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Recombent and Reclined Folds of the Mt. Cube Area New Hampshire - Vermont

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TRIP A-6

RECUMBENT AND RECLINED FOLDS OF THE MT. CUBE AREA NEW HAMPSHIRE - VERMONT

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Introduction

The purpose of the field trip is to study the outcrop pattern and minor structures of recumbent and reclined folds believed to be northern extensions of the Skitchewaug Nappe (read Thompson, et al., 1968, for necessary background material). The rocks exposed in the folds also afford an opportunity to identify the mineral assemblages of pelitic schists, quartzites, calc-silicate rocks, and amphibolites regionally metamorphosed to kyanite-staurolite grade. The trip consists of two 1 1/2 mile woods traverses; there will be no roadcut stops. The traverse across the Jacobs Brook recumbent syncline utilizes lumber roads through open woods. The Wilmot Mountain traverse is a strenuous hike through thick underbrush and blow-down.

Acknowledgements

The field work on which the field trip is based was done under the direction of Professors J. B. Thompson, Jr., M. P. Billings, and John Haller, while the writer was a graduate student at Harvard University. Professor John B. Lyons made available laboratory facilities at Dartmouth College and contributed to many field conferences during the course of the work. Messrs. J. C. Hepburn, G. Patterson, A. C. Hine, and D. Walker assisted in the field work.

Stratigraphy

The uncomformity between the Pre-Silurian and Siluro-Devonian rocks is folded by the Jacobs Brook recumbent syncline and by the Wilmot Mtn. reclined fold. The Pre-Silurian rocks exposed in the limbs of the Jacobs Brook recumbent syncline are hornblende amphibolite and quartz-feldspar-biotite gneiss of the Middle Ordovician Ammonoosuc Volcanics. The Partridge Formation,

found overlying the Ammonoosuc Volcanics in other areas, is absent. Quartz conglomerate, quartzite, and quartz-mica schist of the late Early Silurian Clough Formation as well as marble, calc-silicate granulite, and biotite schist of the Late Silurian Fitch Formation occupy the core of the recumbent syncline.

Pre-Silurian rocks of the Wilmot Mountain reclined fold include horblende amphibolites and amphibolites with assemblages of colorless and pleochroic amphiboles. These rocks belong to the outcrop belt of the Post Pond Volcanics of the Orfordville Formation (read Hadley, 1942, for a complete review of previous work in the Mt. Cube area) and are possibly correlative with the Ammonoosuc Volcanics. Quartz conglomerate of the Clough Formation and calcareous schist of the Fitch Formation lie at the base of the Siluro-Devonian succession. Mica schists of the Lower Devonian Littleton Formation are the youngest rocks exposed in the reclined fold (read Rumble, 1969a, 1969b, for the justification of correlating these rocks with the Siluro-Devonian section).

Structure

The Siluro-Devonian rocks of the Mt. Cube area record at least two periods of pervasive folding. The older of the two sets of folds are recumbent and reclined folds such as the Jacobs Brook recumbent syncline and the Wilmot Mountain reclined fold (Figure 1). The younger folds are upright folds such as the NNE-trending Cottonstone Mountain and Bronson Hill anticlinoria (Figure 1).

The Jacobs Brook recumbent syncline lies in the mantle of the Smarts Mountain dome, one of a series of gneiss domes that together make up the Bronson Hill anticlinorium. It is evident from the hook-shaped outcrop pattern of the recumbent syncline that it has been refolded by the NNE-plunging Smarts Mountain dome (Figure 1, Figure 2). The minor folds of the Jacobs Brook area consist of an older and a younger group. The older group of folds is parasitic to the recumbent syncline and is of reclined or recumbent orientation. The younger group of folds is of upright orientation and is parasitic to the Smarts Mountain dome.

The Wilmot Mountain reclined fold is exposed in the west limb of the Cottonstone Mountain anticlinorium (Figures 1 and 3).

