TRIP B-12

PRECAMBRIAN STRUCTURE AND STRATIGRAPHY OF THE SOUTHEASTERN ADIRONDACK UPLANDS

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ABSTRACT: The area of interest for this paper is the northern portion of the Bolton Landing quadrangle and adjacent parts of the North Creek and Paradox Lake quadrangles. Although there appear to have been at least five episodes of folding in the region, the southeastern Adirondacks appear to have undergone only four of the events (F-1, F-3, F-4 and F-5). F-1 folds are large nappes. F-3 folds range from isoclinal to tightly appressed similar folds in the study area. F-4 folds are moderately appressed similar folds, and F-5 folds are relatively open similar folds. A large body of charnockite associated with F-3 folding has the geometry of a nappe but was emplaced as a magma in advanced stages of crystallization. A structural dome of leucocratic granite was produced anatectically and solidified after F-5 folding. Similar dome-like bodies of granite which do not show evidence of anatexis have fabric elements suggesting they were subjected to all four episodes of folding. The stratigraphic column of metasedimentary "formations" interspersed with "formations" of layered granite and quartzofeldspathic gneiss proposed by Walton (Walton and deWaard, 1963) is reinterpreted as recumbent synformal bodies of metasedimentary

rocks separated by antiformal granitic nappes whose amplitudes are measured in tens of kilometers.

STRUCTURE

The southeastern-south central Adirondacks appear to have been subjected to at least five episodes of folding (Turner, 1979). F-1 folds are the most enigmatic because they fold foliation, but no earlier fold set has yet been recognized in the three-dimensional domain of basement plus supracrustal rocks in the study area. They are also the most difficult to map due to the subsequent multiple deformations of the terrane. F-1 folds are large nappe structures, the axial planes of which strike east-west and dip gently to the north (vertically in the one root zone recognized). F-1 fold axes plunge gently east or west, depending on later cross folds.

F-2 folds are isoclinal to tightly appressed similar folds. They are associated with intrusion of highly viscous charnockitic magma from the vicinity of the Marcy anorthosite massif on the north. Axial planes strike east-west and dip moderately to the north, with dip becoming steeper and approaching vertical at the southern margin of the charnockite. Plunge of axes is shallow.

F-3 folds are isoclinal to tightly appressed similar folds in this area. They are associated with intrusion of highly viscous charnockitic magma from somewhere to the south or southeast. Axial planes strike progressively from N 30 E to S 80 E from west to east across the Bolton Landing quadrangle and dip moderately to the southeast and south. Plunge of axes is gentle to the northeast and southwest, depending on the domain of cross-folding and doming.

F-4 folds are moderately appressed similar folds. Axial planes strike S 60-70 E and dip steeply south to vertically. Axial plunge is 0-20 degrees east or west, depending on cross fold domain.

F-5 folds are open similar folds whose axial planes strike gradationally from N 20 E in the southeastern Adirondacks to N 20 W in the south central Adirondacks. Dip of axial planes is very steep to vertical. Axial plunge is horizontal

F-1 nappes have been studied to the west of the study area (Turner, 1979; McClelland and Isachsen, 1979; and others) but evidence for such in the Bolton Landing quadrangle is still circumstantial. F-2 nappe-like bodies of charnockite have been reported a few kilometers to the north of the study area (Turner, 1979), but no F-2 structures are yet recognized in this area. An F-3 nappe-like body of charnockite and associated structures comprise a significant portion of the study area (Turner, 1971 and 1979). F-4 folds are common and well-defined in the study area. F-5 folds are present in the study area and commonly produce a basin and dome map configuration because of their high angle of intersection with F-3 and F-4 folds.

F-1 and F-2 folds are locally difficult to distinguish from each other because of the similarity of axial plane orientation in some portions of the Adirondacks. Romey and Jacoby (1978) believe that in the northwest Adirondacks F-1 folds are enormous nappes, but they have not yet been able to demonstrate the existance of such. McClelland and Isachsen (1979) suggest that the Wakely Mountain nappe (F-1) of DeWaard and Walton (1967) may have an amplitude on the order of 70 kilometers. The length of the trace of the axial plane in the root zone of the Wakely Mountain nappe is on the same order of magnitude as its amplitude, although there is a suggestion from preliminary studies that the axial trace may continue a few tens of kilometers to the southeast into the North Creek quadrangle.

F-2 folds associated with the intrusion of charnockitic magma from the north are of limited regional significance. Although the charnockitic lobe, which has some features of a nappe structure, has an axial trace length on the order of 50-70 kilometers, the degree of appression of folds south of its "leading edge" decreases away from the contact.

F-3 folds are hypothesized to be associated with the intrusion of a charnockitic magma from the southeast because elements of the geometry of the charnockitic sheet or lobe (Turner, 1971) are parallel to elements of these folds. In the study area, F-3 folds are isoclinal to tightly appressed and have been suggested to be portions of nappes (Turner, 1979). To the west northwest of the study area, F-3 folds become progressively less appressed and, in the Newcomb quadrangle, can be described as open folds. To this extent, F-3 folds may be of as limited a regional significance as are F-2 folds.

