding is difficult to discern. However, some horizons contain many shale clasts of various sizes (up to 1 foot in diameter). While many of these "mud chips" are randomly oriented, most lie nearly parallel to bedding.

The contact between the lower and upper Cheshire is sharp-to-interbedded over a distance of less than 2 feet. Its convolute nature indicates local downcutting. The massive quartzite is interpreted to have been formed in the deepest and highest energy, subaqueous, environment of the Cheshire Formation.

The vertical sequence of units on the western limb of the Lincoln anticline is compatible with a rift-clastic model of Late Precambrian sedimentation in west central Vermont. During initial rifting, alluvial fan deposition predominated, forming the basal conglomerate of the Pinnacle. The biotite greywacke and conglomerates of the lower Pinnacle and resedimented deposits of the upper Pinnacle represent sub-aqueous basin fill. The end of rift-clastic sedimentation led to the deposition of the Fairfield Pond and the shallow-water marine siliciclastics of the Cheshire Formation.

STRUCTURE

The field area is dominated by the Lincoln anticline, and by major north-south trending thrusts and shear zones. These features developed as a result of the first lower Paleozoic event, F1. The second event, F2, was not as intense as the first, but is seen throughout the entire area. Metamorphism accompanied each event, with the first being at a higher grade.

Five S-surfaces are recognized in the Lincoln area (Figure 4), two of which are found exclusively in the Mt. Holly complex. S0 refers to Late Precambrian and Lower Cambrian bedding. The latest two surfaces are lower Paleozoic schistosities and affect both the basement and cover rocks.

The two surfaces in the basement complex are bedding and the Grenvillian schistosity. Rare, thin (< 10 inches), vitreous quartzite defines bedding in the Mt. Holly. The Grenvillian schistosity is a thin, dark but faint compositional layering most common in the Mt. Holly granofels. It is particularly useful for identifying basement rocks in the field where it is at high angle to, and cut by, the Paleozoic dominant schistosity (S1).

Bedding is well-preserved throughout the western sequence of the Lincoln anticline. In the Cheshire Formation, many primary structures such as ripple marks, burrowing, and cross beds are observed. In the allochthonous eastern sequence, several rare, thin (< 4 inches) beds of grey, vitreous quartzite are the best indicators of stratification.

S1/F1

The first major lower Paleozoic deformation is referred to as F1. The S1-schistosity formed axial planar to F1-folds, and is the dominant schistosity in the Lincoln area. S1 is best developed in the core of the Lincoln anticline and on its eastern limb. Statistically, S1 trends roughly north-south and dips moderately to the east. In the quartz-feldspar schists of the cover rocks, S1 is a conspicuous 1/4 inch wide lamination. F1-fold hinges are rare, and are isoclinal, especially in the Pinnacle Formation.

As shown on the Geologic Map of Vermont (Doll and others, 1961), major doubly plunging anticlinoria are present in west-central Vermont. Structural analysis has shown that the Lincoln anticline is an F1 structure, suggesting that similar structures in western Vermont are also early folds. In the Lincoln area, the F1 hinges plot as a weak girdle within S1 in stereographic projection and reflect both the doubly plunging nature of the minor F1 folds, and subsequent deformation by F2.

Major thrust faults and shear zones of F1 age generally exhibit a penetrative schistosity or mylonitic fabric parallel to S1. Furthermore, they are commonly folded by later F2-folds, on both small and large scales (for example, map location B-8).

Major Shear Zones

F1 shear zones are defined in the field by a laterally continuous zone of rocks with a well-developed mylonitic fabric that decreases in intensity across strike away from the zone. The shear zone in the Mt. Holly complex (map location N-8) is predominantly in the quartz-feldspar granofels (Ymhg). There, deformation increases from a well-spaced fracture cleavage to a schist with a muscovite-rich foliation. On fractures parallel to the inferred transport direction, the schistosity is planar and parallel. On fracture faces perpendicular to the transport direction in the most deformed areas, the schistose granofels has an augen-like aspect as the schistosity has begun to anastamose around newly-formed porphyroblasts.

The shear zone parallel to the Cheshire/Fairfield Pond contact is marked by the phyllonite of the lowermost Cheshire (Cca). F1-shear is responsible for severely transposing Cheshire bedding and worm burrows with deformation decreasing away from the contact upsection.

