UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Field trip guidebook to selected metallic mineral deposits in the Glens Falls 1^{0} x 2^{0} quadrangle, New York, Vermont, and New Hampshire

by

J.F. Slack[1/], G.R. Robinson, Jr.[1/], and J.M. McLelland[2/]

[1/] U.S. Geological Survey, Reston, VA 22092

[2/] Colgate University, Hamilton, NY 13346

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This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature.

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PREFACE

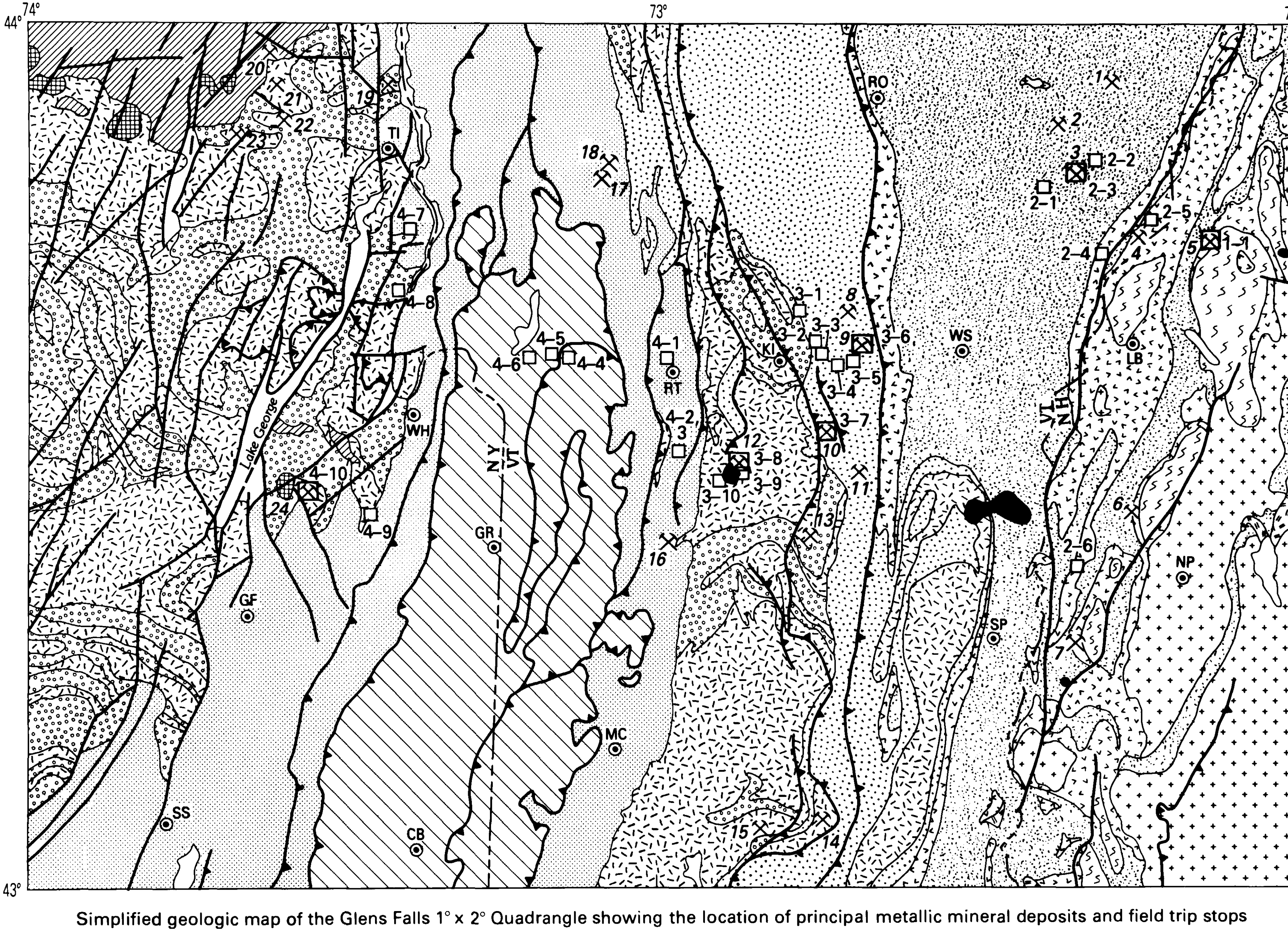
This guidebook was originally written for the final Glens Falls CUSMAP field trip, held September 16-19, 1986. The Glens Falls 1° x 2° quadrangle (New York-Vermont-New Hampshire) is one of a number of 1:250,000-scale quadrangles investigated under the auspices of CUSMAP (Conterminous United States Mineral Assessment Program). The field trip described here is designed to show the principal metallic mineral deposits and related geology of the Glens Falls 1° x 2° quadrangle. Because of time limitations, only representative examples of the most important types of deposits are described in this guidebook. Areas having newly recognized mineral potential are included also, in the hope of stimulating additional study.

The geologic map and explanation, which precede the roadlog, allow the reader to determine the location of individual field trip stops and their regional geologic setting. More detailed geologic maps are available for most of the stops in Vermont and New Hampshire, which are published (commonly at 15-Minute scale) as part of bulletins of the Vermont Geological Survey, and, in New Hampshire, with papers in older (1940s-1950s) bulletins of the Geological Society of America.

Some of the descriptions of geological stops on the field trip are reproduced from previously published guidebooks. The stops in the eastern cover sequence of the Green Mountain massif and a few of the stops in the shelf sequence are taken largely from the roadlog of Thompson (1972). In the Orange County copper district, the stops and descriptions in and surrounding the Elizabeth mine are duplicated from Slack and Atelsek (1983). The quarry stops and traverse across metamorphosed hydrothermally altered volcanic rocks are reproduced, in part, from Spear and Rumble (1986).

Many people have helped to bring this field trip and guidebook to fruition. John Lyons and Half Zantop supplied samples from Holts Ledge for study and analysis, and provided logistical help in locating the veins; Chuck Ratte assisted in selecting the stop at the Taggart mine. Appreciation is also extended to Frank Spear and Doug Rumble for permission to visit their excursion sites, and to Peter Robinson (as editor) for providing a preliminary copy of their IMA guidebook during planning of the trip. Finally, gratitude is expressed to all of the property owners who have graciously allowed access to their land on the field trip. Those persons who may later follow this roadlog are urged to ask permission from local landowners in order to cross private property. This will help to insure continued access for geologists on future trips in the region.

John F. Slack
U.S. Geological Survey
National Center, Mail Stop 954
Reston, Virginia 22092



Simplified geologic map of the Glens Falls 1° x 2° Quadrangle showing the location of principal metallic mineral deposits and field trip stops

MAP EXPLANATION

Intrusive Rocks

CRETACEOUS AND JURASSIC	Syenite, granite, gabbro
MISSISSIPPIAN AND UPPER DEVONIAN	Two-mica granite
MIDDLE AND LOWER DEVONIAN	Chiefly granodiorite
UPPER PROTEROZOIC	Meta-anorthosite; Metagabbro

Stratified Rocks

LOWER DEVONIAN, SILURIAN, AND ORDOVICIAN (?)	Clastic and carbonate metasedimentary rocks
SILURIAN (?) AND ORDOVICIAN	Metavolcanic and minor metasedimentary rocks
UPPER AND MIDDLE ORDOVICIAN	Granitic gneiss (Oliverian domes)
ORDOVICIAN AND CAMBRIAN	Carbonate and quartzite (Shelf facies)
ORDOVICIAN, CAMBRIAN, AND UPPER PROTEROZOIC	Slate and Graywacke (Slope facies); Clastic metasedimentary rocks (Slope and basin facies)
UPPER PROTEROZOIC	Mainly felsic gneiss (metamorphosed granite); Clastic and carbonate metasedimentary rocks

Principal Metallic Mineral Deposits

1. Ely mine (Cu ± Zn)
2. Orange and Gove mines (Cu)
3. Elizabeth mine (Cu + Zn ± Ag)
4. Waterman mine (Cu ± Zn)
5. Holts Ledge (W + Mo ± Bi)
6. Croydon mine (Cu + Zn)
7. Neal mine (Cu ± Au)
8. Chateauguay mines (Au)
9. Taggart mine (Au ± Pb ± Cu)
10. Plymouth Union mine (Fe)
11. Rooks mine (Au ± Pb ± Cu)
12. Copperas Hill mine (Fe ± Au)
13. Okemo Mountain (U)
14. East Jamaica (U)
15. West Jamaica (U)
16. Vail mine (Fe + Mn)
17. Brandon mine (Fe)
18. Lion Hill mine (Zn + Pb)
19. Crown Point mines (Fe)
20. Moose Mountain (Fe + Ti)
21. Hammondville mines (Fe)
22. Skiff Mountain mine (Fe)
23. Paradox Lake mines (Fe)
24. Fort Ann mines (Fe)

Cities and Towns

LB	Lebanon, NH	MC	Manchester, VT
NP	Newport, NH	GR	Granville, NY
RO	Royalton, VT	WH	Whitehall, NY
WS	Woodstock, VT	TI	Ticonderoga, NY
SP	Springfield, VT	GF	Glens Falls, NY
KI	Killington, VT	CB	Cambridge, NY
RT	Rutland, VT	SS	Saratoga Springs, NY

2
Metallic mineral deposit

2–3
Field trip stop

High angle fault
dashed where approximate

Thrust fault
Sawteeth on upper plate

0 — 20 MILES

0 — 30 KILOMETERS

Geology compiled and modified
from Thompson and McLelland, 1986

DAY 1 - HOLTS LEDGE VEINS, NEW HAMPSHIRE

The purpose of this day is to visit mineralized quartz veins on Holts Ledge, along the Dartmouth College Skiway east of Lyme, New Hampshire. The veins are unusual for the region in that they locally contain coarse scheelite, which prompted selective mining for tungsten in the early 1950s. The geology of the Holts Ledge area is described in Hadley (1942), and the regional setting is shown by Lyons and others (1986).

