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SOME BASEMENT ROCKS FROM BEAR MOUNTAIN TO THE HOUSATONIC HIGHLANDS*

By Leo M. Hall,[1] Henry L. Helenek,[2] Richard A. Jackson,[1]

Katherine G. Caldwell,[1] Douglas Mose,[3] and Daniel P. Murray,[4]

INTRODUCTION

This field trip is designed to illustrate some of the rock types and structural features present in Precambrian terranes between Bear Mountain, New York and the Housatonic Highlands in western Connecticut (Fig. 1). As indicated on Figure 1, exposures in the Hudson Highlands (Reading Prong), New Milford Massif, Bear Hill Massif, and the Housatonic Highlands will be visited. Basal Paleozoic rocks, the Poughquag Quartzite and Lowerre Quartzite, in contact with Precambrian gneisses are present at Stops 3, 4, 5, and 6 (Fig. 1) and it is interesting to compare the eastern more feldspathic and per-aluminous Lowerre facies to the western clean quartzite and arkosic Poughquag facies.

The Hudson Highlands are conveniently divided into two sections, the Western Highlands and the Eastern Highlands, by the Ramapo-Canopus fault zone (Fig, 1). This fault zone has had a long complicated tectonic history (Ratcliffe, 1971) and the basement rocks on opposite sides of this zone are dissimilar to a certain extent. The most abundant rocks in the Western Highlands are hornblende granite and other granitic gneisses along with charnockitic gneisses (Stops 1 and 3) whereas biotite granitic gneiss and amphibolite, both of uncertain origin, and biotite-hornblende-quartz-feldspar gneiss (Stop 2) are the most abundant rocks in the Eastern Highlands. Paleozoic deformation and metamorphism has had a much greater effect on rocks in the Eastern Highlands. Aeromagnetic studies (Harwood and Zietz, 1974) indicate a distinct difference in the magnetic character of the rocks in each region, with those in the Eastern Highlands having a much lower magnetic intensity than those in the Western Highlands. Rocks in the Eastern Highlands have magnetic signatures similar to the Fordham Gneiss to the south and to the basement massifs in western Connecticut and thus seem to be more akin to them than to the Western Highlands (Fig. 1). Lithic similarities also exist between the Fordham Gneiss and some of the rocks in the Eastern Highlands and it appears that they are at least parially equivalent stratigraphically and very similar structurally. A definitive understanding of the relationship between them is a major problem that needs detailed study.

Paleozoic rocks in the region display an increasing grade of metamorphism toward the east, up to the sillimanite-orthoclase zone (Balk, 1936; Vidale, 1974), and apparently the more intimate structural involvement of the basement and cover rocks toward the east is directly related to this increase in metamorphic grade. This intimate involvement between basement and cover is evident in the Manhattan Prong toward the south (Hall, 1968) and will be observed in western Connecticut at Stops 4 and 5 on this field trip (Fig. 1). The exposure of Precambrian gneiss resting directly on top of the Cambrian Lowerre Quartzite at Stop 4 along

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*Helenek, Murray, and Mose provided the data for the first three stops of the field trip and Jackson, Caldwell, and Hall are responsible for the last three stops. The text for the guidebook has been jointly prepared by all participating leaders.

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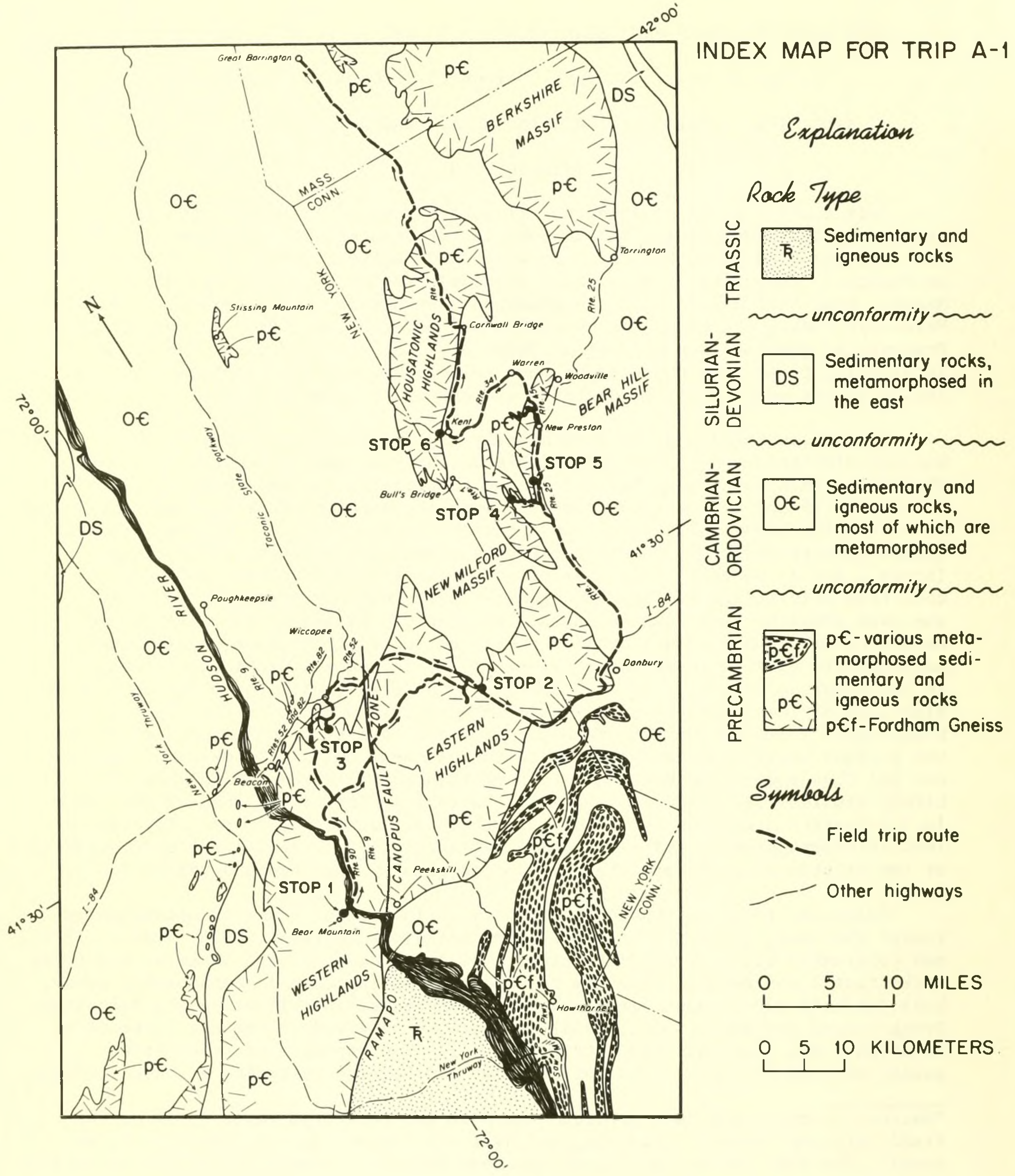


Figure 1. Index map and route for field trip A-1.

the east side of the New Milford massif is particularly spectacular and betrays the complex structural character of the New Milford massif which is currently being studied by Katherine Caldwell. The Bear Hill massif (Fig. 1) was also intimately involved with the deformation of the cover rocks and is currently being studied in detail by Richard Jackson. Gregory and Robinson (1907) and Agar (1929) are among the earlier geologists who studied the rocks in western Connecticut and interpreted the gneisses in the Bear Hill region to be Precambrian. Subsequent work by Gates (1952) led to the interpretation that these gneisses are part of the Paleozoic section. Jackson has found the Cambrian Lowerre Quartzite unconformably truncating rock units in the gneisses (Stop 5) and consequently has reinstated the earlier interpretation that these gneisses are Precambrian basement. The bedrock geology of the New Milford and Bear Hill massifs and their associated cover rocks is strikingly similar to that found in most of the Manhattan Prong and may also be similar to that associated with the Eastern Highlands. This is true with respect to the nature of the cover rock stratigraphy, some of the basement rock types, and the intimate structural relations between basement and cover. The pink quartz-feldspar gneiss and the pink augen gneiss (Stops 5 and 6) in the basement in western Connecticut bear a striking resemblance to the Yonkers Gneiss in the Manhattan Prong.

The autochthonous as opposed to allochthonous nature of the basement rocks that will be visited on this trip remains as a regional geologic problem. Various interpretations of these relationships have been suggested (Isachsen, 1964) and Dallmeyer (1974). This specific problem will not be addressed directly on this field trip however most people would agree that if any large scale thrusting of the basement has occurred it must also have involved at least part of the cover rock section. On the other hand, the shearing along the Poughquag-Precambrian contact at Stop 6 (Fig. 1) suggests the possibility that the cover may have broken loose and sheared over the basement at least locally. Present and future studies will undoubtedly shed more light on this regional problem.

ACKNOWLEDGEMENTS

We wish to thank Marie Litterer for drafting the figures in exceptionally fine fashion. We are also appreciative of the cooperation extended to us by the personnel of the Harriman State Park, the Sharpe Environmental Center, the New York State Police, the Eliot D. Pratt Education Center, and to Mr. and Mrs. Lardner for allowing us to park on their property at Stop 4.

WESTERN HIGHLANDS

Lithology - The most common rock types and their approximate relative abundances are hornblende granite and granitic gneiss (35%), various charnockitic quartz-plagioclase gneisses (27%), amphibolite and related rocks (15%), paragneiss (13%), and alaskite (5%). Biotite granite gneiss (3%) and calcareous, ferruginous and quartzitic metasediments (2%) are subordinate. Most of these rocks are interpreted as either meta-volcanic or meta-sedimentary on the basis of bulk composition and association. Zircon populations of the hornblende granitic rocks are characteristic of plutonic rocks (Eckelmann and Helenek, 1975) thus the hornblende granites probably represent sills and phacoliths intruded prior to and during the major deformation and metamorphism. Alaskite, Canada Hill granite and the Canopus pluton (Ratcliffe et.al., 1972) are the only unequivocal Precambrian intrusive igneous rocks.

Stratigraphy - The following stratigraphic sequence has been identified in the Western Highlands (Helenek, 1971; Jaffe and Jaffe, 1973):

Unit C. Migmatitic paragneiss and Canada Hill type granite with subordinate amphibolite and quartz-plagioclase leucogneiss and minor calcareous ferruginous and quartzitic metasediments.

Unit B. Quartz-plagioclase gneisses with subordinate amphibolite and calc-silicate gneiss and minor additional meta-sediments.

Unit A. Hornblende granite and granitic gneiss.

The history represented by this stratigraphy has been interpreted in various ways. Offield (1967) proposed that Unit B was metamorphosed and intruded by Unit A producing an ancient Precambrian basement which was subsequently eroded. Unit C was then deposited unconformably on this ancient basement and the entire section was then metamorphosed and deformed. Helenek (1971) concluded that Unit A represents remobilized basement that was initially overlain by Units B and C and that the Canada Hill type granite was derived by partial melting of paragneiss. Jaffe and Jaffe (1973) interpret Unit C to be the oldest in the sequence and Unit A to be a thick section of meta-rhyolite at the top.

Structure - At least three periods of folding have effected the rocks in the Western Highlands and the earliest fold generation (F_1) resulted in regional isoclinal folds. The second generation of folds (F_2) developed as plane cylindrical, isoclinal folds with southeast dipping axial planes and axes that plunge approximately N35°E at 10° parallel to the regional lineation (B'_2). A localized set of open folds (F_3) with nearly vertical axial planes and axes that plunge N45°E at 30° refolded elements of F_1 and F_2-folds. Data for the dominant fabric elements S_o and B'_2 are presented in (Figure 2 A + B).