Both shear zones contain slickensides and prominent down-dip stretching lineations (elongate or elliptical clusters of minerals).

Major Thrust Faults

Although a complete depositional sequence of Late Precambrian metasedimentary rocks is found to the west of the Mt. Holly complex, a tectonic stratigraphy is in evidence to the east. Major thrust contacts are primarily defined by the mutual truncation of units against the fault contacts and the presence of slivers of Proterozoic Y-age slivers along the faults.

The Jerusalem thrust: The depositional contact between the Pinnacle and eastern Underhill Formation (as shown by the Geologic Map of Vermont, Doll and others, 1961) is now reinterpreted as a major F1 fault, the Jerusalem thrust. The Jerusalem slice consists totally of the rocks of the Underhill quartz-laminated schist (CZuql), and is structurally overlain by rocks of the Underhill slice to the east and south.

The Jerusalem thrust is a sharp but interlayered contact (over an interval of < 10 feet) between the quartz-laminated schist and the massive biotite greywacke of the Pinnacle Formation (CZpbg). Immediately adjacent to the contact, the quartz-laminated schist contains many small scale, asymmetrical disharmonic folds which were produced by shear across the original detachment surface. The fault zone is refolded by F2 in outcrop and in map view (map location B-8).

In the Elder Hill area (map location J-8), the quartz-laminated schist is in contact with muscovite schists of the Pinnacle (CZpcm). Furthermore, a sliver of Proterozoic Y-age granofels is found directly on the contact. To the south, the Jerusalem thrust may rest directly on basement but relationships are obscured by glacial cover.

The Underhill thrust zone: The easternmost fault, the Underhill thrust, traverses the entire field area and is considered the major tectonic break in the region. More than one thrust may define the base of the Underhill slice. It is therefore, referred to as a thrust zone. The "thrust" separates metavolcanic rocks, foliated quartzite, and garnetiferous schist of the Underhill slice from the quartz-laminated schist (CZuql) in the north and from basement and/or Hoosac rocks in the south.

Figure 5 is from a field sketch of the best exposure of a fault from this zone at the bridge in South Lincoln (map location P-9). There, a calcareous green schist of the autochthonous (possibly parautochthonous) Hoosac Formation (hg and hbg) is in sharp contact with a sliver of mylonitized quartzite considered to be of Proterozoic Y-age (mh). The mylonite also exhibits strong down-dip elongate mineral grains and clusters that indicate the transport direction.

Immediately adjacent to the quartzite, are exposures of matrix-supported, stretched cobble conglomerates of the basal Hoosac Formation (hc) which are overlain in turn, by more Hoosac schists (hb). The outcrop is an actual sliver of the depositional basement/cover contact imbricated upsection into the Hoosac proper. This contact is nowhere exposed in situ.

Blue-green amphibole rich metabasite may help define the Underhill thrust zone because it is not found in any of the cover rocks to the west. The Underhill slice may be a composite of many imbricate faults as demonstrated by the presence of a Proterozoic Y-age sliver (map location K-10), and by the nature of the garnet isograd. In the northern part of the field area, the isograd separates the well-foliated quartzite of CZund from garnetiferous schist. Also, the size and abundance of the F1-age garnet porphyroblasts rapidly decreases away from the "isograd" on the high intensity side. More work needs to done along this zone in the future.

S2/F2

A second, less intense, lower Paleozoic event (F2) clearly deforms the major faults and the dominant schistosity. In the Pinnacle Formation, and in the schists to the east, F2 is commonly a small-scale, asymmetrical folding of the dominant schistosity. Broad flexures of more competent beds, and rare incipient spaced or crenulation cleavage also characterizes F2. F2 is most intense in the grey phyllite of the Fairfield Pond Formation where S2 is commonly a penetrative slip-cleavage. To the west, in the Cheshire Formation, F2 is absent.

S2 trends to the north and is nearly parallel to S1 but dips more steeply to the west (Figure 4). F2 fold hinges plot along a girdle parallel to S2, and indicate that the axes are doubly-plunging.

Evidence for a third deformation was only seen at one outcrop but it may become more abundant to the north.

METAMORPHISM

Petrographic analysis of oriented thin sections shows that specific mineral assemblages grew during each deformational event, and that the first lower Paleozoic event reached a higher grade than the second event.

