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A5: Grafton Notch State Park: Glacial Gorges and Streams Under Pressure in the Mahoosic Range, Maine

Alice M. Doughty
Bates College, alice.doughty@gmail.com

Woodrow B. Thompson
Maine Geological Survey

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GRAFTON NOTCH STATE PARK: GLACIAL GORGES AND STREAMS UNDER PRESSURE IN THE MAHOOSIC RANGE, MAINE

By

Alice M. Doughty, Dept. of Geology, Bates College, Lewiston, ME 04240
and Woodrow B. Thompson, Maine Geological Survey (retired), Augusta, ME 04333
email address: alice.doughty@gmail.com cell: (207) 318-8220

INTRODUCTION

The focus of this field trip will be the glacial geology (U-shaped valley, gorges, and an esker) but the exposed bedrock offers glimpses of Devonian granite with pegmatite intrusions. We will drive as a caravan in our own vehicles along the scenic Route 26 into Grafton Notch State Park, northwest of Bethel, Maine. Carpooling is highly recommended. The field stops are at five designated park landmarks and one sand pit. There is an optional strenuous hike with a 1000 foot elevation gain to Table Rock over 1.9 miles. This optional hike is best for experienced and adventurous hikers who enjoy lots of rock steps, bolted rebar steps, boulder scrabbles, and extraordinary views (not available in bad weather).

Logistics: Wear hiking shoes or boots with good traction, pants to prevent bug and tick bites, and layers in case the weather turns cold or rainy. Avoid steep or slippery places on ledges next to cliffs and fast-moving streams. There are toilets/outhouses at three of the stops (Screw Auger, Spruce Meadows and Old Speck) and at the initial meeting place. No shops are available on the way or in the state park, so please bring your food and water with you.

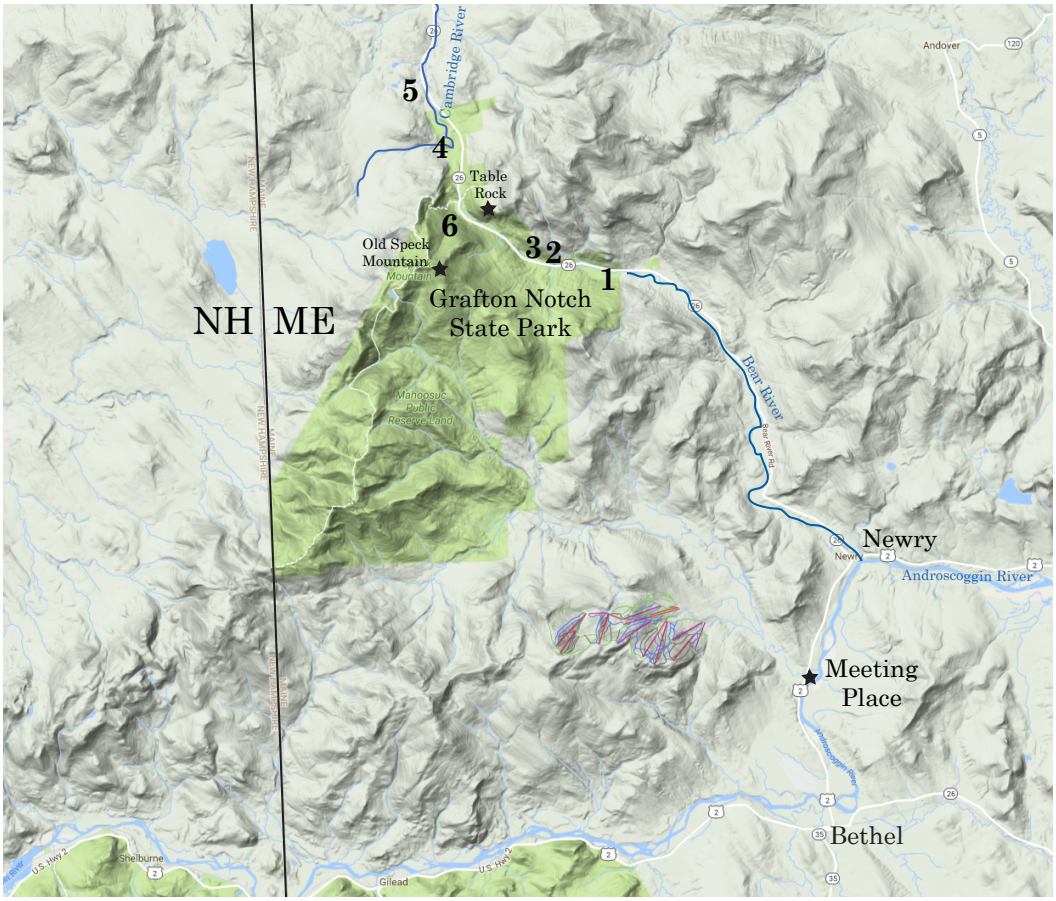

Figure 1. Google Maps view of the field trip area northwest of Bethel, Maine.