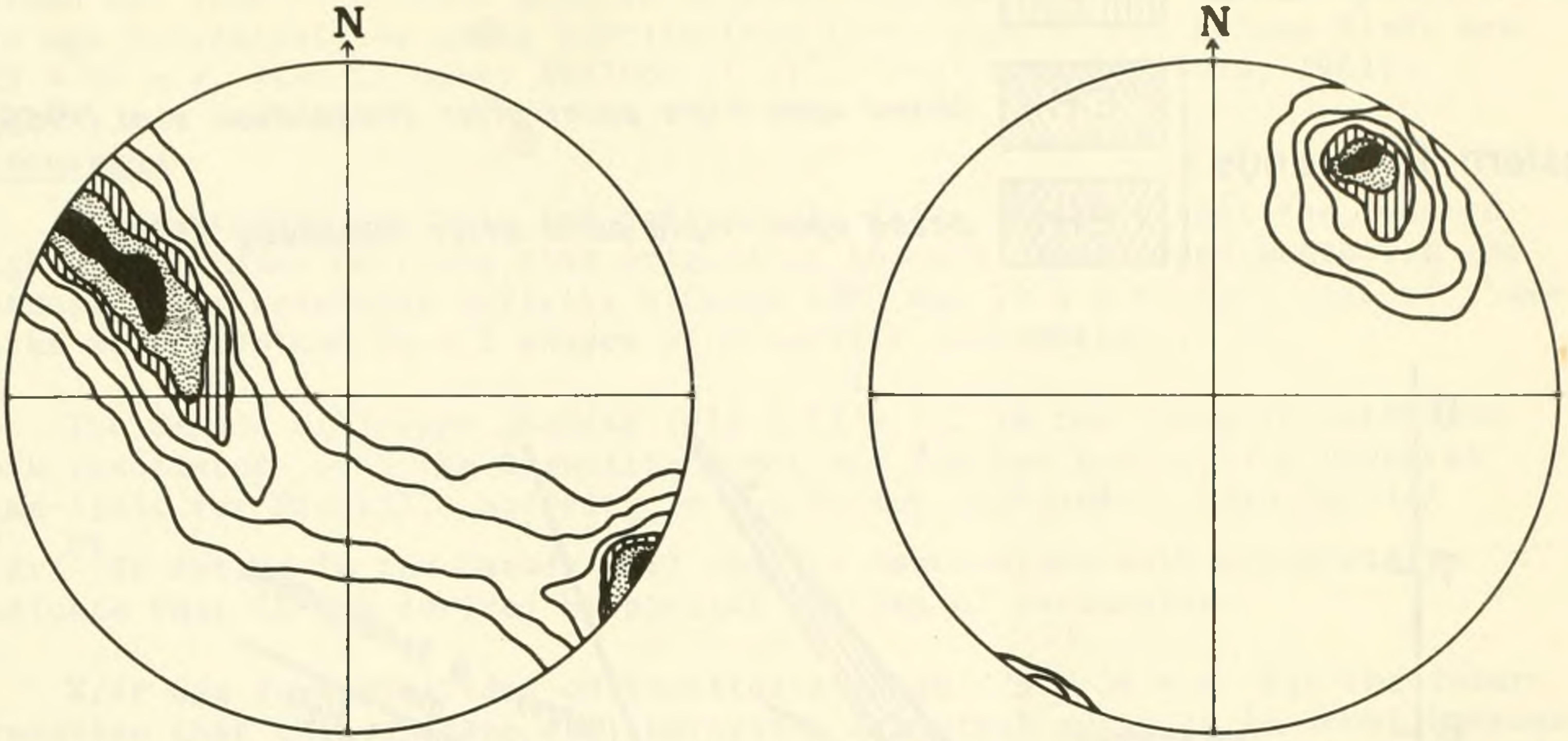
Metamorphism - Critical minerals in the mafic rocks are clinopyroxene-orthopyroxene-hornblende-biotite-quartz-plagioclase and opaques and orthopyroxene-garnet-hornblende-quartz-plagioclase-microperthite in hornblende granitic rocks. These phases imply lower granulite facies metamorphism, and are compatible with the pressure-temperature conditions established in the Western Highlands (Fig. 3) by Dallmeyer and Dodd (1971). The horizontal bar on Figure 3 indicates the pressure and was obtained by applying a modified version of the cordierite-garnet geobarometer described by Hutcheoson et. al. (1974) to compositional data for these minerals. Retrograde metamorphic effects increase markedly from the Hudson River eastward to the Canopus fault.

Geochronology - The following Rb/Sr whole rock ages have been determined by Mose et. al. (1975):

Unit	Rock Type	Age ± 1σ	$(^{87}Sr/^{86}Sr)_o \pm 1\sigma$
A	Hornblende granitic gneiss at Crows Nest	1169 ± 14 m.y.	0.7055 ± 0.0006
B	Quartz-plagioclase gneiss	1115 ± 85 m.y.	0.7033 ± 0.0007
C	Paragneiss	1139 ± 10 m.y.	0.7067 ± 0.0004
A	Hornblende granite at Bear Mtn.	1086 ± 8 m.y.	0.7020 ± 0.0005
C	Partial melt from paragneiss (Canada Hill type granite)	914 ± 12 m.y.	0.7193 ± 0.0005

These age determinations are in good agreement with the 1170 m.y. zircon age from the "Canada Hill gneiss" (quartz-plagioclase gneiss?) and the 1060 m.y.

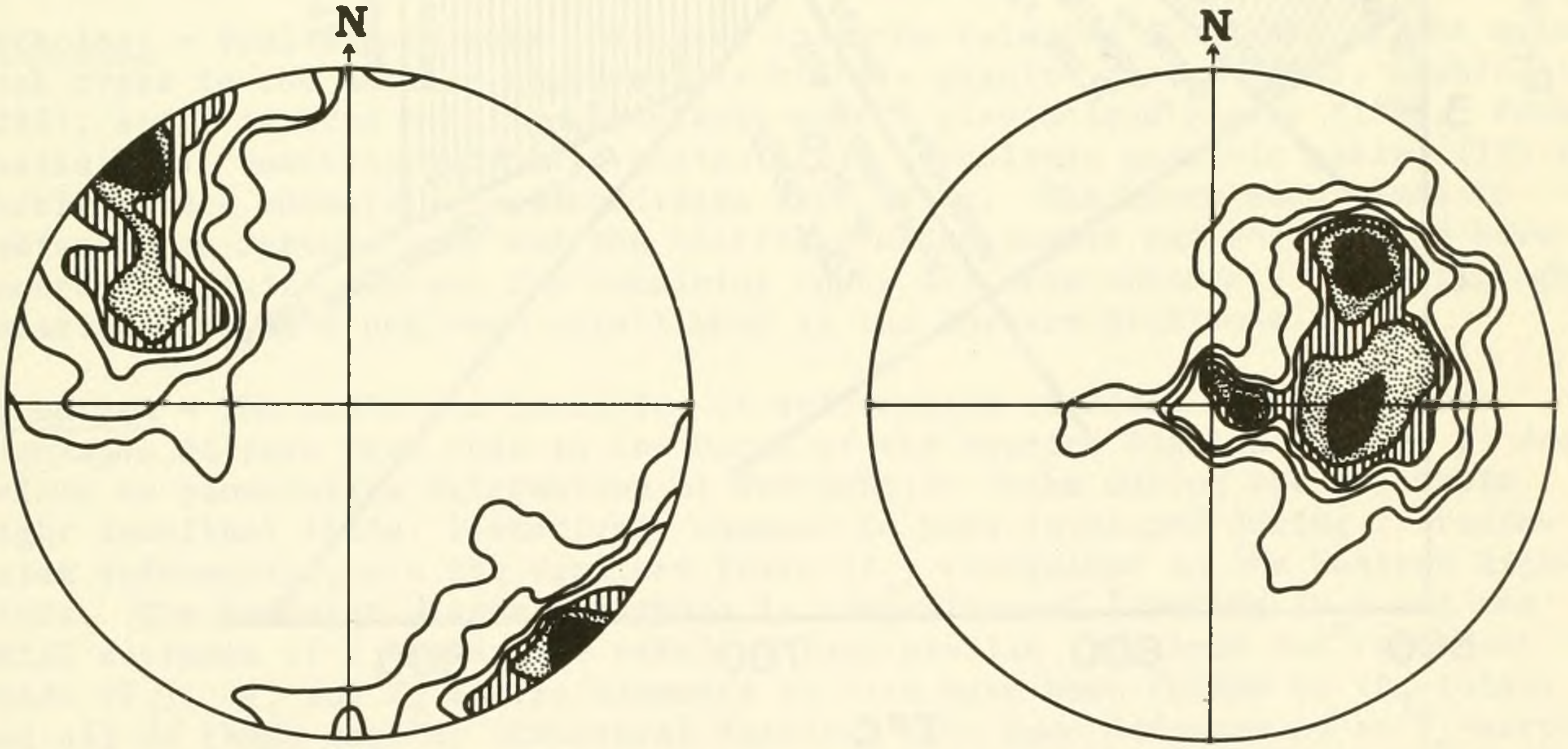
WESTERN HIGHLANDS



A. POLES TO PLANAR FEATURES
N = 3258
1, 2, 3, 4, 5, 6 % CONTOURS

B. LINEATIONS
N = 415
2, 5, 10, 15, 20, 25 % CONTOURS

EASTERN HIGHLANDS



C. POLES TO PLANAR FEATURES
N = 890
1, 2, 3, 4, 5, 6 % CONTOURS

D. LINEATIONS
N = 396
1, 2, 3, 4, 5, 6% CONTOURS

Figure 2. Equal-area diagrams summarizing planar and linear data for the Western Highlands (A and B) and the Eastern Highlands (C and D).

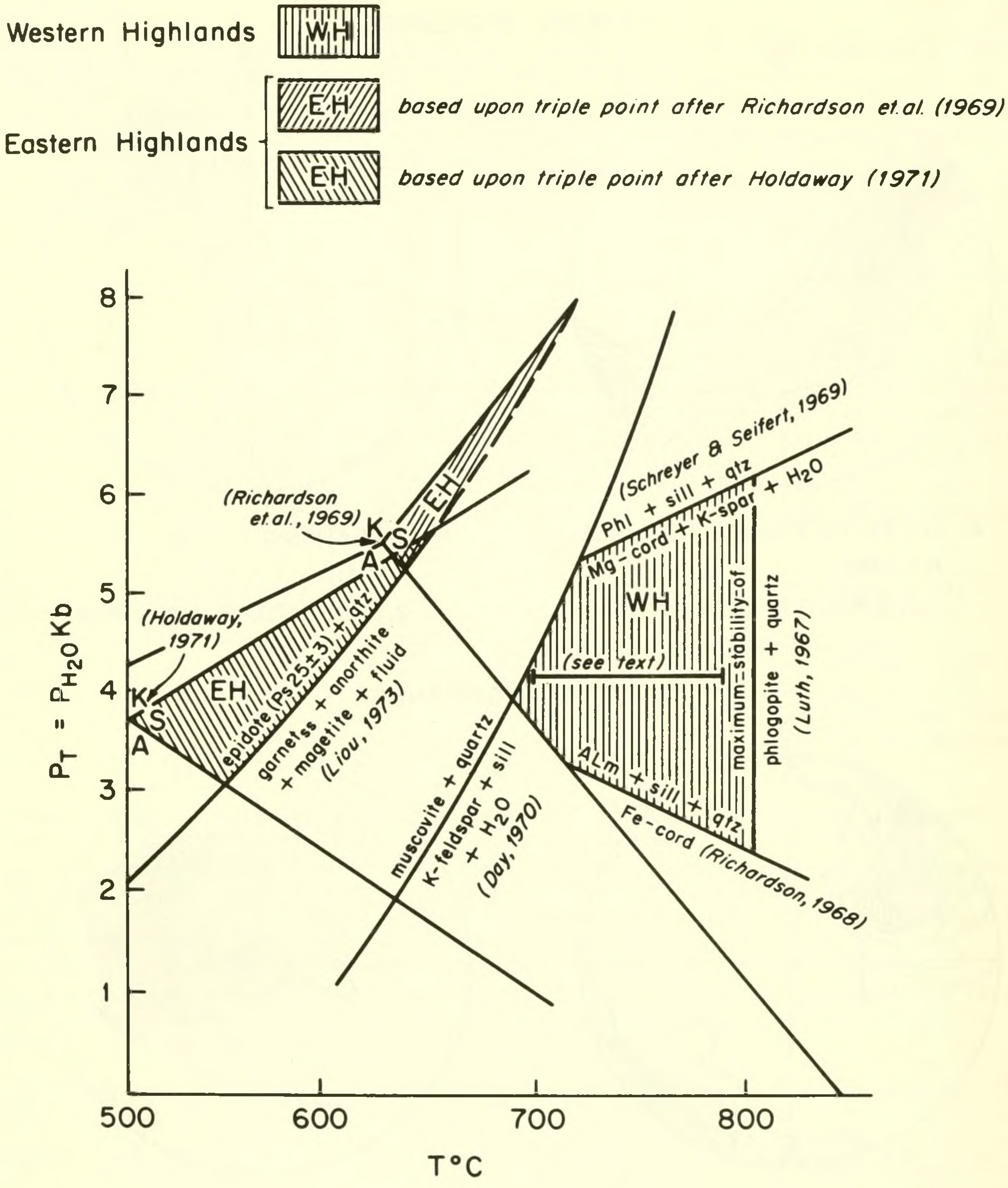


Figure 3. P-T conditions during metamorphism in the Hudson Highlands.

zircon age from hornblende granite at Bear Mountain (Tilton et al., 1960). K/A age determinations using biotite from rocks west of the Hudson River are 829 ± 34 m.y. (1σ, 12 ages) (Tilton et al., 1960; Long and Kulp, 1962).

Discussion

Stratigraphic analysis and radiometric dates indicate that the Western Highlands consist of rocks that originated through clastic sedimentation and intrusive and extrusive activity between 1200 and 1075 m.y. ago. All of these rocks were involved in all phases of Grenville deformation.

The Canada Hill-type granite (914 ± 12 m.y.) is the youngest intrusive rock associated with the Grenville event and its age indicates a youngest time-limit for Grenville activity in the Hudson Highlands. High initial $^{87}Sr/^{86}Sr$ ratios in the Canada Hill and its association with paragneisses indicate that it was derived by partial melting of paragneiss.

