

Stratigraphy and structural geology of the Pinnacle Formation between the Lamoille and Winooski rivers northwestern Vermont

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Abstract

Detailed mapping (1:24000 scale) of the Pinnacle Formation between the Winooski and Lamoille Rivers in northwestern Vermont has allowed the revision of the stratigraphy and structural geology. The Brome Thrust separates the eastern and western stratigraphic sections of Pinnacle. The western section is subdivided into two members: an upper member including quartz pebble conglomeratic unit and a rhythmically bedded wacke slate unit, and a lower member of massive medium to coarse-grained quartz feldspar wacke. The eastern section of Pinnacle includes interbedded greenstone and volcanoclastic rocks. The eastern section is mapped as one unit containing beds of greenstone. The major structures in the field area from west to east consist of: the Browns River anticline, the Abbey Brook syncline, and the Jericho anticline. The eastern limb of the Jericho anticline is truncated by the Brome Thrust fault to the south and its axis is sheared out by a related fault to the north. These faults are an extension of the Brome Thrust of Quebec.

Introduction

A 1:24,000 scale geological map of the field area was completed during the summer 1994 field season (plate 1a and b). This map extends the area of detailed, 1:24,000 scale, mapping by tying in with the work of Doolan (1987) in the Gilson Mountain

quadrangle to the north and the work of Dorsey and others (1983) to the west in the Milton quadrangle (figures 1 and 2). The mapping has led to new understanding of the stratigraphy and structure of the field area (plate 1a).

This report will describe that stratigraphy and structure and is designed to supplement the geological map, structural overlay and geological cross sections (Plates 1a,1b, and 2).

Stratigraphy

Two of the goals of this study have been realized: 1) the dividing of the Pinnacle into lithostratigraphic subdivisions, and 2) the definition of contact relationships and the estimation of the thickness of the Pinnacle Formation.

1) Lithostratigraphic Subdivisions

Western sequence

The stratigraphy of the Pinnacle Formation is divided into a western and an eastern sequences by the Brome Thrust (plate 1a). The western sequence is further broken down into three units.

CZpl-

The lower member of the Pinnacle Formation (CZpl) is the lowest unit observed in the western sequence. This blue-gray massive wacke is exposed in the axis of the Browns River anticline (plate 1a). It typically forms in large whaleback outcrops and underlies the rounded hills in this part of the field area. The lower member is rich in feldspar as well as blue, black and clear quartz

and lacks black slate interbeds. Light siltstone rip-up clast horizons are present but much less common than in the overlying member. Siltstone rip-up clasts (to 5 cm.) are most often found randomly spaced. The lower member contains a galena-like metallic porphyroblasts, is locally pyritiferous and is less schistose than the upper member of the Pinnacle Formation.

CZpu-

The massive wacke unit is overlain by the upper member of the Pinnacle Formation (CZpu). This member consists of bedded wacke some of which is extremely rich in feldspars and pebble to cobble conglomerate (CZpc) observed near the upper contact with the Fairfield Pond Formation.

The bedded wacke contains interbeds of black slate and light colored siltstone and dark slate clasts rip-up conglomerates. The tops of the shale beds were observed ripped up and incorporated in the next few centimeters of wacke at several localities. Bedding consists locally of rhythmic .5 to 1 meter thick beds distinguishable by finer grained material in between as is exposed in the Browns River under the Route 15 bridge in Jericho. Grading and scouring of the underlying bed in these rythmites gave topping direction.

The bedded wacke coarsens upwards into a discontinuous polymictic pebble to cobble conglomerate unit of the uppermost upper Pinnacle. This conglomerate contains a variety of clast types including meta-siltstone, slate and meta-sandstone but is distinguishable from the rip up horizons in the upper Pinnacle

metawacke unit by the presence of large (>.5 cm.) blue quartz pebbles.

Eastern section

The eastern section contains wacke interbedded with volcanics and volcanoclastic rock types. The rocks of this sequence are more highly deformed exhibiting a better developed cleavage and tight small scale folds. Chloritic fine to medium grained volcanoclastics and quartz rich wackes dominate the sequence. Pitted weathering calcareous greenstones were found in this sequence. In this eastern section no attempt at stratigraphy is made by this study . Greenstones are mapped where observed.