BEDROCK GEOLOGY

Metamorphic rocks

Grafton Notch cuts through part of the Mahoosuc Range, which includes metamorphic bedrock ~420 million years old. We will not be visiting any locations with metamorphic rocks, but the area includes:
OCAd: Ordovician Cambrian Dear River formation (slate, quartzite, phyllite)
Sp: Silurian Perry Mountain formation (sandstone, shale, quartzite)
Srac: Silurian Rangeley formation "A" member lithic sandstone (sandstone, conglomerate)
Sr: Silurian Rangeley formation (mudstone, sandstone)

Intrusive rocks

Mafic and Felsic Intrusions. Highly altered Oam: Ordovician Ammonoosuc Volcanics (mafic and felsic volcanics, medium rank amphibolite facies) outcrop in the region, but we will be in the D1b(m),3: Devonian granite (muscovite accessory mineral) (Milton, 1961; Moench et al., 1995; Thompson, 2001). Three major orogenies lead to the formation of the Appalachian Mountains: Taconic, Acadian, and Alleghenian. The granite we will visit formed during the Acadian orogeny in the Devonian (410 to 400 Ma) when the collision of continental fragments, called Avalonia, and the North American paleocontinent, Laurentia, closed of the southern Iapetus Ocean (Eusden et al., 2013).

Bedrock features. Thrust faults and sheet jointing (caused by erosion of overlying rock above the granite releases stress) may be visible at Mother Walker Falls. Episodic glaciers eroded this landscape to create features such as small cirques, steep cliffs on the valley walls, and a U-shaped valley (Fig. 2 & 3). Rivers continue to flow through gorges and potholes created during the last ice age when the rivers were under pressure and contained large quantities of sediment, such as glacial flour.

Figure 2. Photograph of the U-shaped valley in Grafton Notch from the Appalachian Trail on Old Speck. Route 26 and the Old Speck parking lot are visible for scale.

SURFICIAL GEOLOGY

Quaternary geology

Fluvial deposits. Floodplains exist in the relatively wide portions of the Grafton Notch valley and adjacent to the Androscoggin River. From the meeting place to the first stop, we will drive over flat areas of farmland that take advantage of the rich and fertile soil of the floodplain.

Glacial deposits. The Laurentide Ice Sheet deposited till with many large erratics on the valley floor (Marvinney and Thompson, 2000). Some of the boulders in the valley resulted from rock fall from the steep valley walls, but there are plenty of rock lithologies different from those of the local bedrock. Glacial-fluvial deposits, such as eskers and outwash, contain large quantities of sand and gravel (Fig. 3). The Grafton Notch area includes the following Quaternary features:

Qs - Quaternary swamp, peat, silt, clay and sand, poorly drained areas leading to wetland formation
Qt - Quaternary till, poorly sorted glacial debris including large erratics
Qg - Quaternary gravel, glacial stream deposit, well-sorted sand and gravel, moderate to high permeability

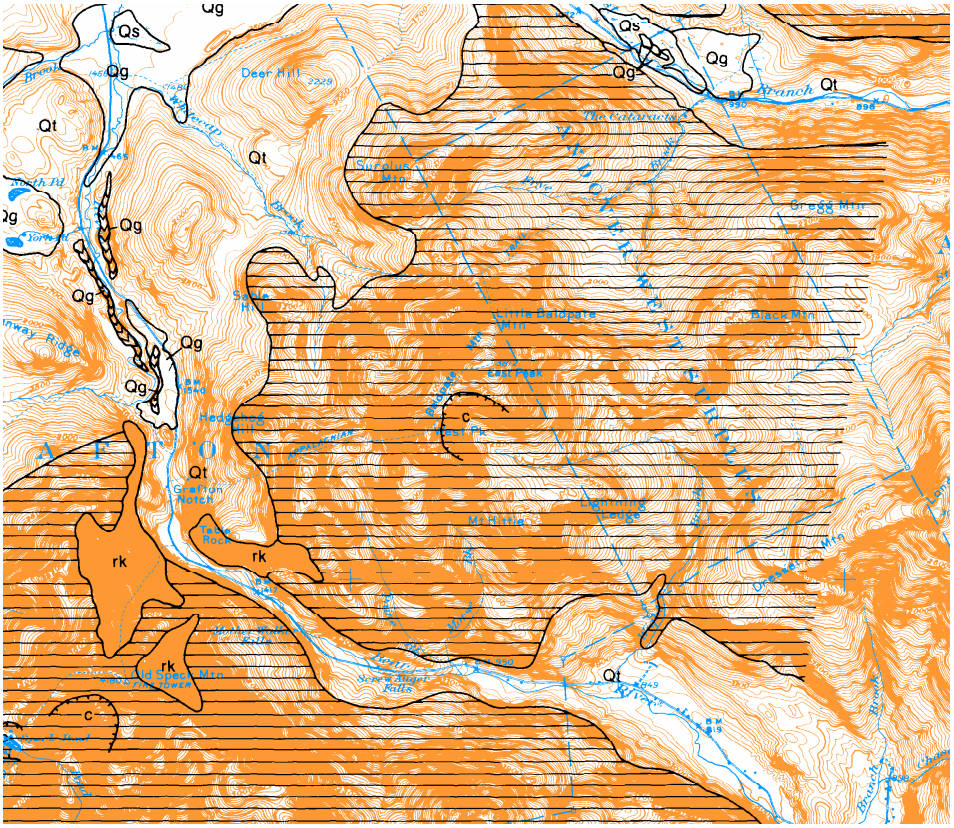

Figure 3. Surficial Geologic Map of Grafton Notch State Park (modified from Caldwell, 1975).

