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Zen, E-an

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Trips A and I STRATIGRAPHY AND STRUCTURE AT THE NORTH END OF THE TACONIC RANGE AND ADJACENT AREAS

Leader: E-an Zen

STRATIGRAPHY

Rocks of the Taconic sequence range from Early Cambrian to Middle Ordovician in age. Rocks of the Synclinorium sequence, included in Pl. A-1, range from Early to Middle Ordovician in age. These are briefly described, from the oldest to the youngest formations:

Taconic Sequence

Biddie Knob formation

This formation consists of purple and green, chloritoid-bearing slate and phyllite, with subsidiary quartzite and rare thin limestone beds. Typical mineral assemblage: muscovite-chlorite-chloritoid-quartz-rutile, with subsidiary paragonite and hematite.

Bull formation

This consists of five members:

METTAWEE MEMBER: Purple and green slate, mudstone, and phyllite, distinguised from the Biddie Knob formation by the lack of chloritoid, which reflects primary compositional differences. This member constitutes the bulk of the formation. A typical mineral assemblage is muscovite-chlorite-albite-quartz-rutile.

BOMOSEEN GREYWACKE MEMBER: Olive-drab, massive greywacke, weathering grey to brick-red. A typical mineral assemblage is stilpnomelane-chlorite-muscovite-albite-microcline-quartz. West of Lake Bomoseen (Pl. A-3), this is the lowest exposed unit and underlies the Mettawee member; however east of Lake Bomoseen and north of the Pine Pond thrust, it is demonstrably within the Mettawee member (stop 4). The Bomoseen greywacke west of Lake Bomoseen conceivably belongs to a lower horizon, stratigraphically relacing the Biddie Knob formation; on the other hand, it may merely be part of a thickened section of the Bull formation, still underlain by the (unexposed) Mettawee member.

ZION HILL MEMBER: This is a massive greywacke or subgreywacke, ranging from 0 to 100 feet thick. The rapid variation in thickness suggests that it may be a shoestring sand, and occurs as discontinous beds confined in general to the middle part of the Bull formation. The base of the rock may be a pebble conglomerate, with load-casting features (stop 3), whereas the top may be a mudstone. Graded bedding is common. The Zion Hill is thus a crucial unit in working out the sense of the stratigraphic succession.

MUDD POND MEMBER: A white, vitreous, medium-grained orthoquartzite with rare dolomitic pods (concretions?). The thickness ranges up to 20 feet; at places two quartzite beds may occur separated by green slate

(stop 4). The Mudd Pond member may not always be present, but occurs near the top of the Bull formation.

CASTLETON CONGLOMERATE MEMBER: A limestone-pebble, slate-matrix, intraformational conglomerate (stop 1). The pebbles carry the Early Cambrian Elliptochephala fauna. It is probably no more than 20 feet thick, and the ratio of pebbles to matrix varies. It occurs near the top of the Bull formation, just above the Mudd Pond member (stop 4).

West Castleton formation

This formation consists largely of grey siltstone and black fissile slate, with rare beds of quartzite, pebble conglomerate, and rusty-weathering dolostone. Near the base of the unit is a black limestone, the Beebe limestone, which is massive but discontinuous. It yields the Early Cambrian Elliptocephala fauna. This formation was called the Hooker by Keith (1932) and the Schodack by Ruedemann (1914), Kaiser (1945), and Fowler (1950). This latter name, however, was incorrectly applied, as pointed out by Theokritoff (1957).

Poultney River Group

This is a large, and undivided rock group, ranging in age from of Upper Cambrian to Middle Ordovician. In the writer's area, six rock types have been recognized; the following is a tentative chronological listing, from the oldest to the youngest:

1. A white-weathering, black argillite with ribbon limestone and cherty beds (stop 1). (Schaghticoke lithology)

2. A limestone-matrix, limestone-conglomerate.

3. White-weathering, green, grey, black, and rarely red argillite, with interbedded thin, buff-weathering quartzite. Typical mineral assemblage: quartz-muscovite-chlorite-albite-microcline (stop 1). ("Poultney slate")

4. A black slate with interbedded brown-weathering, ankeritic, massive black quartzite with edgewise conglomerate (stop 1). Graded bedding and channel filling are abundant. ("Hatch Hill" lithology)

5. A soft red slate with thin dolomitic and quartzose beds. ("Indian River")

6. A black slate with massive black greywacke beds, commonly showing graded bedding and containing angular rock fragments. (Unnamed)

Units 1 and 3 are Dale's "Hudson white beds" (1898, p. 185). Unit 4 is Larrabee's "Zion Hill quartzite" (1939, p. 51). Unit 5 is Keith's Indian River formation (1932, p. 403), and unit 6 is Dale's Hudson grits (1898, p. 187).

A major unconformity probably separates the West Castleton formation from the Poultney River group. This conclusion is based on overlap relations as well as gaps in the stratigraphy. At least another unconformity exists in the Poultney River group, below unit 6.

The thicknesses of the various formations cannot be stated because of the intense deformation. The Lower Cambrian units are probably no more than 2000' thick, however, and the Poultney River group perhaps no more than 1000'.

Synclinorium Sequence

Rocks of the Synclinorium sequence have been described by various authors (Cady, 1945; Fowler, 1950). On the map (Pl. A-1), the following units are shown:

1. The Beekmantown limestone, consisting, in the map area, of the Bascom formation (Cady, 1945, p. 542) and the Chipman formation (Cady and Zen, 1959). A sugary-textured, grey, massive variety of the Bascom has been mapped in part by Fowler as the Whipple marble (1950, p.32); its reinterpretation will be the subject of an optional Sunday afternoon trip.

