TRIP A-4

GEOLOGY OF MASCOMA MANTLED GNEISS DOME NEAR HANOVER, NEW HAMPSHIRE

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Introduction

This trip will show the core and mantle rocks of the Mascoma Dome, which is one of the best examples of the Oliverian belt of mantled gneiss domes. The trip will emphasize the geological features which led me to reinterpret the core rocks of the domes as part of an Ordovician Volcanic and intrusive complex--possibly an island arc.

The stratigraphy of the area is the classical Littleton (youngest), Fitch, Clough, Ammonoosuc sequence of Billings (1937). My work has added a new stratigraphic unit called "Holts Ledge Gneiss" or "stratified core-rock of the Mascoma Dome" below the Ammonoosuc Volcanics. The area has been mapped at inch to the mile scale by Chapman (1939: Mascoma Quadrangle) and Hadley (1942: Mt. Cube Quadrangle). These authors should be consulted for detailed descriptions of the units. My field and geochronologic data and the resulting interpretations are given in two papers (Naylor, 1968; 1969). The latter summarizes the Mascoma area geology and geochronology and reviews the general mantled gneiss dome problem. It is called to your attention in lieu of a general discussion in this guidebook.

A New Hampshire road map and copies of the Mascoma and the Mt. Cube 15 minute quadrangles will be useful on the trip.

REFERENCES CITED

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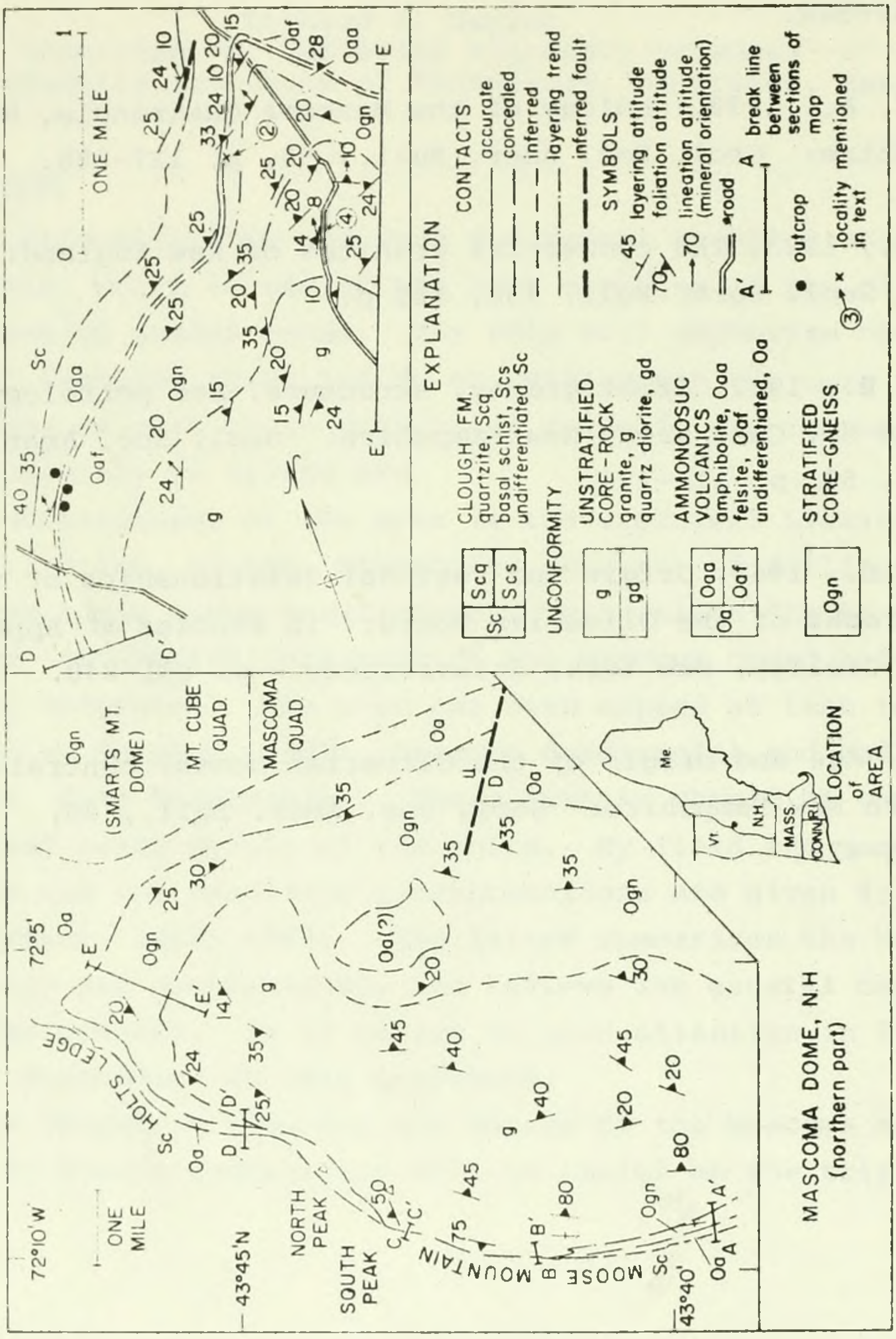