2) Thickness and Contact Relationships

The thickness of the western Pinnacle was measured on the hinges of the folds giving a more accurate measure since limbs of folds in lower greenschist facies rocks may be thinned by pressure solution of quartz during deformation (plate 2). The overall thickness of the western Pinnacle is greater than 2,600 meters, base of which is not exposed. In the core of the Browns River anticline 1,400 meters of the lower Pinnacle member (CZpl) is exposed. The overlying bedded wacke of the upper member is from 1,200 to 1,800 meters thick and the uppermost quartz pebble conglomerate unit varies from 0.0 to 200 meters thick.

The contact between the Fairfield Pond and the Pinnacle formations is repeated three times by folding. In all cases it is

characterized by a fairly rapid (10 to 15 meter) transition from coarse granule size quartz-rich wacke of the Pinnacle to fine grained dark blue gray siltstone and phyllite. Interbeds of coarse wacke were observed locally in the lowermost Fairfield Pond. The contact is drawn at the first siltstone or phyllite bed of a meter or more in thickness. The uppermost Pinnacle contains abundant distinct blue quartz grains (2-3 mm.) floating in medium to coarse grained sand. The contact is locally calcareous and may be roughly correlate to the White Brook Dolomite of Quebec.

Structure

Mapping of the field area has revealed three major folds and one major fault which had not been recognized in previous work (figure 1; plate 1a). The fault shown in the eastern portion of the map separates the western and eastern stratigraphic sequences of the Pinnacle Formation and is an extension of the Brome Thrust of southern Quebec (plate 1a).

Fold axes were located by the use of three independent factors: 1) bedding and cleavage relationships, 2) younging direction, and 3) verging direction of small scale parasitic folds.

Browns River Anticline

The Browns River anticline is the westernmost fold in the map area. Its axial trace extends parallel to the Browns River from Essex Center, VT to Westford, VT. The dominant schistosity (S2) is axial planar to this fold (plate 2). The browns river anticline plunges shallowly (18°) to the south and is cored by the lower

Pinnacle member of the western section. The plotting of bedding data on equal area stereonet supports the existence of this anticline. The western limb of the anticline shows steeper bedding than the bedding on the eastern limb. This difference is the difference between the dip of the limbs of the overturned anticline.

Abbey Brook Syncline

The Abbey Brook syncline is cored by Fairfield Pond Formation. Its axial plane is also parallel to the dominant schistosity (S2). The finer grained rocks of this syncline (Fairfield Pond Formation) may have accommodated large amounts of shortening perpendicular to the dominant cleavage plane (pure shear). Bedding in the Fairfield Pond exposed in this syncline is boudined and attenuated.

Jericho Anticline

The Jericho anticline is also an overturned structure in the western Pinnacle section plunging shallowly to the south. The Pinnacle exposed in this anticline is of the upper member (plate 2). This anticline is constrained by overturned graded bedding near the contact with the Fairfield Pond Formation on its western limb and upright bedding exposed in the Browns River (Route 15) in Jericho as well as bedding cleavage relationships on the limbs.

Cleavage

The dominant cleavage (D2) is consistent west of the Brome Thrust (figures 7-10). This cleavage is axial planar to the large and small scale folds west of the Brome Thrust. An earlier cleavage

(S1) was observed folded in the hinges of parasitic folds. This S1 cleavage is bedding parallel and not associated with any mappable folds.

Brome Thrust

The Brome Thrust divides the western and eastern Pinnacle sequences. The thrust is characterized by well developed cleavage, quartz veining, and small scale (hand-sample) folds with transposed limbs. To the east of this fault lies Pinnacle rocks including interbedded greenstone and thinly bedded chlorite schist of volcanoclastic origin.

The Brome Thrust of the field area is interpreted as an extension of the Brome Thrust of Quebec which separates the Mansville section to the west from the Oak Hill section to the east (Colpron 1990, Rose 1993). The Brome thrust has been mapped in Vermont by Schoonmaker (in progress) in the Enosburg Falls area and by Doolan (1987) in the Gilson Mountain Quadrangle.

Acknowledgments

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References Cited

Colpron, M., 1990, Rift and Collisional Tectonics of the Eastern Townships Humber Zone, Brome Lake Area, Quebec: University of Vermont, Master Thesis.