K/Ar age determinations on biotites average 829 ± 34 m.y. but the interpretation that this average age represents a thermal event is in doubt because no igneous rocks are known to have formed at this time. Another interpretation is that the biotite in these rocks reached its argon retention temperature of about 300°-350°C about 830 m.y. ago. Using biotite-hornblende pairs, with hornblende ages of about 900 m.y. and a hornblende retention temperature of about 500-550°C, Sutter and Dallmeyer (1972) proposed that the late Precambrian uplift occurred at a rate of about 10^{-5} meters per year.

EASTERN HIGHLANDS

Lithology - Preliminary work indicates that the relative abundance of the major rock types in the Eastern Highlands is biotite granite gneiss (58%), amphibolite (23%), and a layered biotite-hornblende-quartz-plagioclase gneiss (13%). Paragneiss (4%), quartz-plagioclase gneiss (1%), hornblende granitic gneiss (1%) and marble (trace amounts) are subordinate rock types. The hornblende granitic gneiss is an igneous rock and the biotite granite gneiss and amphibolite have uncertain origins whereas the remaining rocks are meta-sediments. Stratigraphic relationships have not been established in the Eastern Highlands.

Structure - The style and intensity of deformation of rocks in the Eastern Highlands differs from that in the rocks of the Western Highlands (Fig. 2) due mainly to penetrative deformation of Precambrian rocks during the Paleozoic. Tight isoclinal folds, tentatively assumed to have developed during a Precambrian deformation, are the earliest folds (F_1) recognized in the Eastern Highlands. The dominant planar structure is compositional layering (S_o) and the axial surfaces of F_1-folds are refolded into similar, reclined and recumbent folds (F_2). F_1 and F_2 fabric elements in turn have been folded by (F_3-folds) and all of these earlier structural features have been deformed by an F_4-warping. Since F_2- and F_3-folds are coaxial, they probably represent a single phase of continuous deformation tentatively believed to have developed during Taconic deformation. The dating of the F_4-folding in this scheme is uncertain.

Metamorphism - Isograds delineated by Balk (1936) immediately north of the Hudson Highlands can be extrapolated across the Hudson Highlands. Reconaissance studies of mineral assemblages from Precambrian rocks in the sillimanite zone indicate upper amphibolite facies conditions. Textural features associated with minerals in these assemblages formed during the F_2 folding. Local relict textures that pre-date F_2 are present, as are retrograde effects that post-date F_2. The calc-silicate assemblage, epidote (Ps_{27})-grandite (And_{51}-$Gross_{38}$-$Other_{11}$)-augite (Wo_{49}-En_{18}-Fs_{33})-plagioclase (An_{30})-quartz-magnetite formed at the time of F_2-folding and defines a narrow range of T and fO_2 (10^{-18} bars). This assemblage coupled with that of sillimanite-garnet-biotite-quartz-feldspar gneiss nearby, defines a pressure-temperature regime for this area as shown in Figure 3.

Geochronology - Rb/Sr whole-rock studies on samples of biotite granite gneiss, from an outcrop in the Eastern Highlands near the Hudson River one-half mile north of Peekskill, indicates that this rock formed at 1256 ±7 m.y. (initial $^{87}Sr/^{86}Sr = 0.7021 \pm 0.0002$). Another whole-rock study on samples of biotite granite gneiss thought to be the same, in the Lake Carmel 7 1/2' quadrangle, yielded an age of 1296 ±18 m.y. (initial $^{87}Sr/^{86}Sr = 0.7032 \pm 0.0003$).

The 1250-1300 m.y. age of the biotite granite gneiss may represent its time of origin by sedimentary or igneous processes. Thus the biotite granite gneiss in the Eastern Highlands is considerably older than rocks in the Western Highlands. Although a Grenville event has not yet been identified in the Eastern Highlands, radiometric dating associated with the Fordham Gneiss (Grauert and Hall, 1973) indicates a relatively short Grenville event, over a 100-200 m.y. span, which ended about 980 m.y. ago and a younger event, 550 to 600 m.y. ago, probably Avalonian, involving the formation of the Yonkers Gneiss. Other dates on the Yonkers Gneiss (Long, 1969) and the Pound Ridge Gneiss (Mose and Hayes, 1975) indicate an Avalonian event in the Manhattan Prong about 580 to 600 m.y. ago.

K/Ar and Rb/Sr single mineral studies have been conducted on specimens from the Hudson Highlands, the Manhattan Prong, and Dutchess County (Long, 1962; Clark and Kulp, 1968). K/Ar age determinations on micas collected from Paleozoic rocks in the sillimanite zone are 387 ± 43 m.y. (1τ, 4 dates) and those from Highlands rocks in the same zone are 389 ± 44 m.y. (1τ, 4 dates). On the other hand, K/Ar mica ages from the garnet and biotite zones in the Manhattan Prong and Dutchess County average 406 ± 36 m.y. (1τ, 6 dates) whereas ages from rocks in these zones of Paleozoic metamorphism in the Eastern Highlands are 755 ± 50 m.y. (1τ, 5 dates).

The K/Ar age determinations on mica in rocks from the Hudson Highlands and the surrounding meta-sediments may be interpreted in various ways. One interpretation, based on the oldest ages from the low grade meta-sediments in the Manhattan Prong, would have a metamorphic event about 460-480 m.y. ago and then a second metamorphic event about 390 m.y. ago based on the average age determinations from high grade zones. Another interpretation is that the K/Ar age determinations on micas from progressively metamorphosed Paleozoic rocks in areas of lower grade metamorphism in the Manhattan Prong indicate a minimum age of 410 m.y. for a major metamorphic event. The younger K/Ar dates, about 390 m.y., from rocks in higher grade areas result from argon loss during uplift and cooling. The second interpretation is preferred because it is corroborated by regional interpretations involving the Ramapo-Canopus fault zone and associated metamorphic and intrusive events (Mose, et. al., in press).

SUMMARY

The Eastern and Western Hudson Highlands have pronounced differences in lithology, structural geology and geochronology. The Western Highlands are underlain by a metavolcanic and metasedimentary sequence that was intruded by syntectonic granitic plutons during the Grenville orogeny (1100-900 m.y.). Most of the rocks in the Eastern Highlands have uncertain origins, but there is little or no evidence that a phase of granitic plutonism occurred there during the Grenville. The data presented above indicate fundamental differences between these two terranes. There are numerous plausible interpretations of the geologic relations between them, but juxtaposition of the Eastern and Western Highlands, possibly two different crustal blocks, by motion along the Ramapo-Canopus fault zone is presently thought to be the most favorable interpretation.

ROAD LOG

Stop 1. Bear Mountain. The field trip participants will assemble at the Bear Mountain Inn parking lot at 9:30 a.m. Stop 1 is a short walk north of Bear Mountain Inn to the roadway north of Hessian Lake (Fig. 4). The exposures that will be studied at this locality are in Harriman State Park and regulations prohibit destruction of the environment in any way. NO HAMMERING, PLEASE!

We are in the axial region of an F_1-antiform (Fig. 4) and the rocks exposed here are typical of those in the Western Highlands (Fig. 1). The petrography of these gneisses is briefly described as follows:

Hornblende granite - The modal composition ranges as follows: quartz (30-40%), mesoperthite (50-70%); accessory biotite, opaques, apatite and zircon. At this locality it is poorly foliated and consists of slightly perthitic microcline, plagioclase,(up to 50% of the feldspar)and equal amounts of biotite and hornblende.

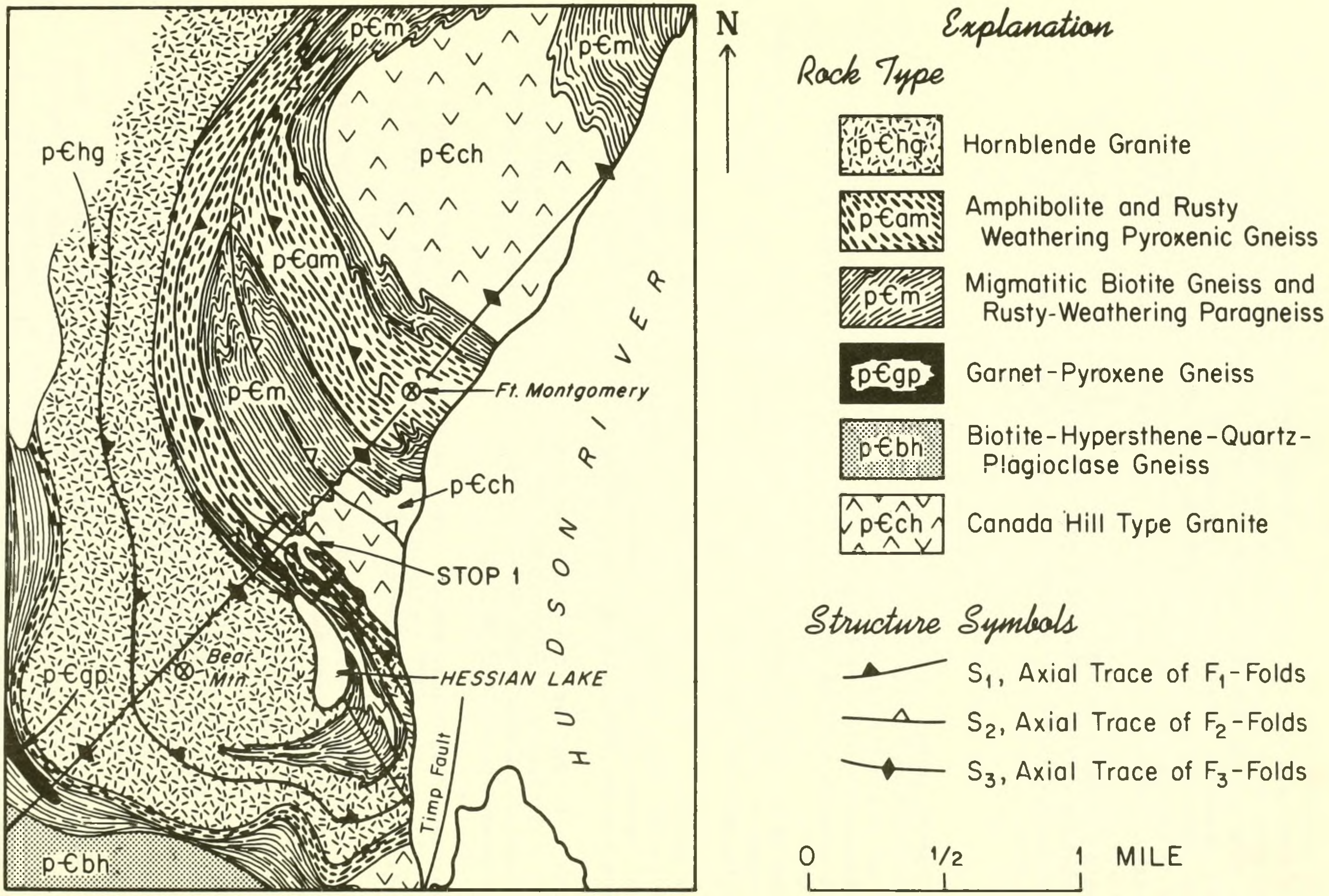
Amphibolite - The amphibolites consist of plagioclase (An_{35-40}; 27-40%), hornblende (37-62%), augitic clinopyroxene (9-18%) and biotite (1-3%) along with accessory opaques, apatite, and zircon. A prominent hornblende lineation is typically present in the amphibolite.

Biotite-pyroxene-plagioclase gneiss (rusty-weathering) - Plagioclase (sodic andesine, 36%), biotite (32%), clinopyroxene (29%) and opaques including some graphite (3%) with accessory apatite and zircon compose this rock.

Canada Hill type granite - This massive rock is composed of quartz, gray-mottled microcline-microperthite and white plagioclase feldspar (An_{24}). Garnet, sillimanite, biotite and graphite are also present in various amounts along with traces of muscovite, apatite, sphene, zircon and tourmaline.

Hornblende granite (pЄhg) is in the core of the F_1-fold (Fig. 4) and is flanked successively by interlayered amphibolite and rusty pyroxenic gneiss (pЄam) and paragneiss (pЄm). The contact between pЄhg and pЄam is folded into isoclinal digitations and compositional layering (S_o) is completely transposed into axial surfaces of F_1-folds.

The gently northwest plunging F_1-folds are on the lower, southwest, limb of a reclined isoclinal antiform(F_2-fold, Fig. 4). The F_2 folds are locally similar in style and typically are more open than the F_1 isoclinal folds. A prominent hornblende lineation is parallel to the F_2 fold axes, B'_2. F_2-folds



Geology by H. Helenek

Figure 4. Geologic map of the region in the vicinity of Stop 1.

occur in the hornblende granite and, although not found in place at this locality, may be observed in a small boulder adjacent to the parking area. An F_2 axial plane foliation is present locally. Open F_3-folds have refolded fabric elements of the F_1- and F_2-folds. F_3-fold axes plunge 37°, N36°E and are almost coaxial with the F_2-fold axes.