2. The Chazy-Trenton limestones, consisting of the Middlebury, Orwell, and Glens Falls formations (Cady, 1945).

3. The black "Hortonville formation" overlying the Glens Falls, perhaps unconformably. This is a black slate or phyllite which resembles the West Castleton formation and also some of the black slate of the Poultney River group. The age of the type Hortonville is subject to question (Zen, 1959), and the writer now suggests reviving Keith's name Ira formation (1932, p. 398) for the belt that runs from Florence (Pl.A-3) south towards Dorset Mountain, a belt that cannot be traced into the type Hortonville with certainty. The name Ira is appropriate, as the writer, in 1958, has found Middle Ordovician fossils in limestone lenses in the phyllite near Ira village.

STRUCTURE

Rocks of the Taconic sequence constitutes a series of imbricate thrust plates (Pl. A-3). Each thrust plate has its intricate internal structure, which however may be obscured by later, transverse, and more open folds that affected all the plates alike, and developed during the formation of the Middlebury Synclinorium. Although each plate has its characteristic stratigraphy, the rock units are broadly similar and there is little problem in correlating the formations.

In the east-central part of the map (Pl. A-1), there is a large, boomerang-shaped tract of Biddie Knob formation, and a half-moon shaped area of the West Castleton formation and the Poultney River group immediately to the northwest. These are the Giddings Brook - Taconic Range anticline and the Ganson Hill syncline, respectively. Taken together, they illustrate the structural motif of the area. (Pl. A-4).

The anticline is interpreted as a recumbent fold, overturned from the east, now lying on its side with nearly horizontal axial plane and nearly north-south axis. Digitations on this anticline are responsible for the Pine Pond thrust and for the areas of Biddie Knob formation to the north and northeast of the boomerang-shaped area. The Ganson Hill syncline is the structural complement of the anticline. East of the crest line of the

Taconic Range, the axial plane of the anticline has been turned beyond the horizontal position so that beds on the under limb of the anticline now actually dip gently west (sections A-A' and B-B', Pl. A-2, also Pl. A-3). Tracing of the units, including the Mudd Pond and the Zion Hill members, from the vicinity of Lake Bomoseen, where primary tops-and-bottoms evidence exists, to the east flank of the Taconic Range (stop 5), conclusively demonstrates that the rocks on the east flank of this Range are Lower Cambrian and are upside-down.

Due to the superposed, later structure of the Middlebury synclinorium, the nearly-horizontal axial plane of the Taconic Range - Giddings Brook anticline dips with a southerly component. This is believed to be responsible for the east-west strike of the beds between the Taconic Range and Lake Bomoseen (stop 4), and for the resulting map pattern. In the field, the large-scale structures are obscured by later folds with north-south axes, and east-dipping axial planes. These folds may be hundreds of feet across and may be the only structures readily observed in individual outcrops. The excellent axial plane cleavages of these later folds render useless cleavage-bedding relations in determining regional stratigraphic sense (stop 4).

The writer's mapping has shown that the Sudbury thrust (Cady, 1945) does not root locally in the Middlebury Synclinorium; instead the trace of the fault disappears under the Taconic sequence. The sequence in the Sudbury thrust slice may be normal rather than inverted; structurally the thrust slice is part of the Taconic sequence and may be a sliver under the main thrust.

In the vicinity of Florence, the Lower Ordovician Bascom formation extends westward abnormally far into the black phyllite terrane. Fowler (1950) interprets this extended area as Whipple marble interbedded with Trenton "Hortonville" formation; the marble however is indistinguishable from undoubted Bascom found a few hundred feet to the east. The marble overlies rather than interbeds with the phyllite, and the contact is sharp. Farther west, a kidney-shaped area of identical marble, mapped by Fowler as type Whipple, is also re-interpreted as Bascom. It is in a syncline underlain on all sides by black phyllite, with minor complications due to thrust faults. Immediately west of here, the black phyllite extends abnormally far up the slope of the Taconic Range, all the way to the summit of Biddie Knob (Pl.A-3). The marble itself extends to an elevation of 1250' up the slope, and is strongly lineated down dip, shown by colour streaking. Taken together with the outcrop relationships near Florence, the structure is interpreted as a nappe of Bascom formation, back-folded into the east edge of the Taconic sequence (section A-A', Pl. A-2). It shows the continuation of intense deformation in this area after the emplacement of the Taconic sequence.

EMPLACEMENT OF THE ALLOCHTHONE AND REGIONAL RELATIONS

The discovery that the Lower Cambrian Taconic sequence, in the east flank of the Taconic Range north of the Castleton River, is upside-down, demonstrates that the Taconic sequence does not constitute an ordinary anticline. Through detailed mapping of the formational contacts, the major structures within the Taconic sequence, as exemplified by the

Giddings Brook - Taconic Range anticline, are as a whole shown to be integral parts of the Middlebury Synclinorium. These structures were folded as part of the south-plunging Synclinorium after the development of the large-scale recumbent folds and thrust faults.

At the north end of the Taconic Range, therefore, the evidence for a Taconic allochthone is overwhelming. Though the trace of this fault can be located on the west side of the area, its location east of the Taconic Range is still conjectural. The gradational contact between the green and black phyllites, and the presence, in the black phyllite southwest of Brandon, of rock units characteristic of the Taconic sequence, however, show that part of the black phyllite east of the Taconic Range must be allochthonous.

The discovery of exotic blocks of Lower Cambrian Taconic rocks in the black slate north and east of Forbes Hill (Pl. A-3; stop 2) and elsewhere along the periphery of the Taconic sequence suggests an explanation for the mechanics of emplacement. (One mile north of Forbes Hill, a 6-inch black limestone carrying Ordovician fossils is interbedded with black slate traceable into outcrops of the "Forbes Hill conglomerate". Moreover, near Sunset Lake a similar rock is found, closely associated with a fossiliferous Middle Ordovician limestone conglomerate). The Taconic sequence, perhaps as soft unconsolidated material, is believed to have moved into a Trenton sea in which black mud was depositing. The allochthonous black argillite and the mud became so intimately commingled that a contact surface, in the ordinary sense, ceased to exist. The continuing deposition of black mud after this diastrophic event would result in local unconformities of Trenton slate over the Taconic sequence, as reported by Bucher (1957) at the south end of the slate belt. The emplacement of the Taconic sequence is thus a Late Trenton event, which tallies with the fact that the youngest rocks in the Taconic sequence is dated as Late Normanskill.