Assuming that the metabasites of the area had similar original compositions, then any difference in mineralogy (or amphibole composition as seen by their pleochroic scheme) are due to differences in metamorphic grade. The metabasite assemblages were then compared and contrasted with the surrounding metasedimentary rocks and an estimation of metamorphic grade was made.

M1/F1

M1, which developed during F1, was zonal with greenschist facies to the west of the Mt. Holly, and epidote-amphibolite facies to the east in the Underhill slice. The absence of biotite in the upper Pinnacle (CZpcl and CZpfd) to the west is probably due to lower potassium content of the original sediment compared to the coarser clastics of the biotite-rich lower Pinnacle. Furthermore, as a consequence of the intensity of M1, relic Grenville-age metamorphic textures are absent in the Mt. Holly except for the turbid hornblende cores in basement metabasite.

The most striking mineral assemblages are found in the metabasite of both the basement complex and the Underhill Formation. Coexisting amphiboles are common in these units and involve the intergrowth of actinolite and a blue-green hornblende which help define a zone that is transitional between the greenschist and epidote-amphibolite facies.

There is the possibility that M1 metamorphic zones may pre-date the major thrusts because the isograd that separates the epidote-amphibolote facies rocks of the Underhill slice from the lower grade rocks to the west nearly coincides with the Underhill thrust zone. A more detailed study of these relationships may demonstrate the degree of tectonic control on the geographical dist·ibution of isograds in this part of Vermont.

M2/F2

A second lower Paleozoic metamorphic event was regional in scope and only attained the chlorite-zone of the greenschist facies. As a result, most thin sections show retrograde chlorite after biotite or chlorite after garnet.

LATE BRITTLE DEFORMATION

The latest major structural event produced the ubiquitous joints and brittle fractures which are best developed in rocks with granular fabrics. Of note is the projection of the inferred reverse fault at Deer Leap across the Hogback anticline into the Rocky Dale area (map location F-1). This fault may be responsible for the apparent offset of the axial trace of the major F1-syncline there. This fracturing is of probable Mesozoic age (Cady, Albee, and Murphy, 1962).

RADIOMETRIC SURVEY

As part of a resource assessment of the basement complex by the Vermont Geological Survey, a preliminary radiometric survey was conducted in the best exposures of the Mt. Holly complex and the basal Late Precambrian clastic unit using a gamma-ray spectrometer. While no significant amounts of radioactivity were found (a maximum of twice background radiation), the highest counts per second were recorded along mapped F1-age shear zones. This suggests that mineralization within such zones may localize radioactive anomalies in the Mt. Holly complex.

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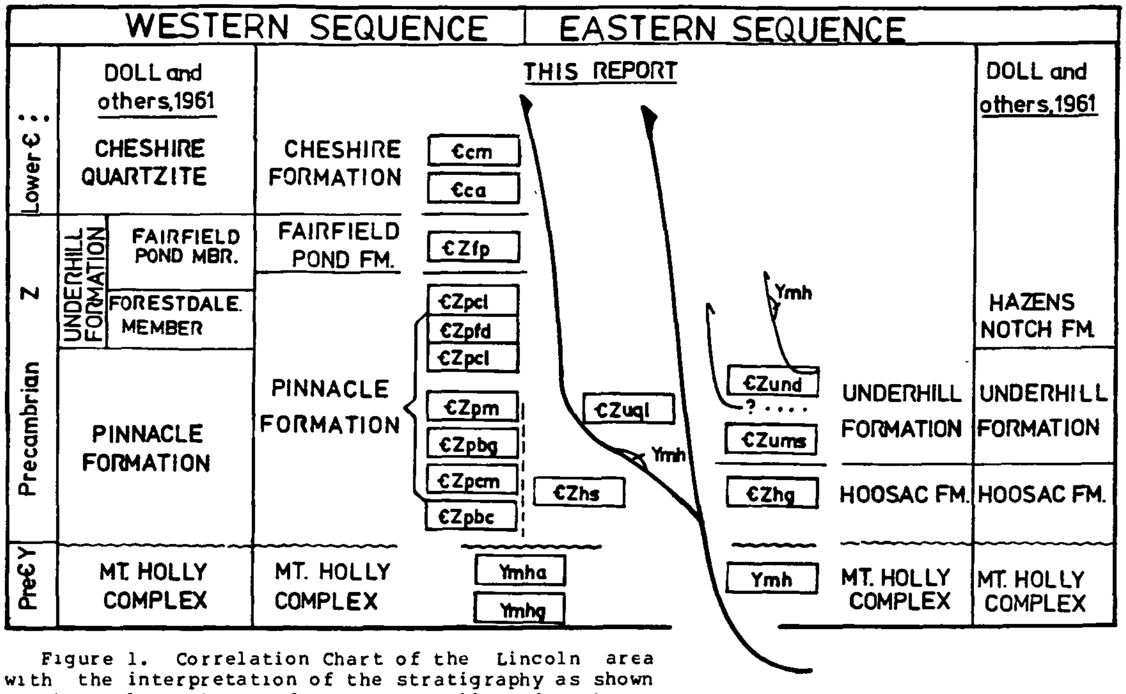