Since the syntectonic hornblende granite has been involved in all phases of deformation, the Rb/Sr age of 1086 ± 8 m.y. and U/Pb zircon age of 1060 m.y. indicate the time of intrusion and the time of F_1-folding. This places an upper limit on Grenville diastrophism in this portion of the Western Highlands.

Field evidence in these exposures clearly indicates that Canada Hill type granite is a late tectonic intrusion which transects linear and planar features in all the gneisses. Thus the 914 ± 12 m.y. Rb/Sr whole rock age of the Canada Hill indicates a minimum age for Grenville diastrophism.

A subsidiary road log is included for an alternative short route in the event that we run short of time. The alternate route reverses the sequence of Stops 2 and 3 and appears in three segments: alternate route to Stop 3 at mileage 11.3, alternate route to Stop 2 at mileage 60.0, and alternate route to Stop 4 at mileage 35.7. Each segment of the subsidiary road log is separated from the main road log by lines. Those using this guidebook in the future should note that more regional geology will be seen on the main route.

Mileage		
Total	Interval	
0.0	-	Leave the Bear Mountain Inn in parking lot and turn left onto the service road. Proceed approximately two hundred yards and turn left onto Routes 9W and 202.
0.5	0.5	Start into the traffic circle and bear to the right and east across the Hudson River via the Bear Mountain Bridge. A view of Anthony's Nose is straight ahead at the east end of the bridge.
1.1	0.6	Turn left (north) at the east end of the bridge onto Route 9D and proceed toward Cold Spring.
9.0	3.4	Bear right onto the side road, Peekskill Rd., note the red Fire Department sign at the junction. Peekskill Rd. allows us to bypass the center of Cold Spring.
9.5	0.5	Turn right (northeast) onto Route 301 at the intersection of Peekskill Rd. with Main St. (Route 301) in Nelsonville.
11.3	1.8	Alternate route to Stop 3 from McKeel Corners follows:
0.0		Proceed north from McKeel Corners toward Fishkill by turning left onto Route 9 from Route 301.
4.7	0.7	Note the exposures of Precambrian at the east edge of the sand and gravel pit on the right (east) side of Route 9.
6.5	1.8	Turn right (east) onto Snook Rd. immediately before the I-84 route marker.
7.4	0.9	Snook Rd. joins Van Wyck Lake Rd. here. Proceed straight ahead on Van Wyck Lake Rd.

7.6	0.2	Junction with Cary Rd. is here. Bear to the right (southeast) staying on Van Wyck Lake Rd. Note the numerous exposures of quartz-plagioclase gneiss.
8.0	0.4	Sand and gravel pit on the right (southwest) side of the road.
8.3	0.3	Small bridge across a small stream. Approximately 600 feet southwest of this bridge there is a fine exposure of the basal Poughquag resting unconformably upon Precambrian migmatitic biotite gneiss. The easiest route to this south facing cliff is along the lane east of the stream.
8.4	0.1	Sharp curve in the road where it turns toward the east (left) and crosses the stream.
8.6	0.2	Turn right (south) into the entrance to Sharpe Reservation.

Follow the main road log from here beginning at mileage 53.4.

Continuation of Main Road Log

11.3	1.8	Intersection of Route 9 with Route 301 at McKeel Corners. Jog right and then left across Route 9 and proceed eastward on Route 301. Several exposures of Canada Hill type granite and paragneiss will be seen as you proceed.
13.7	2.4	Sampling locality for Rb/Sr whole rock dating (914 m.y.) of Canada Hill type granite is on the hill at the left.
14.7	1.0	Sampling locality for Rb/Sr whole-rock dating (914 m.y.) of the Canada Hill type granite.
15.3	0.6	Highly sheared Canada Hill type granite and paragneiss. The shearing here is probably associated with movement along the Ramapo-Canopus fault zone.
16.1	0.8	The Appalachian trail crosses the road (Route 301),here near the south end of Canopus Lake. The lake lies in the Ramapo-Canopus fault zone and as one looks northward along the lake the Western Highlands are toward the left and Eastern Highlands are toward the right. Exposures of grayish-white-weathering Canada Hill type granite are visible along the west shore of the lake.
20.6	3.1	Junction of Farmers Mills Rd. with Route 301 at sharp curve in Route 301. Proceed straight ahead onto Farmers Mills Rd. and continue to the junction with Route 52 north of Lake Carmel.
24.9	1.4	Exposure on the right is a sampling locality for Rb/Sr whole-rock dating (1296 ± 18 m.y.) of the Reservoir Granite.
25.5	0.6	Exposure on the right is a sampling locality for Rb/Sr whole-rock dating (1296 ± 18 m.y.) of the Reservoir Granite.
26.5	0.3	Bear right (south) onto Route 52 and proceed toward Lake Carmel.
28.5	0.4	Bad intersection at the junction of Routes 311 and 52. Turn left (east)onto Route 311 and proceed across the south end of Lake Carmel into the village and continue eastward on Route 311.

29.4	0.9	Turn onto the eastbound entrance ramp for I-84.
30.8	1.4	Large rock cuts on both sides of I-84 and the large cut on the westbound lane is Stop 2 (Figs. 1 and 5). Stop here to briefly observe the entire rock cut from a distance (refer to Figure 5).
32.8	2.0	Bear right onto the exit ramp for exit 19 which leads onto Route 312.
33.1	0.3	Turn left (northeast) onto Route 312 crossing the bridge over I-84 and then turn left onto the I-84 westbound entrance ramp and proceed west on the interstate highway.

35.7 2.6 Stop 2. I-84 Rock Cut. Pull vehicles well off the highway onto the shoulder. People are not permitted to cross the highway and it would be best if you stay in the grassy area off the shoulder after you leave your vehicle. This is definitely a camera stop!

The petrography of the Precambrian gneisses at this rock cut is summarized as follows:

Biotite granite gneiss - The dominant minerals are quartz, microcline/plagioclase (An_{15-30}) (ratio is varied) and biotite is minor. Accessory muscovite, zircon, epidote, apatite, and opaques commonly with rims of sphene are present.

Amphibolite and/or hornblende gneiss - Plagioclase (An_{20-50}, 35-40%), hornblende 40-45%), clinopyroxene (up to 12%) and biotite (up to 15%) are the common minerals. Hornblende rims are typically present on the clinopyroxene and accessories are quartz, apatite, calcite, sphene, garnet, epidote and opaques.

Biotite-hornblende-quartz-plagioclase gneiss - Quartz, plagioclase hornblende and biotite with minor microcline, epidote and sphene make up this rock.

Pyroxene-hornblende-quartz-plagioclase gneiss - plagioclase, quartz, hornblende and pyroxene along with minor garnet and sulfide constitute this rock.

Garnet-pyroxene-epidote nodules - Grandite (And_{51} $Gross_{38}$ $Other_{11}$) and ferroagite (Wo_{49} En_{18} Fs_{33}) with subordinate amounts of interstitial epidote, plagioclase and quartz in addition to accessory sphene, opaque, microcline and scapolite are present.

The earliest folds (F_1) are isoclinal and of varied size and orientation. A large F_1-fold extends through much of the outcrop (Fig. 5) and several smaller F_1-folds are present (Fig. 5, in the vicinity of point A). A pre-F_1 set of isoclinal folds may be present but their existence requires more thorough study to be proven.

Compositional layering (S_o) (Fig. 6A) and the axial surfaces of F_1-folds are refolded into reclined, recumbent, and inclined similar F_2-folds (Fig. 5, point B). Orientations of the axial surfaces (S_2') and fold axes (B_2') of the F_2-folds are shown on Figure 6 (C and D). Some of the more spectacular folds in the exposure are F_2-folds (Fig. 5, point C). Syntectonic granite accompanied the F_2-folding and is folded about B_2' (Fig. 5, point D). Late tectonic granite seams were injected preferentially along surfaces subparallel to the axial surfaces of F_2-folds (Fig. 5, point F) and a series of low angle thrust faults are also subparallel to the axial surfaces of F_2-folds (Fig. 5, point J). The most recent apparent motion along some of these faults is in a normal sense.