The Taconic sequence may have been moved in from the site of the present Green Mountains. Available fossil evidence suggests a correlation of at least the upper part of the Poultney River group with the Moretown - Cram Hill sequence (Thompson, in Rodgers, et al., 1952). The Moretown - Cram Hill sequence of eastern Vermont is thick and contains much volcanic material, in contrast to the Poultney River group which is relatively thin and free of volcanics. This change seems to fulfill the paleogeograghical requirements for rocks deposited at the site of the present Green Mountains, as the Moretown - Cram Hill, as well as the underlying rocks, are units typical of eugeosynclinal deposits, and somehow these must pass westward into the typical miogeosynclinal deposits of carbonates and orthoquartzites characterized by rocks of comparable age and found in the Middlebury Synclinorium.

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SUGGESTED TOPOGRAPHIC SHEETS FOR TRIPS A AND I

Castleton, Vermont - 15 minutes, scale 62,500
Thorn Hill, Vermont - New York - 7½ minutes, scale 24,000 (stop 1)
Benson, Vermont - New York - 7½ minutes, scale 24,000 (stop 2)
Bomoseen, Vermont - 7½ minutes, scale 24,000 and 31,680 (stops 3 and 4)
Proctor, Vermont - 7½ minutes, scale 24,000 and 31,680 (stop 5)

Trip A Road log

0.0 West end of Municipal parking lot in front of Hotel Bardwell. Head west on Evelyn Street left of Killington Bank.

0.1 Turn left (west) onto West Street.

0.2 Traffic light; go straight ahead.

0.9 Bear left on Route 4 (Columbian Avenue) beyond railraod tracks. BEWARE OF TRAFFIC! Stay on Route 4 for the next 16 miles.

2.6 Upper Cambrian Danby dolostone with quartzite beds in roadcut; beds dip west.

2.7 Mid-Trenton black phyllite overlying the dolostone.

3.8 West Rutland.

4.8 Main quarries and mills of Vermont Marble Company to the right and behind; quarries are in Upper Canadian marbles. Steep hills to right and ahead are in the green phyllite of the Taconic sequence, dipping gently west.

6.2 Road cut in the Lower Cambrian Biddie Knob formation.

6.6 View of Bird Mountain; cliffs are in the "Bird Mountain grit", correlative of the Zion Hill quartzite. Surrounding low areas are underlain by the Biddie Knob formation.

10.1 Lower Cambrian Mettawee slate (Bull formation) in pastures to the left.

11.5 Village of Castleton; continue ahead.

13.1 Castleton Corners; continue ahead.

14.7 Bomoseen greywacke on the right; this is the type locality.

15.6 Quarry in Castleton conglomerate (Bull formation), here at the nose of a north-plunging syncline.

16.1 Bear left with Route 4. Town of Fair Haven.

16.5 Turn right on Route 22A and follow it for 500 feet. Then go straight ahead (West Street) where Route 22A turns right, by the Methodist Church.

18.0 Bridge over Poultney River; STOP 1

Stratigraphy in the upper part of the Taconic sequence. Immediately under the bridge the purple and green slate of the Lower Cambrian Bull formation (Mettawee member) is exposed. A minor syncline here contains a black slate of unknown classification. The next group of out-

crops downstream along the river shows the Mettawee slates again, in addition it shows the Castleton conglomerate member. Here, the "conglomerate" ranges from true pebble conglomerate to thin bedded limestone, demonstrating that the conglomerate is in fact intraformational. This is significant, because many Early Cambrian fossils in the Taconic sequence were found in the "pebbles". The next large outcrop, west of the river, shows "unit 1" of the Poultney River group. Notice the hard, "glazed" appearance of the jet black slate, and the ribbony limestone. Delicate cross-bedding in the latter indicates a top-west sense. The cherty beds are rather unusual. The last group of outcrops in the river bed shows the rock types in units 3 and 4 of the PRG. Notice the abundant graded bedding and channel-filling, all indicating top-west sense. At the north end of the outcrops, a minor fault is exposed. The significance of the disharmonious folds in unit 3 here is uncertain; they may represent slump structures.

Climb out of the river channel and walk west to a north-south gravel road. Follow the road south. Cuts along the road expose units 3 and 4 again. Turn left at road junction and back to car.

Turn around and return to Fair Haven.

19.4 Turn left (north) onto Route 22A; same corner as mileage 16.6.

20.7 Bomoseen greywacke to the right.

21.2 Castleton conglomerate; the limestone beds show all gradations between good beds and pebbles. The matrix here is a greenish grey silty slate; locally however it is a black calcareous grit, the "Eddy Hill grit".

21.6 Slate and ankeritic quartzite of the Poultney River group; west (normal) limb of the syncline whose east limb was examined at STOP 1.

22.5 Bomoseen greywacke.

22.8 Mudd Pond quartzite (Bull formation) to the right by the school house.

23.0 Turn left on West Haven road. Outcrops to the east of Route 22A here are the West Castleton formation at the base of the ledges and Bull formation (green slate) on top; section is inverted.

23.2 Beginning of wide area of outcrops of Lower Ordovician carbonates, including the Bascom and Chipman formations.

24.4 Bridge over Hubbardton River; black slate west of the bridge. This slate is mid-Trenton in age.

25.1 Bear right onto gravel road.

25.6 STOP 2

Forbes Hill "conglomerate".