Figure 1. Correlation Chart of the Lincoln area with the interpretation of the stratigraphy as shown on the Geological Map of Vermont (Doll and others, 1961).

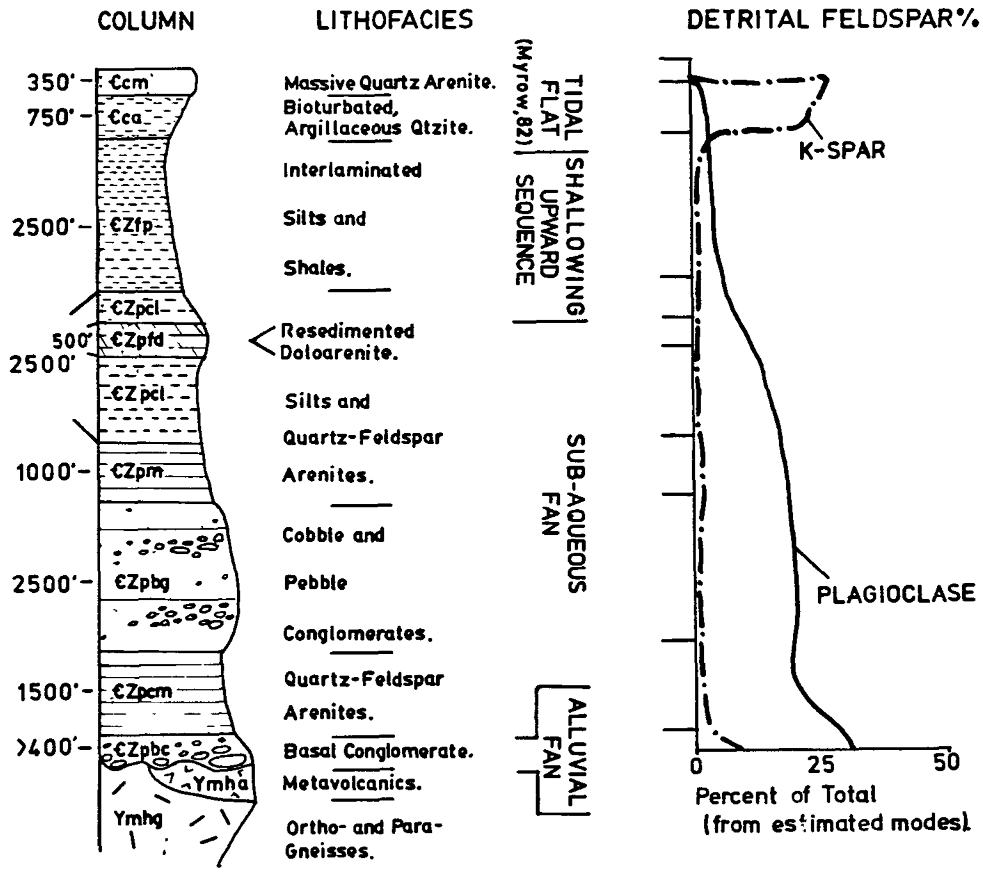

Figure 2. a) Stratigraphic column for the western limb of the Lincoln anticline in the Lincoln area, Vermont. Lithofacies of each unit and interpreted depositional environment are shown to right of column. Lithic designators same as map. b) Percent of total detrital feldspar throughout the column based on estimated modes from thin sections. Separate curves given for potassium feldspar and plagioclase.