Figure 1. Geologic map of northern part of Mascoma Dome. Generalized geologic map (modified from Chapman, 1939, and Hadley, 1942) showing location of detail maps. Detail geologic map of northern end of dome.

After R. S. Naylor, 1969, Geol. Soc. America Bull., v.80, p.407

Figure 1.

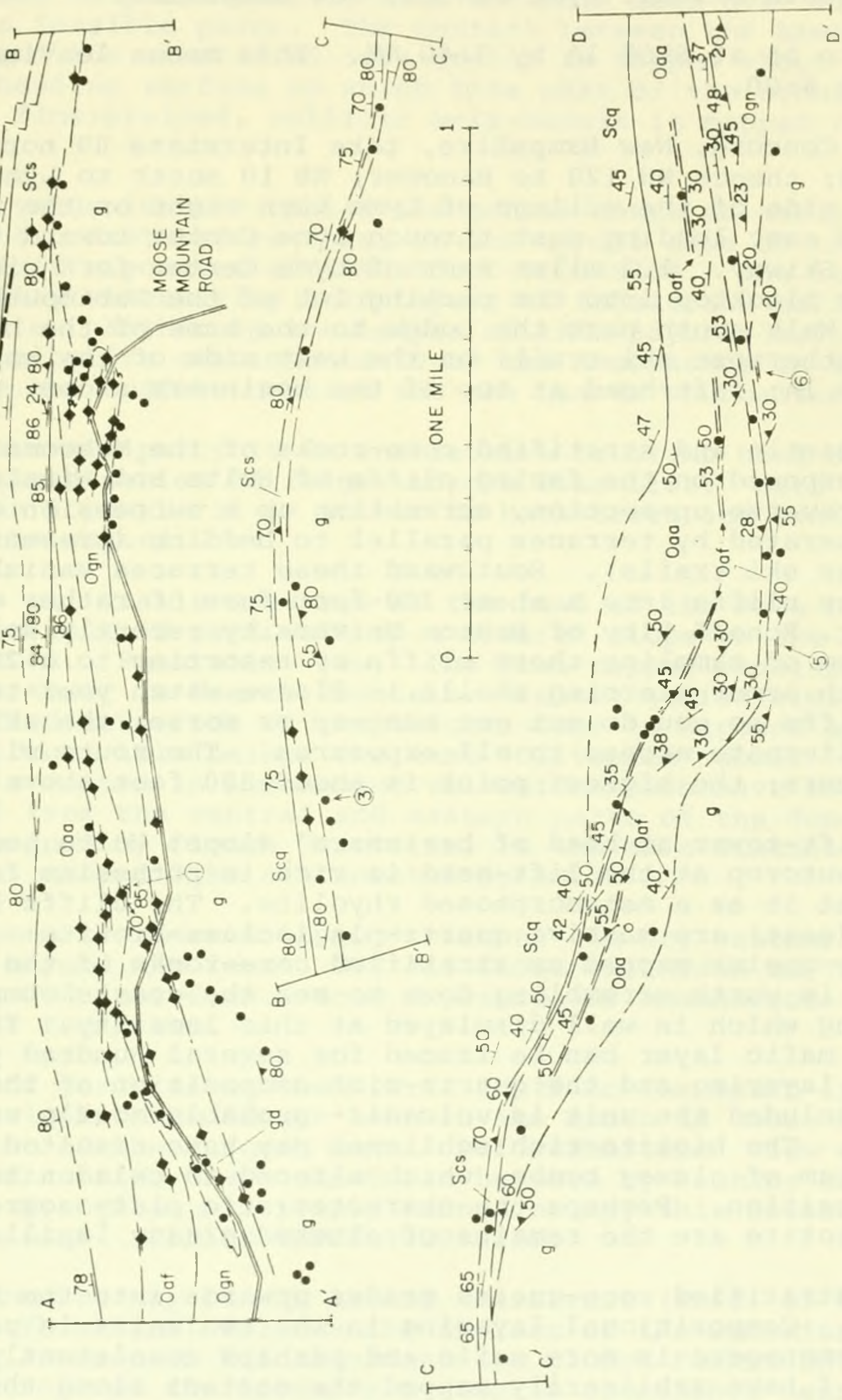

Figure 2. Geologic maps of western margin of Masoma Dome. For location of maps and explanation see Figure 1.

After R. S. Naylor, Geol. Soc. America Bull., v. 80, p. 408

Figure 2.

ROAD LOG FOR TRIP A-4

Assembly Point

DARTMOUTH SKIWAY, Lyme Center, New Hampshire.

Try to be at STOP 1A by 9:40 AM. This means leaving CONCORD by 8:00.

From Concord, New Hampshire, take Interstate 89 north to to exit 18; thence NH 120 to Hanover; NH 10 north to Lyme. On the north side of the village of Lyme turn right on the unnumbered paved road east leading east through Lyme Center toward the Dartmouth Skiway. 1.2 miles east of Lyme Center fork right and follow the blacktop into the parking lot of the Dartmouth Skiway. Lock up. Walk south past the Lodge to the base of the beginners slope (southermost ski trail) on the west side of the road. Hike up to STOP 1A; lift-head at top of the beginners slope.

The mantle and stratified core-rocks of the Mascoma Dome are well exposed on the facing cliffs of Holts and Winslow Ledges. We will traverse up-section, scrambling up a succession of low cliffs separated by terraces parallel to bedding (presently utilized as ski trails). Southward these terraces vanish, merging the cliffs into a sheer 200-foot face of rather crumbly rock. (Mr. Ronald Kley of Boston University recently solved the problem of sampling these cliffs by resorting to a 20 mm cannon with armor-piercing shells.) Please watch your traverse on the cliffs so you do not get hung-up or worse; the ski trails provide alternate access to all exposures. The route will take about 2 hours; the highest point is about 800 feet above the cars.

STOP 1A Lift-tower at head of beginners' slope; Holts Ledge.