In the study area F-3 folding produced an incipient axial planar foliation in the more quartzose units, but pre-existing foliation in gneissic units is folded by F-3 folds. In one outcrop of "basement" paragneisses, polycrystalline aggregates of sillimanite are rotated into parallelism with the axis of a large F-3 fold. In other outcrops, sillimanite needles parallel the axes of F-3 folds. Mineral lineations, measured axes of minor folds and beta intersection stereographic projections are in close agreement with respect to F-3 folds in the area.

The tabular body of charnockite associated with F-3 folding underlies about 340 square kilometers of terrane and is 300-400 meters thick in the study area. Berry (1961) studied the eastern portion of the body in the Whitehall quadrangle. He found evidence of shearing near the base of the sheet and hypothesized that it had been emplaced by thrust faulting. Careful examination of the base of the body in the study area has produced no evidence which would support Berry's hypothesis.

The charnockitic body is sill-like, although its "leading edge" is rounded or lobate. Some igneous layering has been mapped in this study area. A central layer of anorthosite is bordered by jotunite below and mixed jotunite, anorthosite lenses and mangerite above. The outer envelope of the body is mangerite on the bottom and in much of the leading edge, but mangerite grades into charnockite on top. The form and igneous layering of this body are strikingly similar to what Crosby (1968) called the Jay-Whiteface nappe in the northeastern Adirondacks and what Martignole and Schrijver (1970a and 1970b) described in the east lobe of the Morin anorthosite massif. Although this author hesitates to use the term "nappe" to describe the charnockitic body because of the connotation of ductile, solid-state flow, and here there is evidence of magmatic emplacement, the shape of the body and the structural association of F-3 folds tend to comport in a general sense with the tectonic concepts associated with nappes. To that end, this author cautiously calls the body "the Lake George nappe" in the same vein as he has termed a similar body at the southern border of the Marcy anorthosite "the Minerva nappe".

F-4 folds are believed to be of regional importance insomuch as folds of similar geometry occur across much of the Adirondacks (Turner, 1979; McClelland and Isachsen, 1979; Geraghty, 1979; Wiener, 1979). All F-4 folds mapped by the author across several quadrangles fold pre-existing foliation but produce a pervasive quartz rodding or lineation parallel to fold axes. F-4 folding produced some of the most easily mapped structures because of these fabric elements, as well as the relatively slight impact of F-5 folding on F-4 features in map pattern. In the quadrangles to the west,however, the low angle of intersection between F-4 axial traces and both F-1 and F-2 axial traces can create some confusion unless attitudes of axial planes are known.

F-5 folds are open similar folds which occur across a significant portion of the Adirondacks. However, the gradual and progressive change in strike of axial planes from the southeast to the south central areas suggests that these folds may be a sub-regional feature. F-5 folds fold foliation and rotate lineations. No mineral fabric ostensibly produced by F-5 folding has been recognized, nor is any expected except perhaps at the petrofabric scale in marble.

Several dome-like structures occur in the study area. Bickford and Turner (1971) described a large granitic dome just to the southeast of Brant Lake, and the reader is referred to that publication for a more complete statement. It should be noted that Turner's concepts of the area's stratigraphy and structure have evolved considerably since that publication. However, in brief, the core of the dome is a highly foliated alaskitic granite (leptite) and is surrounded by a heterogeneous assemblage of granitic paragneisses which lie stratigraphically below the basal metasedimentary unit. Modal analyses of most of the alaskitic rocks plot near the ternary minimum composition on the 2000 kg/cm^2 isobaric diagram of the system $Or-Ab-SiO_2-H_2O$ (Tuttle and Bowen, 1958). The temperatures around the ternary minimum correspond to temperatures of metamorphism recently suggested by Bohlen and Essene (1979) for this area.

STRATIGRAPHY

Metasedimentary strata which are interpreted to be the base of a relatively coherent sequence of metasedimentary rocks are in contact with various granites, granitic gneisses, paragneisses and charnockitic rocks in the study area. The stratigraphic column, from the base, is: garnet-sillimanite gneiss (khondalite), a local highly graphitic schist, marble, thinly interbedded graphitic-pyritic-sillimanitic schists and quartzites, a thick quartzite, and possibly another section of thinly interbedded schists and quartzites. Total thickness is difficult to estimate because of structural complexity. To the north and west, the basal khondalite and graphitic schist disappear, leaving the marble as the basal unit. In the Paradox Lake quadrangle, immediately to the north, Walton (Walton and deWaard, 1963) suggested that the basal marble rested on an unconformity because of the diversity of rock types in contact with one of the surfaces of the stratum of marble. Although this author has proposed that the charnockites which are in contact with the marble were emplaced as highly viscous magmas in a catazonal tectonic environment, there is agreement with Walton's hypothesis of an unconformity with respect to the geometric relationship between the marble and the other granitic gneisses.

