LYME, NH-VT 7 ½' QUADRANGLE

Intrusive Rocks *

- **Jd** — **diabase dike:** Black, fine-grained diabase
- **Db2b** — **Bethlehem Gneiss:** Gray to pink, moderately foliated biotite-muscovite granodiorite, porphyritic (orthoclase up to 2cm)
- **Oo 2-3A** — **Oliverian Holts Ledge Gneiss:** Gray, foliated quartz diorite, tonalite and granodiorite, with sparse amphibolite layers
- **Oo1b** — **Oliverian Mascoma Granite:** Weakly foliated biotite granite

* Designators follow usage of Lyons et al. (1997)

Fault Rocks

Jsz Silicified zone

Metamorphic Rocks

Dl Littleton Formation: Gray muscovite schist

- Dlvf: Felsic metavolcanics (dacite?)

Sf Fitch Formation: Biotite granofels and calc-silicate schist

Sc Clough Quartzite: White to gray quartzite and metaconglomerate

Ops Partridge Formation: Dark gray phyllite and schist

- Opf: Felsic metavolcanics (rhyolite tuff?)

Oa Ammonoosuc Volcanics

- ▽ Pillows (topping direction ***not*** implied by symbol)
- P Pyroclastics, breccia or agglomerate
- Oas: Dark gray schist
- Oac: Thinly bedded quartzite and garnet schist, local coticule
- Oaf: Felsic metavolcanics (rhyolite tuff?)
- Oafx: Phyric felsic metavolcanics (crystal tuff?)
- Oam: Mafic metavolcanics (basalt to andesite?)

md — **metadiabase dike**

mg — **metagabbro dike or stock**

mf — **metafelsite dike**

Bedrock Geology of New Hampshire portion of Lyme, NH-VT 7 ½' Quadrangle

Summary

Bedrock of the Lyme Quadrangle consists of a central arch of Ordovician rocks (Orfordville anticlinorium of Hadley, 1942) flanked on either side by the Devonian Littleton Formation and associated rocks, which also overlie an Ordovician-cored dome in the southeast corner of the map. The Ordovician rocks were originally deposited as volcanic flows and ash falls (Ammonoosuc Volcanics), interlayered with marine black shales (Partridge Formation), which extend the length of New Hampshire and represent the remains of an ancient volcanic island arc. During the Taconian Orogeny, a mountain-building episode that resulted from the collision of this arc with land masses farther west, the Ordovician rocks were deformed by folds inclined or overturned toward the east. A pervasive metamorphic foliation formed at this time.

Erosion eventually leveled the resulting mountains to the point where a beach sand (Clough Quartzite), carbonate-rich materials (Fitch Formation) and mud and sand deposits (Littleton Formation) were unconformably deposited on top of the Ordovician rocks. The whole package was again deformed and metamorphosed during a second mountain-building episode, the Acadian Orogeny, as another land mass became accreted to the continental margin from the east. Upright folds were superposed on the older structures. The Oliverian gneiss domes to the east of the quadrangle, mantled by the volcanics and younger rocks, pushed up from below along the length of the Bronson Hill anticlinorium. Younger igneous rocks intruded as molten masses during this disturbance, represented in the Lyme Quadrangle by the south end of the Indian Pond pluton (Bethlehem Gneiss), which is exposed from Lyme Center to Bear Hill.

Much later, as the modern-day Atlantic Ocean opened, the Ammonoosuc fault developed along the Connecticut River valley, bringing low grade metamorphosed volcanics on the west side down to the same level as the higher grade rocks on the east.

Main contributions of the present mapping

Contacts between the major rock units of this map are not much different from those mapped by Hadley (1942), Naylor (1969) and Rumble (1969). (Rumble, following the example of Thompson et al. (1968), reassigned Hadley's Post Pond Volcanics to the Ammonoosuc Volcanics, and divided the pelitic rocks of Hadley's Orfordville Formation between Littleton and Partridge Formations.)

On the present map the Ammonoosuc Volcanics have been separated into felsic and mafic rocks. However, some felsic volcanic layers are now assigned to the Partridge Formation, and black pelitic horizons also occur in the Ammonoosuc. The resulting map pattern shows the following relationships: mafic, felsic, and pelitic rocks were deposited as facies of each other, not in any consistent stratigraphic order. Black pelites are much thicker on the east limb of the Orfordville anticlinorium, and entirely absent above the Oliverian Mascoma dome. In the north part of the quadrangle, the pelites overlie the volcanics, which plunge northward beneath them in late, open folds. Distinctive, thin-bedded quartzite and schist, locally with coticule layers, may represent bedded chert west of the old Skunk Hollow road. Numerous metamorphosed dikes, both mafic and felsic, cut the pelites, suggesting that both mafic and felsic volcanism continued into the time when the Partridge was being deposited. Alternatively, the black pelites in the north could be stratigraphically below the volcanics in an overturned (early) fold. This seems less likely if indeed the pelites to the north connect on the ground to those east of the volcanics, as mapped by Hadley (1942).