Notice the character of the "blocks" in the black slate matrix:

gray vitreous quartzite, punky-weathering dolomitic sandstone, and green slate. All these types can be matched with units in the Taconic sequence (Mudd Pond, units in the West Castleton, and Mettawee, resp.) immediately east. The blocks are all angular and randomly oriented; their sizes seem to correlate with rock hardness. Although the age of the matrix slate is unknown here, a similar rock (even more spectacular but less accessible) about 1/2 mile northwest of here has been traced into an outcrop containing interbedded fossiliferous Ordovician limestone. The matrix is thus presumably Ordovician.

Forbes Hill, west of the road, is underlain by Lower Ordovician Chipman formation dipping gently east but much folded. To the east, the wooded knoll in the valley is underlain by the Bomoseen greywacke. The valley itself is underlain by the weak Mettawee slate. The line of scarp in the distance is the Great Ledge, whose base is of Mettawee slate but whose face is of Bomoseen greywacke, dipping gently east. To the south of the outcrop, the wooded knobs in the middle distance are made up of Ordovician black slate, including more of the "conglomerate".

PLEASE REFRAIN FROM HAMMERING THE OUTCROP. THIS OUTCROP CAN BE POUNDED OUT OF EXISTENCE BY A GROUP OF THIS SIZE; IT IS TOO CRITICALLY IMPORTANT HOWEVER TO SUFFER SUCH AN EARLY DEATH. ALL THE RELEVANT FEATURES CAN BE SEEN, AND SEEN BETTER, ON THE NATURAL SURFACES. SO PLEASE COOPERATE - THANK YOU.

Turn around and proceed back towards Fair Haven.

28.4 Turn right onto Route 22A (same corner as mileage 23.0)

31.4 Turn left for short cut to Route 4.

32.0 Junction with Route 4; proceed straight ahead (same corner as milage 16.1).

33.9 Castleton Corners (same corner as mileage 13.1); turn left onto Route 30, going north.

34.3 Hills to the right are the Sunset Hill, underlain by the black slates of West Castleton formation. Kootenia fordi (Walcott) has been found here.

37.5 View across the lake (Lake Bomoseen) towards the abandoned quarry of Cedar Mountain. The bluff face is the keel of a recumbent syncline, overturned to the west and plunging south. Mettawee slate; top of the Bull formation.

38.0 Green Mettawee slate to the left of road.

38.6 A thrust fault is exposed on the cliff. Black West Castleton slate overridden by green Mettawee slate; the black slate is badly crumpled here and is in normal succession to the green slate of mileage 38.0.

38.7 Black West Castleton slate and Beebe limestone member, in normal succession above the green slate of mileage 38.6, lying above the thrust fault.

39.5 Purple and green Mettawee slate to the right.

40.1 Turn left onto gravel road.

40.3 STOP 3.

Primary sedimentary features in the Zion Hill member.

Almost the entire peninsula is made up of the Zion Hill quartzite, dipping gently east. The green colour of the quartzite on a fresh surface is due to chlorite. Spots of limonitic stain is also common. The rock is medium-grained and fairly well sorted, with subrounded grains of quartz and feldspar. At water's edge on the west side, one outcrop shows load-casting features against the underlying green slate. The individual grains are 1 cm. or less across here; in other outcrops they range up to 15 cm. and include slate and limestone. The load-casting feature and graded bedding as a whole indicate that the unit is right-side up; these features have been used extensively in the areal mapping and give consistent stratigraphic sense.

Across the lake, a rocky prominence, Page Point, can be seen. It is underlain also by the Zion Hill quartzite, showing graded bedding on the east side (upside-down), and gradation into mudstone on the west side. Drag folds also show that the section is upside-down. These two belts thus define an overturned anticline; this is cored by the Biddie Knob formation which follows the valley of Giddings Brook from Hubbardton on east. This anticline swings south near Biddie Knob, and the Zion Hill quartzite, with its primary sedimentary sense, shows that the east flank of this structure south of Biddie Knob, corresponding to the belt of Zion Hill west of Lake Bomoseen at Page Point, is upside-down.

West of Page Point, the Zion Hill is followed by the Mettawee slate, and eventually, at Cedar Mountain and Neshobe Island, by the West Castleton formation in the center of a recumbent syncline visible in the Cedar Mountain quarry. East of Stop 3, the Mettawee slate visible on the road is followed by black West Castleton slate (fossiliferous, Lower Cambrian) in the wooded hills visible from the road.

LUNCH STOP. THIS IS PRIVATE PROPERTY; WE ARE PERMITTED TO BE HERE BY THE COURTESY OF THE OWNER. PLEASE DO NOT POUND THE ROCK INDISCRIMINATELY AND DO NOT LEAVE ANY LITTER BEHIND! BRING IT BACK TO THE CAR AND DUMP IT IN ONE OF THE ROADSIDE TRASH CANS - WE WILL COME TO ONE SHORTLY. ALSO, BEWARE OF POISON IVY. THEY ARE THICK HERE.

Turn around and return to Route 30.

40.5 Route 30; turn left and continue on north.

41.3 Zion Hill quartzite (Bull formation) on the normal limb of the Giddings Brook fold. A minor thrust fault is exposed.

42.6 Village of Hubbardton. Turn right onto gravel road.

43.3 Bridge over Giddings Brook. Mettawee slate on the inverted limb of the Giddings Brook fold.

43.6 Turn left.

43.7 Quartzites to the right of the road are the Zion Hill member on the normal limb of the Giddings Brook fold.

44.2 Sharp cobble ahead held up by the Zion Hill quartzite.

44.9 Biddie Knob formation; return to the reverse limb of the Giddings Brook fold.

45.1 Two small recumbent anticlines in the Zion Hill quartzite are exposed in the road cut to the right.

45.4 STOP 4

Stratigraphy in the lower part of the Taconic sequence. The recumbent folds of the Giddings Brook and Ganson Hill area.

The pasture east of the farmhouse, south of the brook, is purple and green Biddie Knob formation - notice the tiny, sparkling cleavage flakes of chloritoid in the rock. Contact with the younger Bull formation is at the north end of the pasture, just south of the foot bridge. North of the bridge, Zion Hill quartzite dips under the Mettawee slate. Knobs to the north show the typical appearance of the quartzite.