- Doolan, B. L., 1987, Stratigraphy and Structure of the Camel's Hump Group Along the Lamoille River Transect, Northern Vermont: in D. S. Westerman ed. , NEIGC 1987: Guidebook for Field Trips in Vermont, Norwich University, Northfield, VT, B2, 152-191.
- Dorsey, R. J., P. C. Agnew, C. M. Carter, E. J. Rosencrantz, R. S. Stanley, 1983, Bedrock Geology of the Milton Quadrangle, Northwestern Vermont: Vermont Geological Survey Special Bulletin, No. 3, 1-14.
- Rose, H., 1993, Stratigraphy, Characterization of Metavolcanic Rocks, and Structural Evolution, in a Cross Section Through the Taconide Zone, Internal Domain, Eastern Townships, Southern Quebec: Regional Implications: University of Vermont, Master Thesis.

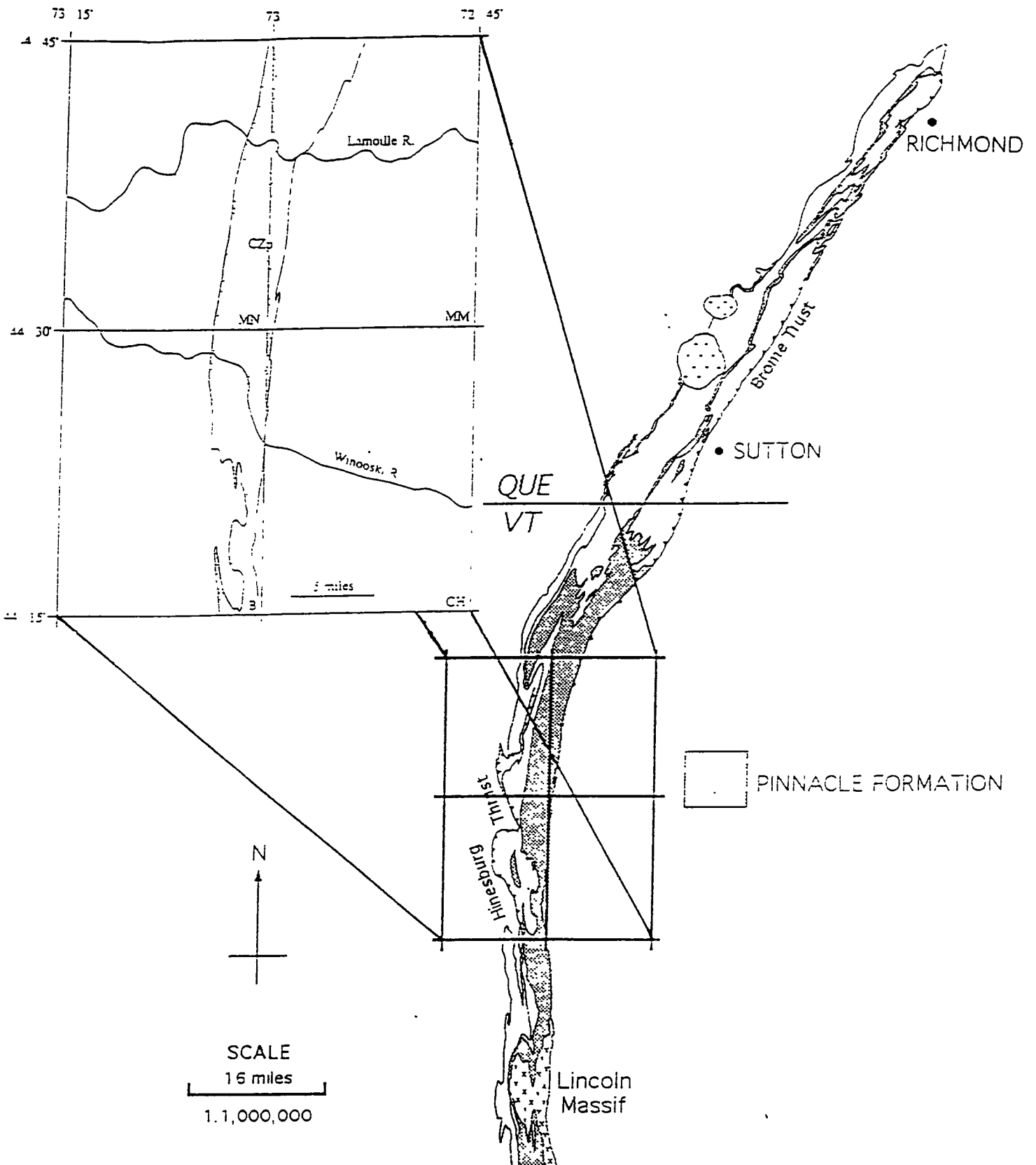


Figure 1. Index map of study area: CZp- Pinnacle Formation; MN- Milton 15' Quad.; MM- Mount Mansfield 15' Quad.; B- Burlington 15' Quad.; CH- Camels Hump 15' Quad.