Mileage	Comments and Descriptions
0.0	Leave Village Lodging Center, Killington Village, Vermont, on access road (north).
4.0	Intersection with U.S. Rte 4. Turn right (east).
10.4	Intersection with VT Rte 100 at West Bridgewater. Bear left and continue straight (east) on Rte 4.
16.1	Intersection with VT Rte 100A at Bridgewater Corners. Continue straight ahead (east) on Rte 4.
24.4	Town of Woodstock, VT. Woodstock Inn on right.
24.5	Intersection with VT Rte 12 (N). Continue straight (east) on Rte 4.
28.4	Intersection with VT Rte 12 (S). Continue straight (east) on Rte 4.
32.0	Cross Quechee Gorge.
34.7	I-89 (S) access road. Turn right to head south on I-89.
38.0	Exit for I-91. Exit right, then bear left to follow I-91 North. Note prominent sulfide-rich alteration zone in road cut immediately after I-89 exit, which is in the Ammonoosuc Volcanics (Post Pond Volcanics) of Ordovician age.
39.8	Cross White River.
49.2	Cross Ompompanoosuc River.
53.1	Exit 14 to VT Rte 113. Exit right.
53.3	Intersection with Rte 113. Turn right (east).
54.7	Intersection with U.S. Rte 5 at East Thetford, VT. Turn right (south).
54.8	Intersection with Lyme Road. Turn left (east).
55.1	Cross Connecticut River.

Daily Mileage	Comments and Descriptions
56.6	Intersection with NH Rte 10. Continue straight (east).
56.8	Intersection with road to Lyme Center. Continue straight ahead (east). Do not follow Rte 10.
58.5	Town of Lyme Center. Continue straight ahead.

STOP 1-1A

60.3 Dartmouth College Skiway. Park in lot at Brundage Lodge. Walk up road past Holts chair lift 0.1 mi to small dark green building. Hike up ski trail past green building, to elevation of approximately 1550 ft. (a steep 550-ft climb). On the lower part of the ski trail are small exposures of Oliverian quartzo-feldspathic gneiss of the Mascoma Dome. This meta-igneous gneiss has been dated by Rb-Sr and U-Pb (zircon) methods, and is approximately 440 to 450 Ma old (Naylor, 1969). The gneiss apparently intrudes Middle Ordovician (450 Ma) Ammonoosuc Volcanics, and developed a metamorphic foliation during the Acadian (Middle Devonian) orogeny. Some pavement outcrops on the lower part of the ski trail expose small (<10 cm-thick) discordant quartz-tourmaline veins. These veins clearly crosscut the Acadian foliation of the Mascoma gneiss and are undeformed, thus indicating a post-Middle Devonian (possibly Mesozoic) age. The veins dip steeply and trend approximately N60°E. Note the prominent hydrothermal alteration associated with some of the veins, which has destroyed ferromagnesian silicate minerals in the host gneiss, and produced a small amount of molybdenite and pyrite in the altered gneiss, and tourmaline along the vein-gneiss contact.

STOP 1-1B Farther up the ski trail are float blocks and outcrops (on the right) of metamorphosed basalt and rhyolite of the Ammonoosuc Volcanics, which mantle this (and most other) Oliverian domes of New Hampshire. Note sulfide-rich nature of the metavolcanics here, especially the pyrite- and pyrrhotite-rich disseminations and lenses in the amphibolites (metabasalts).

STOP 1-1C At 1550-ft elevation (flat area just below very steep section) is blue flagging on tree left of trail. Head east (left) down slope here. Exposed in cliff face is one large (3-m thick) and several smaller (<1 m-thick) mineralized quartz veins. The Holts Ledge veins were discovered prior to World War II apparently by H. M. Bannerman, and studied briefly by J. B. Thompson, Jr., one of his students at the time. The actual mined veins are near the base of the cliffs below, as no scheelite (or tungsten) has been found at this specific site. Mineralogically the veins contain widespread tourmaline, with locally common pyrite and molybdenite, and sparse bismuthinite and arsenopyrite (?); mineral collections from the general Holts Ledge area (e.g., Dartmouth College) also contain coarse scheelite in similar vein quartz material. Spectrographic analyses of a suite of 18 samples of vein and adjacent wall rock from this area show elevated values for As (to 340 ppm), Be (to 150 ppm), Bi (to 3400 ppm), Cu (to 310 ppm), Mn (to 3400 Mn), Mo (>1000 ppm), P (to 2100 ppm), Pb (to 210 ppm), and Zn (to 340 ppm); Au was not detected by atomic absorption methods (limit 0.05 ppm) in any of the analyzed samples.

On the slope below the large quartz vein is a loose block of semi-massive sulfide, consisting of abundant pyrrhotite and minor chalcopyrite. This block probably originated from an outcrop of Ammonoosuc Volcanics above, and was dislodged during construction of the ski trail. It is clearly unrelated to the mineralized quartz veins of the area.

Follow blue flagging south along base of outcrops on right to see several other veins. (DANGER: slope below here on left leads to a >100-ft cliff). Along outcrops on right are exposed several veins intercalated with Oliverian (Mascoma) gneiss and unmetamorphosed mafic dikes of probable Mesozoic age. One of the dikes displays chilled (fine-grained) contacts against the gneiss and is apparently unaltered, but age relationships with respect to the veins are unclear. At least one of the quartz veins is in contact with one of the dikes, and detailed field examination here may provide evidence for constraining the age of the veins (probably Carboniferous or Mesozoic).

Farther along the outcrop face (last blue flagging) is an irregular mineralized zone containing abundant black tourmaline, some of which forms disseminations and foliation-controlled replacements in the altered wall rocks. (NOTE: Do not go beyond this point, as it is extremely dangerous).

--	Return down ski trail to bus at Brundage Lodge, and back to Lyme.
63.8	Intersection with NH Rte 10. Continue straight ahead. Follow Rte 10 south towards Hanover.
74.1	Intersection with NH Rte 120. Continue straight (south) on Rte 10.
74.5	Dartmouth College green. Follow Rte 10.
74.7	Intersection with NH Rte 10A. Turn right (west).
75.2	Cross Connecticut River.
75.8	Exit for I-91 (S). Turn right onto I-91 South.
80.0	Cross White River.
80.9	Exit 10 for I-89 (N). Turn right onto I-89 North.

Daily Mileage	Comments and Descriptions
83.8	Exit 1 for U.S. Rte 4.
84.1	Intersection with Rte 4. Turn left onto Rte 4 west. Follow Rte 4 back to Killington Village.
119.5	Arrive Killington Village.

-- End of Day 1 Road Log --

DAY 2 - METAMORPHOSED VOLCANOGENIC SULFIDE ENVIRONMENTS

The purpose of this day is to visit volcanogenic sulfide deposits and their associated metamorphosed country rocks. The deposits occur in two belts, one in eastern Vermont, and the other mainly in western New Hampshire (locally in easternmost Vemont). The former belt contains chiefly sediment-hosted massive sulfide deposits within the Orange County copper district (the Vermont copper belt) of probable Ordovician age, including those at the well-known Elizabeth mine, site of the largest past metal production in New England. Geologic coverage of this area is available in Doll (1944[?]) and Rolph (1982). The regional setting is shown by Doll and others (1961).

The latter belt, to the east along the Connecticut River, consists mainly of Ordovician metavolcanic rocks, locally with distinctive mineral assemblages and bulk compositions that reflect premetamorphic submarine hydrothermal alteration. Geologic coverage of stops in this volcanic belt is available in Hadley (1950), Lyons (1955), and Lyons and others (1986).

Daily Mileage	Comments and Descriptions
0.0	Leave Village Lodging Center, Killington Village, on access road (north).
4.0	Intersection with U.S. Rte 4. Turn left (west).
4.1	Intersection with VT Rte 100 (N). Turn right (north).
12.0	Town of Pittsfield.
14.9	Intersection with VT Rte 107. Bear right on Rte 107.
23.4	Intersection with VT Rte 12 (S). Continue straight on Rte 107.
25.3	Intersection with VT Rte 12 (N). Turn right and continue on Rte 107.
28.0	Intersection with I-89. Turn left onto I-89 South.
36.2	Cross White River.
37.0	Exit 2 off I-89 at town of Sharon, VT. Turn right onto exit.
37.2	Intersection with VT Rte 132. Turn left (north) onto Rte 132.

STOP 2-1

41.6	Stop at crest of hill (new road cut). Outcrops are of Waits River Formation, in the core of the Strafford Dome. Rocks here are intensely deformed quartzose metalimestone, metadolostone, and minor sulfidic metapelite. Note shallow-plunging recumbent folds, quartz-rich segregations, and local pegmatitic

lenses. The pegmatites here may be a surface manifestation of a buried granitic body related to the formation of the Strafford Dome.

43.6 Intersection with Strafford Road. Turn right and continue on Rte 132. Town of South Strafford.

STOP 2-2

48.3 Pull off road on right, at metal guard rail. Walk down (right) to outcrops along creek. Exposures here are typical clastic metasedimentary rocks of the Gile Mountain Formation in this area. Principal lithology is foliated quartz-mica schist, with minor lenses of calcareous mica schist. Note transposed bedding in parts of the outcrop.

-- Turn around and return to South Strafford.

51.9 Intersection with unmarked road. Turn left and cross small bridge.

52.1 Intersection with South Strafford - New Boston Road (unmarked). Turn left.

53.4 Elizabeth mine tailings visible in valley to left.

53.5 Access road (second dirt road) to Elizabeth mine. Bear right onto access road.

STOP 2-3

54.2 Parking area (left) for access to south pit of Elizabeth mine. The Elizabeth mine is the largest past metal producer in New England, with approximately 3.2 million tons of ore produced from stratabound and stratiform massive sulfide deposits. The ores were discovered in 1793, but mining did not begin until 1809. The deposit was initially mined for copperas (iron sulfate), which at the time was used in treating timber, as a dye, in the purification of sewers, and in the manufacture of ink. The main periods of metal production were from 1830 to 1930 (intermittently), and continuously from 1943 until 1958, when the mine closed permanently. The Elizabeth mine produced principally copper, with minor byproduct zinc, silver, gold, and pyrrhotite (for sulfuric acid). Details of the mining history are given in McKinstry and Mikkola (1954) and Howard (1969).