Go southwest down from these knobs, follow lumber trail west, then north, around the south end of wooded hill. In the pasture: Zion Hill quartzite and Mettawee slate. Sharp, wooded knob to the southwest is a recumbent syncline of these same units. In the valley: Biddie Knob formation.

Where the trail branches near a ravine, stick to the east side of the gully. In the gully: green Mettawee slate. Continue on trail to a small pasture. First outcrop is Mettawee slate; at the northwest corner is a flat-lying outcrop of black limestone. This same limestone is seen a short distance north to underlie the green slate; it is the Beebe limestone, basal to the younger West Castleton formation. The section thus must be inverted; the cleavage-bedding relation is a later feature and cannot be trusted.

200 feet northwest, in another pasture, the black West Castleton formation is exposed. The contact of West Castleton and Bull can be traced in detail to yield an upside-down and gently south-dipping section.

Follow the overgrown pasture north-northeast. The trail nearly follows the Bull-West Castleton contact. At the end of clearing, go east into woods. A few poorly exposed Castleton conglomerate exist here. The quartzite beds, soon to be encountered, are Mudd Pond. Two beds exist, separated by green slate. Continue east to top of 1330' knob in the open. Notice the dolomitic pods in the quartzite; notice the structure, with the quartzite beds keeling over at the north end - apparently here is the nose of a major fold barely preserved. Notice the attitude of the slaty cleavage swinging over with the structure. The structure is in fact an inverted syncline, with older beds in the center. It has a north-south axis and

southerly plunge; it is formed during a second deformation (contemporaneous with the formation of the Middlebury Synclinorium?) superposed upon the already-existing inverted section. The slaty cleavage presumably belongs to the first deformation.

At the northeast side of the top, notice the Castleton conglomerate with extreme deformation of the pebbles - these are b-lineated relative to the second folding. Time and interest permitting, a short trip south, along the ridge of the hill, will encounter the Bomoseen greywacke, both underlain and overlain by green Mettawee slate; it is not exposed along the trail whence the group ascended the hill. Unfortunately, the best outcrops are not readily accessible from this hill.

Go north from the hilltop. In the woods, the black West Castleton is seen to underlie the Bull. Continue north to transverse gully; follow it east to farmyard. Go across dirt road up sharp knob. Poultney River (?) slate near the core of the Ganson Hill syncline. Ganson Hill is the group of knobs to the west.

Go east across stout barb-wire fence. BEWARE OF BLACK ANGUS BULLS! KEEP IN CLOSE FILE. Black slate up to the sharp ridge; on the east side Beebe limestone outcrops.

On the shore of Mudd Pond the quartzite bearing the same name dips very gently south. Section is normal; we are on the north limb of the Ganson Hill syncline. North of the pond, Bomoseen greywacke holds up the outlet, underlain to the north by purple Mettawee slate and finally more Biddie Knob formation. Go south in pasture. Green slate above the Mudd Pond, with cleavage-bedding relation again indicatinga normal section although the sequence is exactly the reverse of that southwest of the 1330' hill. Continue south in pasture; green slate followed by black slate and several large outcrops of Beebe limestone. A last outcrop is the Mudd Pond quartzite again, in two beds; this is the same belt that was studied on the 1330' hill and on the reverse, south limb of the Ganson Hill syncline.

Walk south along dirt road to road junction; Biddie Knob formation in the gully to the south. Walk west to car.

Continue east.

45.9 Road cut is in Biddie Knob formation.

47.0 View of Biddie Knob (2008'); top of the knob marks the contact between black phyllite to the east and green phyllite (Bull) to the west. Biddie Knob formation begins at 1800' level on the west slope and continues to the road. This formation crosses to the east side of the Taconic skyline at the col south of Biddie Knob. Small wooded hill to the left and ahead is held up by Zion Hill quartzite on the normal limb of the Giddings Brook fold.

47.4 Zion Hill quartzite in woods to the right.

48.7 Zion Hill to the right. Cliffs are held up by Zion Hill quartzite.

51.0 Road cut in Biddie Knob formation of the Pine Pond thrust slice.

54.6 Hooker Hill to the right; type locality of Keith's Hooker formation, now called the West Castleton.

55.0 Road cut in purple and green Mettawee slate, including a poor outcrop of the Castleton conglomerate. The strata strike east-west and dip vertically. East (left) of the valley this sequence is masked by a higher tectonic unit, the Bird Mountain thrust slice, which makes up the hills to the east and south.

55.5 Route 4. Turn left (east) and continue to Rutland. End of itinerary.

Trip I Road Log

Mileage

0.0 Junction of Routes 3 and 7 just east of Pittsford Mills. Proceed west on Route 7.

2.2 View of Coxe Mountain ahead to the right. The ledges on the lower slopes are Lower Cambrian Cheshire quartzite dipping east and overturned; the mass of the mountain is underlain by Lower Cambrian (?) Mendon series.

2.3 Turn left on secondary paved road.

2.9 Outcrops north of road are Lower Cambrian Dunham dolostone.

3.0 Crossing Otter Creek.

3.1 Middle Cambrian (?) Winooski dolostone in road cut; section is inverted.

3.3 Turn left (south). Hamlet of Florence.

3.7 Turn right just before the second underpass.

3.9 Bear right, follow gravel road.

4.0 Road cut in Lower Ordovician (?) Shelburne marble; commercially this is the most important marble unit in western Vermont.

4.3 Lower Ordovician Bascom formation in pasture left of road.

4.6 Bascom marble resting on black phyllite south (left) of road; marble in the knolls and phyllite to the west.

5.0 Bear left.

5.4 Road cut in black phyllite; probably Middle Ordovician Ira formation.

5.5 Outcrops in fields to the right are black phyllite; either West Castleton or Ira. Taconic fault must be nearby although it is concealed. Hills to the northwest are in the Bull and Biddie Knob formations.