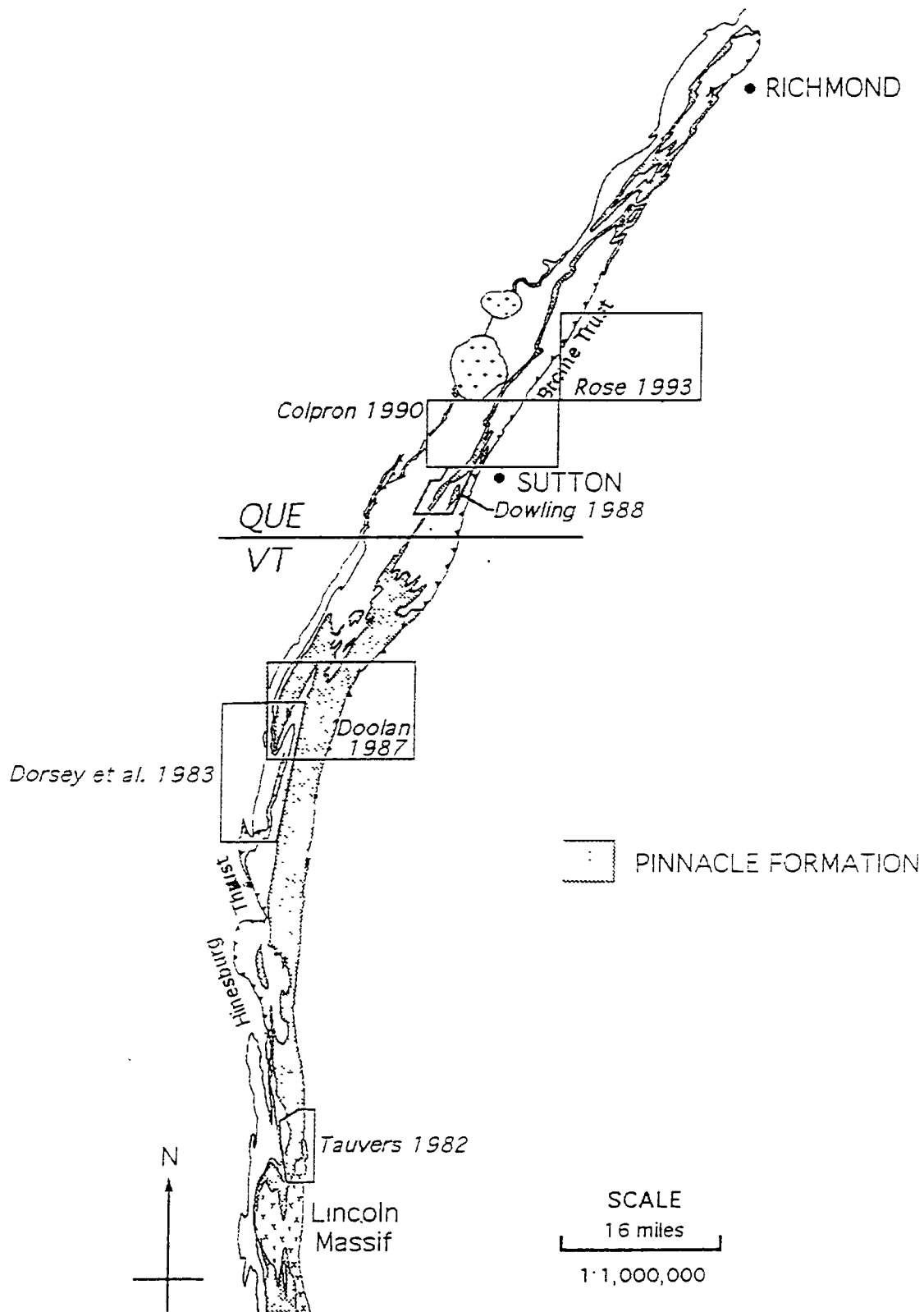