The geology of the deposit has been recently restudied at various scales. Rolph (1982) mapped the surrounding area, emphasizing structure and stratigraphy. A review of the deposit setting including geology, mineralogy, and preliminary geochemistry was published by Annis and others (1983). Currently, the massive sulfide deposits and their enclosing host rocks are the subject of a detailed sulfide deposits investigation by the U.S. Geological Survey, which involves surface mapping, logging and sampling of drill core, rock and mineral chemistry, and isotope studies. The Elizabeth deposit, within a dominantly clastic metasedimentary sequence of Ordovician (?) age, is considered to be a Besshi-type massive sulfide and an ancient analog of the actively-forming deposits in the Guaymas Basin, Gulf of California, and the recently discovered deposits on the southern Gorda Ridge, off the coast of northern California.

The massive sulfide ores at Elizabeth are within the Gile Mountain Formation, which in the vicinity of the mine consists of regionally metamorphosed (amphibolite-facies) pelitic schist, with minor graywacke, impure quartzite, and amphibolite. The amphibolites, of presumed submarine volcanic origin, are volumetrically minor and occur principally to the west and north of the mine, near the stratigraphic base of the Gile Mountain Formation (see Rolph, 1982). The wall rocks of the deposit are lithologically unusual (compared to the surrounding country rocks), and contain significant amounts of mica, tourmaline, carbonate, sodic plagioclase, amphibole, and spessartine (Mn-rich) garnet. Such lithologies are considered to be metamorphosed hydrothermal alteration zones and(or) exhalative chemical sediments. Annis and others (1983) provide details on the nature of these unusual lithologies and their relationship to the massive sulfide ores. Figure 3 in Annis and others (1983) shows the relationship of geology to the mine coordinate grid system, which is used on the following stops.

STOP 2-3A

Walk across road (west) up small road through old mine haulageway to center of south (No. 2) pit, approx. at coordinate 8600N. The sulfide ore zone here forms an overturned, nearly isoclinal synform, striking N5°E and plunging gently (<10°) to the north. The sulfide layer and overlying (hangingwall) rocks in the core of the synform have been largely mined out in this area.

STOP 2-3B

Walk north along east side of pit approx. to coordinate 9200N, to examine lithologies in the stratigraphic footwall of the ore zone (lower part of the mine sequence). Exposures here show (from east to west): 1) calcareous hornblende schist, 2) minor disseminated to partly massive sulfide of the No. 3 orebody, 3) biotite-rich schist, and 4) beds of resistant impure quartzite. The quartzites directly underlie the main (No. 1) orebody in this area. However, to the north and south along strike, the stratigraphy is different, and the footwall of the main massive sulfide zone is underlain by a dolomitic feldspar rock (Stop 2-3F below).

STOP 2-3C

Walk north to area immediately north of the northern end of the south pit, approx. at coordinate 9500N. This area exposes the lower part of the stratigraphic hangingwall of the main (No. 1) orebody. From east to west, the sequence (in ascending order) consists of: 1) massive pyrrhotite with minor chalcopyrite, 2) sulfidic tourmalinite, 3) actinolite-phlogopite schist (very thin here), 4) laminated hornblende-plagioclase rock, and 5) coarse garnet-mica schist (with minor hornblende). Note that in this area the tourmalinite appears to be a facies equivalent of the massive sulfide ore.

STOP 2-3D

Walk north along strike across dirt access road to small prospect pit, approx. at coordinate 9600N. Outcrop here is well-layered vuggy tourmalinite containing locally abundant albite and minor green (Cr-bearing) muscovite. The vuggy nature of the tourmalinite is apparently the result of weathering out of sulfides (disseminated pyrrhotite and chalcopyrite).

STOP 2-3E

Walk north to area of small square shaft (filled), approx. at coordinate 9700N. The ledge next to the shaft is composed of sulfidic actinolite-phlogopite schist, in places showing fine-grained thin laminae of albitic plagioclase. Also note here another exposure of laminated hornblende-plagioclase rock.

STOP 2-3F

Walk north to southern end of north (No. 1) pit, approx. at coordinate 10,000N. Exposed on east side of pit is a slightly layered dolomitic feldspar rock, forming the immediate stratigraphic footwall of the sulfide orebody. Note orange weathering pits (after carbonate), minor lenses of gray clinozoisite, and plagioclase-rich felsic matrix. This rock may represent part of a footwall alteration zone.

STOP 2-3G

Walk west across south end of north pit, then north along west wall (east of old road), to approx. coordinate 10,600N. Small outcrops here show calcareous coticule rock in the stratigraphic hangingwall of the mine sequence, consisting of fine-grained quartz, calcite, biotite, and abundant spessartine (Mn-rich) garnet.

STOP 2-3H

Walk west about 200 feet to view outcrops of typical Gile Mountain Formation surrounding the mine sequence, here consisting of foliated quartz-mica-garnet schist and rare interbeds (<10 cm-thick) of graphitic kyanite-mica schist.

--	Turn around and return on access road towards South Strafford.
56.4	Intersection with unmarked road. Turn right and cross small bridge.
56.6	Intersection with Rte 132. Turn right (east).
62.8	Union Village dam on left.
64.2	Intersection with Union Village Road. Bear right up hill. Do not follow Rte 132.

STOP 2-4

68.2	Pull off road on right. Walk down paved road <0.1 mi to small road to right leading to open field. Walk along border of trees and field (keep left) to top of small hill. Outcrops at crest of hill (clearing in woods) expose excellent metamorphosed pillow basalts of the Ordovician Ammonoosuc (Post Pond) Volcanics. Metabasalts here contain relatively undeformed amygdules and sparse plagioclase phenocrysts. Note that pillow structures suggest tops face to the west in this area.
69.7	Intersection with Church Street, town of Norwich. Turn left (east).
70.5	I-91 overpass.
70.7	Junction with U.S. Rte 5. Continue straight ahead on Rte 5.
75.2	Intersection with Rte 132. Turn left (west) on Rte 132.
75.5	I-91 overpass.
75.6	Intersection with Hog Back Road. Turn right (up hill).
75.8	Drew Farm. Turn right on small gravel road (between barn and house) and proceed north to lower quarry. Permission is needed here to enter private property at quarries.

STOP 2-5A

76.6	Stop at lower quarry. This quarry (for construction stone) is in the Ammonoosuc Volcanics of Ordovician age. A view to the southwest (along strike) shows Blood Mountain, approximately

1.2 mi (2.0 km) away, on which is located a small (<0.5 million ton) copper-rich massive sulfide deposit in altered greenstones.

STOP 2-5B

Proceed north along dirt road approx. 1500 ft to upper quarry. This quarry also exposes rocks within the Ordovician Ammonoosuc Volcanics. Here, the lithologies are diverse and include fine- and coarse-grained amphibolites, mafic and felsic dikes, and felsic agglomerates (at west end of quarry). Spear and Rumble (1986) propose that these features, together with the thickness of the Ammonoosuc Volcanics in this area, are a reflection of an ancient volcanic center. In terms of metamorphism, most mafic rocks in the quarry have mineral assemblages that include hornblende + plagioclase + ilmenite ± cummingtonite ± quartz ± epidote, but a few samples contain four coexisting amphiboles (anthophyllite + gedrite + cummingtonite + hornblende) ± garnet (Spear and Rumble, 1986). Four-amphibole assemblages suggest metamorphism of previously altered mafic volcanic rocks, in which high-temperature seawater-derived hydrothermal fluids introduce Mg (and in some cases Fe), and leach Ca, K, and commonly Na from basalt (see, for example, Mottl, 1983). Subsequent regional metamorphism of such hydrothermally altered rocks produces mineral assemblages containing one or more Mg-rich orthoamphiboles (anthophyllite, gedrite) and(or) the Mg-rich clinoamphibole, cummingtonite; Ca-rich clinoamphiboles (actinolite, hornblende) occur in abundance in rocks with little (or no) depletion of calcium. By contrast, metamorphism of unaltered basalts yields one- or two-(clino)amphibole (actinolite, hornblende) + plagioclase assemblages. In general, rocks with orthoamphibole as the principal mafic mineral have substantially altered bulk compositions (see Schumacher, 1983, for details). The multi-amphibole assemblages in this area may have formed from the same submarine hydrothermal system that formed the small Blood Mountain (Waterman) massive sulfide deposit to the southwest. Another possibility, however, is that these Mg-rich amphibole rocks represent the products of a separate hydrothermal system, with a potential for a new (undiscovered) massive sulfide deposit in the area.

STOP 2-5C

77.0 Walk about 0.3 mi northwest from upper quarry, along north edge of field into woods (initially along a logging road), following red flagging. This traverse crosses from relatively unaltered (east) to highly altered (west) volcanic rocks. The unaltered lithologies are dominantly hornblende-plagioclase amphibolites. Farther along the traverse are Mg-rich altered metabasalts containing anthophyllite + cummingtonite + gedrite ± hornblende ± cordierite ± chlorite ± biotite ± plagioclase ± quartz; one very aluminous outcrop contains quartz + biotite + staurolite + kyanite + fibrolite (sillimanite) + relict cordierite (Spear

Daily Mileage	Comments and Descriptions
	and Rumble, 1986). At the end of the traverse (at yellow flagging approx. 350 ft southwest from first altered volcanics) is the type locality of the mineral wonesite. Wonesite is an Na-rich trioctahedral mica discovered at this locality in 1979 (Spear and others, 1981). In this outcrop, it occurs in assemblages including phlogopite + talc + orthoamphiboles (particularly anthophyllite) + chlorite + cordierite $\pm$ quartz (Spear and Rumble, 1986). The presence of an Na-rich phase in abundance in an Mg-rich composition here may reflect premetamorphic submarine hydrothermal alteration with a very low water/rock ratio (see Mottl, 1983).
--	Return (south) along dirt road to Drew Farm.
77.4	Intersection with Hog Back Road. Turn left.
77.7	Intersection with Rte 132. Turn left (south).
78.1	Intersection with Rte 5. Turn right (south).
82.7	I-91 overpass.
83.5	Intersection with Main Street, Norwich. Turn left (east).
83.9	Intersection with I-91 (S). Exit left and follow I-91 South.
88.1	Cross White River.
89.3	I-89 underpass.
108.1	Exit 8 at Ascutney, VT. Take exit (right) off I-91.
108.3	Intersection with VT Rte 131. Turn left (east) on Rte 131.
108.8	Intersection with Rtes 5 & 12. Continue straight ahead (east) on Rte 131.
109.2	Cross Connecticut River. Begin NH Rtes 12 & 103.
109.7	Intersection with NH Rte 12A. Continue straight (east) on Rtes 12 & 103.
113.1	Intersection with Elm Street, city of Claremont, NH. Turn left (Do not cross bridge).
113.3	Intersection with North Street (at traffic light). Turn right.