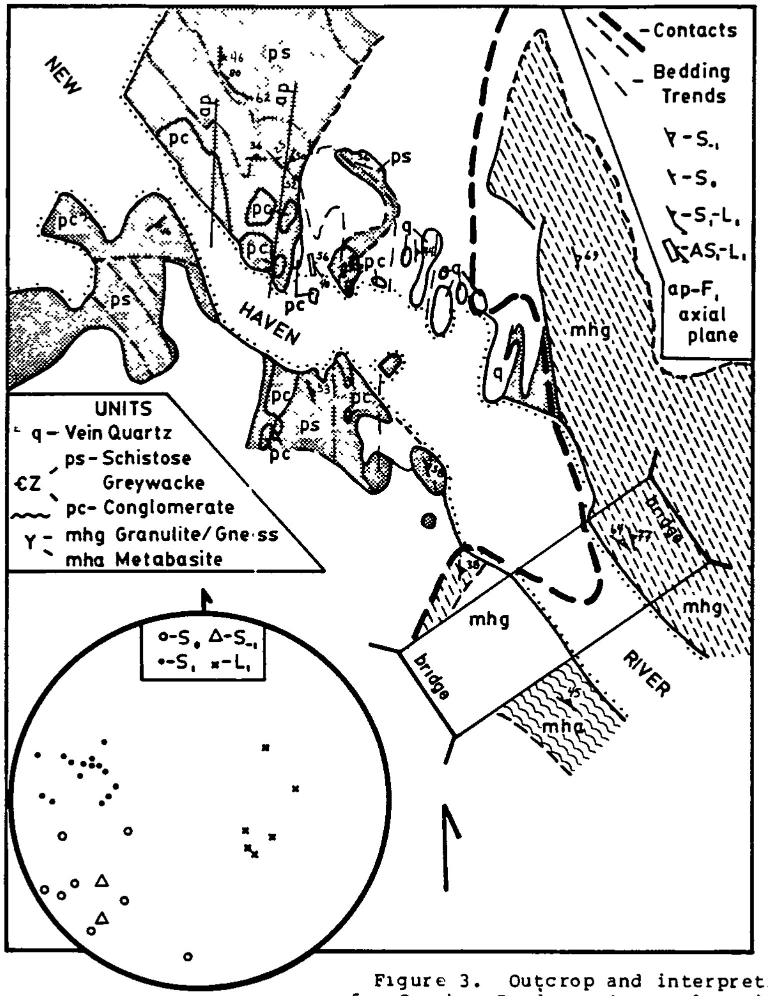

Figure 3. Outcrop and interpretive structure map of Crash Bridge (map location L-8). S-1 = Grenvillian schistosity; S0 = bedding in Pinnacle Formation; S1 = First generation schistosity and axial surfaces; L1 = first generation fold hinges.

AGE	S-SURFACE & DESCRIPTION		GENERATION	STYLE	ORIENTATION
?		NOT DEVELOPED	F_3	RARE, BROAD CHEVRON FOLDS OR KINKING.	NO DATA
POST-TACONIC	S_2	AXIAL SURFACE OF FOLDS OF S_1	F_2	CRENULATION, CHEVRON, AND SLIP CLEAVAGE.	AS: N10E, 84W L: Girdle-N4W, 60E
TACONIC	S_1	DOMINANT SCHISTOSITY	F_1	TIGHT ISOCLINAL	AS: N6E, 30E L: Girdle-N0W, 74E
€Z & €	S_0	BEDDING			
Pre€ Y	S_{-1}	GRENVILLIAN SCHISTOSITY	GRENVILLE-AGE DEFORMATION	VARIOUS	AS: N44W, 62E
?	$S_{0:Ymh}$	BEDDING IN THE MT. HOLLY			

Figure 4. S-surface summary diagram.