The older minor folds of the Wilmot Mountain area are of reclined orientation and have an axial surface schistosity. Younger, upright folds in schistosity are parasistic to the Cottonstone Mountain anticlinorium. The Wilmot Mountain reclined fold was tilted into its present position at the same time that the Jacobs Brook recumbent syncline was refolded by the Smarts Mountain dome. It is also probable that the Jacobs Brook recumbent syncline and the Wilmot Mountain reclined fold were formed at the same time.

Regional Metamorphism

Although the pelitic schists of the Jacobs Brook recumbent syncline and the Wilmot Mountain reclined fold are kyanite- and staurolite-bearing, they belong to different metamorphic subfacies. The quartz-muscovite schists of the Jacobs Brook recumbent syncline are characterized by the incompatibility of kyanite and biotite. Mineral assemblages such as staurolite-chlorite-biotite, and kyanite-chlorite-staurolite occur instead. In contrast, the assemblages kyanite-staurolite-biotite and kyanite-staurolite-garnet-biotite are common in the quartz-muscovite schists of Wilmot Mountain.

The porphyroblastic minerals of both areas are usually oriented with their longest dimensions lying in the plane of the schistosity which is parallel to the axial surfaces of the older folds. Recrystallization was not, however, limited to the older period of deformation because the folded schistosity and rotated porphyroblasts of the younger folds show no cataclasis.

REFERENCES CITED

Hadley, J. B., 1942, Stratigraphy, structure, and petrology of the Mt. Cube area, New Hampshire; Geol. Soc. Amer. Bull., v. 53, p. 113-176.

Rumble, D., 1969a, Stratigraphy of the Orfordville Formation, western New Hampshire-eastern Vermont; (abs.), Geol. Soc. Amer., Abstracts with Programs for 1969, Part I, p. 52.

Rumble, D., 1969b, Geological problems of the Mr. Cube area, New Hampshire-Vermont; unpublished Ph.D. thesis, Dept. Geological Sciences, Harvard University.

Thompson, J. B., Jr. and P. Robinson, T. N. Clifford, N. J. Trask, Jr., 1968, Nappes and gneiss domes in west-central New England; p. 203-218, in Studies of Appalachian Geology Northern and Maritime, E-an Zen, et al., eds., John Wiley, New York.

