TRIP A-8

BEDROCK GEOLOGY OF THE OSSIPEE LAKE AREA

J. Robert Wilson
Phillips Academy
Andover, Massachusetts

Introduction

This trip will study some igneous and metamorphic rocks on the southeastern edge of the White Mountain batholith and in the Ossipee Mountains ring dike complex. The oldest rocks are sillimanite-mica schists of the Littleton formation (Early Devonian). These schists are intruded by gray, medium-grained, two-mica calc-alkaline granitic rocks of the New Hampshire Plutonic Series (Middle Devonian) and by pegmatite. The pegmatite is somewhat younger than the granitic rocks of the New Hampshire Series. There are also volcanic rocks (rhyolite, andesite, basalt and breccia) and coarse-grained to porphyritic, pink and green hypersolvus granites and porphyritic quartz syenite of the White Mountain Plutonic-Volcanic Series (Early Jurassic). Quarternary glacial deposits (sand plains, reworked stream deposits, a couple of eskers) cover most low-lying parts of the area. There will be ample opportunity to collect hand specimens. This area has been mapped at 1:62,500 by Wilson (1969). For a regional setting refer to Billings (1956) and Doyle (1967).

Littleton Formation

The Littleton Formation crops out in a broad belt across the center of the area and is always intimately associated with pegmatite and granitic rocks of the New Hampshire Plutonic Series. This formation contains pelitic schist (sillimanite-almandite-plagioclase-muscovite-biotite-quartz with tourmaline in places), granofels (plagioclase-mica-quartz with minor almandite), calc-silicate granofels (sphene-actinolite-quartz-biotite-labradorite) and migmatite gneiss. The sillimanite is fibrolitic and commonly is intimately associated with biotite to give the mica a matted appearance in thin section. The pelitic schist was apparently not aluminous enough to have produced andalusite or kyanite prior to sillimanite. Judging from experimentally determined stability relations, the sillimanite can be interpreted as a superimposed high temperature product of intense and extensive plutonic intrusion between roughly 4 to 7 kb (about 15 to 27 km of rock of S. G. 2.75) and between roughly 650 and 700°C. For discussions on the regional distribution of the Al_2SiO_5 polymorphs see Albee (1968) and Thompson and Norton (1968), in E-an Zen, Studies of Appalachian Geology: Northern and Maritime: John Wiley and Sons, Inc., Interscience, N. Y.

The structure of the Littleton Formation in this area remains indistinct due to the glacial cover and extensive outcrops of pegmatite and plutonic rocks of the New Hampshire series. The schistosity is consistently parallel to the bedding, which consists of alternating beds of schist and granofels a few cm. thick. The bedding-schistosity generally strikes in a northeasterly direction. There are lineations due to crinkle axes that plunge to the southwest. Top/bottom criteria are extremely rare (some graded bedding). Assuming congruous drag folds, the structure in the eastern part of the area appears to be situated on the southeast limb of a syncline plunging to the southwest.

The Littleton Formation can be continuously traced from the Littleton-Moosilauke district into this area (Billings, 1955). The fossil studies in and near that district confirm the age of the Littleton Formation to be Lower Devonian in the type locality (Billings and Cleaves, 1934; Boucot and Arndt, 1960). The Silurian rocks in Southwestern Maine, the Eliot and Berwick Formations (Doyle et al., 1967), have been correlated with the fossil bearing slates of the Waterville, Maine district (Osberg, 1968) lying 90 miles to the northeast. Hussey has mapped the structure in these Silurian rocks and has shown the stratigraphy to proceed up-section towards the northwest from the south edge of the Sebago batholith. The Kezar Falls and Newfield areas mapped by Gilman form a link between the Silurian rocks to the southeast and this area. Thus the rocks assigned to the Littleton Formation in this area can be traced to the northwest and east into strata that overlie Silurian formations and are considered to be Lower Devonian.

New Hampshire Plutonic Series

WINNIPESAUKEE QUARTZ DIORITE

In this area the Winnipesaukee quartz diorite is restricted to the Ossipee Mountains. This rock is light gray, medium-grained, equigranular and composed of quartz, sodic andesine, orthoclase, biotite and muscovite. This rock locally exhibits a mylonitic texture suggestive of faulting or crushing.