STOP 2-6

113.7	Turn right onto small paved turnaround (before traffic light). Walk across street to large outcrops. Rocks here are well-layered metavolcanics of the Ammonoosuc Volcanics. Exposed are a wide range of lithologies including greenstone, quartz-eye porphyritic rhyodacite (?), and felsic agglomerate. The top of the outcrop contains lensoidal volcanic fragments in some units. Note local disseminated sulfides (chiefly pyrite) and apparent metamorphosed hydrothermal alteration zones (e.g., muscovite-rich assemblages). One small area of base-metal sulfides (pyrite + sphalerite + minor galena & chalcopyrite) occurs in a thin (<3 cm-thick) stratabound zone at the south end of the outcrop (nearest traffic light). Spectrographic and atomic absorption analyses of a channel sample across this mineralized zone show 2.4% Zn, 5000 ppm Pb, 500 ppm Cu, 3 ppm Ag, and 0.13 ppm Au (K.C. Watts, Jr., pers. commun., 1986).
--	Turn around and return (west) to Vermont.
114.8	Intersection with NH Rtes 12 & 103. Turn right (west). Return to Killington via VT Rtes 131 & 100 (through Ludlow).
165.9	Arrive Killington Village.

-- End of Day 2 Road Log --

DAY 3 - IRON AND GOLD DEPOSITS IN THE GREEN MOUNTAINS REGION

The purpose of this day is to visit diverse types of metal deposit and related geology in the Green Mountains region. Included are stops at a small strata-bound iron deposit, at an auriferous quartz vein system, and at several types of gold-bearing deposits associated with the Cuttingsville stock, an alkaline intrusive complex of Cretaceous age. Regional geologic coverage of these stops is available in Doll and others (1961).

Daily Mileage	Comments and Descriptions
0.0	Leave Village Lodging Center, Killington Village, on access road (north).
4.0	Intersection with U.S. Rte 4. Turn right (east).
STOP 3-1	
6.0	Pull off to left of highway, at red barn next to Shelburne Valley Inn. Walk across road (west) to outcrops of basal polymictic conglomerate in lower part of the Tyson Formation of Late Proterozoic or Early Cambrian age. (NOTE: No Hammers Here!) Exposed are deformed cobbles of Precambrian quartzite and felsic gneiss, and pebbles of blue (rutilated) quartz. Valley to the left is underlain by stratigraphically overlying dolomite (visited at next stop).
8.5	Intersection with Mission Farm Road. Turn left.
STOP 3-2	
9.1	Pull off on right at slight bend in road. Walk across road (left) to outcrops exposing contact between the Tyson and overlying Hoosac Formations of Late Proterozoic or Early Cambrian age. The Hoosac Formation here consists mainly of coarse albitic schist (metapelite). Dolomite within the upper part of the Tyson Formation is exposed underneath the overhanging ledge (Hoosac). Variable amounts of magnetite occur locally along this contact, interpreted by Thompson (1972) as metamorphosed terra rosa, formed originally during Early Paleozoic weathering of the dolomite.
9.3	Intersection with Rte 4. Turn left (east) on Rte 4.
10.3	Intersection with VT Rte 100 (S). Bear left and continue straight (east) on Rte 4.

STOP 3-3

10.7 Pull off on right of highway at small turnout. Walk up road (east) to outcrops on left of Late Proterozoic or Early Cambrian Pinney Hollow Formation. Chief lithology here is pale green chloritoid-bearing phyllite or schist containing both muscovite and paragonite. Note pods and lenses of quartz, and a distinctive crenulation cleavage developed in this outcrop. This stratigraphic unit hosts several gold-bearing quartz veins (or vein systems) in the region, such as at the Rooks mine to the south. The Pinney Hollow Formation also contains stratabound (and apparently stratiform) mineralization at the Spathic iron mine on Weaver Hill, about 1.5 mi east of the village of Tyson, where lenses of massive siderite were mined for spathic (carbonate) iron in the 1860s. This small deposit is important because in addition to siderite it locally contains disseminated pyrrhotite and chalcopyrite, thin (1-3 cm-thick) lenses of massive pyrrhotite and pyrite, and pale brown Mg-amphiboles (anthophyllite and(or) gedrite). The presence of the sulfide concentrations and the Mg-amphiboles suggest that the siderite deposit at the Spathic mine formed from a submarine hydrothermal system, possibly associated with volcanogenic massive sulfide mineralization. A larger analog may be the Helen siderite deposit in southern Ontario recently described by Morton and Nebel (1984).

STOP 3-4

11.9 Pull off on right at small paved road before bridge. Walk back (west) to large outcrops of the Ottauquechee Formation of probable Cambrian age. Exposures here include carbonaceous and non-carbonaceous schist, quartzite, and quartz-feldspar granofels (metagraywacke). Also note pods and lenses of quartz, and complex isoclinal folds. Regionally, this formation contains many small ultramafic bodies (see Doll and others, 1961), some of which have been mined for talc, asbestos, and verde antique ("serpentine marble").

14.6 Pull off highway at turnout on left. Walk back (west) along road to outcrops of Stowe Formation of probable Early Ordovician age. Principle lithology here is green quartz-chlorite schist containing abundant large garnets, and pods and lenses of quartz. To the north this formation contains significant amounts of greenstone and amphibolite (see Doll and others, 1961), and a small deposit of sulfide-rich magnetite iron formation (quartz + magnetite + pyrite + minor pyrrhotite & chalcopyrite) developed at the Udall mine east of Morrisville, Vermont (north of the Glens Falls quadrangle).

15.9 Intersection with road to Bridgewater Center. Turn left (north).

18.1 Village of Bridgewater Center.

18.3 Intersection with Dailey Hollow Road (unmarked). Turn left, before crossing small bridge.

19.5 Intersection with unmarked road. Bear left, taking the left (lower) fork.

STOP 3-6

19.6 Park at or near red garage behind white house (Note: Permission is needed here to enter private property). Walk across front yard and downstream along creek <0.1 mi, to confluence with Washburn Brook. Go up Washburn Brook (southwest) approx. 150 ft (to elev. 1300 ft), to Taggart mine on left. The Taggart mine is located in the uppermost part of the Stowe Formation, very near the contact with the overlying Moretown Member of the Missisquoi Formation. The mine was worked in the 1850s, with company reports at that time indicating ore values of 1.87 oz/ton Au. At the entrance to the old mine are good exposures of both concordant and discordant vein quartz, and extensively altered wall rocks. Rocks on the dump here contain minor amounts of sulfide minerals (chiefly pyrite and/or pyrrhotite), including some disseminations in the wall rocks.

Spectrographic analyses of 8 samples of vein and wall rock from this mine show elevated values for B (to 500 ppm), Co (to 50 ppm), Cr (to 300 ppm), Cu (to 2000 ppm), Mo (to 10 ppm), Ni (to 100 ppm), Pb (to 200 ppm), and Zn (to 300 ppm). Gold was detected in 7 of the 8 samples, typically with concentrations in the range 0.02 - 0.08 ppm; one sample of iron-stained quartz and micaceous wall rock from the entrance of the upper adit contains 0.16 ppm (160 ppb) Au.

-- Turn around and return to Rte 4.

23.3 Intersection with Rte 4. Turn left (east).

23.5 Intersection with VT Rte 100A at Bridgewater Corners. Turn right (south).

28.5 Slack Hill (!) on left.

29.6 Village of Plymouth, VT, on right (Birthplace of Calvin Coolidge).

STOP 3-7

30.6 Pull off on right, before Salt Ash Inn (Note: Permission is needed here to enter private property). Walk back behind inn (to left of small wood building) to the old Plymouth-Union iron mine. This is representative of the Tyson iron deposits in the area, which were discovered in 1825 and mined from 1836 to 1855. The deposits consist of magnetite and(or) hematite disseminations and thin massive lenses localized along the Tyson-Hoosac contact. The stratigraphic setting here is the same as at Stop 3-2. The small dump, near the opening to the mine, contains many magnetite-rich rocks for sampling.

30.7	Intersection with VT Rte 100, at village of Plymouth Union. Turn left (south) onto Rte 100.
35.9	Village of Tyson, site of old iron furnaces.
39.6	Intersection with VT Rte 103. Turn right (west).
49.1	Intersection with VT Rte 140. Continue straight (west) on Rte 4.
52.0	Intersection with Shrewsbury Road (unmarked), town of Cuttingsville. Turn right (north) before bridge.
52.4	Intersection with Shunpike road (unmarked), at Shrewsbury Fire House. Turn right.

STOP 3-8

53.2 Intersection with small dirt road to left, at upper (east) end of open field. Park and walk up road north along field edge to crossing with jeep trail under powerline. (Note: private property; permission to enter should be obtained from Mr. Stephen Korzun, Rutland, Vermont). Proceed west-northwest along powerline trail toward ridge on Copperas Hill, site of the Copperas Hill massive pyrrhotite deposit (Doll, 1969). In the saddle before the ridge is a block of xenolith-rich dike rock, typical of the post-tectonic Cretaceous intrusives in the Shrewsbury area. The dikes here contain abundant xenoliths of Precambrian gneiss and quartzite in a dark matrix which weathers preferentially relative to the xenoliths. Near the ridge crest are outcrops of amphibole-bearing feldspathic gneiss. At the ridge crest, outcrops consist of relatively unaltered Precambrian calcite marble. Continue walking along the jeep trail to the northwest, where a gossan is developed over late-stage siderite-chlorite-pyrite alteration in the marble. The two northernmost production trenches for pyrrhotite occur just south of the jeep trail at the crest of the ridge (see Rudnick, 1986).