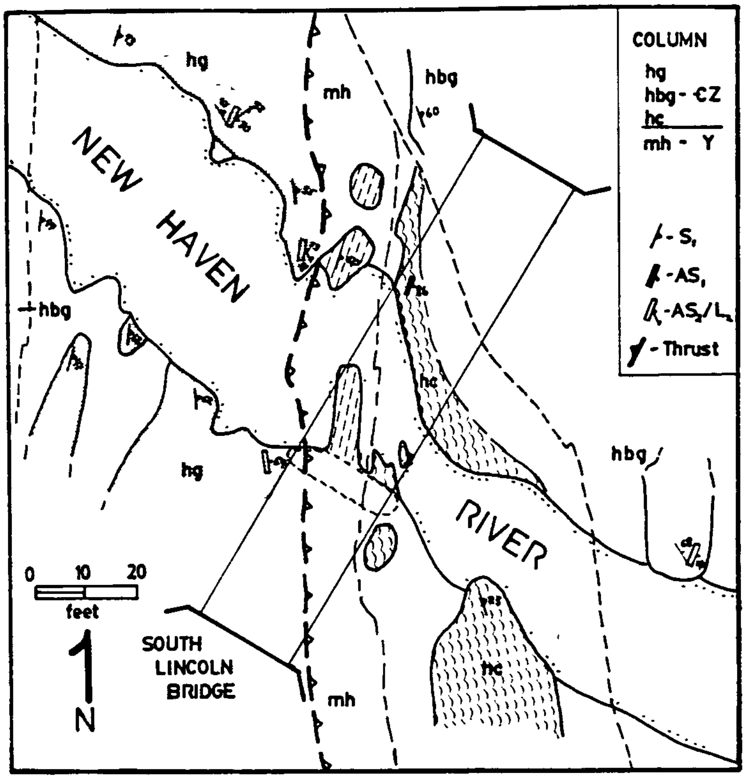

Figure 5. Interpretive structure map of the outcrop at the bridge in South Lincoln, Vermont (from a field sketch) (map location P-8). CZ = Late Precambrian; Y = Proterozoic Y. Units: hg = Hoosac greywacke; hbg = Hoosac biotite greywacke; hc = Hoosac basal conglomerate; mh = Mt. Holly mylonitic quartzite. S1 = first generation schistosity; AS1 = first generation axial surfaces; As2/L2 = second generation axial surfaces with fold hinges.