Walton (Walton and deWaard, 1963) proposed a stratigraphy for the southeastern Adirondacks which consisted of metasedimentary "formations" interlayered on a large scale with "formations" of granitic gneisses. He distinguished the "layered" granitic gneisses from the "basement" granitic gneisses with the general observation that the former tended to be K-feldspar rich and the latter plagioclase feldspar rich. Turner (1970) accepted Walton's stratigraphy and added a unit to it without essentially any modification of concept. This author does not now concur with Walton's general observation and has found that the spectrum of layered granitic gneisses generally corresponds petrographically with the spectrum of basement granitic gneisses. This author (1979) proposed that the layered granitic gneisses are actually basement granitic gneisses emplaced in a pseudo-stratigraphic column as the cores of a pile of large nappes.

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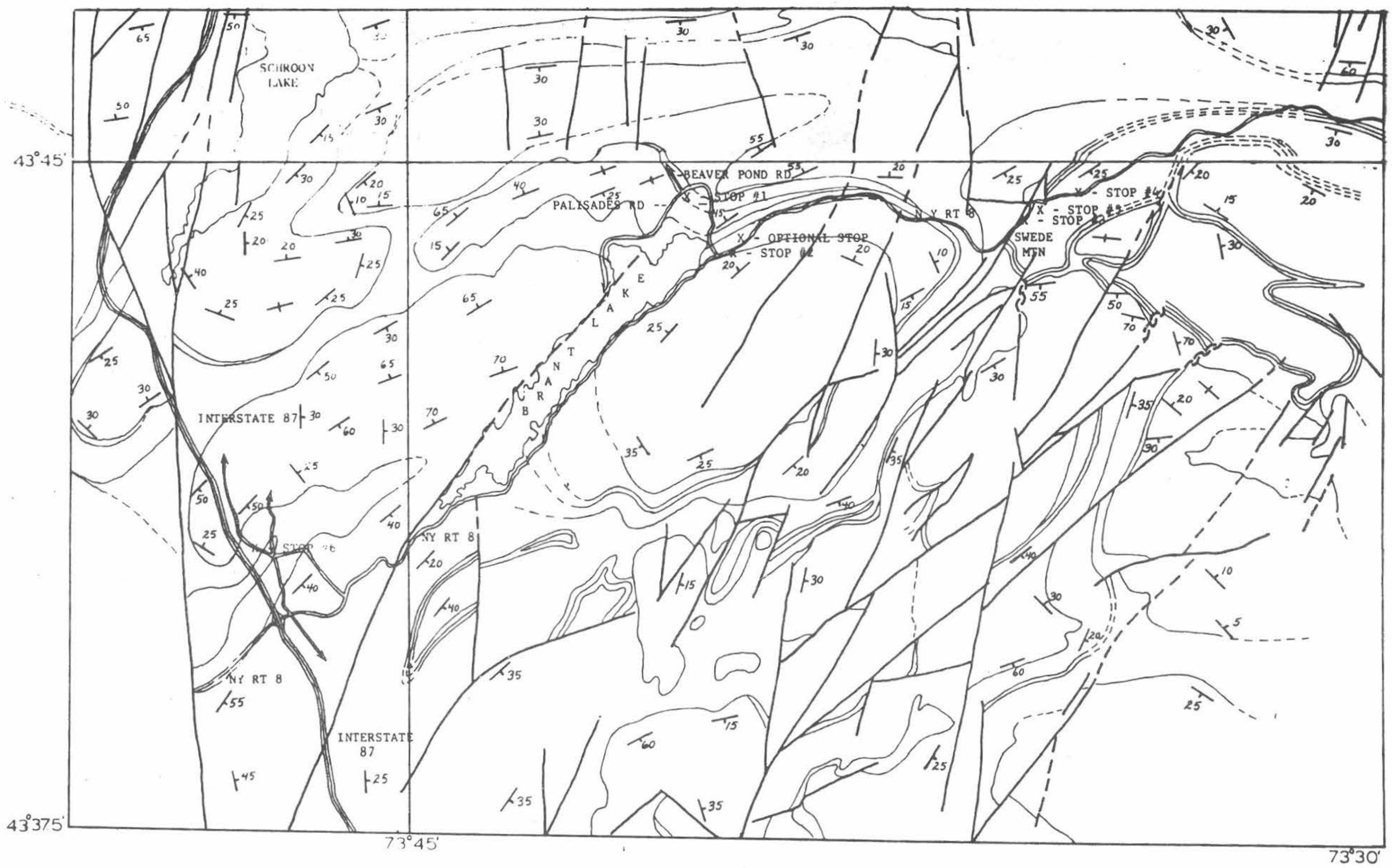
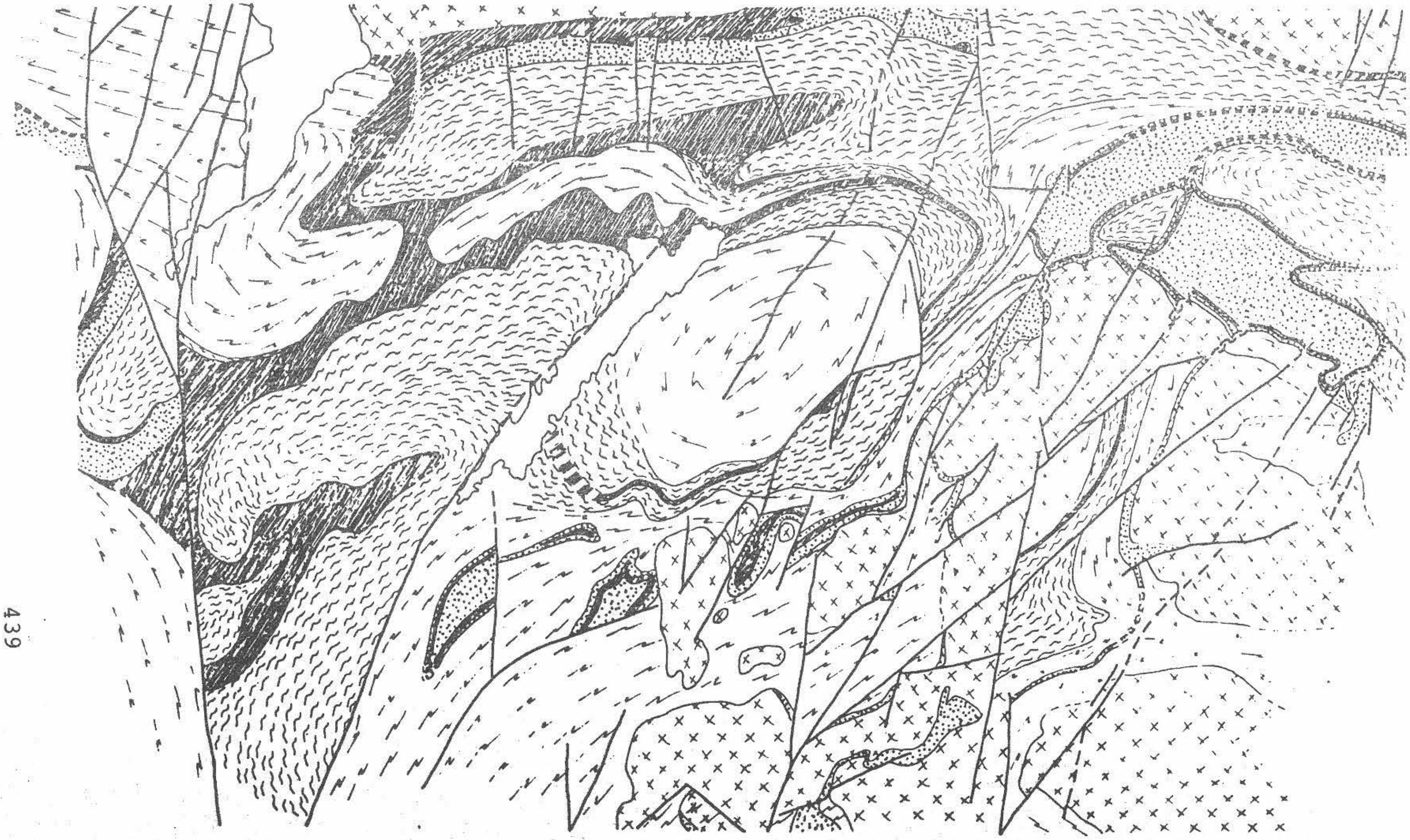


LOCATIONAL MAP - SAME AREA AS BEDROCK MAP WITH OUTLINE OF GEOLOGIC CONTACTS AND REPRESENTATIVE ATTITUDES. FROM UPPER LEFT, SE CORNER SCHROON LAKE QUADRANGLE, SOUTHERN BORDER PARADOX LAKE QUADRANGLE, NE CORNER NORTH CREEK QUADRANGLE AND N HALF BOLTON LANDING QUADRANGLE.

PLATE 1

(ACKNOWLEDGEMENT - NORTH CREEK PORTION BY GERAGHTY (1973) AND PARADOX LAKE PORTION BY WALTON (1960))



1 .5 0 1 2 3 4 5 10 15

KILOMETERS

BEDROCK GEOLOGY OF PARTS OF THE SCHROON LAKE, NORTH CREEK, PARADOX LAKE AND BOLTON LANDING QUADRANGLES, ADIRONDACK MOUNTAINS, NEW YORK.