5.6 Bear left.

6.1 Flat-lying Bascom formation to the right, resting on black phyllite.

6.6 Bascom marble resting on black phyllite left of road.

6.9 Turn right. USE LOW GEAR!

7.1 STOP 5.

Stratigraphy and structure at the east flank of the Taconic Range.

PLEASE NOTE. THIS IS A ROUND-TRIP WALK OF NEARLY 3 MILES AND A CLIMB

OF OVER 1000 FEET, MUCH OF WHICH IS BUSHWHACKING. PLEASE MAKE SURE YOU ARE PREPARED FOR THIS. PLEASE DO NOT GO OFF ON YOUR OWN; THERE IS A MAZE OF LUMBER TRAILS ON WHICH ONE CAN GET LOST EASILY. STAY WITH THE GROUP.

Start on footpath by the hunting lodge, el. 820'; follow it west. Outcrops along the trail are black Ira or "Hortonville" formation. The black phyllite near the western margin of this rock type, however, may be Taconic; the contact is hidden.

1090' elevation. Trail forks. Bear left on overgrown branch.

1150'. Leave trail, go up slope. Black phyllite. At 1450', near top of steep slope, ledges of grey to green, massive, silty rock with visible porphyroblasts of albite up to $\frac{1}{2}$ mm. across. This rock is typical of the green-black contact along the east flank of the Taconic Range at its north end. At 1480', this rock passes gradationally into green, fine, micaceous phyllite, directly traceable into the Mettawee slate south of Mudd Pond (stop 4). At 1510', in open meadow on top of knoll, there is a ten-foot white quartzite with dolomitic pods. This rock is like the Mudd Pond member and occupies a similar position relative to the green-black contact as at the type locality.

Continue northwest up the knob in the woods, elevation 1650'. Keep WNW to the next knob, el. 1710'. Notice the green phyllite is without chloritoid.

Go west down. At 1650' there are two large outcrops of a white-weathering, vitreous, pale green, limonite-stained quartzite which resemble the Zion Hill. To the west, the phyllite begins to acquire chloritoid.

Go south to hit trail in the col; follow trail west to 1470' and see good outcrops of coarsely-grained chloritoid-bearing green Biddie Knob formation.

The succession of rock units are, in reverse order, the same as those seen at stop 4 - Biddie Knob, Mettawee, Zion Hill, Mettawee, Mudd Pond, Mettawee, and black slate. In fact, the same rock units can be traced continuously into the outcrops of stop 4. It will be recalled that at stop 3 primary tops evidence was seen in the Zion Hill member; it was pointed out that at Page Point, across Lake Bomoseen, the Zion Hill was inverted. This same inverted belt was seen at stop 4, and again at the present stop. Thus the stratigraphic correlation is proved by direct tracing, and the east flank of the Taconic Range in the vicinity of Biddie Knob must, therefore, represent an inverted section of Lower Cambrian rocks. This fact of an inverted sequence overlying a normal succession of the Synclinorium sequence cannot be explained by any scheme of simple sedimentary succession, even ignoring the fossil evidence.

Notice also that the chloritoid-bearing strata here occur west of the chloritoid-free green phyllite. Since the grade of regional metamorphism increases eastward, this fact shows that the basis of demarkation of the Biddie Knob and Mettawee, namely the presence of chloritoid in the former, is stratigraphically valid; the difference is not merely due to differences in metamorphic grade.

If the trail were followed westward, the Biddie Knob would be succeeded by purple and green Mettawee, Zion Hill (with graded bedding to show normal sense), Mettawee, Bomoseen, Mettawee, Castleton, and finally West Castleton with basal Beebe limestone. The two limbs of the structure thus correspond closely.

The group, however, will follow the trail <u>east</u>, and thence return to the cars.

A

A'

1500'
0

B

B'