Continuing northwest under the powerline one encounters an amphibolite horizon, another calcite marble layer, feldspathic gneiss, and a small pipe-like body of pyritic trachyte in contact with feldspathic gneiss.

Return to the abandoned trenches and proceed southwest downhill following an overgrown trail to the base of two large trenches. The trenches north of the trail here expose lenses of strata-bound massive pyrrhotite and ankerite-ferrodolomite alteration of calcite marble, interpreted as epigenetic replacement bodies related to the Cretaceous alkaline intrusions of the area.

Southwest of the trail is a gossan developed on large pyrrhotite roast piles. The pyrrhotite was originally mined in the 1830s and 1840s for copperas (iron sulfate), possibly including production of minor amounts of copper (see Doll, 1969).

The massive sulfide bodies consist mainly of pyrrhotite, with minor chalcopyrite and arsenopyrite, and variable amounts of gold. Spectrographic and atomic absorption analyses of 18 samples from here show significant amounts of Ag (to 80 ppm), As (to 1.8%), Au (to 17 ppm), Bi (to 260 ppm), and Cu (to >5000 ppm); samples of gossan from this area contain up to 3 ppm Au.

-- Walk back down to Shunpike road. Turn around and return to Cuttingsville.

54.3 Intersection with Rte 103. Turn right (northwest).

STOP 3-9

54.4 Pull off into used car lot on left, immediately after crossing bridge (Note: Permission is needed to park here). Walk down to Mill Brook, then upstream about 300 to 500 ft to pavement outcrops along bank on right, to a pyrite-rich mineralized stockwork. This stockwork occurs on the eastern margin of the Cuttingsville intrusive complex of Cretaceous age. The fresh rock in this area was mapped by Eggleston (1917) as pulaskite, a type of nepheline-bearing syenite. During low water, at least two textural and mineralogical variants of pulaskite are visible; a few felsic and mafic dikes are exposed in this area also. The rocks here are cut by a rectilinear fracture/joint system which is host to pervasive hydrothermal pyrite-sericite-carbonate alteration; trace amounts of wolframite and molybdenite are present locally. When normalized relative to aluminum contents, the altered rocks show extreme enrichment in potassium, depletion in sodium, and little change in calcium content relative to unaltered pulaskite. A zone of potassium feldspar alteration occurs in the steep rock ledge forming the north wall of the river above the pavement outcrops. The dominant mineralized fracture trends are N80^{o}E,65^{o}N; NS,58^{o}E; and N60^{o}W,15^{o}NE. Spectrographic and atomic absorption analyses of 5 pyrite-rich samples from this area show elevated values for Ag (to 2 ppm), As (to 500 ppm), Au (to 1.7 ppm), Cu (to 50 ppm), and W (to 1000 ppm).

-- Turn around and head back south on Rte. 103.

57.0 Intersection with VT Rte 140. Turn right (west) on Rte 140.

57.3 Stop sign. Turn right and follow Rte 140 (right after railroad tracks).

Daily Mileage	Comments and Descriptions
58.8	Intersection with Dawson Hill Road. Turn right (north).

STOP 3-10 (Optional)

59.8	Intersection with small dirt road (on right), at crest of Dawson Hill road. Park and walk east along road, past power-line, to small saddle along west ridge between Granite and Hateful Hills. Turn and proceed north along ridge crest for approximately 1300 ft, to prospect left of trail. Samples from the small dump (next to water-filled shaft) contain locally abundant pyrite and molybdenite in altered syenite. Spectrographic and atomic absorption analyses of 5 samples from here show elevated values for Au (to 0.2 ppm), Cu (to 100 ppm), and Mo (to 2000 ppm). An area of altered syenite to the north (along contact with Precambrian gneiss) contains up to 1.3 ppm Au.
--	Turn around and return to Killington via Rtes 103 & 100.
97.2	Arrive Killington Village.

-- End of Day 3 Roadlog --

DAY 4 - MINERALIZATION IN THE SHELF SEQUENCE, THE TACONICS, AND THE ADIRONDACKS

The purpose of this day is to visit a variety of metal deposits and mineralized rocks to the west of the Green Mountains, in carbonates and quartzites of the shelf sequence, in slates and graywackes of the Taconic Allochthons, and in Proterozoic crystalline rocks of the eastern Adirondacks. The last stop of the day is at the Podunk iron mine, which developed stratabound and apparently stratiform magnetite ores within alaskitic gneiss. Regional geologic coverage of these stops is found in Doll and others (1961), Zen (1964), and Fisher and others (1962).

Daily Mileage	Comments and Descriptions
0.0	Leave Village Lodging Center, Killington Village, on access road (north).
4.0	Intersection with U.S. Rte 4. Turn left (west).
4.1	Intersection with VT Rte 100 (N). Continue straight on Rte 4.
11.2	Village of Mendon. Continue straight (west) on Rte 4.
15.0	Intersection with U.S. Rte 7, city of Rutland. Turn right (north) on Rte 7.
15.4	Intersection with Crescent Street (at traffic light). Turn left (west).
15.9	Intersection with Grove Street (at light). Turn right (north).
16.7	Rutland Country Club on left.
<u>STOP 4-1A</u>	
17.4	Pull off on right, near powerline. Walk across road (west) along powerline about 0.2 mi, to small ridge (elev. approx. 800 ft). Outcrops along ledge are in uppermost part of the Cheshire Quartzite of Early Cambrian age, here exposed on the west flank of a south-plunging syncline. Walk back along powerline, crossing outcrops of dolomite breccia at the base of the Dunham Dolomite. Return to paved road.
<u>STOP 4-1B</u>	
17.6	Continue straight ahead (north) on Grove Street. Outcrop on right side of road is dolomite breccia, part of the Dunham Dolomite of Early Cambrian age. To the north in Canada, this formation contains two types of mineralization. Both are in southeastern Quebec and include occurrences of stratabound sphalerite and galena at several sites near the town of Dunham, and uraniferous phosphatic material at Saint-Armand along the Vermont border (see Gauthier and others, 1985b).

Daily Mileage	Comments and Descriptions
17.9	Intersection with McKinley Avenue. Turn right (east).
19.0	Intersection with Rte 7. Turn right (south).
20.5	Intersection with Rte 4 (E). Continue straight on Rte 7.
25.6	Intersection with VT Rte 103. Continue straight (south) on Rte 7.
27.6	Cross Mill River.

STOP 4-2

28.0	Pull off highway on right. Outcrops here are Winooski Dolomite of Middle Cambrian age, near the contact with the stratigraphically lower Monkton Quartzite. Exposed are well-bedded dolomite and sandy dolomite, with minor dolomitic quartzite and gray shale. Outcrop in center island of highway includes pyritic shale unit, highly iron-stained. Note here that the pyrite is apparently <u>not</u> fracture-controlled, but is present as disseminations and thin laminations. Some other fractures in these outcrops do contain pyrite, but most are filled with barren quartz ± carbonate. To the north near Brandon, Vermont, this part of the shelf stratigraphy (particularly the Monkton) hosts a small stratabound lead-zinc-copper deposit at Lion Hill associated with layered magnetite iron formation. The nature of the sulfide mineralization at Lion Hill, and the presence of the iron formation, suggest analogy with some stratiform, apparently exhalative massive sulfide deposits in Ireland (e.g., Tynagh), and imply a potential for similar mineralization elsewhere in the Early Paleozoic shelf sequence of western Vermont and eastern New York (Clark, 1986).
28.2	Intersection with small cross road. Turn left and head back north on Rte 7.

STOP 4-3

29.0	Pull off on right (after crossing river), just past small paved road to right. Outcrops on right are dolomites of the Winooski, with locally abundant pyrite. Pyrite here fills fractures and seams, and is in places intergrown with pale brown prisms of tourmaline. Some of the pyrite, although apparently epigenetic, is bedding-controlled and nearly massive.
30.9	Intersection with Rte 103. Continue straight (north) on Rte 7 to Rutland.
35.1	Intersection with Rte 4 (W). Turn left and follow Rte 4 west through Rutland.

37.8 Intersection with VT Rte 3. Continue straight (west) on Rte 4.

39.4 Intersection with VT Rte 4A. Bear right and follow U.S. Rte 4 west towards Castleton.

STOP 4-4

46.5 Pull off highway on right. Large roadcut outcrop here is in the St. Catherine Formation (Doll and others, 1961) of probable Early Cambrian age. This unit comprises a major part of the Bird Mountain and Giddings Brook slices in the northern part of the Taconic allochthon (see Doll and others, 1961; Zen, 1964).

The outcrop here is in the Bird Mountain slice, and consists of green slate, with lesser purple slate, black sulfidic slate, limestone, and graywacke. In the center portion of the outcrop, the black rusty slates contain many paper-thin laminations of pyrite that appear to be syngenetic. Note that the abundant discordant veins here, as elsewhere in the Taconics, are nearly all barren quartz $\pm$ carbonate, with only local minor (generally rare) crystals of pyrite.

STOP 4-5 (Optional)

47.6 Roadcut on right of typical variegated green and purple slates of the St. Catherine Formation, here exposed in the Giddings Brook slice. The purple colors are caused by fine-grained mixtures of hematite (red) and chlorite (green), whereas the gray or green colors of the slates reflect the conversion of hematite to magnetite mixed with chlorite (Zen, 1964).

STOP 4-6

50.1 Roadcuts of the West Castleton Formation of Early to Middle Cambrian age, in the Giddings Brook slice. The major lithology here is carbonaceous and sulfidic slate or phyllite, with minor thin interbeds of siltstone, sandstone, and limestone. Note complex folding and abundant east-dipping thrust faults, and many barren quartz $\pm$ carbonate veins. Pyrite occurs here in several forms including disseminations, thin semi-continuous laminations, stratabound coarse-grained (euhedral) segregations, and as isolated small concretions (rare). Spectrographic analyses of 8 pyrite-rich samples from this area show elevated values for As (to 500 ppm), Ba (to 1000 ppm), Cu (to 300 ppm), Mo (to 200 ppm), Ni (to 50 ppm), Pb (to 100 ppm), Sb (to 100 ppm), and Zn (to 200 ppm); Au was detected in only one sample by atomic absorption methods, at a value of 0.004 ppm (4 ppb). These metal values may not be truly anomalous, when compared to pyritic black shales elsewhere (e.g., Vine and Tourtelot, 1970).