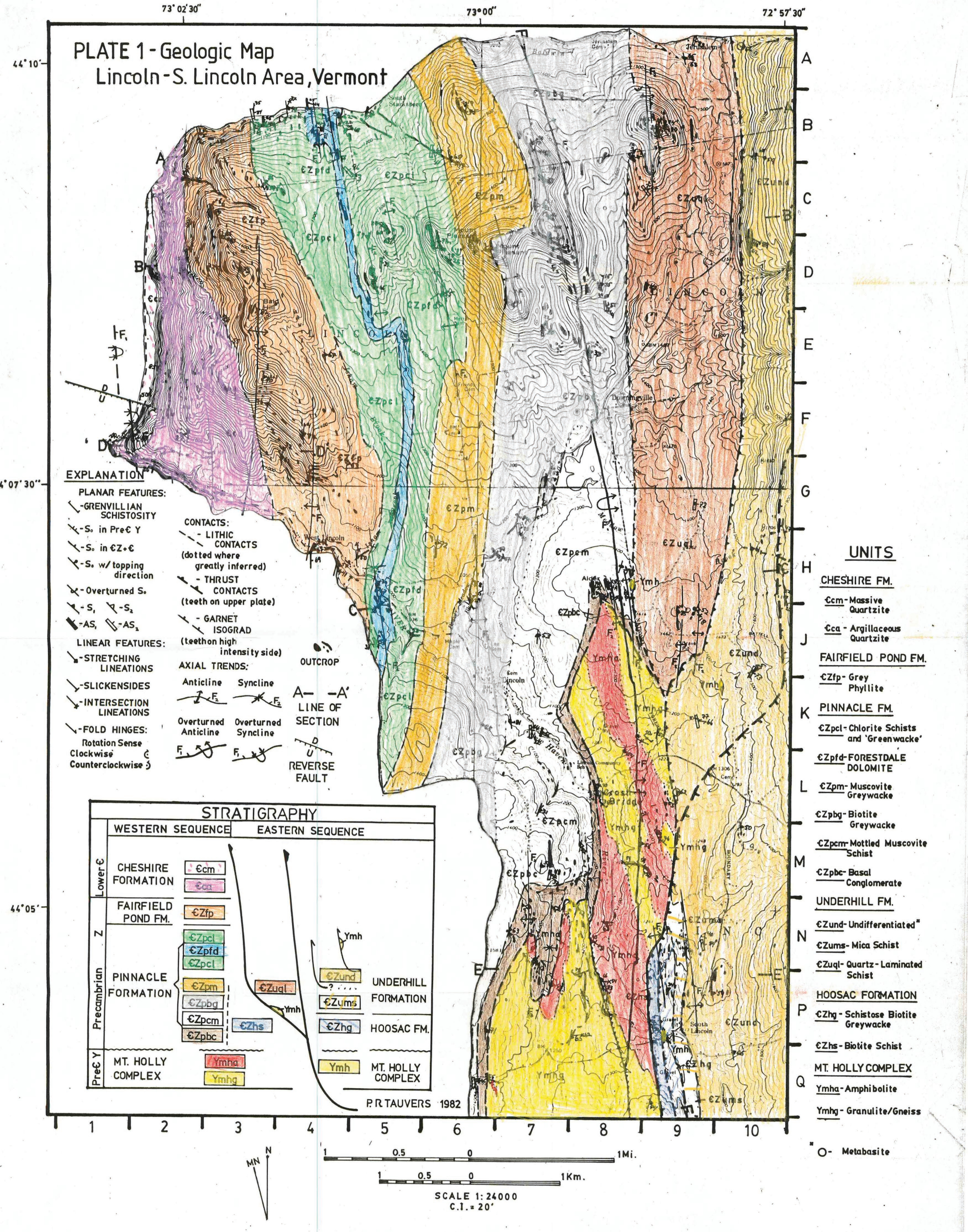

PLATE 1 - Geologic Map
Lincoln - S. Lincoln Area, Vermont
73° 02' 30"
73° 00'
72° 57' 30"
44° 10'
44° 07' 30"
44° 05'
EXPLANATION
PLANAR FEATURES:
-GRENVILLIAN SCHISTOSITY
-S₀ in Pre€ Y
-S₀ in €Z+€
-S₀ w/ topping direction
-Overturned S₀
-S₁ -S₂
-AS₁ -AS₂
LINEAR FEATURES:
-STRETCHING LINEATIONS
-SLICKENSIDES
-INTERSECTION LINEATIONS
-FOLD HINGES:
Rotation Sense
Clockwise
Counterclockwise
CONTACTS:
- LITHIC CONTACTS (dotted where greatly inferred)
- THRUST CONTACTS (teeth on upper plate)
- GARNET ISOGRAD (teeth on high intensity side)
AXIAL TRENDS:
Anticline
Syncline
Overturned Anticline
Overturned Syncline
OUTCROP
A— —A' LINE OF SECTION
REVERSE FAULT
STRATIGRAPHY
WESTERN SEQUENCE
EASTERN SEQUENCE
Lower €
CHESHIRE FORMATION
€cm
€ca
FAIRFIELD POND FM.
€Zfp
Z
Precambrian
PINNACLE FORMATION
€Zpcl
€Zpfd
€Zpcl
€Zpm
€Zpbg
€Zpcm
€Zpbc
€Zuql
€Zhs
€Zund
€Zums
€Zhg
UNDERHILL FORMATION
HOOSAC FM.
Pre€ Y
MT. HOLLY COMPLEX
Ymha
Ymhg
Ymh
P.R. TAUVERS 1982
UNITS
CHESHIRE FM.
€cm - Massive Quartzite
€ca - Argillaceous Quartzite
FAIRFIELD POND FM.
€Zfp - Grey Phyllite
PINNACLE FM.
€Zpcl - Chlorite Schists and 'Greenwacke'
€Zpfd - FORESTDALE DOLOMITE
€Zpm - Muscovite Greywacke
€Zpbg - Biotite Greywacke
€Zpcm - Mottled Muscovite Schist
€Zpbc - Basal Conglomerate
UNDERHILL FM.
€Zund - Undifferentiated"
€Zums - Mica Schist
€Zuql - Quartz-Laminated Schist
HOOSAC FORMATION
€Zhg - Schistose Biotite Greywacke
€Zhs - Biotite Schist
MT. HOLLY COMPLEX
Ymha - Amphibolite
Ymhg - Granulite/Gneiss
" O- Metabasite
A B C D E F G H J K L M N P Q
1 2 3 4 5 6 7 8 9 10
MN N
1 0.5 0 1 Mi.
1 0.5 0 1 Km.
SCALE 1:24000
C.I. = 20'