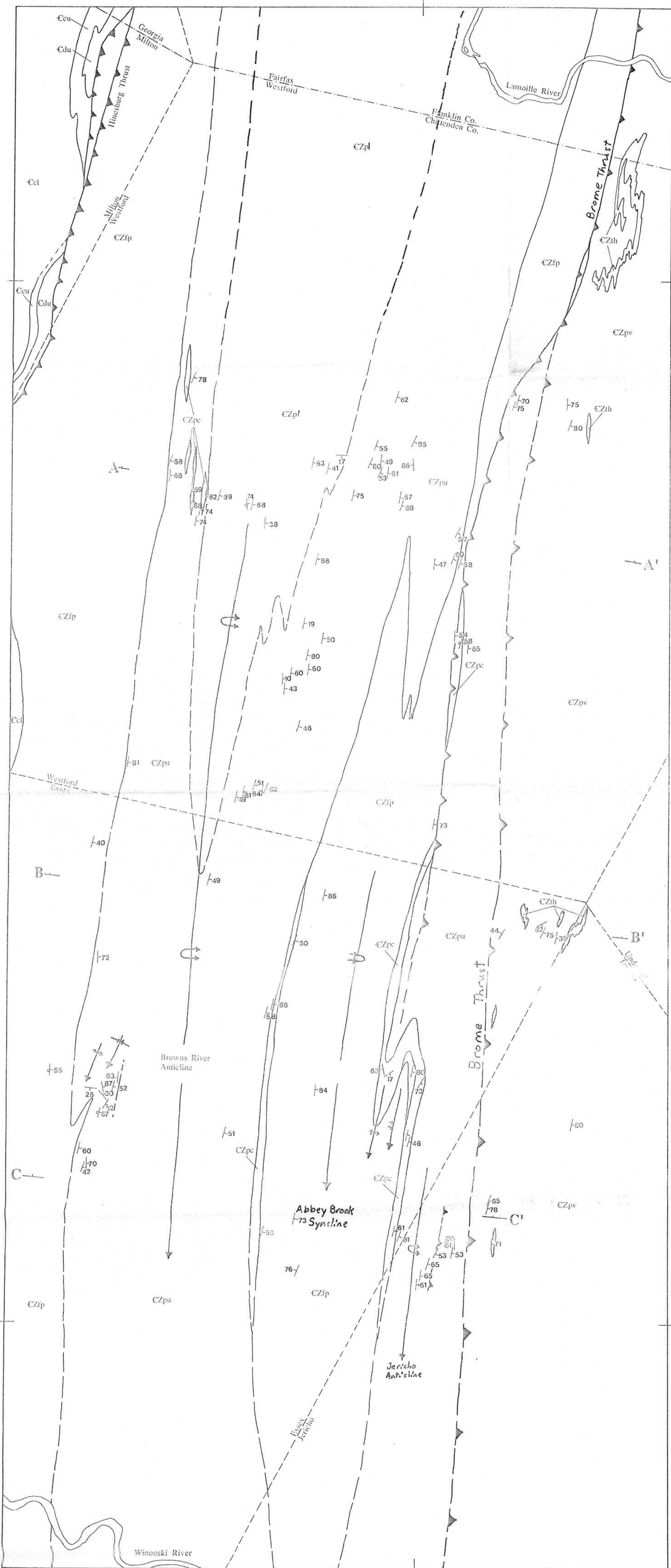