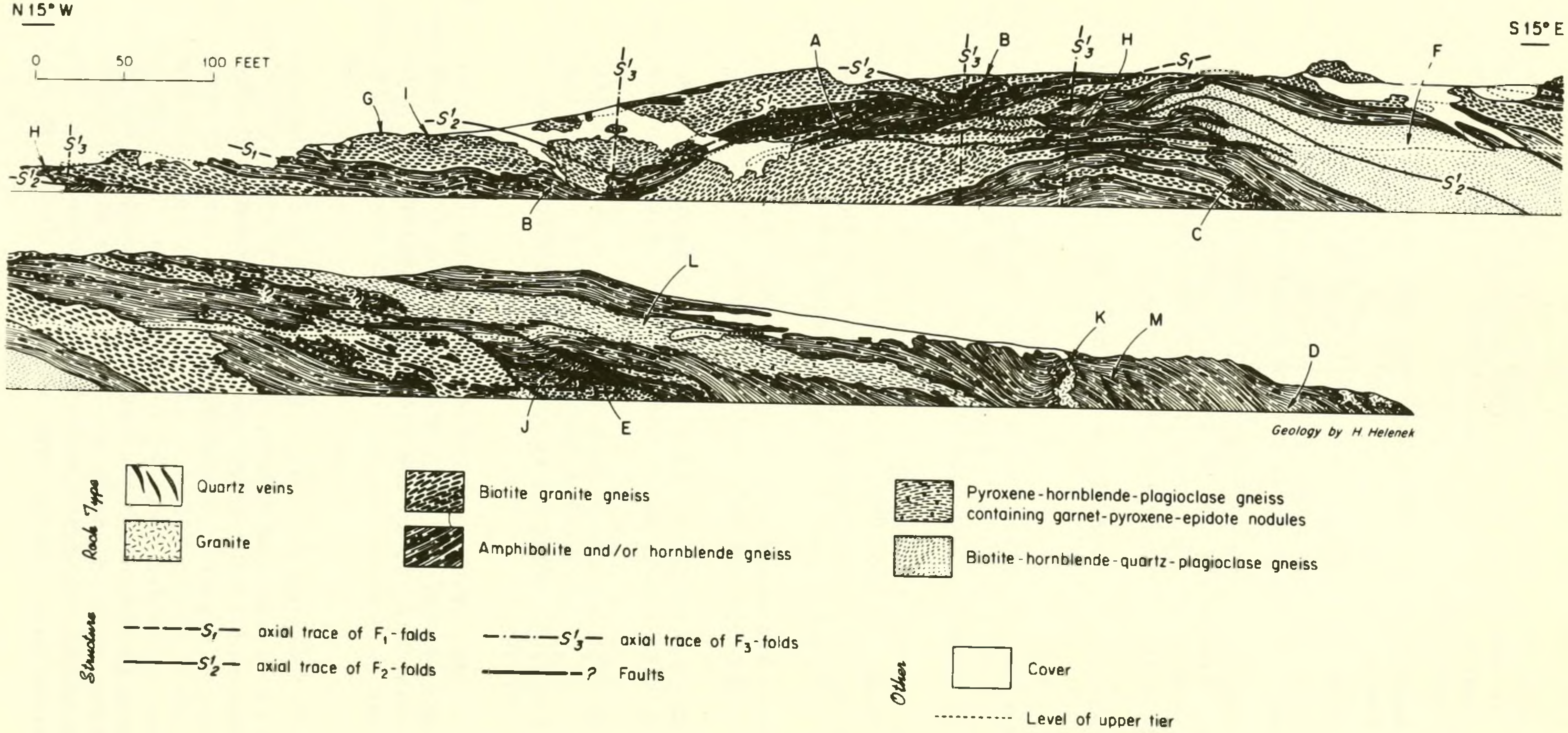
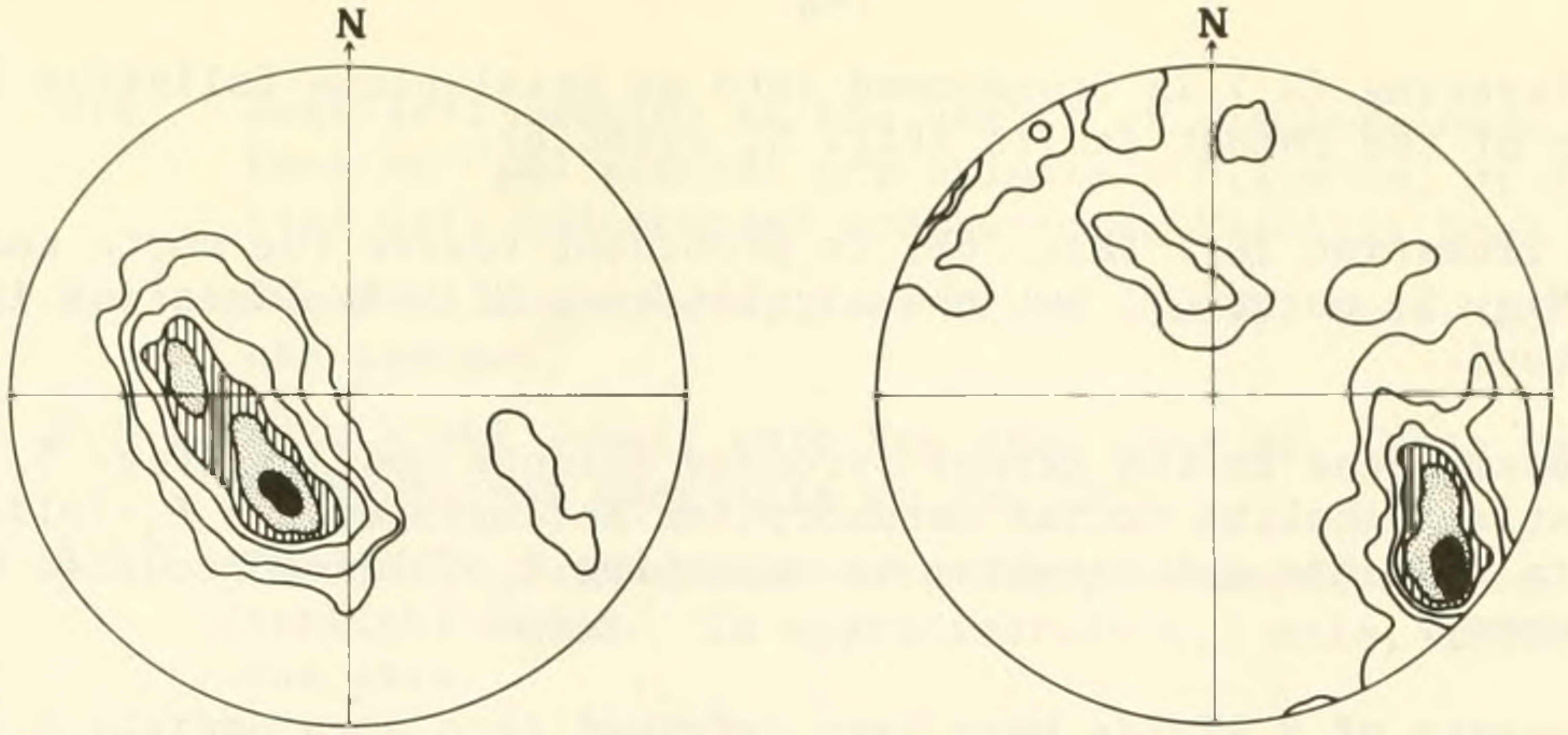
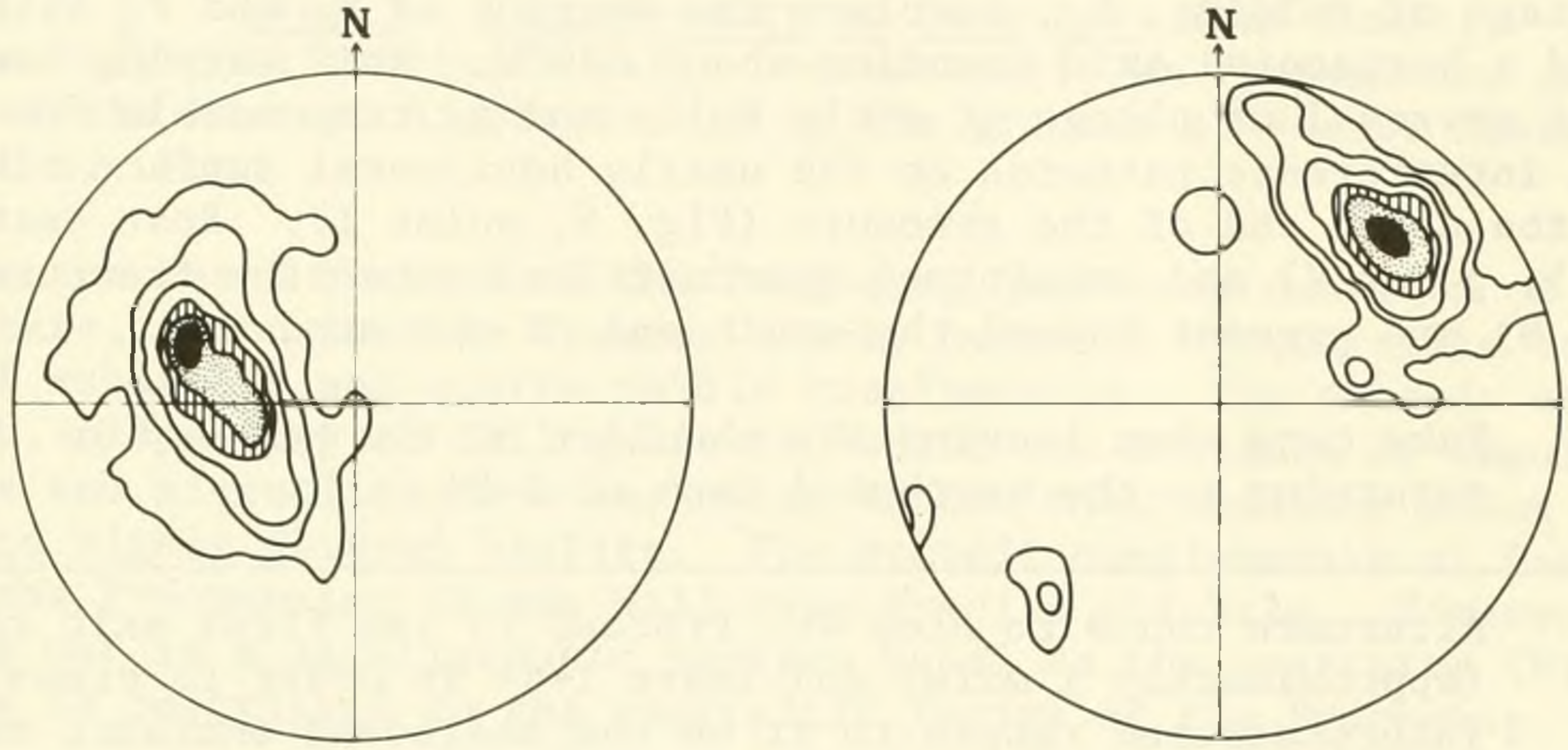


Figure 5. Rock-cut on the westbound lane of I-84 near Lake Carmel, Stop 2. Letter symbols are referred to in the text.



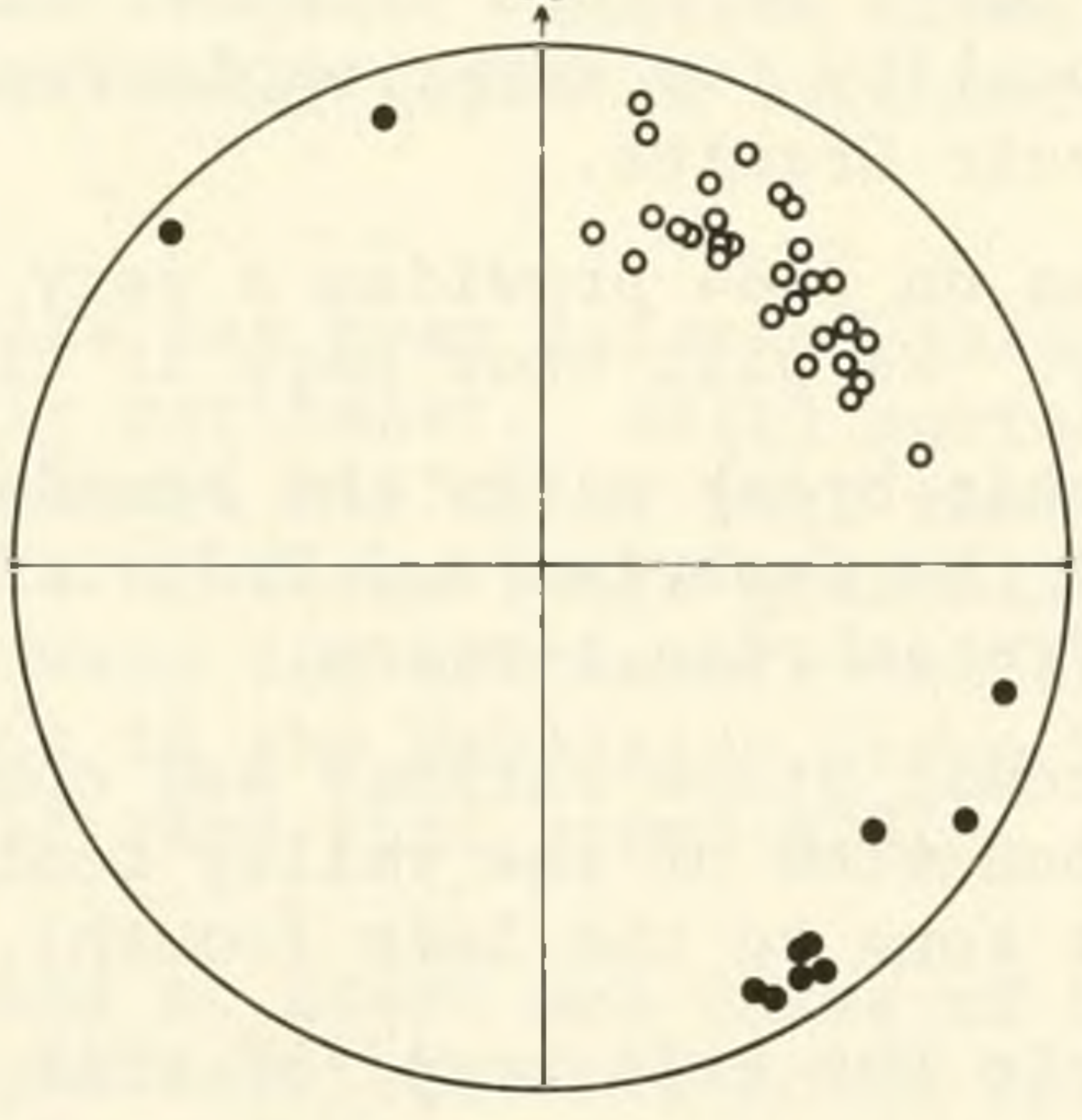
A. POLES TO COMPOSITIONAL LAYERING (S_0)
N = 622
1, 2, 4, 6, 8, 10% CONTOURS

B. MINERAL LINEATIONS (L_M)
N = 130
1, 3, 6, 9, 12, 15% CONTOURS



C. POLES TO F_2 AXIAL PLANES (S'_2)
N = 236
1, 3, 6, 9, 12, 15% CONTOURS

D. F_2 FOLD AXES (B'_2)
N = 71
2, 4, 8, 12, 16, 20% CONTOURS



E. ○ 29, F_3 FOLD AXES (B'_3)
● 11, POLES TO F_3 AXIAL PLANES (S'_3)

Figure 6. Equal-area diagrams of structural data from the rock-cut on the westbound lane of I-84 near Lake Carmel, Stop 2.

Compositional layering (S_o) is transposed into an axial plane foliation (S_2) in the vicinity of the thrust faults (Fig. 5, point E).

A mineral lineation (L_M) (Fig. 6B) is prominent toward the north end of the exposure (Fig. 5, point G), but the significance of this lineation is not clearly understood.

Mineral assemblages in the garnet-pyroxene-epidote nodules (Fig. 5, point L) indicate that amphibolite facies metamorphism accompanied the F_2-folding. Radiometric data indicate metamorphism accompanying F_2-folding occurred during the Taconic orogeny.

Fabric elements of F_2-folds have been deformed into open upright F_3-folds. These F_3-folds are the gentle warps that refold the F_2-folds (Fig. 5, point H). Poles to the axial surfaces of F_2-folds lie on a girdle defining an axis oriented N55°E, 28°N (Fig. 6C) which coincides with the fold axes (B_3') of F_3-folds (Fig. 6E). The nearly coaxial relationship between the F_2- and F_3-folds suggests, but doesn't prove, that they were formed during one deformational event.

A final stage of folding, F_4, involves the warping of F_2 and F_3 fabric elements around a horizontal axis trending about N20°W. This warping has resulted in the reversal of plunge of early folds and is responsible for the dome-and-basin interference patterns on the nearly horizontal surface of the upper tier at the north end of the exposure (Fig. 5, point I). Post tectonic granite (Fig. 5, point K) and undeformed quartz-filled extension fractures (Fig. 5, point M) are present toward the south end of the exposure.

35.7		Take care when leaving the shoulder of the highway in returning to the westbound lane of I-84.

35.7		Alternate route to Stop 4: Proceed to the first exit ramp (approximately 1 mile) and leave I-84 in order to cross the interstate and return to it on the eastbound entrance ramp. Proceed east to Danbury, Connecticut and continue according to the main road log at mileage 88.3.