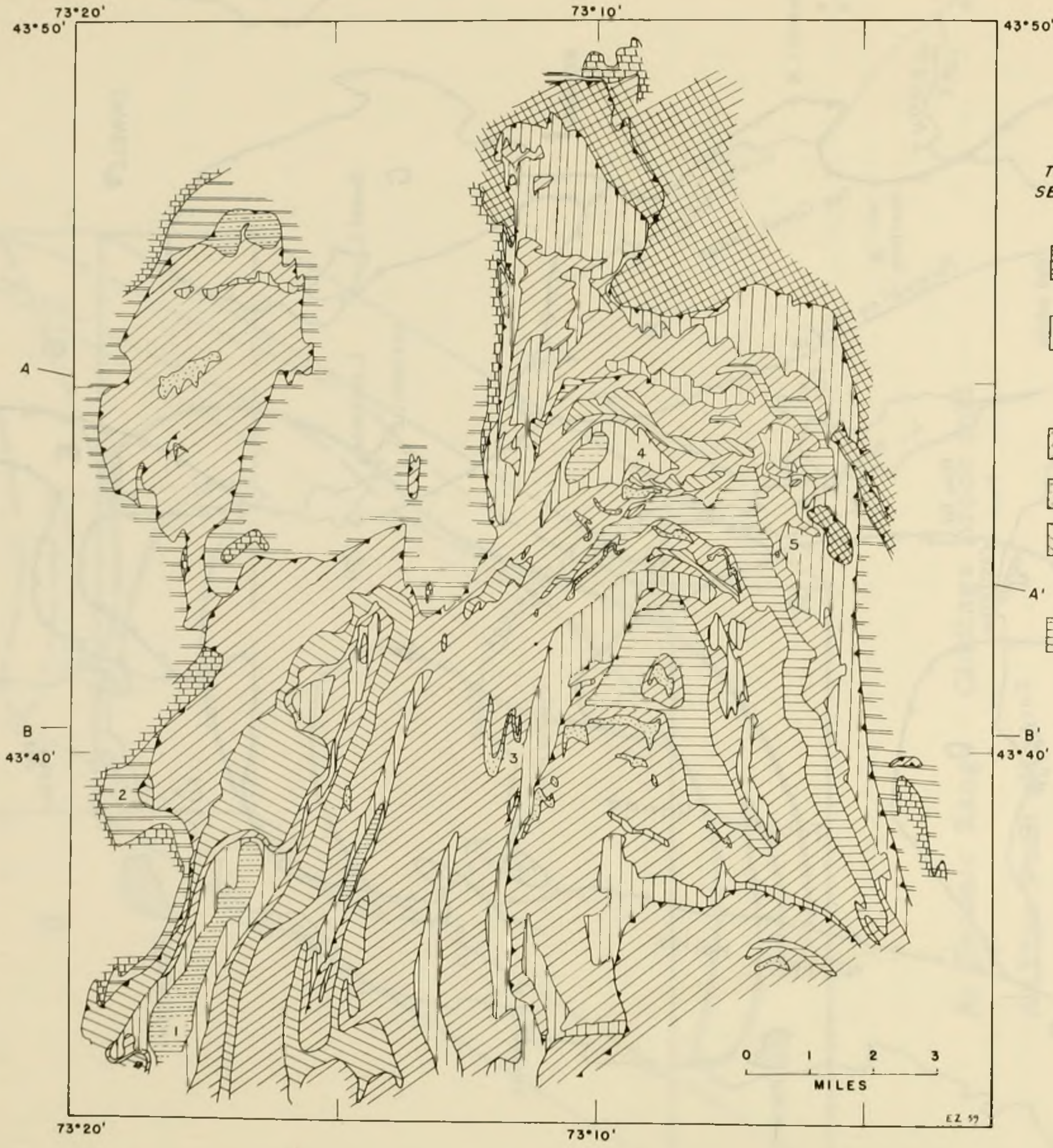
EZ 59

2000'
0

NO VERT. EX.

0 1 2
MILES

Plate A-1



LEGEND

TACONIC SEQUENCE

- POULTNEY RV. GROUP (U.€.-M.O.)
- WEST CASTLETON FM. (L.€.)
- BULL FM. (L.€.)
- METTAWEE SL.
- ZION HILL QTZT.
- BOMOSEEN GRAYWACKE
- BIDDIE KNOB FM. (L.€.?)

SYNCLINORIUM SEQUENCE

- "HORTONVILLE" FM. (M.O.)
- UNDIFFERENTIATED M. ORD. LS. (GLENS FALLS, ORWELL, MIDDLEBURY)
- UNDIFFERENTIATED L. ORD. FMS. (CHIPMAN & BASCOM)

- CONTACT
- FAULT (CARATS ON UPFAULTED SIDE)