The outcrop at the lift-head is rich in potassium feldspar. I interpret it as a metamorphosed rhyolite. The cliffs below the lift (east) are massive quartz-plagioclase-biotite-hornblende gneiss mapped as stratified core-rocks of the Mascoma Dome. It is worth scrambling down to see the coarse compositional layering which is well displayed at this locality. The prominent mafic layer can be traced for several hundred yards. From this layering and the quartz-rich composition of the rocks, I have concluded the unit is volcanic--probably mostly water-laid tuff. The biotite-rich schlieren may have resulted from metamorphism of glassy bombs, which altered to celadonite shortly after deposition. Perhaps the characteristic platy aggregates of fine biotite are the remains of altered glassy lapilli.

The stratified core-gneiss grades upwards into the Ammonoosuc Volcanics. Compositional layering in the two units is parallel, but the Ammonoosuc is more mafic and perhaps consistently finer grained. I have arbitrarily mapped the contact along the surface above which the mafic layers constitute more than 50 percent of the section. This is generally consistent with the criteria applied by other workers. There is no harm in considering the stratified core-gneiss as a lower member of the Ammonoosuc Volcanics. Owing to the controversy over its origin and since it is a distinctive lithological unit, I prefer to treat the Gneiss unit as a separate formation, to which I have informally applied

the name Holts Ledge Gneiss. Unfortunately, in print I was persuaded to use the more cumbersome name, "stratified core-gneiss of the Mascoma Dome".

STOP 1B Cross up to next higher ski trail--Don Worden's Schuss; proceed about 70 yards uphill, then scramble down over first ledges at a feasible place. The contact between the Ammonoosuc Volcanics and the stratified core-gneiss is mapped about 10 feet below the bedding surface on which this part of the schuss is laid. The fine-grained, sulfidic meta-basalt is mapped in the Ammonoosuc.