Continuation of Main Road Log

40.3	4.6	Cross the county line between Putnam and Dutchess counties and note the large exposure of Reservoir Granite. This is a sampling locality for Rb/Sr whole-rock dating (1296 ± 18 m.y.) of the Reservoir Granite.
43.2	2.9	This rest area on I-84 provides a very scenic view of the Hudson Valley. We will stop here if time permits.
45.6	2.4	This topographic break marks the boundary between the subdued topography of the Cambrian and Ordovician terrane and the more rugged Precambrian terrane.
45.8	0.2	Cross the Taconic State Parkway and continue west on I-84. There is a good view of the valley controlled by the Ramapo-Canopus fault zone to the left (south).
47.8	2.0	Bear right onto the exit ramp for exit 15, Lime Kiln Rd.
48.2	0.4	Bear right (north) onto Lime Kiln Rd.
49.3	1.1	Divided highway ends here. Continue approximately 0.1 mile and turn left (west) onto Route 52 and proceed westward.

51.0	0.8	Bear left (south) at the hamlet of Wiccopee onto Fishkill Hook Rd. and proceed approximately 0.1 mile, or less, and bear left and proceed southward on Fishkill Hook Rd.
52.1	0.4	The road forks here; bear right (south) onto West Hook Rd. and proceed.
52.8	0.7	Turn right (west) onto Van Wyck Lake Rd. Note the exposures of Poughquag Quartzite on the left.
53.4	0.1	Turn left into entrance to Sharpe Reservation and proceed straight ahead. In approximately 0.1 mile, drive through the gate.
53.7	0.3	Continue straight ahead past the road intersecting from the left.
53.8	0.1	Bear to the right where the side road intersects from the left.
53.9	0.1	Continue straight ahead, up the hill and pass intersection of side road on right.

54.0 0.1 *Stop 3*. *Unconformity at Deer Lake* (and lunch). This locality, where the Poughquag Quartzite rests unconformably on Precambrian gneisses typical of the Western Highlands, is on the grounds of Sharpe Reservation of the Fresh Air Fund.

Here the basal portion of the Poughquag Quartzite consists of an arkosic conglomerate, approximately 1 meter thick, overlain by quartzite containing lenses of subarkose and quartz pebble conglomerate. The arkosic conglomerate is drab, olive-gray to dull yellowish-white and consists of angular clasts of quartz and microcline in a sericitic matrix that contains minor amounts of zircon and highly altered biotite. The arkosic conglomerate at Deer Lake resembles the Precambrian Canada Hill type granite slightly. However it undoubtedly maps out as a stratigraphic horizon basal to the quartzite (Fig. 7). *Scolithus* is restricted to the quartzitic facies of the Poughquag.

Hornblende granitic gneiss, migmatitic biotite gneiss and amphibolite are the Precambrian rocks present here. The gneisses are finer grained and more highly altered than equivalent rocks in the Bear Mountain area probably due to the extensive brittle deformation that has occurred here. Quartz and feldspar are strained, hornblende is totally or partially replaced by green mica (biotite?), epidote, actinolite (?) and opaques. Biotite contains radiating acicular inclusions and is totally or partially replaced by chlorite, epidote, white mica and opaques.

The Poughquag Quartzite has been deformed into a series of open, symmetrical, folds, plunging gently northeast. Axial surfaces trend about N46°E and dip 80° NW and fold axes plunge N45°E, at less than 12°. Northeast of this locality the axial surfaces of these folds gradually change in trend toward the north and change in dip toward the southeast. Southeast of Wiccopee, about 1 mile north of Stop 3, folds in the Wappinger Group have axial surfaces oriented about N7°E, 58° SE and fold axes that trend N25°E, and plunge 14° NE.

Plastic deformation and at least one phase of brittle deformation have effected the Precambrian gneisses here but folds related to plastic deformation remain undetected in these exposures. Here and in immediately adjacent areas steeply dipping minor faults and microfractures occur in the gneisses. Most of the minor faults are strike-slip faults and the majority have a left-lateral sense. N52°W, N10°W and N27°E are the three prominent kinds of strike-slip movement. Quartz veins here are probably related to Paleozoic deformation.

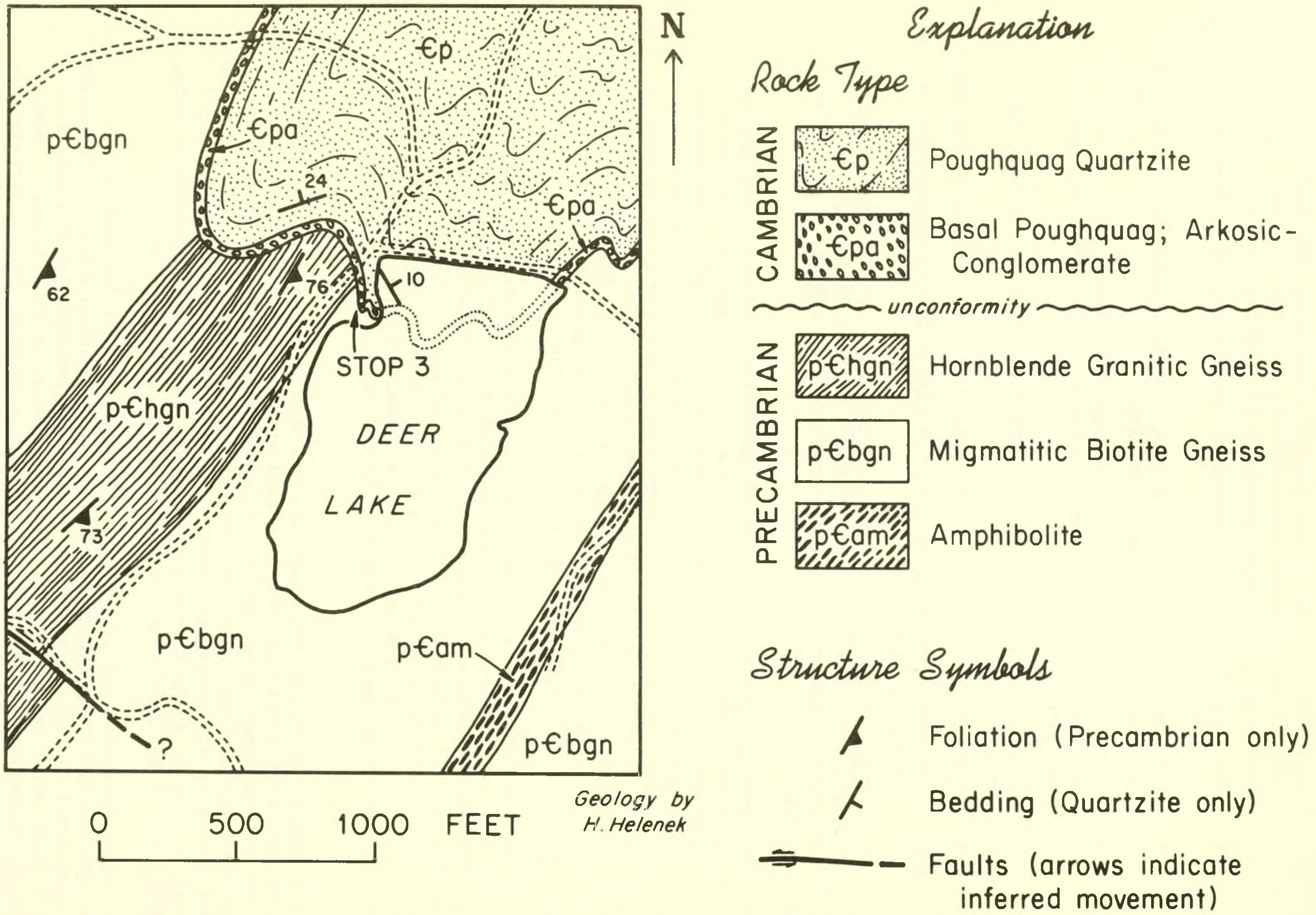


Figure 7. Geologic map of the region in the vicinity of Stop 3 on Sharpe Reservation.

54.0	-	Retrace route to the entrance to Sharpe Reservation.
54.6	0.6	Turn right onto Van Wyck Lake Rd. and proceed eastward toward West Hook Rd.
55.2	0.6	Turn left onto West Hook Rd. and in approximately 0.7 mile bear left onto Fishkill Hook Rd. at the junction of West Hook and East Hook Rds.
56.8	1.6	Bear right in the hamlet of Wiccopee and proceed a short distance to Route 52. Turn right (east) on Route 52 and retrace route back onto I-84.
58.6	1.8	Turn right (southeast) onto Shenandoah Rd.
58.7	0.1	Bear right (south) onto Lime Kiln Rd. (divided highway). Proceed south and cross overpass (I-84) in approximately 1.1 miles.
60.0	1.3	Enter the eastbound lane of I-84 and proceed to Danbury, Connecticut.

60.0	-	Alternate route to Stop 2: Take exit 19 at Route 312 and then proceed according to the main road log starting at mileage 32.8.

Continuation of Main Road Log

88.3	7.3	Stay toward the left and exit from I-84 onto Route 7 north.
89.1	0.8	Turn right onto Route 7 north and proceed to New Milford, Connecticut.
93.1	1.4	Woodville Marble is exposed in the road cuts being made in conjunction with the construction of new Route 7. Continue north on Route 7 toward New Milford.
100.3	7.2	Turn right (east) onto Route 67 and proceed across the Housatonic River. Keep to the left and go through the first traffic light and cross the railroad tracks. Turn left (north) onto Railroad St., at the second traffic light.
100.8	0.3	This is a complicated intersection with Bennett St. but continue essentially straight through it and onto Wellsville Ave. (Route 129).
102.4	0.3	Bear left at the fork onto Merryall Rd. (Route 129) and proceed northeasterly.
103.1	0.7	Turn left (west) onto Long Mountain Rd. and cross the West Aspetuck River.
103.6	0.5	Jog right and then left staying on Long Mountain Rd. at its junction with Aspetuck Rd.
103.8	0.2	Proceed straight ahead onto the dirt road (Bennett Rd.) at this junction.
104.2	0.4	There is a sharp curve to the left at the crest of this ridge and then a private drive on the left. Stay toward the right here and continue along Bennett Rd.
104.6	0.4	Stop 4. The "New Milford Massif" west of Long Mountain. A short traverse will be made from here along the road and then north to the vicinity of the power line.

Dark-gray to black-and-white, well-layered biotite-hornblende gneiss and thin beds of amphibolite constitute most of the Precambrian bedrock here. The Cambrian Lowerre Quartzite consists of brown-weathering sillimanite-microcline-biotite-quartz feldspar schist and schistose gneiss with prominent sillimanite-rich nodules,interbedded with feldspathic quartz granulites and slabby, gray- or tan-weathering quartzite. The base of the Lowerre is more siliceous and the sillimanitic schistose rocks predominate above. This is an example of the Lowerre Quartzite grading upward into rocks lithically similar to Manhattan C and is taken as further evidence that Manhattan C was deposited during the Cambrian and is an eastern facies of the Lowerre Quartzite (Hall, 1968 and 1971). Locality A on the traverse (Fig. 8A) is particularly striking because it clearly shows the basement gneisses physically on top of the Lowerre and the contact between the two units dipping gently northward. A large quartz-feldspar pegmatite is present near the power line and numerous inclusions of the country rock are present in the pegmatite near the contact.

The basement here occupies the core of an early isoclinal fold and the Lowerre is present on opposite limbs of the fold (Fig. 8A). The early isoclinal fold has been refolded as is clearly displayed by the sinistral map pattern of the Precambrian-Lowerre contact on both limbs of the early isoclinal fold (Fig. 8A). It is this later fold that accounts for the inverted Precambrian-Lowerre relationship that is present at locality A (Fig. 8A). Some of the rocks very close to the contact particularly at locality B display a cataclastic texture which is interpreted to be due to shearing along the unconformity during folding. The amount of transport associated with this shearing has not been determined but present indications are that it was not very large.

A prominent foliation and mineral lineation, that lies in the plane of foliation, developed during an early deformation. At the present time in the course of study of this area, it is not certain whether this foliation and lineation developed during Precambrian deformation or during the isoclinal folding involving the Lowerre Quartzite. The great circle spread of poles to foliation and the plunge of associated minor folds (Fig. 8B) indicate that the later sinistral fold plunges approximately N35°E at 20°.

The traverse at this stop will continue along the axial surface of the later antiformal fold toward the top of the hill where we will be able to see the Lowerre Quartzite physically on top of the basement. At this point we will be located on the eastern limb of the early isoclinal whereas locality A (Fig. 8A) is on the western limb of this early fold.

104.6	-	Return to vehicle, turn around, and return to Long Mountain Rd. by travelling south and east on Bennett Rd.
105.4	0.8	Junction of Bennett Rd. with Long Mountain Rd. and Vista Rd. Proceed straight ahead on Long Mountain Rd.
105.6	0.2	Jog right and then left, staying on Long Mountain Rd. at the junction with Aspetuck Rd.
106.1	0.5	Turn right (south) onto Merryall Rd.
106.8	0.7	Make an extremely sharp left turn (north) onto Paper Mill Road and proceed northward. The gneisses of the Bear Hill Massif are on the left (west) and the Lowerre Quartzite and Woodville Marble are toward the east.
108.8	0.2	Turn into the Eliot D. Pratt Education Center parking lot on right.