BRIAN BUDDINGTON TURNER 1979

PLATE 2

Quartzite, sillimanitic schists gneisses

Marble

Biotite-qtz-plag-(garnet) paragneiss (locally migmatic)

Pink granite gneiss w/ or w/o hornblende, biotite, garnet

Charnockitic suite

TRUE NORTH

OUTCROP - STOP #4 - SOUTH SIDE OF N.Y. ROUTE 8, NEAR NORTH POND, BOLTON LANDING 15' QUADRANGLE - THREE FOLD SETS.

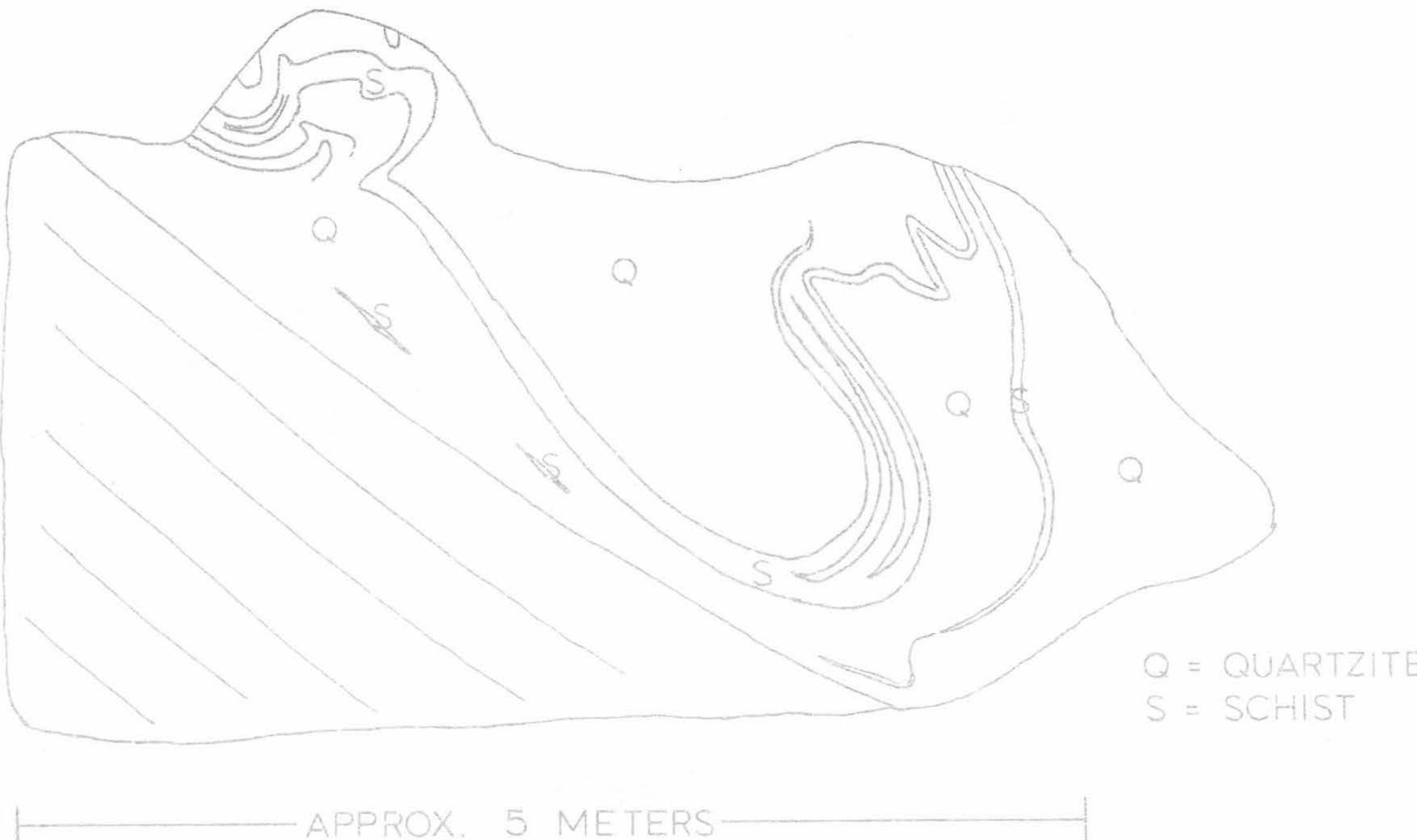
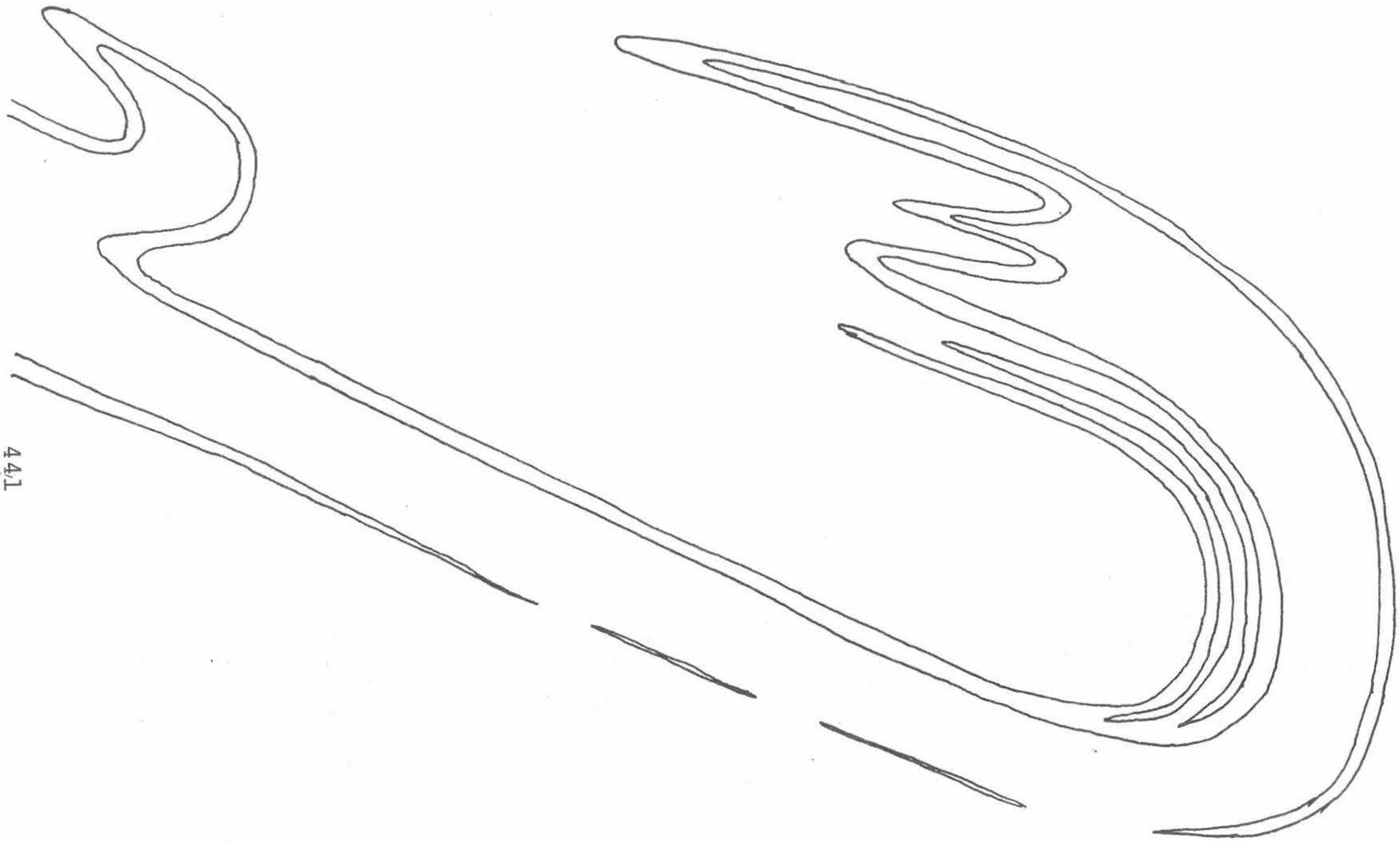
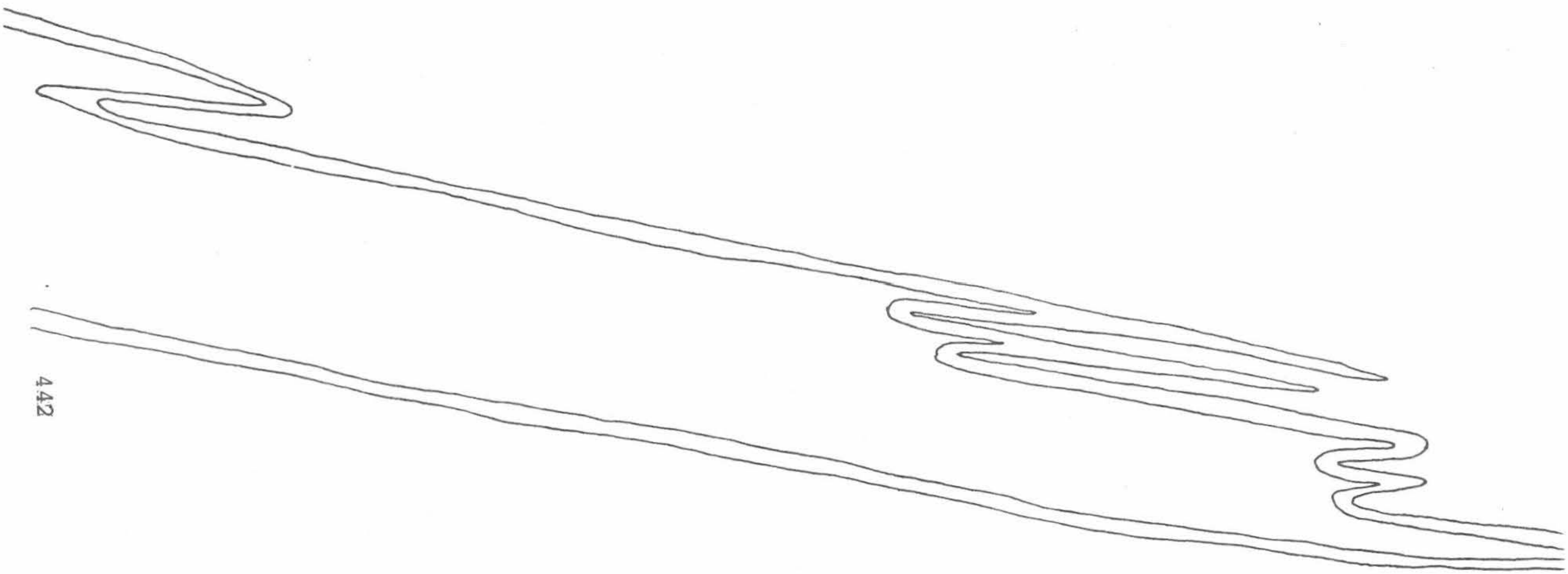