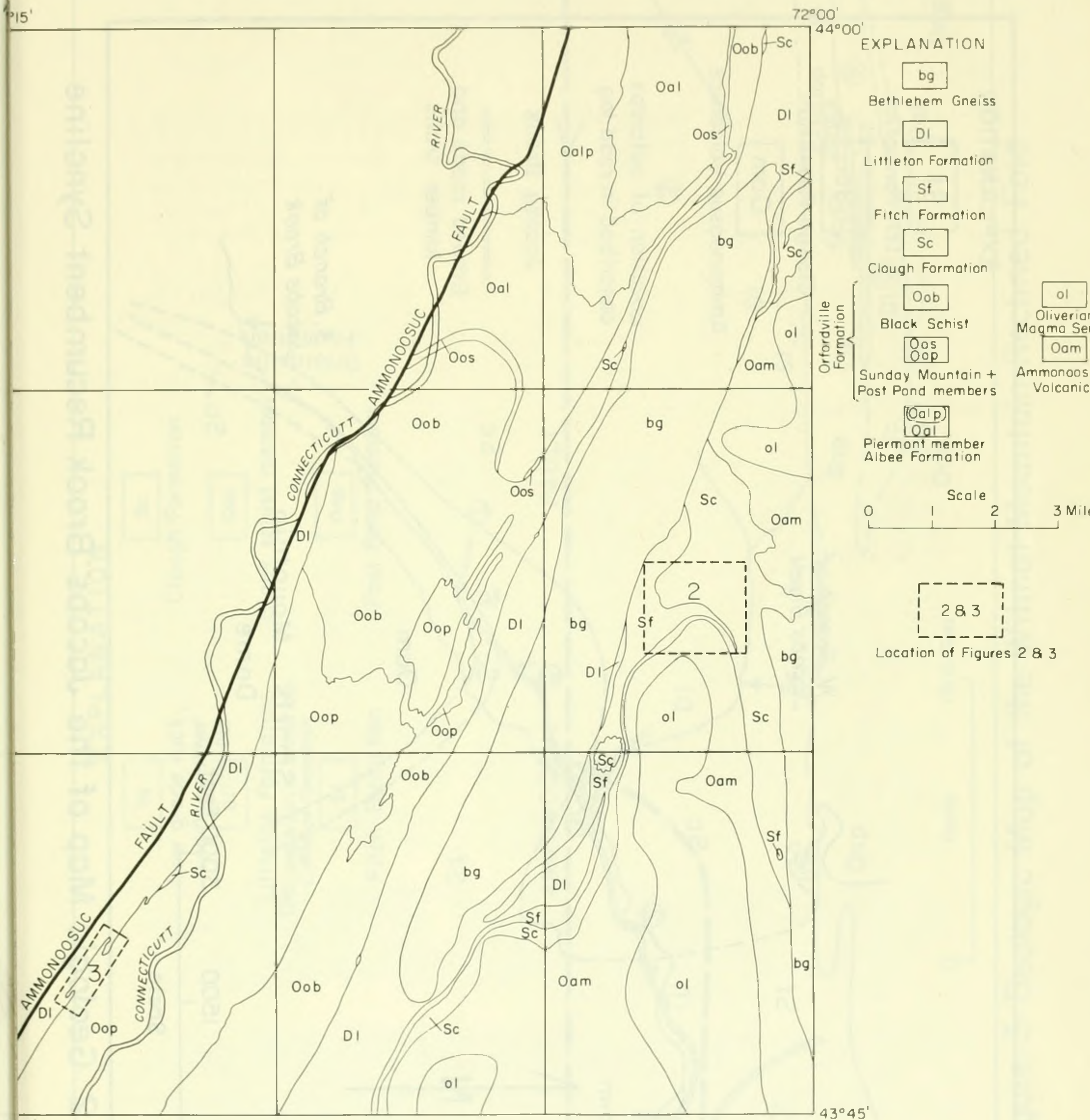

Figure 1 Geologic Map of the Rocks East of the Ammonoosuc Fault, Mt. Cube Quadrangle (after Hadley, 1942 and Rumble, 1969)