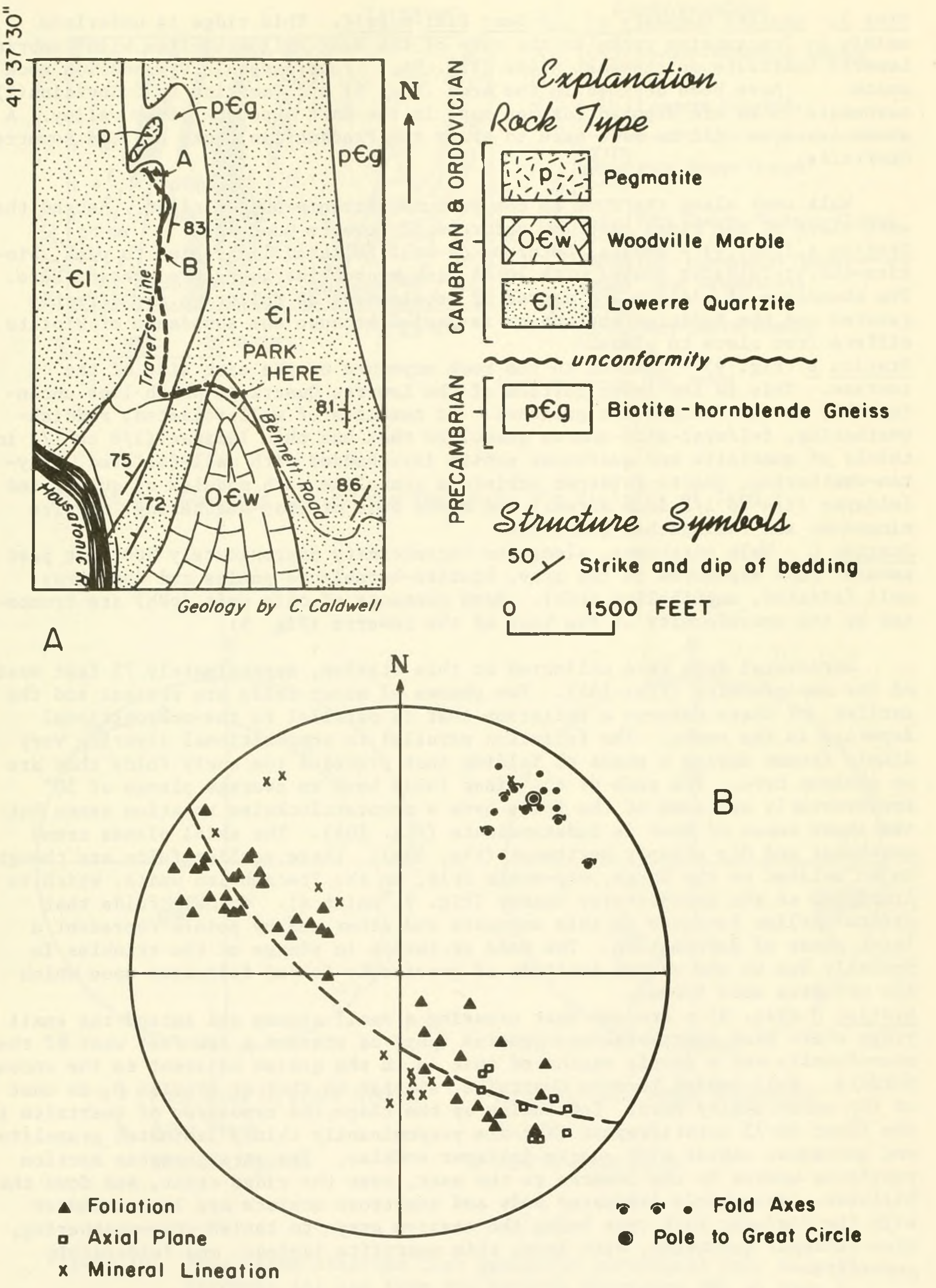


Figure 8. Geologic relations in the vicinity of Stop 4 are shown on the geologic map (A) and equal-area diagram (B).

Stop 5. Eastern boundary of the Bear Hill Massif. This ridge is underlain mainly by Precambrian rocks in the core of the Bear Hill Anticline with Cambrian Lowerre Quartzite on the east slope (Fig. 9). Four mappable Precambrian rock units have been defined in the area (Fig. 9) and Cambrian to Ordovician(?) carbonate rocks are exposed further east in the East Aspetuck River valley. A short traverse will be made here to study the Precambrian rocks and the Lowerre Quartzite.

Walk west along the road to the pasture entrance on the right. Ascend the east slope of the ridge past low outcrops of Lowerre Quartzite.

Station A (Fig. 9) - Several outcrops of well foliated light-pink to pink, biotite-quartz-feldspar gneiss with local pink microcline augen are present here. The abundance of biotite and degree of development of foliation are directly related and the foliated appearance is varied because the abundance of biotite differs from place to place.

Station B (Fig. 9) - Descend to the rock exposure on the east side of the terrace. This is the lower portion of the Lowerre Quartzite which lies unconformably on the Precambrian gneisses. It consists of well-foliated, reddish-weathering, feldspar-mica-quartz granulite that has thin laminae (1/8 to 1/2 inch thick) of quartzite and quartzose schist interbedded with well-foliated, gray- to tan-weathering, quartz-feldspar schistose granulite with nodules of quartz and feldspar (1/4 to 1/2 inch across) and minor beds of gray-weathering, massive micaceous and feldspathic-quartzite.

Station C - Walk northeast, along the unconformity approximately 800 feet past several rock exposures in the gray, biotite-hornblende gneiss and dark-gray, well foliated, amphibolite (pЄh). Both contacts of this unit (pЄh) are truncated by the unconformity at the base of the Lowerre (Fig. 9).

Structural data were collected at this station, approximately 75 feet west of the unconformity (Fig. 10A). Two phases of minor folds are present and the earlier of these deforms a foliation that is parallel to the compositional layering in the rocks. The foliation parallel to compositional layering very likely formed during a phase of folding that preceded the early folds that are so obvious here. The axes of the minor folds have an average plunge of 50° southwesterly and some of the folds have a counterclockwise rotation sense but the shear sense of most is indeterminate (Fig. 10A). The axial planes trend northeast and dip steeply northwest (Fig. 10A). These earlier folds are thought to be related to the large, map-scale fold, in the Precambrian units, which is truncated at the unconformity nearby (Fig. 9, point A). Crinkle folds that deform earlier features at this exposure and other nearby points represent a later phase of deformation. The wide variation in plunge of the crinkles is probably due to the varied attitude of previously folded foliation upon which the crinkles were formed.

Station D (Fig. 9) - Proceed east crossing a small stream and ascend the small ridge where pink quartz-feldspar gneiss (pЄp) is present a few feet west of the unconformity and a deeply weathered zone is in the gneiss adjacent to the unconformity. Well-bedded Lowerre Quartzite, similar to that at Station B, is east of the unconformity here. Continuing up the ridge, the exposures of quartzite in the first 50-75 stratigraphic feet are predominantly thinly laminated granulite and quartzose schist with quartz-feldspar nodules. The stratigraphic section continues upward in the Lowerre to the east, over the ridge crest, and down the hillside. The thinly laminated beds and quartzose schists are less abundant with the dominant rock type being the massive gray- to tanish-gray-weathering, mica-feldspar quartzite, with local thin quartzite laminae, and feldspathic quartzite.

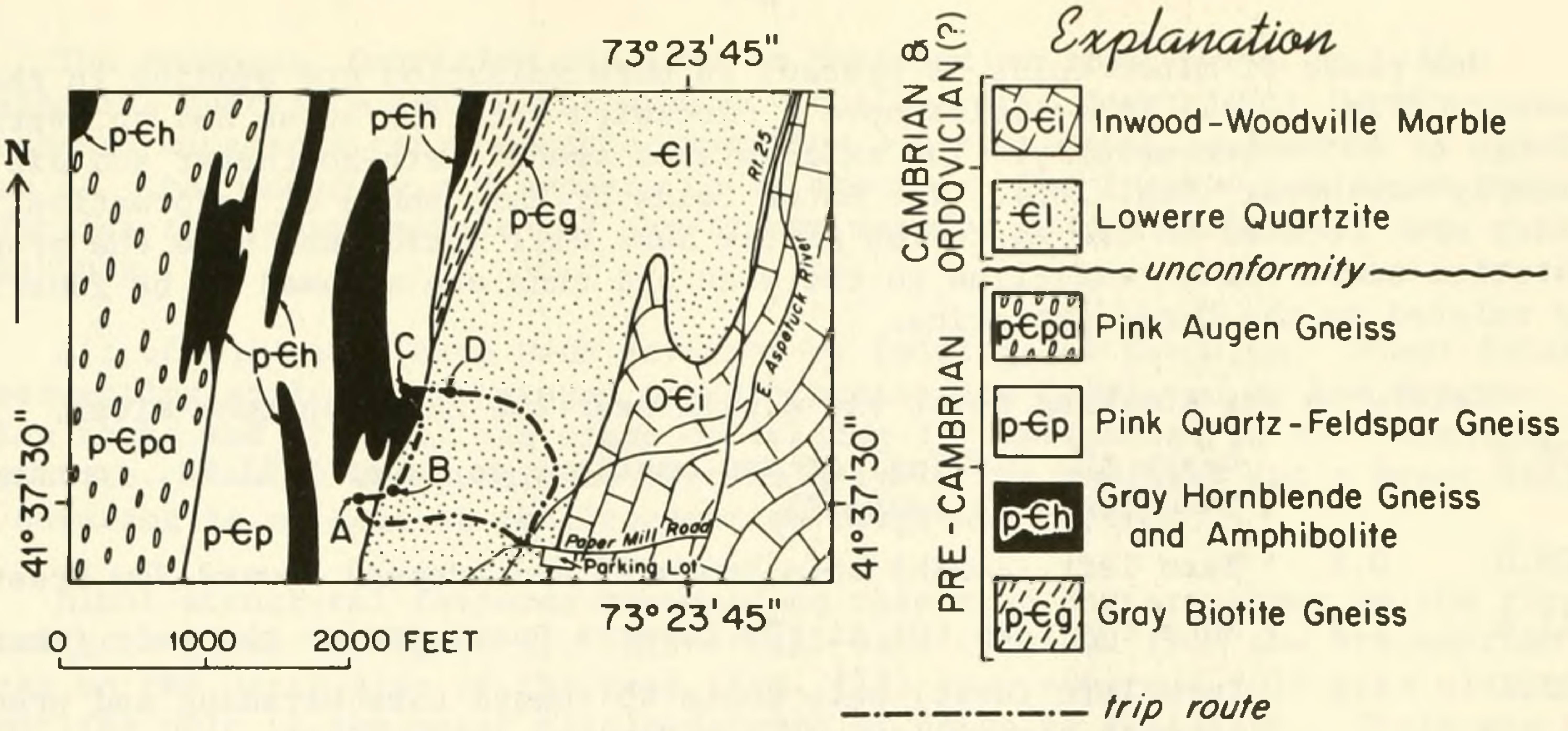


Figure 9. Geologic map of the region in the vicinity of Stop 5.