FIGURE 1



PROJECTED CONFIGURATION OF FIG. 1 IF LAST FOLDS (F-4) WERE REMOVED. F-2 (?) SYNFORM IMPOSED ON F-1 ISOCLINE.

FIGURE 2



PROJECTED CONFIGURATION OF FIGURE 1 IF BOTH REFOLD SETS (F-4 and F-2 (?)) WERE REMOVED.

F-1 ISOCLINE REMAINS.

FIGURE 3

FIELD TRIP

Although the field trip departs from the RPI Houston Field House, the road log mileages for the two legs of the trip start at the ends of the ramps for northbound Exits 24 and 25 of Interstate 87 (the Adirondack Northway) for future reference. The distance from RPI to Exit 24 is approximately 65-70 miles.

MILE - FIRST LEG

0.0 Field trip starts at end of ramp of northbound Exit 24, Interstate 87. Turn right toward Bolton Landing. Within 50 meters turn right again and head south on the River Road.

0.5 STOP #1 - Outcrops on right (west) side of road are largely alaskitic granites with some strongly contorted layers of paragneiss. Although the outcrop is just outside the leader's field area, it was mapped at his suggestion by McConnell in 1964 and is deemed to be "basement". A two-meter exposure of an isoclinally refolded isoclinal fold is one of the main features of this stop. The first-formed fold has axial plane foliation and is believed to be an F-1 fold. The second-formed fold deforms foliation and is believed to be an F-3 fold. The other important feature of this exposure is the strong suggestion that the granite is an anatectic product of the paragneisses.

Turn cars around, head back to I87 and continue north to Exit 25. RESET mileage for the second leg of the field trip which begins at the end of the ramp for northbound Exit 25.

MILE - SECOND LEG

0.00 End of ramp, Exit 25. Turn right onto N.Y. Route 8 and proceed eastward through the hamlet of Brant Lake and thence along the lake of the same name (Bolton Landing 15' quadrangle).

7.3 Turn left onto Palisades Road. It is difficult to see this turn until you are practically on top of it. Go 1.3 miles to the first stop of this leg.

8.7 STOP #1 - At the T-intersection with the Beaver Pond Road, an outcrop of Older Paragneiss (informal stratigraphic name) is located on the south side of the road. The outcrop contains a heterogeneous group of gneisses, quartzites and amphibolites. Of particular interest are the rotated (penetrative) clots of sillimanite and minor folds whose axes plunge about 20° in an azimuthal direction of 60°-65°, which is the local axis of F-3 folding. This unit is believed to lie unconformably below the base of the supracrustal metasedimentary rocks, and in the opposite stratigraphic direction grades into granitic gneisses. A whole-rock, Rb-Sr age of 1210± 45 m.y. has been obtained from this outcrop.

Turn around and head back to N.Y. Route 8; turn left on Rt. 8.

10.3 STOP #2 - Brant Lake Gneiss (informal name) is exposed on the south side of the road. This rock is found throughout a structural dome to the south of this exposure. This granitic gneiss has a very uniform modal composition of approximately 35% quartz, 25% microcline, 30% sodic plagioclase, 3% mesoperthite, 5-7% biotite and 1% opaques. The granitic rocks of this dome yield a whole-rock, Rb-Sr age of 1119±39 m.y. It has been proposed that this granitic gneiss is an anatectic product of the Older Paragneiss (Bickford and Turner, 1971). This is a very brief stop.