TRONDHJEMITE

In the northeast portion of this area the most common granitic rock, other than pegmatite, is trondhjemite, a light-gray, fine-grained, equigranular rock composed of quartz (30%), plagioclase (An_{29}, 45%), orthoclase (8%), biotite (16%), and muscovite (1%), with a trace of monazite.

QUARTZ MONZONITE

There is one small stock of quartz monzonite. It is entirely surrounded by Conway granite in the north-central part of the area. This rock is light-gray, medium- to coarse-grained and subporphyritic. It contains traces of sillimanite.

CONCORD GRANITE

This rock is fairly common throughout the central portion of the area. It is light-gray, medium-grained, equigranular and contains traces of almandite and sillimanite locally. This rock grades into quartz monzonite in places. The name is equivalent to binary granite, but is intended to specifically imply the youngest granite of the New Hampshire Plutonic Series.

Pegmatite

Pegmatite is extremely common throughout the central part of the area.

White Mountain Plutonic-Volcanic Series

MOAT VOLCANICS

The Moat Volcanics consist primarily of porphyritic rhyolite, porphyritic basalt, ba salt and basaltic breccia. Some andesitic tuff and welded tuff is also present. Besides flows, there are several places where the volcanics appear to be the remnants of shallow pipes or plugs. L. R. Page has observed what he considers to be the dip slopes of cone sheets on the west side of the Ossipee Mountains. In places it is at first questionable whether one is observing the Albany Porphyritic Quartz Syenite or a variety of shallow intrusive volcanics.

ALBANY PORPHYRITIC QUARTZ SYENITE

This rock contains microperthite (60%), anorthoclase (10%), quartz (20%), hastingsite (10%) with minor biotite, augite, magnetite, zircon, fayalite and apatite. The hastingsite is poikilitic. Some of the anorthoclase is mantled with rims of of K-spar. Some hastingsite occurs as a reaction rim around small augite grains.

MT. OSCEOLA GRANITE

This rock is a coarse-grained, equigranular, olive-green to gray granite. It is about 75% microperthite, 20% quartz with 1 to 8% hastingsite, plus minor hedenbergite, fayalite, fluorite, apatite, albite and zircon.

CONWAY GRANITE

The Conway granite has been dated by various workers using samples collected in the Redstone Quarry. The generally accepted age is 185 m.y.

This rock is typically a medium- to coarse-grained, light pink to buff colored, equigranular biotite granite. The biotite is extremely iron-rich. Fluorite, magnetite, fayalite, zircon, allanite, rutile, apatite and molybdenite are also present. The Redstone quarry has also been the source of well crystallized miarolitic cavities in the Conway granite containing large, euhedral crystals of quartz and microcline-perthite.

DIKE ROCKS

The most common dike rock in this area is camptonite. Two large camptonite dikes occur, both containing euhedral barkevikite. Spessartite and felsite dikes also are present, along with the usual diabase.

REFERENCES (CITED AND GENERAL)

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Topographic maps needed: Ossipee Lake, North Conway U.S.G.S. 15-minute topographic sheets