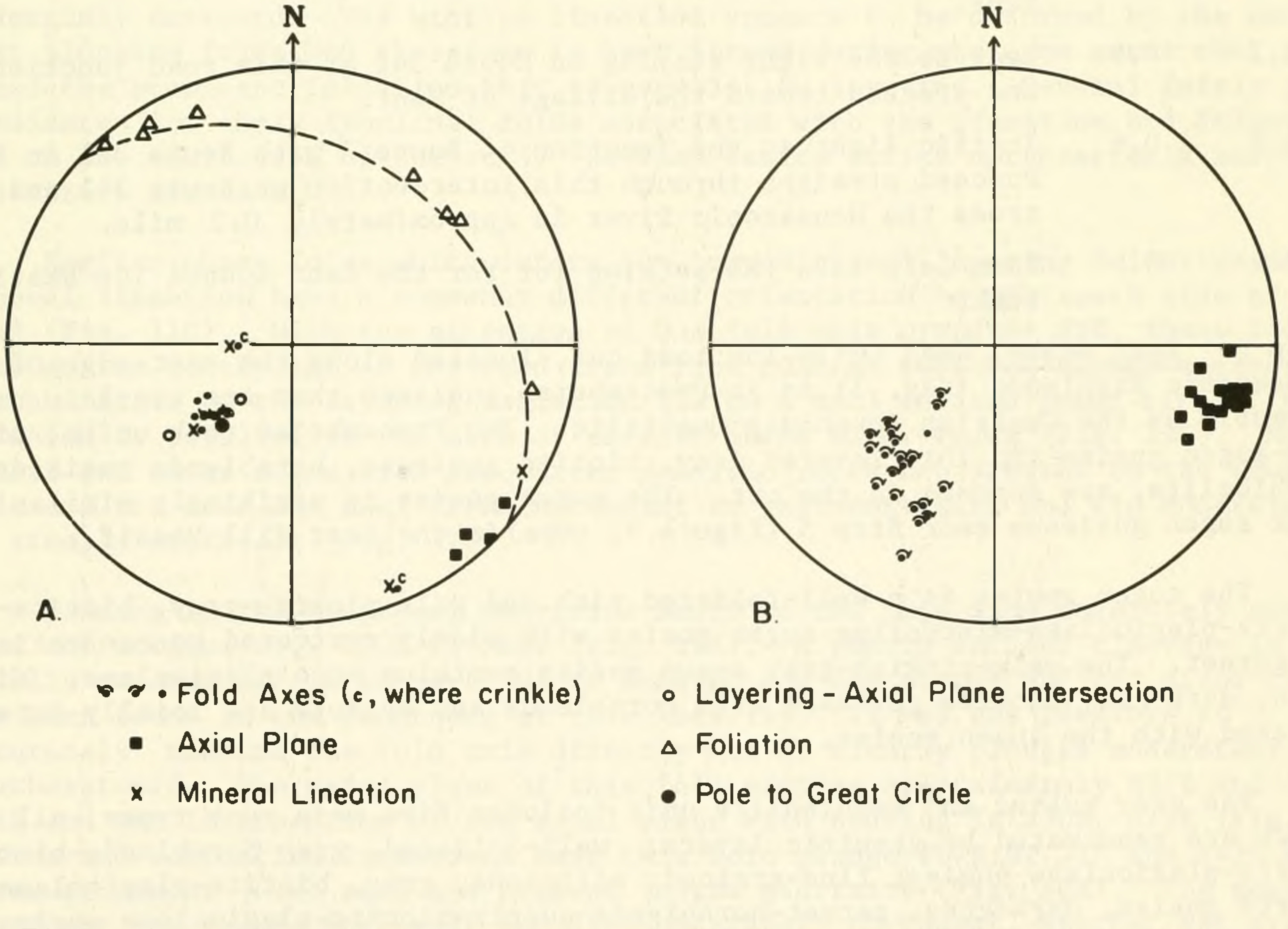


Figure 10. Equal-area diagrams that summarize structural data from the basement (A) and from the Lowerre Quartzite (B) at Stop 5.

One phase of minor folds is present in both foliation and bedding in the Lowerre (Fig. 10B). These folds have a clockwise rotation sense and an average plunge of 45° southwesterly. The axial planes trend north-northeast and dip steeply northwest (Fig. 10B). The minor folds of this phase of deformation, which are located on the east limb of the Bear Hill Anticline, have the proper rotation sense for an anticline to the west and thus are assumed to be genetically related to the large anticline.

Return to the starting point via a path near the East Aspetuck River.

108.8	-	Leave the parking lot and continue on Paper Mill Rd. to the junction with Route 25.
109.0	0.2	Turn left (north) onto Route 25 and proceed toward New Preston.
111.6	2.2	Note the road cut in the Lowerre Quartzite on the left (west).
113.1	1.5	Turn left (west) onto Route 45 toward Lake Waramaug and proceed through the village of New Preston on Route 45.
113.7	0.6	Stop sign is at the intersection at the south end of Lake Waramaug. Go through the intersection bearing to the right and continue on Route 45 to Warren.
116.9	0.6	Stop sign where Route 45 joins Route 341, bear left onto Routes 341 and 45 and proceed westward.
118.5	1.6	Bear left at the fork in the highway and proceed a short distance to the traffic light in Warren. Continue through this intersection proceeding westward on Route 341 to the village of Kent.
126.3	4.9	Bear to the right staying on Route 341 at this road junction and proceed toward the village of Kent.
126.9	0.6	Traffic light at the junction of Route 7 with Route 341 in Kent. Proceed straight through this intersection on Route 341 and cross the Housatonic River in approximately 0.2 mile.
127.4	0.5	Turn left into the parking lot for the Kent School ice-skating rink.

Stop 6. Kent School Road Cut. The road cut, located along the east edge of the Housatonic Highlands (Fig. 1),is in Precambrian gneisses that are overlain unconformably by the Cambrian Poughquag Quartzite. Two Precambrian rock units, pinkish-augen gneiss and interlayered gray, biotite gneisses, hornblende gneisses and amphibolite, are exposed in the cut. The augen gneiss is strikingly similar to pink augen gneisses near Stop 5 (Figure 9, pЄpa) in the Bear Hill Massif.

The augen gneiss is a well-foliated pink and pale-pinkish-gray, biotite-quartz-plagioclase-microcline augen gneiss with widely scattered concentrations of garnet. The pale-pinkish-gray augen gneiss contains more plagioclase. Minor thin, dark-gray biotite gneisses with hornblende and epidote are locally interlayered with the augen gneiss.

The gray gneiss and amphibolite unit includes five main rock types, all of which are penetrated by granitic layers: well-foliated, gray hornblende-biotite-quartz-plagioclase gneiss, fine-grained, siliceous, gray, biotite-plagioclase-quartz gneiss, dark-gray, garnet-hornblende-quartz-biotite-plagioclase gneiss, dark-gray biotite amphibolite, and light-gray calc-silicate-rocks.

The Poughquag Quartzite consists of interbedded light-brown or buff-weathering quartzite and coarse-grained conglomeratic quartzite. Deeply weathered micaceous,conglomeratic-quartzite 3-5 feet thick is present at the base of the Poughquag and appears to be sheared. The Precambrian augen gneiss underlies this conglomerate and the higher massive quartzite beds of the Poughquag.

All of the rocks have been deformed by folding and faulting. Minor folds representing at least two stages of deformation are displayed in the Precambrian rocks and at least one stage of folding is represented in the Poughquag Quartzite. Faults are prominent particularly in the gneisses and a great deal of shearing is evident at the Precambrian-Poughquag contact.

Minor structural features measured at this road cut are shown on the three equal area plots in Figure 11. Structural data recorded from the Precambrian rocks on the north side of the road (Fig. 11B) show numerous fold axes clustered about the pole to the great circle defined by poles to foliation. These are the axes of the earlier of two sets of folds present in the Precambrian here and they plunge S22E at 42° (Fig. 11B). Trends of these fold axes are scattered from S07E to S40E, and the associated axial plane foliation strikes from N20W to N20E and dips 70°-80° easterly. Foliation that is parallel or subparallel to the compositional layering,also folded by this deformation, probably formed during an even earlier deformation. Poles to this foliation consititue a well-defined great circle and beta maximum. Crinkles deform both the compositional layering foliation and the axial plane foliation of the southeast plunging folds. These crinkle axes trend from S26W to S58W and plunge gently to moderately southwest (Fig. 11B). Biotite lineation trends from S35E to N85E and plunges moderately eastward. The biotite lineation appears to be deformed by the southeast plunging folds and therefore to have formed during the same event that produced the prominent foliation that is parallel to layering. Several fairly good candidates for early isoclinal folds associated with the lineation and foliation are on the south side of the road. Several faults strike northeasterly and dip moderately southeast.

Earlier phase folds which deform the compositional layering foliation and mineral lineation have a somewhat different orientation on the south side of the road (Fig. 11C). With the exception of one fold axis trending ESE, these fold axes on the south side of the road trend from S02E to S08E and plunge moderately south. Poles to the layering foliation lie on a well defined great circle, the pole to which is parallel to the axes of earlier phase minor folds (Fig. 11C). Many faults and shear zones with associated granitic rocks are present on the south side of the road and most trend northeast to east-northeast and dip moderately to steeply southeast (Fig. 11C).

Bedding in the Poughquag Quartzite south of the road dips moderately southeast and strikes from N30E to N80E (Fig. 11A). A poorly defined cleavage is locally present and is subparallel to bedding and one poorly defined minor fold has been found in the Poughquag at this locality. It was not possible to accurately measure the fold axis directly but it clearly plunges moderately southeastward. The axial plane of this fold strikes approximately N37E and dips 39SE and the intersection of the axial plane with bedding is S30E, 37SE (Fig. 11A). Quartz and tourmaline lineations near this fold plunge S57E at 31° and S47E at 20°. Three prominent joint sets are present in the quartzite (Fig. 11A). The most prominent set trends northeast and dips moderately northwest, another set trends N10W and is nearly vertical while the third set trends approximately N45W and is

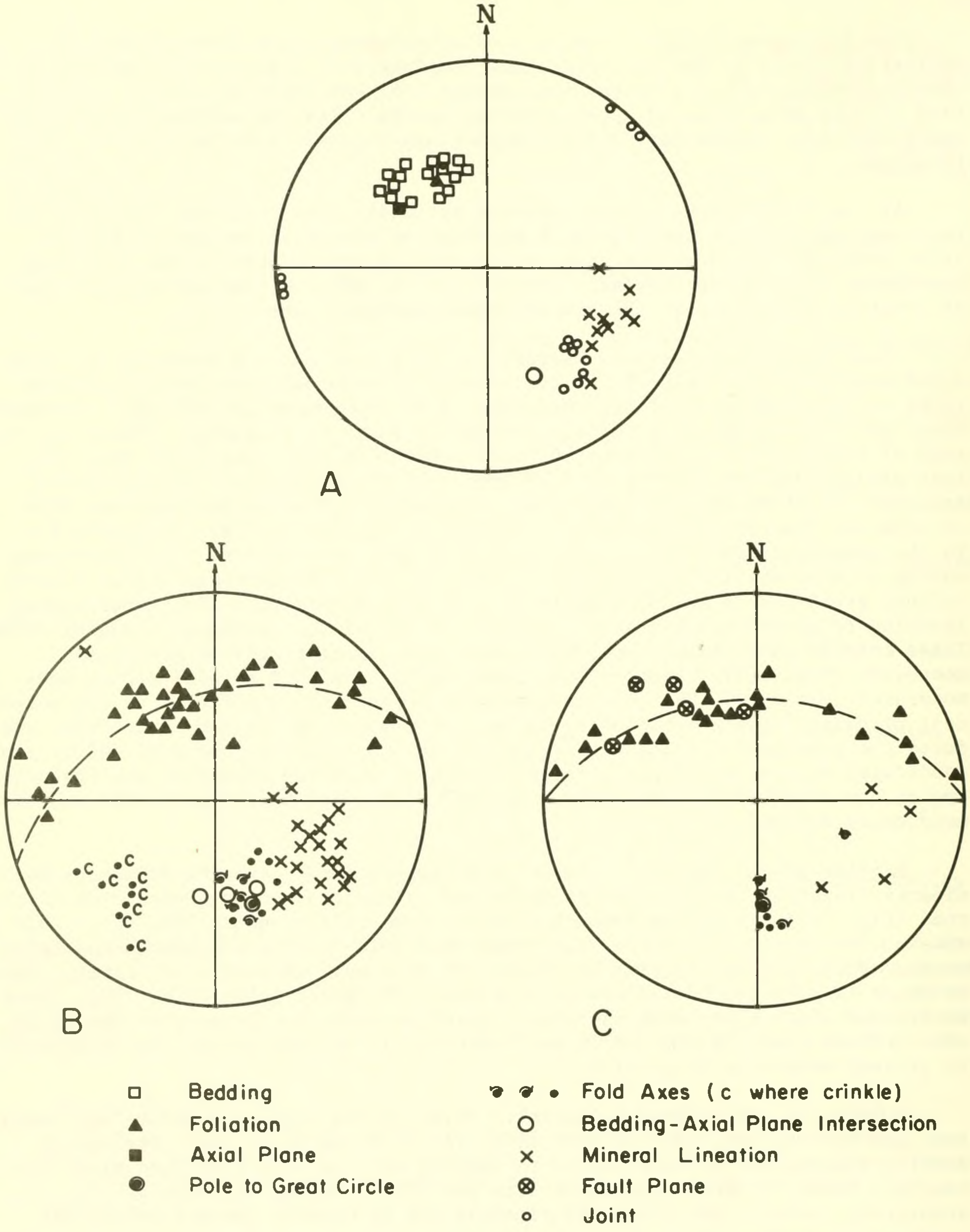


Figure 11. Equal-area diagrams summarizing structural data from the Poughquag Quartzite (A) and from the basement north of the road (B) and south of the road (C) at Stop 6.

nearly vertical.

A three to five foot thick zone of shearing is evident near the Precambrian-Poughquag contact. Both the augen gneiss and micaceous quartz conglomerate were involved in this shearing as indicated by the cataclastic texture and deep weathering of both rocks in this zone. The extent of movement along this zone is not certain at the present time in the on going study of the Kent quadrangle. It may represent minor local shearing along the contact between rocks of contrasting ductility during folding or it may represent a major, more regional, fault where the Paleozoic cover has sheared over the basement.

127.4	-	Leave the parking lot and turn right (east) onto Route 341. Proceed across the Housatonic River to the traffic light at the junction of Route 7 with Route 341.
128.0	0.6	Turn left (north) onto Route 7 and proceed north on Route 7 to Great Barrington, Massachusetts. The trip from Kent to Great Barrington takes approximately one hour,or a little less, depending on traffic conditions.

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