10.7 OPTIONAL STOP - (1979 NEIGC-NYSGA will not stop here) - Older paragneiss in the road cut on the north side of Rt. 8 consists of quartzofeldspathic gneisses with accessory biotite and garnet. Most, if not all, minor isoclinal folds in this exposure show axial planar foliation. This paragneiss mantles the structural dome whose granitic core rock was observed at Stop #2, and may be traced almost continuously around the dome (see Plate 2 of accompanying description).

14.7 STOP #3 - In the road cut on the east side of the road is perhaps the simplest set of folds in the Swede Mountain structural complex. A large isoclinal synform is outlined by the contrast between quartzite and sillimanitic schists. Sillimanite needles just above the quartzite closure plunge about 5° in an azimuthal direction of 80°. Closer to the road, a minor fold crenulation plunges 20° in an azimuthal direction of 80°. The synform is thought to be an F-3 fold. The isoclinal synform is clearly refolded. A stereographic beta diagram of attitudes of compositional layers shows an intersection which plunges 22° in an azimuthal direction of 116°, which comports with the axis of F-4 folding. About 15 meters uphill along the road cut, a pair of refolded isoclinal folds about 3 meters long may be observed. Measurements of hinges and crenulations in these produce the same pair of data as for the large refolded synform.

15.4 STOP #4 - Pull into turn-out area on the right and park. Walk back across Rt. 8 and continue east for about 50 meters. On the south side of the highway is a low road cut about 70 meters long. An isoclinal fold, whose limbs may be traced 55 meters to its closure, is exposed. Crenulations in the hinge plunge about 10° in the azimuthal direction of 103°. At least one minor isoclinal fold within the larger isocline displays axial plane foliation. This is probably an F-1 fold. In the eastern part of the road cut, the limbs of the isocline have been refolded by an F-4 fold. A beta diagram of the refold shows an axis plunging 30° in the azimuthal direction of 117°.

Returning to the western end of the road cut, and at about right angles to the cut, the outcrop portion of the exposure contains evidence of three episodes of folding (see Figures 1,2 and 3 of accompanying description). A complex F-1 isocline has been isoclinally refolded into an F-? synform, and several smaller F-4 folds have been superimposed on the refolded mass. Axial plane foliation in the F-1 fold has been rotated by F-?, and a weak F-4 foliation with strong quartz rodding penetrates the outcrop. A beta diagram of compositional layers in the nose of the synform shows an intersection plunging about 5° in an azimuthal direction of 110°. This does not correspond with an F-3 axis, and may represent an F-2 refold. A beta diagram of the limbs of the refold shows an intersection plunging 15-20° in an azimuthal direction of about 120°, which corresponds with F-4 fold axes. Although the beta maxima are only 10° apart in azimuth, the difference is believed to be real because measured hinge axes correspond with the 110° beta direction and measured quartz rods with the 120° beta direction.

Return to vehicles, continue around turn-out loop back to Rt. 8, turn left and proceed back in a westerly direction.

16.0 Pull into turn-out area on left. At this point the group may wish to split into two parties. Assuming that time permits, the leader will take a group of physically able participants on a 4-kilometer hike (total distance) to examine evidence of large nappe structure in Swede Mountain. Those persons not wishing to take the hike are invited to examine the 1.0 kilometer of nearly continuous exposure of Swede Mountain beside Rt. 8, which includes the structures seen at Stop #3.

After returning from the hike, if time still permits, an attempt will be made to round up all participants for a final but optional stop. Proceed westerly on Rt. 8 toward I87.

28.3 Within seeing distance of I87, turn right onto the Starbuckville Road, continue until a long one-lane bridge is crossed and look for an intersection.

29.0 Turn left onto the River Road and go 0.25 miles.

29.25 STOP #6 (optional) - You are in the northeast quadrant of the North Creek 15' quadrangle, mapped by Geraghty (1973). The outcrops on the east side of the road are predominantly quartzofeldspathic schists and gneisses with abundant biotite, sillimanite and garnet (kinzigite) and quartzite. The author believes the kinzigite is an iron-rich facies of the basal khondalite seen in Swede Mountain. Some minor folds display axial plane foliation and may be F-1 folds. Numerous axial traces of minor folds strike 60°-70° in azimuth, a biotite-sillimanite crenulation shows plunge of about 42° in an azimuthal direction of 59°, a beta diagram of one fold shows an intersection at plunge 26° in an azimuthal direction of 53°, and one minor fold hinge plunges 15° in an azimuthal direction of 70°. The foregoing reflect F-3 folding. Several F-4 cross folds are present and measured lineations and hinges have a range of plunges of 45° to 55° in azimuthal directions of 115° to 120°. At least one F-5 fold is apparent in the cutcrop, and its axial trace is about 10° in azimuthal direction.

GOOD LUCK ON YOUR TRIP HOME!