Figure 2. Location of other investigations of the Pinnacle Formation in Vermont and Quebec.

PLATE 1a

Bedrock Geology of the Pinnacle Formation Between the Lamoille and Winooski Rivers, VT.

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- EXPLANATION**
- CAMBRIAN**
 - CHESHIRE FORMATION
 - Ccu Upper dolomitic mbr.
 - Ccl Lower argillaceous mbr.
 - FAIRFIELD POND FORMATION
 - CZfp
 - PINNACLE FORMATION
 - CZp
 - CZpc Quartz pebble conglomerate
 - CZpu Upper metawacke member
 - CZpl Lower metawacke member
 - CZpv Eastern volcanics
 - CZpth Tibbet hill volcanics
 - PRECAMBRIAN**
- MAP SYMBOLS**
- Lithic contact (dashed where inferred)
 - Thrust fault, teeth on upper plate (dashed where inferred)
 - PLANAR FEATURES**
 - Bedding
 - Bedding where tops of beds are known
 - Bedding overturned
 - LINEAR FEATURES**
 - Trace of anticline
 - overturned
 - Trace of syncline
 - overturned

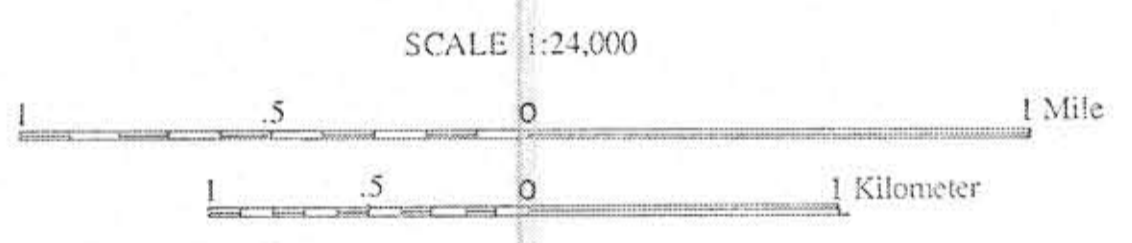
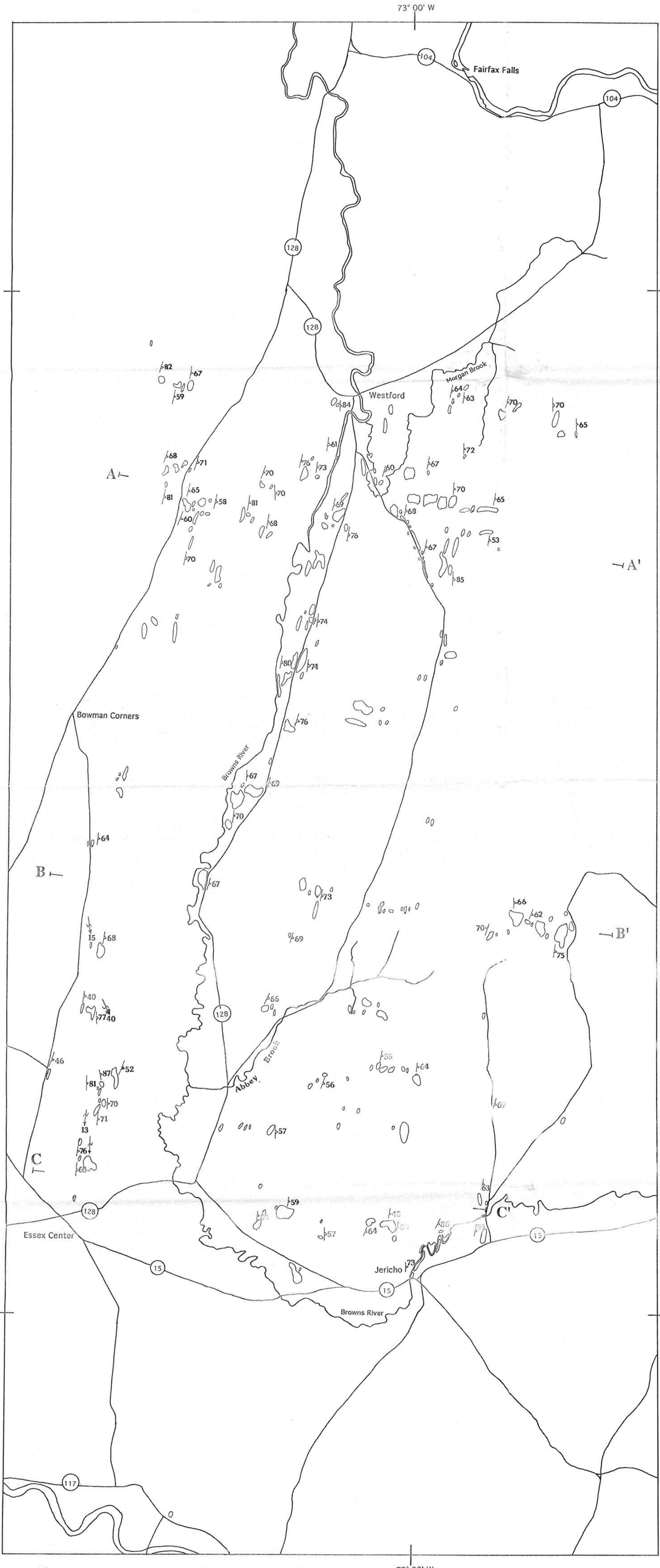


PLATE 1b

Structural Geology and Outcrop Map of the Pinnacle Formation Between the Lamoile and Winooski Rivers, VT.