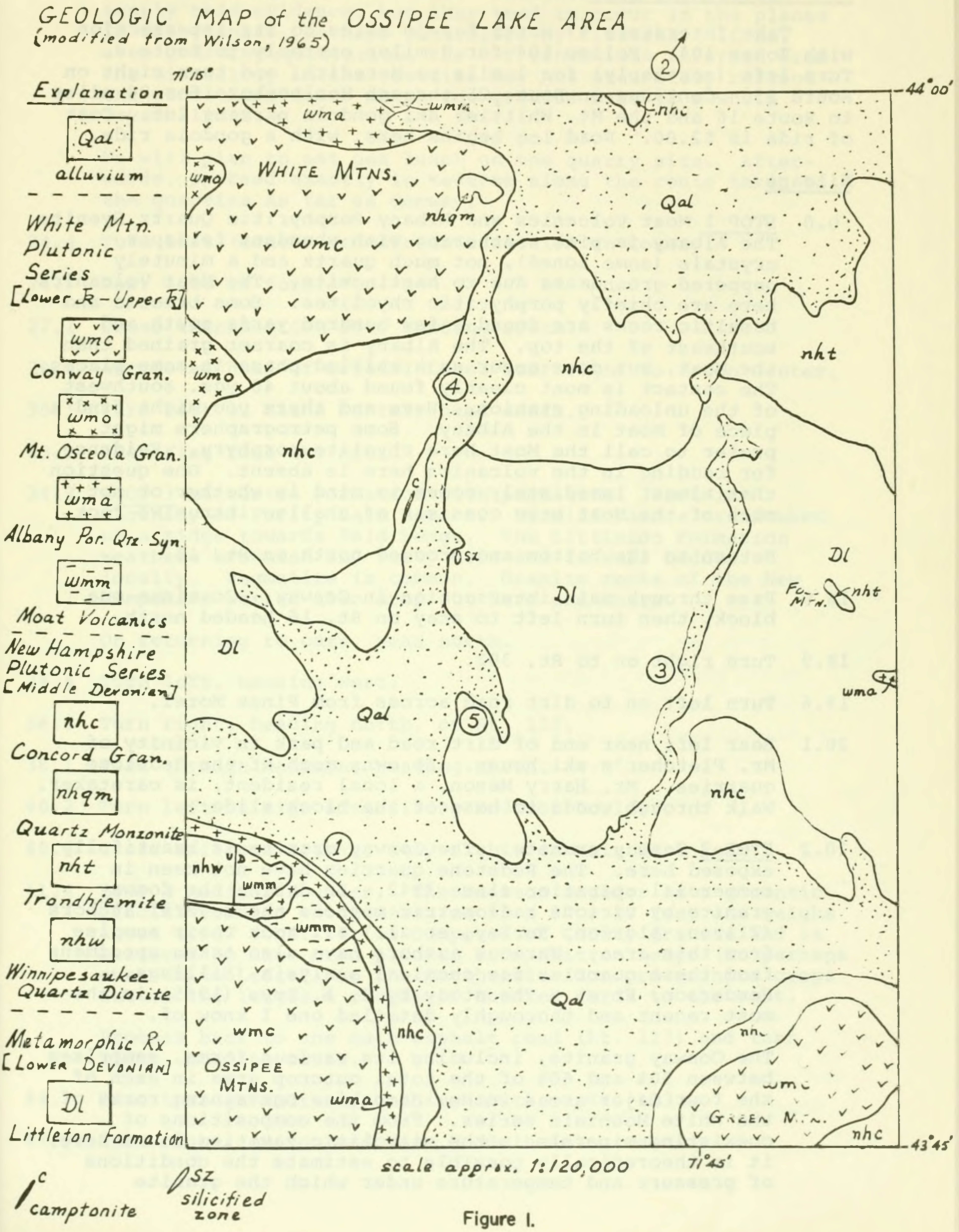
GEOLOGIC MAP of the OSSIPEE LAKE AREA
(modified from Wilson, 1965)
71°15'
44°00'
43°45'
71°45'
Explanation
Qal
alluvium
White Mtn. Plutonic Series
[Lower Jr - Upper Tr]
wmc
Conway Gran.
wmo
Mt. Osceola Gran.
wma
Albany Por. Qtz. Syn.
wmm
Moat Volcanics
New Hampshire Plutonic Series
[Middle Devonian]
nhc
Concord Gran.
nhqm
Quartz Monzonite
nht
Trondhjemite
nhw
Winnipesaukee Quartz Diorite
Metamorphic Rx
[Lower Devonian]
Dl
Littleton Formation
c
camptonite
Sz
silicified zone
WHITE MTNS.
OSSIPEE MTNS.
GREEN MTN.
Fox Mtn.
scale approx. 1:120,000
1
2
3
4
5

Figure I.

ROAD LOG FOR TRIP A-8

Take Interstate 93 north for 30 miles to its intersection with Route 104. Follow 104 for 9 miles easterly to Route 3. Turn left (northerly) for 1 mile to Meredith, and turn right on Route 25. Continue on Route 25 through Moultonboro for 24 miles to Route 16 and the Mt. Whittier ski gondola parking lot. Cost of ride is $2.00. Road log begins here, with a gondola ride.

Mileage

0.0 STOP 1 Moat Volcanics and Albany Porphyritic Quartz Syenite The Albany is pink weathering with abundant feldspar crystals (some zoned), not much quartz and a minutely peppered groundmass due to hastingsite. The Moat Volcanics here are chiefly porphyritic rhyolites. Some breccia and basaltic rocks are found a few hundred yards south and southeast of the top. The Albany is coarser grained than the Moat, but does occur as a chilled phase in some places. The contact is most clearly found about 40 yds. southwest of the unloading station. Here and there you might find a piece of Moat in the Albany. Some petrographers might prefer to call the Moat here rhyolite porphyry. Evidence for bedding in the volcanics here is absent. One question that almost immediately comes to mind is whether or not much of the Moat here consists of shallow intrusive rock.

