SMARTS MOUNTAIN, NH 7 ½' QUADRANGLE

By Peter Thompson

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** — **Smarts Mountain Granodiorite:** Light gray, weakly foliated, magnetite-bearing biotite granodiorite to tonalite
- **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)

Metamorphic Rocks

- **Dl Littleton Formation:** Gray, fine-grained muscovite-rich schist
  - Dlvf: Felsic metavolcanics (dacite?)
  - Dlvm: Mafic metavolcanics (hornblende-garnet gneiss)
- **Sf Fitch Formation:** Biotite granofels, sandy marble and calc-silicates
- **Sc Clough Quartzite:** White to gray quartzite and metaconglomerate
- **Ops Partridge Formation:** Dark gray phyllite and schist
  - Opf: Brown- to white-weathering felsic metavolcanics (rhyolite tuff?)
  - Opfx: Phyric felsic metavolcanics (crystal tuff?)
- **Oa Ammonoosuc Volcanics**, undifferentiated
  - ∇ Pillows (topping direction ***not*** implied by symbol)
  - P Pyroclastics, breccia or agglomerate
  - Oas: Dark gray schist
  - Oaf: Brown- to white-weathering felsic gneiss (rhyolite tuff?)
  - Oam: Green to black mafic hornblende-epidote and hornblende-plagioclase gneiss (basalt to andesite?)
- **md** — **metadiabase dike:** Dark, even-grained hornblende gneiss
- **mf** — **metafelsite dike:** Light gray, massive, biotitic felsite

Bedrock Geology of Smarts Mountain, NH 7 ½' Quadrangle

Summary

Bedrock of the Smarts Mountain Quadrangle is dominated by a pattern of layered metamorphic rocks surrounding four large bodies of metamorphosed igneous rocks: the Ordovician Smarts Mountain and Mascoma domes, and the Devonian Indian Pond and Mt. Clough plutons. Much has been written about the relationship between the domes and the mantling sequence of rocks (Hadley, 1942; Naylor, 1969; Rumble, 1969). Most geologists now agree that the Ammonoosuc Volcanics were deposited on top of the Oliverian rocks within the domes. The core of the Mascoma dome yielded an age of 444 +/-8 Ma and the upper, Holts Ledge Gneiss in the dome, 445 +/-25 Ma (Rumble, CHECK NEIGC PAPER).

The volcanic rocks were originally deposited as flows and ash falls (Ammonoosuc Volcanics), which extend the length of New Hampshire and represent the remains of an ancient volcanic island arc. In the northwest corner of the quadrangle, they are succeeded upwards by marine black shales (Partridge Formation). 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 folded and pressed downward into the crust.

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. The Oliverian gneiss domes, mantled by the volcanics and younger rocks, pushed up from below. Younger igneous rocks intruded as molten masses during this disturbance, represented in the Smarts Mountain Quadrangle by two plutons of Bethlehem Gneiss: the south end of the undated Indian Pond pluton, which terminates at Bear Hill, and the west margin of the Mt. Clough pluton (410 +/-5 Ma, U/Pb, Aleinikoff, 1989).

Much later, as the modern-day Atlantic Ocean opened, the Ammonoosuc fault developed along the Connecticut River valley, west of this quadrangle. The only manifestation of this rifting here are three diabase dikes: one in Trout Brook near the west boundary and two in Clough Branch north of Cummins Pond.

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.)

On the present map the Ammonoosuc Volcanics have been separated into felsic and mafic rocks. In the northwest corner of the quadrangle it seems that mafic, felsic, and pelitic rocks were deposited as facies of each other, not in any consistent stratigraphic order, although favoring pelite upwards. The map pattern is complicated by both early and late folds. By contrast, black pelites are entirely absent above the Oliverian domes. The map pattern shows that the contacts between mafic and felsic volcanics are not conformable with the overlying Clough Quartzite. There is no evidence to suggest that the mafic and felsic pattern here is the result of folding rather than primary facies relationships. Lava pillows and pyroclastic textures, as well as mafic and felsic dikes, are preserved in several places, especially in the north branch of Grant Brook.

The contacts between mafic and felsic rocks in the Ammonoosuc are comformable with the underlying Holts Ledge Gneiss in the Mascoma dome, as discussed at length by Naylor (1969). The present mapping shows, however, that the contacts are truncated by the Smarts Mountain body. Perhaps this is one of the Oliverian domes that entirely intruded its own cover during the doming.

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 the Indian Pond pluton 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.