In many parts of the Taconics, the West Castleton Formation and the overlying Hatch Hill Formation (Late Cambrian) appear to be the hosts for major lead, copper, zinc, and barium geochemical anomalies in panned concentrates of stream sediments (Day and others, 1986). These anomalies may be related to sedex-type (sedimentary-exhalative) mineralization, based on the occurrence of a small lead-zinc deposit near White Creek, New York, just 1 mi south of the southern border (42° latitude) of the Glens Falls $1^{\circ} \times 2^{\circ}$ quadrangle. The White Creek mineralization consists of stratabound (but not stratiform) sphalerite, galena, and very minor pyrite, carbonate, and K-feldspar in a quartzite-conglomerate sequence (probably the Mudd Pond Quartzite) in the uppermost part of the Nassau (St. Catherine) Formation, just below the base of the West Castleton Formation (see Potter, 1972). The geologic setting of the Taconics is very similar to other areas containing significant sedex-type Pb-Zn-Ag deposits (e.g., Selwyn Basin, Canada), and suggests a potential for such polymetallic mineralization in many parts of the Taconic Allochthon.

Another set of geochemical anomalies in the Taconics implies potential for a very different type of mineralization. In addition to the base metals, geochemical data from panned concentrates (Day and others, 1986) show anomalous amounts of gold, silver, arsenic, antimony, bismuth, tin, and molybdenum. These anomalies are not necessarily related to the base-metal anomalies, and may reflect a separate style of mineralization in the region. A possibility is epigenetic gold-bearing quartz veins or stock-works in black slate, such as in the West Castleton and (or) Hatch Hill Formations. One bedrock gold occurrence is known in such a setting at the Little Colfax mine, 2.5 mi north-northwest of Cambridge, New York, where a complex quartz stockwork is localized in black slate. The fracturing and brecciation that hosts the stockwork mineralization at Little Colfax probably were caused by faulting (especially thrust faulting) during the emplacement of the Taconic Allochthon; the source of the other gold anomalies in the Allochthon may also be related to the many fault zones of the region. A recently discovered gold deposit in Czechoslovakia (>1 million tons @ 4-5 grams/ton) is situated in similar quartz stockworks in Devonian black slate, and with precisely the same suite of associated anomalous metals (Aichler and others, 1986); the gold concentrations in black slates of the Beauceville Formation in southeastern Quebec (Gauthier and others, 1985b) may be comparable. Analogy with the Czechoslovakian and Quebec deposits suggests a potential for a previously unrecognized type of mineralization in the Taconics, consisting of gold-bearing quartz stockworks in black slate.

55.2 Cross Poultney River at New York state line. Continue straight (west) on Rte 4.

Daily Mileage	Comments and Descriptions
61.8	Intersection with NY Rte 22 in Whitehall, NY. Turn right (north) on Rte 22.
62.6	Large roadcuts in khondalite (sillimanite-garnet-quartz-feldspar gneiss), with a bulk chemistry approximating that of shales.
63.2	Enter long roadcut of calcsilicates, marble, and quartz-feldspar gneiss. Swede Mt. quartzite on hill to east.
63.6	Quarry in Swede Mt. quartzite on each side of highway, metagabbro on west.
64.3	Bridge over South Bay (Lake Champlain).
65.5	Roadcuts through quartz dioritic gneiss.
67.0	Roadcuts of garnetiferous charnockite that constitute most of the Lake George thrust sheet.
67.8	Parking area.
68.7	Road to Hulett's Landing. Inequigranular charnockite exposed in roadcuts.
70.7	Roadcuts in garnetiferous charnockite.
70.9	Large roadcut of ferrogabbro with a low-dipping marble at the north end.
71.8	Intersection with Dresden Station Road. Continue straight (north) on Rte 22.
72.0	Large roadcut of ferrogabbro containing xenocrysts and xenoliths of andesine and anorthosite.
72.3	Ferrogabbro.
78.3	Overlook - steeply dipping, highly folded gneisses in roadcut to west.

<u>STOP 4-7</u>

78.9	Angular unconformity between Proterozoic Grenville gneisses and basal conglomerates of the Upper Cambrian Potsdam sandstone. The deeply weathered gneisses have nearly vertical dips. The age of the weathering is uncertain but appears to post-date the unconformity.
--	Turn around and return south on Rte 22.

STOP 4-8

85.4 High roadcut at sharp bend in Rte 22, just south of a steep hill with a passing lane on the northbound side.

The roadcut here consists of several different lithic types, which, on average, strike approx. N70°W and dip 45-50°S. Strong ribbon lineations occur in several places and trend approximately N70°W with near-horizontal plunges. Isoclinal fold axes parallel the lineations. Several discordances can be seen in the west wall of the cut and are almost certainly due to displacement along early faults.

At the southwest end of the roadcut (beware of poison ivy) is a dark ferrogabbro (Table 1 (a)) containing chalk white grains of andesine plagioclase. As the ferrogabbro is traced northward it becomes increasingly deformed and passes into a mylonite. Near the contact of the ferrogabbro with underlying metasediments, it is difficult to distinguish the ferrogabbro from mylonitized quartzitic rocks. The contact marks the sole of a large folded thrust sheet of charnockitic and ferrogabbroic gneisses that has been preserved in the core of the Whitehall syncline. Klippen of this sheet are found on the west side of Lake George. Kinematic indicators (primarily feldspar tails asymmetric to foliation) suggest an east-over-west sense of displacement. The southeast side of the roadcut exposes a typical Adirondack olivine metagabbro which contains garnet coronas between olivine and plagioclase, as well as plagioclase clouded by green spinel.

North of the olivine metagabbro is a sequence of sillimanite-garnet-feldspar-quartz rocks with variable amounts of biotite and graphite. These are referred to as khondalites (Table 1 (b)) and have whole-rock chemical compositions similar to Proterozoic shales. They are interlayered with marbles containing angular rotated fragments of quartz-feldspar-diopside assemblages.

The metagabbro also exhibits a chill margin which survived metamorphic recrystallization, probably due to an absence of fluids. In places the metagabbro-khondalite contact truncates foliation in the khondalite, making it appear as if the metagabbro was emplaced subsequent to formation of the metamorphic fabric. However, the local presence of foliation within the metagabbro demonstrates that the truncation is only apparent and is caused by the difficulty of recrystallizing the metagabbro.

Near the north end of the cut are exposures of a rusty sulfidic rock known as the Dixon Schist. Mineralogically, this rock consists of garnet + biotite + quartz + feldspar ± sillimanite. In addition it contains abundant pyrrhotite and graphite, the latter accounting for the schistose character of the unit. The Dixon Schist was the major source of graphite mined in the

	region during the early part of this century. Occurrences of khondalite, marble, and Dixon Schist are common in the eastern Adirondacks, some of which contain anomalous metal concentrations. Reconnaissance sampling of these units has been carried out at two sites, one here at the Dresden stop, and the other along roadcuts (NY Rte 8) just west of Hague, New York. Spectrographic analyses of 26 khondalites from these two areas show elevated values for Ag (to 2 ppm), Co (to 90 ppm), Cu (to 120 ppm), Mn (to 1.9%), Ni (to 270 ppm), P (to 3100 ppm), and Zn (to 270 ppm). Analyses of 5 samples of Dixon Schist show slightly high values for Cu (to 140 ppm), Mo (to 29 ppm), P (to 1900 ppm), and Ni (to 200 ppm); 8 samples of associated carbonate and calc-silicate rock are judged to lack metal anomalies. Atomic absorption data for all 39 samples revealed gold in only one, a graphitic khondalite from the Hague locality that contains 0.17 ppm Au. The significance of these metal values is unclear, but a resource potential for gold may be indicated. This is based not only on the anomalous gold value in the khondalite, but also on the general geology of this part of the Adirondacks. These metasedimentary units, which in places have associated amphibolites of probable submarine volcanic origin, are broadly similar to the supracrustal sequences hosting two recently opened gold mines, one in Quebec and the other in central Sweden. Both mines contain stratabound and apparently strati-form gold deposits. The geology of the Quebec deposit, in the Grenville Province at Montauban north of Montreal, has been described by Gauthier and others (1985a).
	The new deposit in Sweden, at Enasen, is still being studied, but a preliminary account of the geology (Willden, 1986) and personal observations (J. F. Slack, 1986) show that the host rocks there are similar in many respects to those exposed in the eastern Adirondacks. Although speculative, these relationships suggest a potential for stratabound, possibly volcanogenic gold in this part of the Adirondacks.
--	Continue south on Rte 22.
96.0	Intersection of Rtes 4 and 22 in Whitehall. Continue straight ahead (south) on Rte 4.
99.7	Small roadcut of metagabbro.
101.4	First new roadcut south of Whitehall. At the north end is marble containing angular, rotated blocks of amphibolite. A diabase dike crosscuts the marble. The marble is underlain by sillimanite-garnet-quartz feldspar gneiss (kinzigite) with white quartz two-feldspar leucosomes (anatectites). Towards the south end of the cut are gabbroic rocks that intrude marble. A pod of grossularite-wollastonite-diopside skarn occurs here. At the southernmost end of the roadcut kinzigites reoccur.

Daily Mileage	Comments and Descriptions
101.7	Enter second new roadcut south of Whitehall. Kinzigites continue for 0.3 mi.
102.0	Pink granitic gneiss with gabbroic pods.
102.4	Junction with Rte 22 at Comstock. Continue straight (south) on Rte 4.

STOP 4-9 (Optional)

102.7 Long roadcuts in marble, and in gabbroic, anorthositic, and metapelitic rocks immediately south of the junction between Rtes 4 and 22 west of Comstock. The roadcut here contains good examples of metamorphosed gabbroic rocks that grade into gabbroic anorthosites (Table 1 (c)) containing a substantial quantity of garnets 2-3 cm in diameter. All of these rocks have intruded marbles and calcsilicates. On the west side of the roadcut, a pod of orange-colored calcsilicate contains the assemblage diopside-grossularite-wollastonite. It is suggested that heat from the intrusions caused this assemblage to form and that this represents a pre-Grenvillian contact metamorphism.