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EXPLANATION

MAP SYMBOLS

PLANAR FEATURES

S1 Schistosity

S1 Schistosity

LINEAR FEATURES

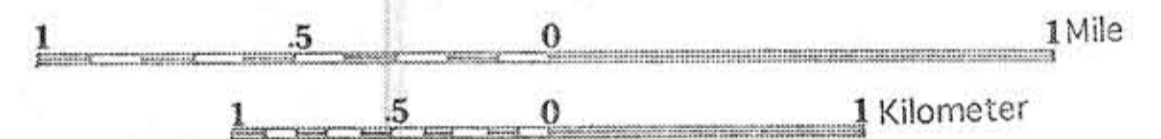
Small-scale fold, east climbing

Small-scale fold, west climbing

128 State Route Numbers

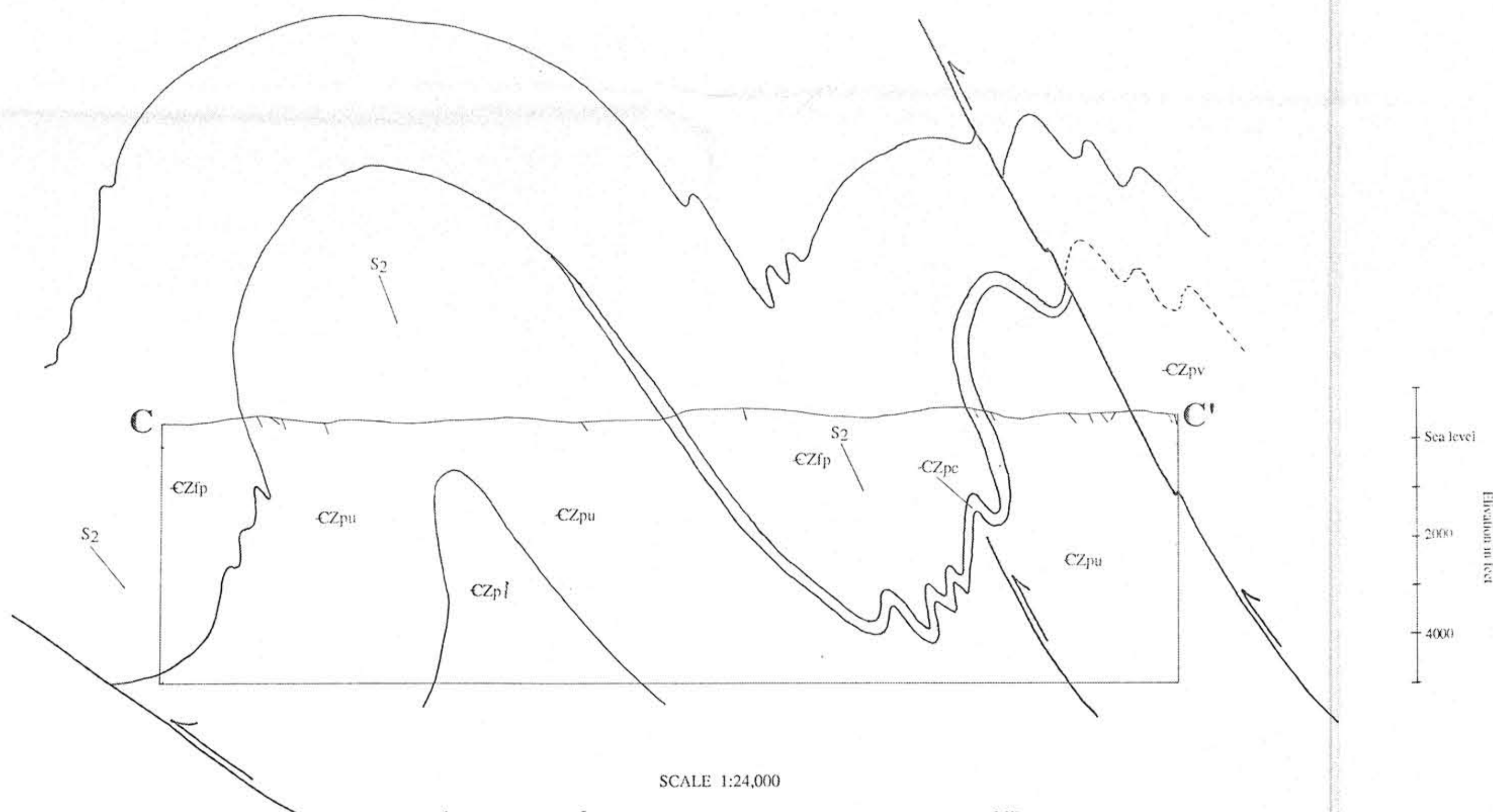