Lava pillows and pyroclastic textures are preserved at numerous places in the mafic volcanics. Pyroclastics are especially abundant near the contact between mafic and felsic rocks, strengthening the interpretation of the felsic rocks as ash-flow or ash-fall deposits. A coarse hornblende gneiss, with possible relict ophitic texture, caps Post Hill. It could be interpreted as a volcanic plug, and the proximity of coarse pyroclastics immediately to the south even suggest that Post Hill may have been an eruptive center. If so, it was likely a minor locus of eruptive activity; vents for the Ammonoosuc Volcanics must have been numerous and widely dispersed up and down the length of the state.

A high-strain zone about two kilometers wide, where foliation is very steep, extends west from the Indian Pond pluton, between the Bronson Hill anticlinorium and the Orfordville anticlinorium. Hadley (1942) proposed that the Partridge-Littleton contact in this zone is the southern extension of the Northey Hill thrust fault. It seems more likely that strain is distributed across the zone rather than being confined along the unconformity. A study of Ar/Ar ratios in muscovite from the steep foliation would be very interesting. Could it date from the Alleghanian Orogeny?

Hadley (1942) interpreted thin, fine-grained, biotitic gneiss layers within the Littleton Formation west of Lyme Center as highly sheared Bethlehem Gneiss. However, these layers greatly resemble felsic metavolcanics in the Partridge and Ammonoosuc, so an alternative interpretation, adopted here, is that they are Devonian metavolcanics. Such layers are known within the Littleton farther north (Rankin, personal communication, 2008).

Joints were measured at many outcrops in an effort to characterize each map unit as to water-bearing capability. The results of that study are still being compiled and will be included in the final report.

DESCRIPTION OF UNITS

Intrusive Rocks

?Jurassic diabase dikes: Black, fine-grained diabase, locally with plagioclase phenocrysts.

Devonian Bethlehem Gneiss: Gray to pink, moderately foliated quartz-plagioclase-orthoclase-biotite-muscovite granodiorite, slightly porphyritic (orthoclase up to 2cm). Hornblende granite locally, for example on Bear Hill.

Ordovician Smarts Mountain Granodiorite: Light gray, weakly foliated, magnetite-bearing biotite granodiorite to tonalite. Local biotite gneiss xenoliths, well exposed on the Appalachian Trail west of Smarts summit.

Ordovician Holts Ledge Gneiss: Gray, foliated quartz diorite, tonalite and granodiorite, with sparse epidote amphibolite layers.

Ordovician Mascoma Granite: Weakly foliated biotite granite and quartz monzonite.

Metamorphic Rocks

Littleton Formation: Gray, fine-grained quartz-muscovite-biotite +/- garnet, +/- staurolite schist with sandy to silty layers up to several centimeters thick. Rusty on some foliation surfaces, but not pervasively so. Layers of gray, strongly foliated biotite-quartz-feldspar gneiss (dacitic?) and minor hornblende-garnet gneiss are interpreted as metavolcanics.

Fitch Formation: Gray, smooth-weathering biotite-quartz feldspar granofels, buff sandy marble, calc-silicate granofels and schist, and calcareous quartzite and schist.

Clough Quartzite: White to gray, well bedded quartzite, quartz pebble conglomerate with quartz matrix and quartz-muscovite-biotite-garnet schist.

Partridge Formation: Dark gray phyllite and fine-grained schist, commonly with biotites across the foliation, +/- garnet, +/- staurolite. Pyrite-rich layers weather very rusty, but elsewhere difficult to differentiate from Littleton. Rusty brown- to white-weathering, gray to white, aphyric felsite is interpreted as rhyolitic tuff. Locally with tiny feldspar and blue quartz phenocrysts and/or pyroclastic textures. Biotite marks the foliation in some horizons.

Ammonoosuc Volcanics, mafic facies: Black to dark green, fine- to coarse-grained, hornblende +/- epidote +/- garnet amphibolite, hornblende schist (basalt and gabbro) and black and white mottled hornblende-plagioclase gneiss (andesite?). Pillows are well exposed at several localities, with more resistant epidote-rich rims. Pyroclastic textures range from breccia to agglomerate. Thinly bedded quartzite and garnet schist (ribbon chert?) with coticule layers is found above the mafic gneiss in one area west of Skunk Hollow. **Felsic facies:** Similar to felsic metavolcanics in the Partridge Formation (see above). Felsite above the Oliverian domes is more biotite-rich than felsite in the Orfordville "anticlinorium". A thick layer of phyric felsite exposed along and north of Slade Brook east of Route 10 is interpreted as a crystal tuff. Dark gray, garnet-bearing schist is exposed near the mouth of Hewes Brook and west of Lyme Hill, and elsewhere as layers too thin to map.