STOP 1C 50 yards further uphill the schuss takes an abrupt upturn to the right. Just before this, on the uphill side of the trail, are good cliff exposures of AMMONOOSUC VOLCANICS. The lower ledges display alternating thin layers of felsic and mafic gneiss and granulite. Higher up are ledges of thin-layered mafic epidote-amphibolite characteristic of the Ammonoosuc in the dome belt. Note the epidote nodules and the quartz tourmaline veins.

With a small party it is instructive to climb hand over hand up the complete series of ledges to the Poma Lift. With a group of more than 6 people it is better to back-track and continue the climb via the schuss.

STOP 1D The ski trails converge at the head of the Poma Lift. From here it is a 50-yard walk up a cleared slope to the overlook at HOLTS LEDGE. Panoramic view. The flat-topped mountain NE with a fire tower is Smarts Mountain. Felsic gneiss similar to the stratified core-rock of the Mascoma Dome is exposed on the steep west face, this being the next "Oliverian" dome. The firetower is rooted in Ammonoosuc volcanics which have not yet been eroded from the central and eastern parts of the dome. Mt. Cube, capped by Clough Quartzite, is the more distant mountain to the left, shaped like a truncated pyramid.

The fence is there with good reason. In dry weather it is safe to go beyond the fence, BUT PAY CLOSE ATTENTION TO THE EDGE--it is 200 feet down. Good exposures of Ammonoosuc Volcanics at the crest.

About 50 yards along the D.O.C. Trail to the south is another overlook. The larger lake to the south is Goose Pond in the center of the Mascoma Dome. A foreshortened view of the cliff containing the contact can be seen by looking back to the north. More than six people cannot occupy this second overlook at one time. PLEASE WATCH YOUR STEP!

STOP 1E Descend by way of the second trail west (left) of the Poma Lift. This trail follows the surface of the unconformity between the Ammonoosuc Volcanics and the Clough Formation. Several outcrops of the latter are readily accessible near Holts Ledge Cabin (D.O.C.) about halfway down.

Return to cars in parking lot for LUNCH.

0.0 Fork in road about 1.5 miles north of Robert Peter Brundage Ski Lodge.

1.2 Lyme Center. LEFT TURN at store, cross bridge, and proceed up steep hill.

2.9 Former Chesley School on left.

3.5 FORK RIGHT on upper road.

4.5 STRAIGHT through cross road, continue up steep hill.

5.9 MERGE with ETNA road (paved), continue south. You are now in MASCOMA QUADRANGLE for rest of trip.

8.2 Cemetery in Hanover Center.

9.8 Cemetery on right.

10.1 Church on left. LEFT TURN at junction 0.1 mile beyond church.

11.8 STRAIGHT at junction, cross bridge.

12.3 LEFT on dirt road which dips steeply; blacktop curves right just beyond turn.

12.7 <u>STOP 2</u> at dirt road on right, park north of house and red barn. Squeeze into as few cars as possible, park and lock the others. Do not block either road.

Drive up dirt road towards WHED-TV tower. At top of Moose Mountain (about 0.7 mile) take right fork; park near houses 0.2 miles south.

Walk to end of road beyond second house. Continue south along cow-path through pasture. Path climbs past ledges of CLOUGH quartzite. Uphill through open orchard at south end of pasture into upper meadow. Continue to top of hill at south end of upper meadow. In open woods to the south are basal beds of Clough quartzite. Immediately east are exposures of weathered muscovite-bearing granite. The granite lies unconformably beneath the Clough. Weathering below the unconformity probably led to an enrichment in Al which became muscovite after Acadian regional metamorphism.

Chapman (1939) mapped a large bulge of granite cutting the Clough one mile north of this stop. His map is in error due to faulty base-map topography. Detailed mapping shows no beds of Clough cut by the granite.

12.7 Return to parked cars. Turn around. Go back out the way we came in.

13.2 LEFT TURN onto blacktop heading south.

16.7 LEFT TURN onto US 4 heading east. Watch stop sign.

18.1 Village of Enfield. Stay on US 4 as it winds to the left.

18.3 LEFT TURN onto Moose Mountain Road at crossroads (at bottom of hill 0.15 mile past Elementary School on left). If you pass Baltic Mills you have gone .5 mile too far on US 4.

18.4 FORK LEFT up hill.

21.4 Road enters woods. This will be Stop 4. Continue straight for Stop 3.

21.8 STOP 3 At trail on right. Park cars so as not to block main road. Lock up.

Follow the trail (right fork about 50 yards east from the road) about 1/2 mile uphill to the abandoned MOOSE MOUNTAIN quarry. This is the quarry shown on most editions of the topographic map.