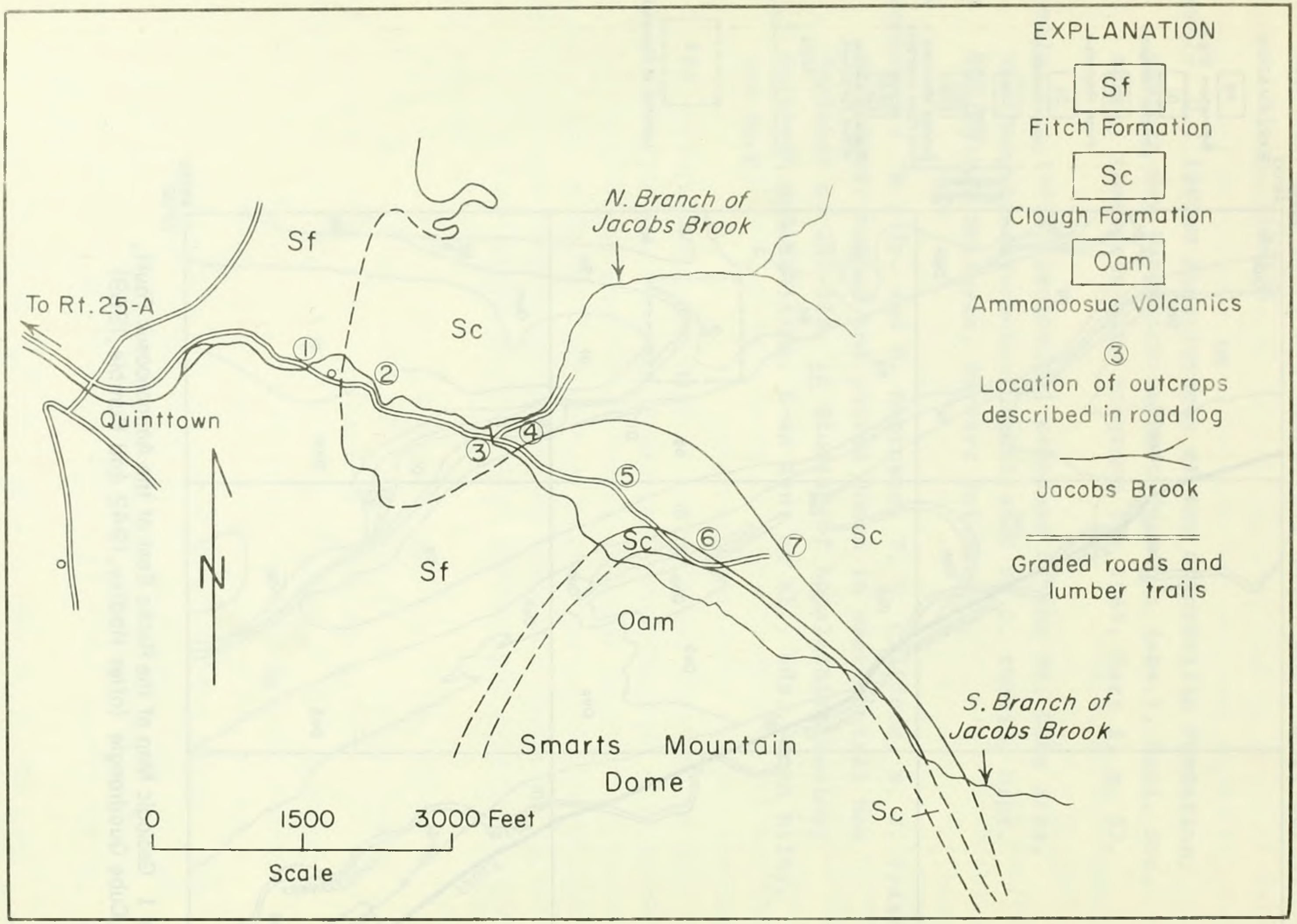

Figure 2 Geologic Map of the Jacobs Brook Recumbent Syncline

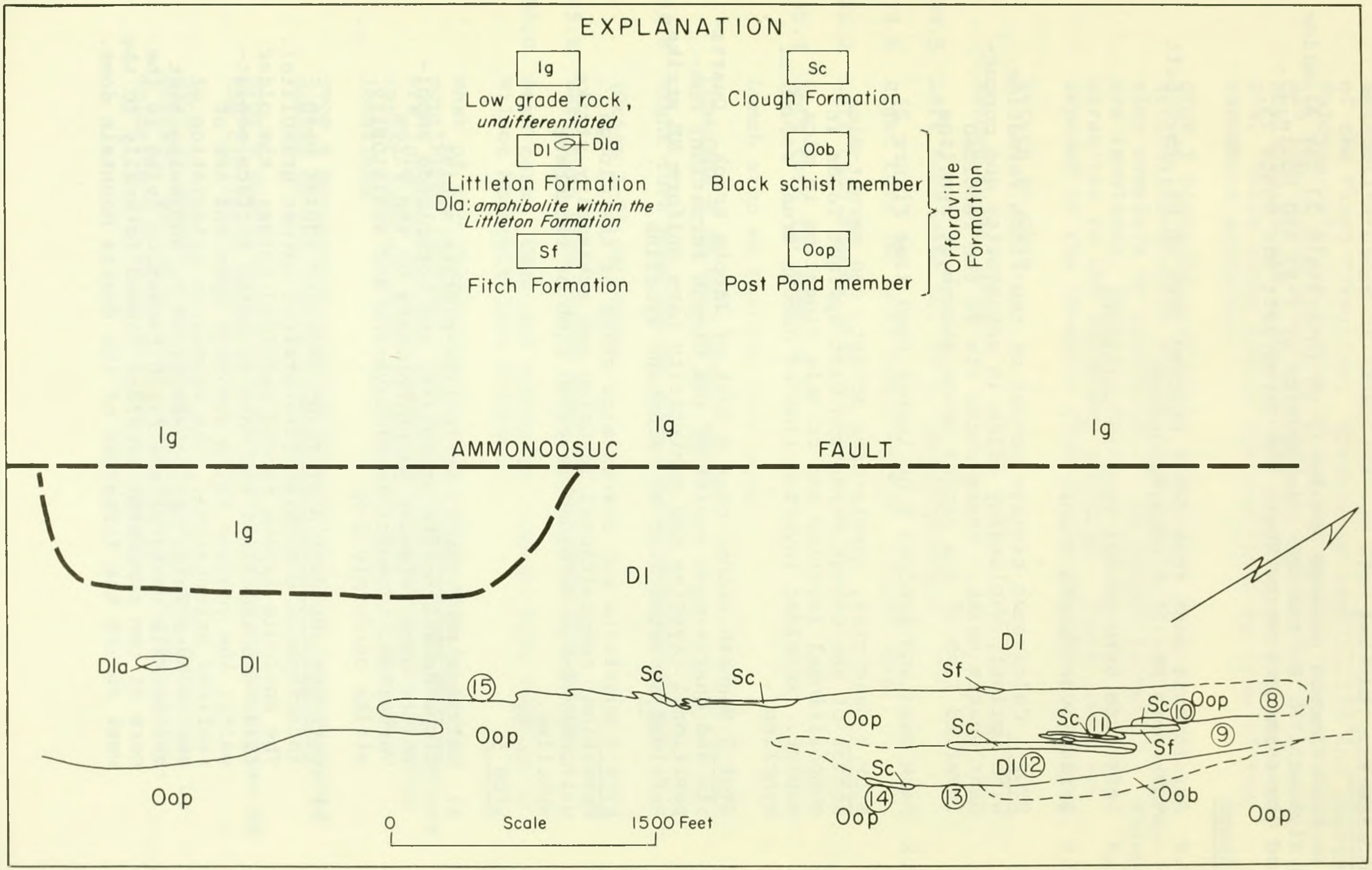

Figure 3 Geologic Map of the Wilmot Mountain Reclined Fold

ROAD LOG FOR TRIP A-6

From Concord proceed northerly on Interstate 23 for 41 miles to Plymouth, N. H. and the intersection of I-93 and Route 25. Road log commences where Route 25A turns left off Route 25.

Mileage

0.0 Rt. 25 exit west from I-93; proceed west on Rt. 25. Left turn onto Rt. 25-A towards Orford.

24.9 Left turn onto gravel road to Quinttown.

27.0 Bridge over Jacobs Brook.

STOP 1 Calcareous biotite schist of the Fitch Formation with upright, N-plunging folds in schistosity and concordant quartz veins. These rocks lie in the refolded inverted limb of the Jacobs Brook recumbent syncline.

27.2 Park cars and proceed E on lumber road (see Figure 2).

STOP 2 Quartzite, quartz-mica schist, and garnet-mica schist of the Clough Formation with upright folds in compositional layering and crinkle lineation in mica schist. Refolded inverted limb of Jacobs Brook recumbent syncline.

STOP 3 Beneath bridge over S fork of Jacobs Brook. Quartzite and quartz-mica schist of the Clough Formation; compositional layering and schistosity have uniform NE strike. Refolded inverted limb of recumbent syncline.

STOP 4 Quartzite and quartz-mica shist of the Clough Formation; compositional layering and schisosity strike uniformly E-W. Refolded inverted limb of recumbent syncline.