A small lens of green ultramafic rock occurs on the east side of the cut. A semiquantitative chemical analysis indicates approximately 35% SiO_2, 16% MgO, 15% CaO, and 12% Fe_2O_3.

At the southeast end of the cut are "straight gneisss" consisting of dark or purple sillimanite-garnet-biotite-quartz-oligoclase gneiss alternating with white two-feldspar quartz layers believed to be anatectites.

112.9	Kelseq Pond Road.
113.0	Hornblende granitic gneiss.
113.6	Powerline.
114.4	Intersection with Flat Rock Road. Basal Potsdam conglomerate is exposed here above unconformity with the Proterozoic.
114.6	Isoclinal recumbent fold with dark metagabbro in core.
115.3	Battle Hill monument. Gabbroic anorthosite, gabbro, and marble.
116.1	Intersection of Rtes 22 and 149 in Fort Ann. Turn right (west) on Rte 149.
120.1	Intersection with Copeland Pond Road.

Daily Mileage	Comments and Descriptions
120.9	Intersection with Hadlock Pond Road.
121.6	Intersection with Buttermilk Falls Road by the Black Rooster Store. Turn north.
122.8	Buttermilk Falls. Continue north.
124.6	Intersection with Taylor Woods Road.
124.9	Pavement ends.
125.4	Camp Wakopiminee.
125.7	Log cabin east of road.
125.9	Powerline.

STOP 4-10

126.0 Walk along small dirt road to east, to Podunk low-Ti magnetite mine. This mine is typical of those in the Fort Ann area (e.g., Potter, Mt. Hope), that are estimated to have together produced 350,000 tons of iron ore. Old state reports (Newland, 1908) indicate that the mines on this hillside were exhausted of magnetite in the late 1800s. The old workings show that the ore horizons were conformable with the enclosing alaskitic gneiss (Table 1 (d), (e), (f)). A few thin, uneconomic ore horizons exhibit conformity with the alaskites and consist of magnetite octahedra and black pyroxene. When hammered the pyroxene yields a green powder. A typical chemical analysis is given in Table 1 (g) and demonstrates that the pyroxene is an aluminous hedenbergitic clinopyroxene. Other mine workings in the area contain similar ore assemblages together with hedenbergite-andradite and hedenbergite-grossularite (Table 1 (h), (i)) skarns; however, the garnet-rich layers rarely contain any magnetite. Apatite commonly occurs in the ore horizon and patches of marble are encountered in places. Reconnaissance ground surveys here (L.C. Gundersen, pers. commun., 1985) indicate a slight radioactivity, which may be related to minor uranium and (or) thorium concentrations. Anomalous amounts of rare earth elements (REE) might also be present, based on analogy with the Mineville-Port Henry magnetite deposits (which are currently being evaluated for recovery of REE), and with similar stratabound (and apparently stratiform) magnetite deposits in Grenville basement rocks near the New Jersey-New York border (Gundersen, 1984).

The relationships described above suggest that the magnetite deposits were formed from sedimentary precursors. The preferred model is similar to that proposed for the Lahn-Dill deposits of central Europe, involving submarine exhalations in an area of volcanism. According to this model, iron-rich exhalative fluids precipitated iron oxides, iron carbonates, or iron sulfides depending upon local pH and Eh. During granulite-facies metamorphism, these iron minerals were reconstituted into magnetite deposits. The enclosing alaskites are interpreted as ash-flow tuffs and K_2O-rich varieties (Table 1 (d)), as well as Na_2O-rich types (Table 1 (f)) that are interpreted as volcanics altered by hydrothermal fluids. The BaO content of some alaskite feldspars approaches 2 wt % and is associated with a disappearance of microcline twinning. A similar model for the Sterling Hill deposits of New Jersey was presented by Frondel and Baum. Buddington, as well as others, argued that the low-Ti Adirondack magnetite deposits were of replacement origin and selectively replaced certain horizons <u>after</u> deformation and metamorphism. This conclusion rested partly on two observations: 1) many ore horizons appear to truncate enclosing lithologies at a small angle, and 2) magnetite grains do not appear to exhibit preferred orientation and occur as unoriented octahedra. The first observation is easily explained in terms of original facies changes between units. Moreover, the apparent truncations are rare and far less impressive that the ubiquitous conformity between layers. The second observation indicates only that the magnetite recrystallized late or annealed. In fact, studies of magnetic anisotropy in the magnetite demonstrate that it <u>does</u> have a preferred orientation parallel to that in the surrounding gneisses, and is commonly rimmed by sillimanite and garnet (Hagni and others, 1969).

The foregoing strongly indicates that the magnetite horizons are the folded, metamorphosed, and annealed derivatives of originally stratiform sediments precipitated from exhalative fluids in a volcanic terrane (McLelland, 1985). High Ba, P, Mn, F, Cl, and REE in some of the iron deposits (e.g., Benson Mines, Mineville) appear consistent with this interpretation.

-- End of Day 4 Roadlog --

-- End of Field Trip Roadlog. Cumulative trip mileage = 508.6.

TABLE 1

Wt. % Oxide	(a) Ferro-gabbro	(b) Khondalite	(c) Gabbroic anorthosite	(d) Podunk-1 Alaskite	(e) Podunk-2 Alaskite	(f) Skiff Mtn.	(g) Podunk Cpx	(h) Podunk Garnet-1	(i) Podunk Garnet-2
SiO_2	47.71	54.3	52.9	69.2	66.05	73.4	46.58	37.8	36.44
Al_2O_3	14.68	21.5	23.2	14.5	13.94	12.6	4.12	22.1	3.71
TiO_2	3.74	2.1	0.79	0.08	1.00	0.42	0.05	--	--
Fe_2O_3	16.18	14.6	3.73	2.67	5.01	4.11	22.14	33.8	26.26
MgO	4.34	1.22	1.81	0.55	1.25	0.42	4.81	1.95	0.08
CaO	9.13	0.55	7.13	0.62	3.43	0.31	21.48	7.35	32.88
Na_2O	1.88	1.41	4.86	1.95	3.60	7.47	0.94	--	--
K_2O	1.03	2.41	2.44	9.19	3.36	0.65	--	--	--
MnO	0.27	0.10	0.05	0.02	0.11	0.01	0.76	1.47	0.25
P_2O_5	0.41	0.11	0.11	0.04	0.25	0.05	--	--	--
LOI	0.32	0.41	0.30	0.21	0.20	0.21	--	--	--
Total	99.65	98.71	99.7	99.61	98.20	99.81	100.89	104.5	99.8

REFERENCES CITED

Aichler, J., Danko, I., Orel, P., Rejl, L., and Vanecek, M., 1986, Prospecting for deep-seated gold mineralization in black shales near Sucha Rudna (northeastern Bohemian Massif): Terra Cognita, v. 6, no. 3, p. 558 [Abstracts from 7th IAGOD Meeting, August 18-22, 1986, Lulea, Sweden].

Annis, M.P., Slack, J.F., and Rolph, A.L., 1983, Stratabound massive sulphide deposits of the Elizabeth mine, Orange County, Vermont, in Sangster, D.F. (ed.), Field trip guidebook to stratabound sulphide deposits, Bathurst area, N.B., Canada and west-central New England, U.S.A.: Geological Survey of Canada Miscellaneous Report 36, p. 41-51.

Clark, S.H.B., 1986, Zinc-lead-copper mineralization in Cambrian shelf carbonate-siliciclastic rocks at Lion Hill near Brandon, Vermont (abstract): Geological Society of America Abstracts with Programs, v. 18, no. 1, p. 9.

Day, G.W., Welsch, E.P., Watts, K.C., Jr., and Gray, J.C., Jr., 1986, Analytical results and sample locality map of non-magnetic and moderately magnetic heavy-mineral concentrates from stream sediments from the Glens Falls 1^{o} x 2^{o} quadrangle, New York, Vermont, and New Hampshire: U.S. Geological Survey Open-File Report 86-422, 112 p.

Doll, C.G., 1944[?], A preliminary report on the geology of the Strafford quadrangle, Vermont: Vermont Geological Survey, Report of the State Geologist, 24th (1943-1944), p. 14-28.

Doll, C.G., 1969, Report on the Cuttingsville pyrrhotite deposit, Cuttingsville, Vermont: Vermont Geological Survey, Economic Geology No. 4, 8 p.

Doll, C.G., Cady, W.M., Thompson, J.B., Jr., and Billings, M.P., 1961, Centennial geologic map of Vermont: Vermont Geological Survey, scale 1:250,000.

Eggleston, J.W., 1918, Eruptive rocks at Cuttingsville, Vermont: American Journal of Science, 4th Series, v. 45, p. 333-410.

Fisher, D.W., Isachsen, Y.W., Rickard, L.V., Broughton, J.G., and Offield, T.W. [Compilers], 1962, Geologic map of New York: New York State Museum and Science Service, Geological Survey, Map and Chart Series No. 5, scale 1:250,000 [Adirondack and Hudson-Mohawk sheets].

Gauthier, M., Morin, G., and Marcoux, P., 1985a, Mineralisations auriferes de la partie centrale de la Province de Grenville, Bouclier Canadien: Canadian Institute of Mining and Metallurgy Bulletin, v. 78, no. 874, p. 60-69.

Gauthier, M., and others, 1985b, Synthese metallogenique de l'Estrie et de la Beauce (Secteur Sud): Ministere de l'Energie et des Ressources du Quebec, Rapport MB 85-20, 191 p.

Gundersen, L. C., 1984, Geochemistry and geology of Precambrian rocks from the Greenwood Lake area, New York and New Jersey: Implications for the genesis of uranium-magnetite deposits (abstract): Geological Society of America Abstracts with Programs, v. 16, no. 1, p. 20.

Hadley, J.B., 1942, Stratigraphy, structure, and petrology of the Mt. Cube area, New Hampshire: Geological Society of America Bulletin, v. 53, p. 113-176.

Hadley, J.B., 1950, Geology of the Bradford-Thetford area, Orange County, Vermont: Vermont Geological Survey Bulletin 1, 36 p.