Contrast the massive character of the quarry rock with the coarsely stratified character of the rocks at Stop 1A. The structure and texture of the rock, its chemical composition, its crosscutting relationships with the stratified rocks, and the aplite and pegmatite veins indicate that the rock is intrusive. The intrusion was probably shallow. Note the presence of magnetite (in well developed octahedra--probably primary) coexisting with biotite and microcline. D. R. Wones (personal communication, 1967) suggests this indicates P_{H_2O} was less than 1.5 kb when the magma crystallized (at higher water pressure all of the Fe could be stable in biotite). The aplite veins indicate that the total pressure was less than P_{H_2O} in the late stages of intrusion--hence, shallow intrusion. This is consistent with the unroofing relationships discussed at Stop 2.

Clough Quartizite unconformably resting on granite supports Moose Mountain, the prominent ridge 1 km west. The granite constitutes the upper part of the intrusive body. Structurally lower intrusive rocks are quartz monzonite. Being somewhat more mafic, they erode more readily and underlie the lower ground east of the granite hills.

Rock from this small quarry was probably used mostly for local construction of foundations and stone walls. A larger quarry in similar rock two miles south (one mile east of Enfield Reservoir) yielded exportable constructional granite used in the Tercentennial monument, Jamestown, Virginia; Plain Dealer Building, Cleveland, Ohio; Carnegie Institute, Pittsburg, Pennsylvania; and Royal Bank of Canada, Winnipeg, Manitoba (Dale, 1923, p. 178).

21.8 Return to cars. Turn around and proceed back the way you came in.

22.2 Road leaves woods, curves left.

22.3 STOP 4 Park cars in front of cabin so as not to block road or drive.

This area is a critical one for working out the relationships between the major rock units in the dome. Significant ourcrops are scattered through about 300 acres of dense brush, but fortunately most of the units are well expressed in the topography, so we can see things from the road.

An unusually mafic phase of the stratified core-geniss ("Holts Ledge Gneiss") is exposed along the road. More felsic gneiss crops out in the fields to the west. The mafic Ammonoosuc Volcanics start further west at the break in slope back of the tree line. The steep slope is covered with talus of Clough Quartzite which crops out nearly continuously along the ridge crest (Moose Mountain)--in other words, the normal stratigraphic succession for the area.

The line of hills to the east is underlain by granite, the first outcrops of which occur about 50 yards east of the road beyond the row of trees. From here south to beyond Stop 5, the contact between the granite and the stratified core-gneiss is roughly concordant.

Immediately north of Stop 4, the granite contact swings abruptly west cutting across the stratified core-gneiss, until the granite eventually comes in contact with the Clough Quartzite where we saw it at Stop 3 (one mile north of here). The Ammonoosuc Volcanics pinch out somewhere in a zone of no exposure. Aplitic veins are abundant in the stratified core-gneiss near the granite.

The field relationships indicate that the Clough Quartzite rests unconformably on all of the older units. The granite is younger than the stratified core-gneiss, but older than the Clough. The relationship between the granite and the Ammonoosuc Volcanics is uncertain here.

Continue south.

22.9 Farmhouse on right.

23.4 STOP 5 Farm with barns to right and left. Park so as not to block any roads. Walk back (north) to curve in road.

This stop shows a concordant stretch of contact between the granite (unstratified core-rock of the Mascoma Dome), and the Holts Ledge Gneiss (stratified core-rock). Granite, slightly more mafic than usual, is exposed in the bend of the road. Note the large aplite vein. Thirty feet south is a large exposure of mafic stratified core gneiss. Note the large epidote nodules and the aplitic veins. The veins were probably originally granite, but the potassium has subsequently reacted into the mafic gneiss. This contact can be traced for several miles locally and is essentially concordant. The Ammonoosuc Volcanics begin at the break in slope beyond the tree line uphill.

END OF TRIP - Continue south back to Enfield Village. Concord and Boston via US 4; make left turn on US 4 at crossroads.

OR

Right on US 4; proceed about 5 miles west to Interstate 89 at exit 17; south for Concord and Boston. For Connecticut and New York, go north on 89 five more miles to Interstate 91 South.

To eat, try Riverside Grill off US 4 at 89 exit 17. Either route to Concord is about the same travel time.