GEOLOGY BY E. ZEN, 1953 - 1958

Plate A-2

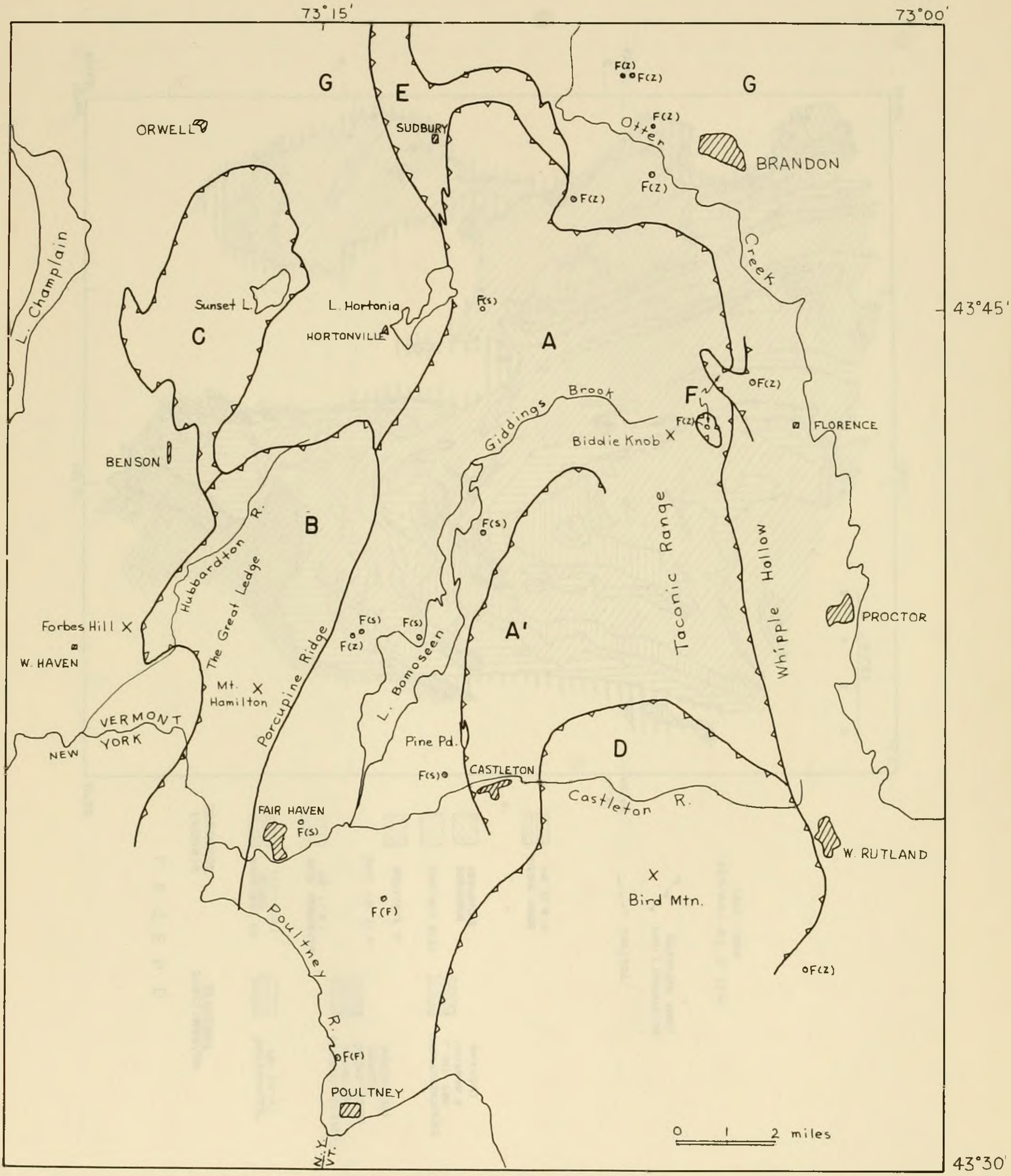
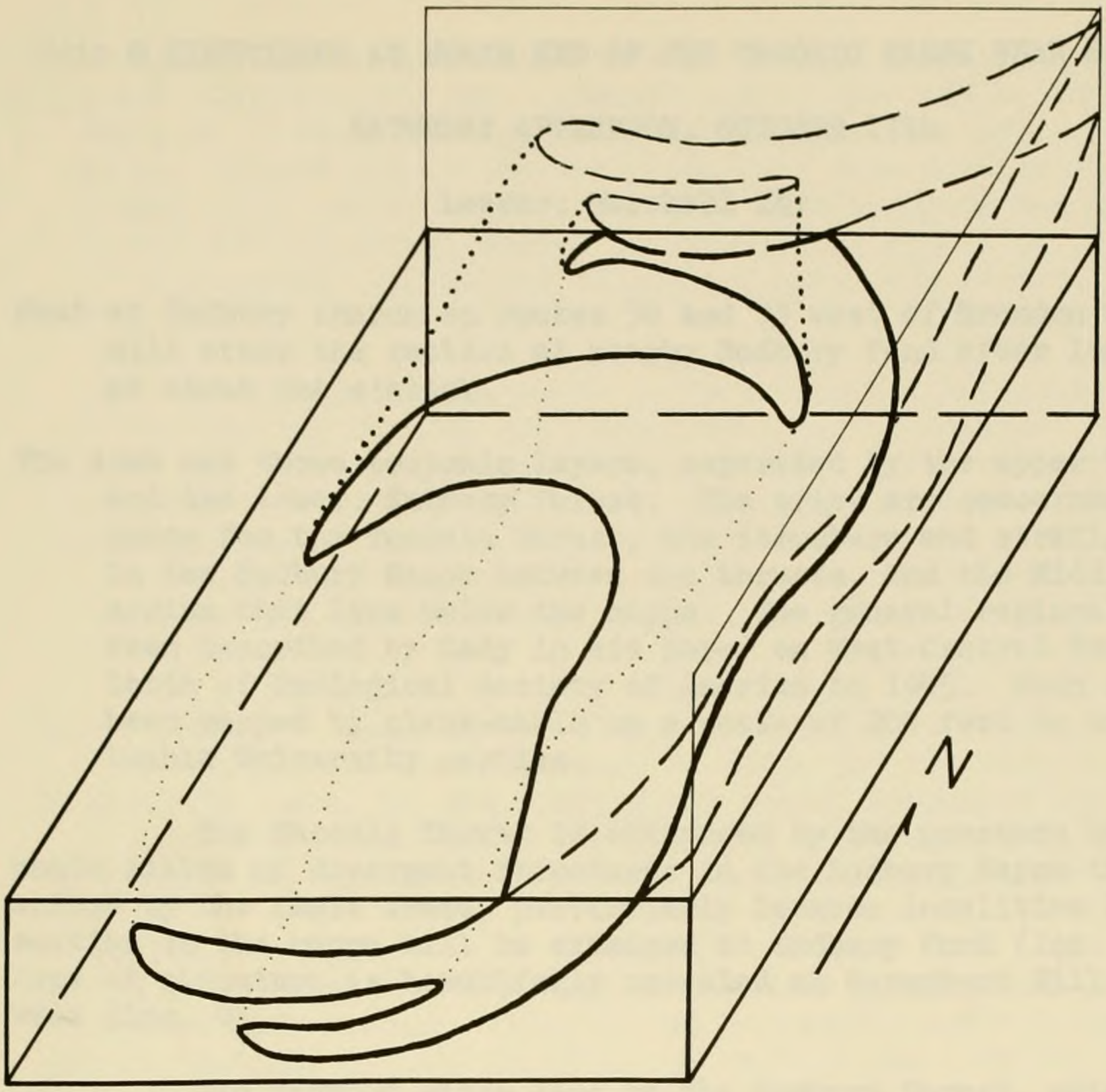

73°15'
73°00'
43°45'
43°30'
G
E
G
ORWELL
SUDBURY
Otter
BRANDON
F(z)
F(z)
F(z)
F(z)
F(z)
Creek
L. Champlain
Sunset L.
L. Hortonia
HORTONVILLE
C
A
F(s)
F
OF(z)
FLORENCE
Giddings Brook
Biddie Knob
BENSON
B
Hubbardton R.
The Great Ledge
F(s)
F(s)
F(s)
F(z)
Taconic Range
Hollow
Whipple
PROCTOR
Forbes Hill
W. HAVEN
Mt. Hamilton
Porcupine Ridge
L. Bomoseen
A'
VERMONT
NEW YORK
Pine Pd.
F(s)
CASTLETON
D
Castleton R.
FAIR HAVEN
F(s)
W. RUTLAND
F(F)
Bird Mtn.
Poultney R.
OF(F)
OF(z)
POULTNEY
N.Y.
VT.
0 1 2 miles

Plate A-3



A: Taconic Range Giddings Brook fold

A': Pine Pond slice

B: Porcupine Ridge - Great Ledge fold

C: Sunset Lake slice

D: Bird Mountain slice

E: Sudbury slice

F: Florence Nappe

G: Middlebury Synclinorium

Plate A-4