Return to the bottom and proceed north on Rt. 16.

16.0 Pass through main intersection in Conway. Continue one block, then turn left to stay on Rt. 16 headed north.

18.9 Turn right on to Rt. 302.

19.6 Turn left on to dirt road across from Pines Motel.

20.1 Bear left near end of dirt road and park in vicinity of Mr. Fletcher's ski house. He owns much of the Redstone quarries. Mr. Harry Mason, a local resident, is caretaker. Walk through woods to base of the block slide.

20.2 STOP 2 Conway granite. The Conway granite is beautifully exposed here. The Redstone quarries have not been in commercial operation since 1942. In dating the Conway granite by various radiometric methods the several authors (Tilton, Aldrich, Hurley, et al.) all took their samples from this area. Various authors have also taken specimens from these quarries for chemical analysis (Billings, Henderson, Frye). The study by J. K. Frye (1965) is the most recent and thoroughly detailed one I know of.

The Conway granite, including its various forms, comprises between 50% and 60% of the total outcrop area in each of the four major areas in New Hampshire containing rocks of the White Mountain series. From the compositions of coexisting minerals in the miarolitic cavities found here, it is theoretically possible to estimate the conditions of pressure and temperature under which the granite crystallized. To do this, however, certain assumptions are necessary concerning the aqueous phase, the most necessary one being that there was one. The cavities themselves supply this evidence, but they tend to occur in the planes in the granite, perhaps controlled by fissures. If so, even granting equilibrium, the P-T conditions inferred from the mineralogy in the cavities may not accurately reflect the conditions under which the granite mass as a whole crystallized.

We will plan to eat our lunch on the quarry site. Afterwards, proceed exactly in reverse along the route taken to the quarries as far as Conway.

24.4 Turn left (south) at main intersection in Conway.

24.7 Bear left at fork.

27.1 Cross intersection 558, heading south.

29.6 Arrive at head of Crystal Lake; bear right to Eaton Center.

30.1 Turn left in Eaton Center; head south.

33.1 Pass King Pine Ski Area.

34.2 STOP 3 Littleton Formation with pegmatite. Park in vicinity of Purity Lake Resort. We will take a trail west up a ridge towards Bald Ledge. The Littleton Formation weathers brownish and rusty here and is well bedded locally. Pegmatite is common. Granite rocks of the New Hampshire series also crop out here and there.

On returning to cars, head north.

34.4 Turn left, heading west.

36.6 Turn right, heading north, on Rt. 113.

38.1 Pass through Madison, heading north.

40.2 Turn left at sign advertising Madison Boulder.

40.8 Cross railroad tracks, stay right, on main dirt road.

41.4 STOP 4 Madison Boulder. The Madison Boulder is a gigantic glacial erratic which measures 83 x 37 x 23 feet and weighs about 4,662 tons. It is composed of Conway granite and is believed to have been plucked from Whitton Ledge (or perhaps even White Ledge?) to the northwest. Concord granite crops out on the ledges a couple of hundred yards to the west.

Proceed back to the main asphalt road (Rt. 113) and turn right, heading south.

44.7 Pass through Madison, heading south on Rt. 113.

47.9 Turn right, on to Lead Mine Road, heading west.

48.6 STOP 5 Madison Lead Mine. The Madison Lead Mine was last worked in the early twenties. The dominant sulfide minerals are galena and sphalerite deposited in a large silicified zone that trends north-south. Smaller silicified zones similar to this one are found all over New Hampshire and are taken as evidence for faulting, followed by mineralization. The main shaft, now water filled, lies just south of the dirt road; tailings lie north of the dirt road and extend to the south shore of Cooks Pond.

Proceed to Rt. 16 by continuing on this dirt road, around the southern tip of Silver Lake, for 1.8 miles, then turn left and proceed south on an asphalt road for 2.2 miles to West Ossipee where you will intersect Rt. 16.

If time and/or interest dictate, there are a couple of optional stops we could make in order to see more of a slightly different variety of the Albany or gneisses in the Littleton Formation.