STOP 5

a) Outcrops near road: Actinolite-biotite schist, diopside-actinolite granulite, and hornblende amphibolite with feldspar porphyroblasts of the Fitch Formation. Compositional layering and schistosity strike uniformly E-W.

b) Outcrops 200 feet N of road: Biotite schist with interlayered coticule (fine-grained garnet granulite). The coticule layers record refolded folds: the older folds are isoclinal and have an axial surface schistosity; the younger folds are more open and are of reclined orientation. The anomalous orientation of the younger folds may be explained by supposing that the ductile rocks of the Fitch Formation lying in the core of the recumbent syncline flowed laterally to the west during the formation of the Smarts Mountain dome.

STOP 6 Quartzite of the Clough Formation overlain by actinolite-diopside granulite and fine-grained quartzite of the Fitch Formation. Hornblende amphibolite and quartz-feldspar-biotite gneiss of the Ammonoosuc Volcanics underlie the Clough and are exposed in lumber road 200' to E. Schistosity and compositional layering strike uniformly E-W. These rocks lie in the right-way-up limb of the recumbent syncline.

STOP 7 Diopside-actinolite granulite, biotite schist, actinolite-biotite schist, and marble of the Fitch Formation overlain by quartzite of the Clough Formation. There are isoclinal, reclined folds in the contact that are parasitic to the recumbent syncline. These rocks are exposed in the inverted limb of the recumbent syncline.

Return to cars.

Return to Rt. 25-A.

29.5 Left turn onto Rt. 25-A, toward Orford.

34.8 Right turn (N) onto combined Rts. 10 and 25-A.

35.2 Left turn across 25-A bridge to Fairlee.

35.4 Left turn (S) onto US 5.

Lunch stop on Fairlee town green.

Continue S on US 5 after lunch.

44.6 Right turn onto gravel road toward Stevens School.

(Cross I-91 on bridge.)

45.8 Left turn onto gravel road (first left past I-91).

50.0 Park cars. Gate and overgrown road on left lead up to Wilmot Mountain (see Figure 3).

Most of the Wilmot Mountain traverse will be across continuous outcrop. The stop locations and descriptions are intended to call attention to important rock types rather then to refer to specific rocks at specific locations.

STOP 8 Hornblende amphibolite of the Post Pond Volcanic member of the Orfordville Formation.

STOP 9 Quartz-muscovite-biotite-garnet-kyanite schist of the Littleton Formation.

STOP 10 Quartz conglomerate of the Clough Formation in contact, to the E, with calcareous quartz-muscovite-chlorite schist of the Fitch Formation.

STOP 11 Continue south along strike. Note the left-hand offsets in the Siluro-Devonian/Pre-Silurian contact. Hornblende amphibolite of the Post Pond Volcanics, to the W, in contact with quartz conglomerate of the Clough Formation. Calcareous quartz-muscovite-chlorite schist of the Fitch Formation and quartz-muscovite-biotite-garnet schist of the Littleton Formation in contact with Clough Formation to E.

STOP 12 Walk across strike to SE. Cross outcrops of quartz-muscovite-biotite-garnet-kyanite-staurolite schist of the Littleton Formation. Note quartz-kyanite veins.

STOP 13 Hornblende amphibolite and hornblende gneiss of the Post Pond Volcanics.

STOP 14 Quartz conglomerate of the Clough Formation in contact to E with hornblende amphibolite of the Post Pond Volcanics and in contact to W with quartz-muscovite-biotite-garnet schist of the Littleton Formation. Amphibolites with colorless amphiboles have been collected from the Post Pond Volcanics in this area.

Return to cars.

If time permits and the group so desires, an additional stop may be made at Stop 15 (Figure 3).

STOP 15 Exposure of the Siluro-Devonian/Pre-Silurian unconformity. The Pre-Silurian rocks are hornblende amphibolites and coticule (fine-grained garnet granulite) schists of the Post Pond Volcanics. The Siluro-Devonian rocks are the quartz-muscovite-biotite-garnet-staurolite-kyanite schists of the Littleton Formation with abundant quartz-kyanite veins. The unconformity has been folded into left-handed asymmetric folds of reclined orientation. The coticule schist records the asymmetric folds in spectacular fashion. Quartz conglomerate of the Clough Formation is found 200 yards to the north along the contact.