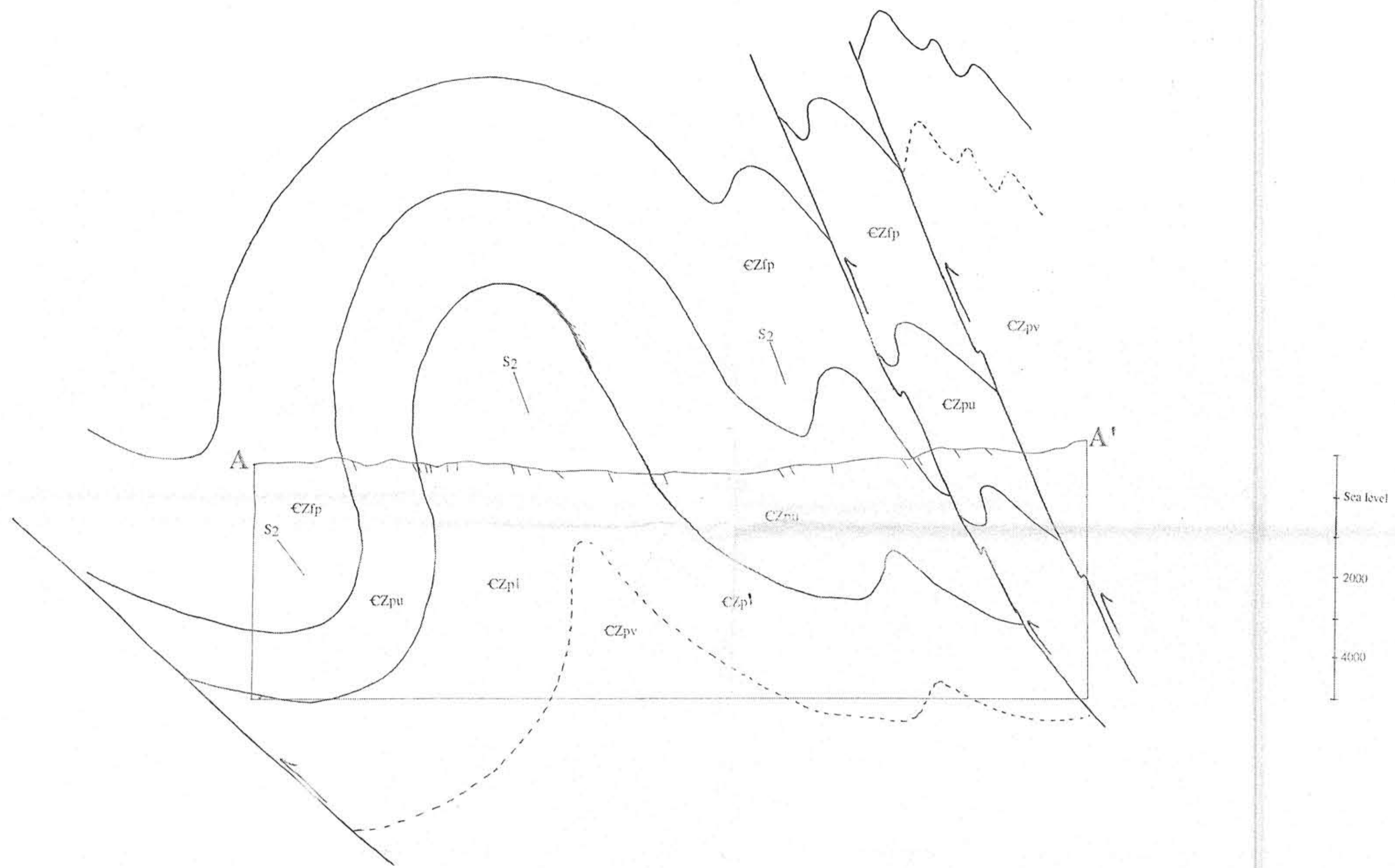
Outcrop

Scale 1:24,000



Field work conducted during the summer of 1994 by Lars C. Chericetti under contract 0960280 Vermont Geological Survey.

Plate 2
 Interpretive Cross Section
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SCALE 1:24,000
 1 0.5 0 1 Mile
 1 0.5 0 1 Kilometer
 No Vertical Exaggeration