Hagni, R.D., Masiello, R.A., and Tumialan, P.H., 1969, Metamorphic aspects of the magnetite-hematite deposit at Benson Mines, New York: Economic Geology, v. 64, p. 183-190.

Howard, P.F., 1969, The geology of the Elizabeth mine, Vermont: Vermont Geological Survey, Economic Geology No. 5, 73 p.

Lyons, J.B., 1955, Geology of the Hanover quadrangle, New Hampshire-Vermont: Geological Society of America Bulletin, v. 66, p. 105-146.

Lyons, J.B., Moench, R.H., Bothner, W.A., and Thompson, J.B., Jr., 1986, Interim geologic map of New Hampshire: Durham, N.H., Office of the New Hampshire State Geologist, scale 1:250,000.

McKinstry, H.E., and Mikkola, A.K., 1954, The Elizabeth copper mine, Vermont: Economic Geology, v. 49, p. 1-30.

McLelland, J., 1985, Possible volcanogenic origin for Adirondack magnetite deposits: Evidence and implications (abstract): Geological Society of America Abstracts with Programs, v. 17, no. 1, p. 54.

Morton, R.L., and Nebel, M.L., 1984, Hydrothermal alteration of felsic volcanic rocks at the Helen siderite deposit, Wawa, Ontario: Economic Geology, v. 79, p. 1319-1333.

Mottl, M.J., 1983, Metabasalts, axial hot springs, and the structure of hydrothermal systems at mid-ocean ridges: Geological Society of America Bulletin, v. 94, p. 161-180.

Naylor, R.S., 1969, Age and origin of the Oliverian domes, central-western New Hampshire: Geological Society of America Bulletin, v. 80, p. 405-428.

Newland, D.H., 1908, Geology of the Adirondack magnetite iron ores: New York State Museum Bulletin 119, 182 p.

Potter, D.B., 1972, Stratigraphy and structure of the Hoosick Falls area, New York-Vermont, east-central Taconics: New York State Museum, Map and Chart Series 19, 71 p.

Rolph, A.L., 1982, Structure and stratigraphy around the Elizabeth mine, Vermont: Unpublished M.S. Thesis, University of Cincinnati, Cincinnati, Ohio, 228 p.

Rudnick, B.J., 1986, A study of the geology and exploration of a pyrrhotite deposit in Precambrian units, Cuttingsville, Vermont: Unpublished M.Sc. Thesis, University of New Brunswick, Frederickton, New Brunswick, 212 p.

Schumacher, J.C., 1983, Stratigraphic, geochemical, and petrologic studies of the Ammonoosuc Volcanics, north-central Massachusetts and southwestern New Hampshire: Unpublished Ph.D. Thesis, University of Massachusetts, Amherst, Massachusetts, 237 p.

Slack, J.F., and Atelsek, P.J., 1983, Roadlog for field trip to stratabound sulphide deposits of west-central New England, in Sangster, D. F. (ed.), Field trip guidebook to stratabound sulphide deposits, Bathurst area, N.B., Canada and west-central New England, U.S.A.: Geological Survey of Canada Miscellaneous Report 36, p. 31-39.

Spear, F.S., Hazen, R.M., and Rumble, D., III, 1981, Wonesite: A new rock-forming silicate from the Post Pond Volcanics, Vermont: American Mineralogist, v. 66, p. 100-105.

Spear, F.S., and Rumble, D., III, 1986, Mineralogy, petrology, and P-T evolution of the Orfordville area, west-central New Hampshire and east-central Vermont, in Robinson, P. (ed.), Regional metamorphism and metamorphic phase relations in northwestern and central New England: Stanford, California, International Mineralogical Association, 14th General Meeting, Field Trip Guidebook, Stanford University, p. 57-93.

Thompson, J.B., Jr., 1972, Lower Paleozoic rocks flanking the Green Mountain anticlinorium, in Doolan, B. L., and Stanley, R. S. (eds.), New England Intercollegiate Geological Conference, Guidebook, 64th Annual Meeting: Burlington, Vermont, University of Vermont, p. 215-229.

Thompson, J.B., Jr., and McLelland, J.M., 1986, Geologic map of the Glens Falls 1^{o} x 2^{o} quadrangle, New York, Vermont, and New Hampshire: U.S. Geological Survey, unpublished map, scale 1:250,000.

Vine, J.D., and Tourtelot, E.B., 1970, Geochemistry of black shale deposits--A summary report: Economic Geology, v. 65, p. 253-272.

Willden, M., 1986, The Enasen gold deposit: Sveriges Geologiska Undersokning, Nr. 67, p. 14-17 [Excursion guide no. 9/10 for 7th IAGOD Symposium, August 18-22, 1986, Lulea, Sweden].

Zen, E-an, 1964, Stratigraphy and structure of a portion of the Castleton Quadrangle, Vermont: Vermont Geological Survey Bulletin 25, 70 p.

ADDITIONAL BIBLIOGRAPHY

Alling, H.L., 1918, The Adirondack graphite deposits: New York State Museum Bulletin 199, 150 p.

Beck, L.C., 1842, Mineralogy of New-York: Albany, W. & A. White & J. Visscher, Publishers, 534 p.

Bothner, W.A., 1978, Selected uranium and uranium-thorium occurrences in New Hampshire: U.S. Geological Survey Open-File Report 78-482, 42 p.

Cameron, E.N., and others, Pegmatite investigations, 1942-45, New England: U.S. Geological Survey Professional Paper 255, 352 p.

Clark, S.H.B., 1987, Zinc, lead, and barium deposits and occurrences in Paleozoic sedimentary rocks, east-central United States: U.S. Geological Survey Miscellaneous Investigations Series Map I-1773, scale 1:2,500,000.

Gair, J.E., and Slack, J.F., 1979, Map showing lithostratigraphic and structural setting of stratabound (massive) sulfide deposits of the U.S. Appalachians: U.S. Geological Survey Open-File Report 1517, scale 1:1,000,000 [4 sheets].

Grant, R.W., 1968, Mineral collecting in Vermont: Vermont Geological Survey, Special Publication No. 2, 49 p.

Hager, A.D., 1861, Economical geology of Vermont, in Hitchcock, E., Hitchcock, E., Jr., Hager, A.D., and Hitchcock, C.H., Report on the geology of Vermont: Descriptive, theoretical, economical, and scenographical: Claremont, N. H., Claremont Manufacturing Company, v. II, p. 733-870.

Henson, M.P., 1982, Gold laden hills and streams of Vermont: Lost Treasure, v. 7, no. 4, p. 54-59.

Hitchcock, C.H., 1878, The geology of New Hampshire: Part V, Economic geology: Concord, N. H., E. A. Jenks, Publishers, 103 p.

Jackson, C.T., 1844, Geology and mineralogy of the state of New Hampshire: Concord, N. H., Carroll & Baker, Publishers, 376 p.

Leo, G.W., 1985, Trondhjemite and metamorphosed quartz keratophyre tuff of the Ammonoosuc Volcanics (Ordovician), western New Hampshire and adjacent Vermont and Massachusetts: Geological Society of America Bulletin, v. 96, p. 1493-1507.

Luedke, E.M., Wrucke, C.T., and Graham, J.A., 1959, Mineral occurrences of New York State with selected references to each locality: U.S. Geological Survey Bulletin 1072-F, p. 385-444.

McHone, J.G., and Wagener, H.D., 1982, National uranium resource evaluation, Glens Falls Quadrangle, New York, Vermont, and New Hampshire: U.S. Department of Energy, Report PGJ/F-025 (82), 31 p.

McLelland, J.M., 1986, Pre-Grenvillian history of the Adirondacks as an anorogenic, bimodal caldera complex of mid-Proterozoic age: Geology, v. 14, p. 229-233.

Morrill, P., 1960, New Hampshire mines and mineral localities: Hanover, New Hampshire, Dartmouth College Museum, 46 p.

Morrill, P., and Chaffee, R.G., 1964, Vermont mines and mineral localities: Hanover, New Hampshire, Dartmouth College Museum, 54 p.

Newland, D.H., 1919, The mineral resources of the state of New York: New York State Museum Bulletin, nos. 223 & 224, 315 p.

Pearre, N.C., and Calkins, J.A., 1957, Mineral deposits and occurrences in New Hampshire exclusive of clay, sand and gravel, and peat: U.S. Geological Survey Mineral Investigations Resource Map MR-6, scale 1:500,000.

____________1957, Mineral deposits and occurrences in Vermont exclusive of clay, sand and gravel, and peat: U.S. Geological Survey Mineral Investigations Resource Map MR-5, scale 1:500,000.

Perry, E.L., 1929[?], The geology of Bridgewater and Plymouth Townships, Vermont: Vermont Geological Survey, Report of the State Geologist, 16th (1927-1928), p. 1-64.

Slack, J.F., Whitlow, J.W., and Annis, M.P., 1984, Gold in stream sediments from the Orange County copper district, east-central Vermont: U.S. Geological Survey Open-File Report 84-889, 21 p.

Smith, B.R., 1976, The Plymouth gold rush: Vermont Life, v. 6, no. 2, p. 8-13.

Smith, G.O., 1904, Quartz veins in Vermont: U.S. Geological Survey Bulletin 225, p. 81-88.

Thompson, J.B., Jr., Robinson, P., Clifford, T.N., and Trask, N.J., Jr., 1968, Nappes and gneiss domes in west-central New England, <u>in</u> Zen, E-an, White, W. S., Hadley, J. B., and Thompson, J. B., Jr. (eds.), Studies of Appalachian Geology: Northern and Maritime: New York, Wiley Interscience, p. 203-218.

White, W.S., and Eric, J.H., 1944, Preliminary report on the geology of the Orange County copper district, Vermont: U.S. Geological Survey Open-File Report, 36 p. [includes 8 separate plates].

Wiener, R.W., McLelland, J.M., Isachsen, Y.W., and Hall, L.M., 1984, Stratigraphy and structural geology of the Adirondack Mountains, New York: Review and synthesis: Geological Society of America Special Paper 194, 55 p.

Zen, E-an, 1967, Time and space relationships of the Taconic allochthon and autochthon: Geological Society of America Special Paper 97, 107 p.