ROAD LOG

MEETING POINT:
9:00 AM at the Androscoggin Rest Area (UTM 356200 m E 4923600 m N) along Routes 26, 2, and 5 just northeast of the Sunday River Brewing Company in Bethel. ***Warning:*** Large mammals are very common in this park, so please take caution as you are driving these roads. There are toilet facilities available at some but not all stops.

Lunch: Bring your lunch, water, snacks, bug spray, sunscreen, and cameras because there will not be any shops in the park.
Physical demands: Avoid steep or slippery places on ledges next to cliffs and fast-moving streams. The optional 2-3 hour hike is steep and includes rock steps, bolted rebar, boulder scrabble, and a steep drop off at the top. By continuing on the optional hike, you acknowledge that you are a fit, capable hiker and are hiking at your own risk.
Entrance fees: There is a **$3 fee per vehicle** for the park; please pay this at the first stop (Screw Auger Falls).

Directions: From Rt 26 in Bethel: Drive north on Rt 26 and turn left in Newry to continue on Rt 26 (Bear River Rd).

This field trip is covered by Maps 10 & 18 in DeLorme's Maine Atlas and Gazetteer. Much of the information below comes from a glacial geology guide to Grafton Notch State Park (Thompson, 2001).

Mileage: Cumulative mileages given here may differ from those shown on your odometer, but the indicated distances between stops are generally accurate.

0.0 MEETING PLACE: Androscoggin River Rest Area (outhouse available), turn right out of parking lot and go N on Rt 26
2.7 Drive north to Newry, turn left at Bear River to continue on Route 26 and Bear RIver Road
12.1 STOP 1: Screw Auger Falls (entrance to parking lot on the left, outhouse available)
13.3 STOP 2: Mother Walker Falls (on the right)
14.1 STOP 3: Moose Cave (on the right)
15.8 STOP 4: Spruce Meadows Picnic Area (on the left, outhouse available)
17.6 STOP 5: Sand and gravel pit (on the left)
20.4 OPTIONAL STOP 6: Old Speck parking lot and Table Rock trailhead (turn around and drive south, look for the Appalachian Trail crossing and the parking lot on the right, outhouse available)

MEETING POINT: ANDROSCOGGIN RIVER REST AREA (45 min)
(UTM 356200 m E 4923600 m N, outhouse available) From Bethel, drive north on Rt. 26, cross over the Androscoggin River, pass the Sunday River Brew Pub and pull into the rest area on the right.

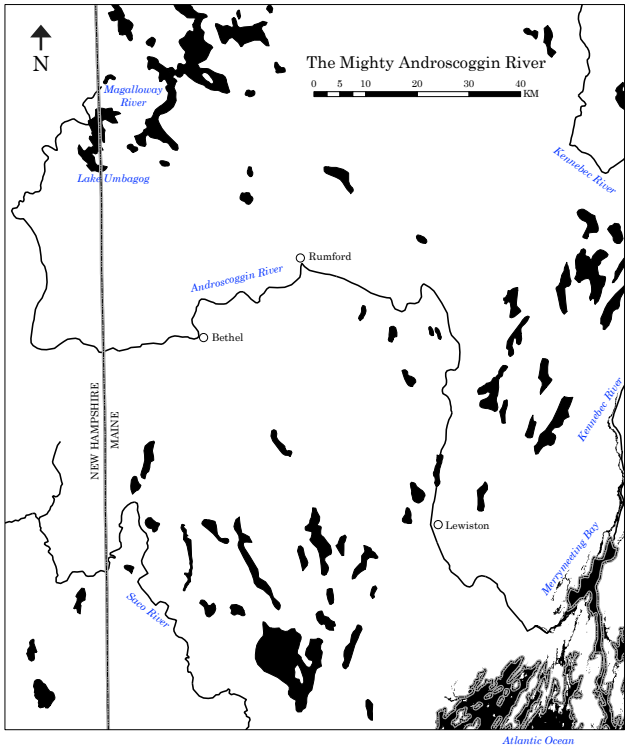

Figure 4. Map of the Androscoggin River from Magalloway River and Lake Umbagog to Merrymeeting Bay and the Atlantic Ocean.

The mighty Androscoggin River flows west from the New Hampshire side of Lake Umbagog, bends south then east to flow back into Maine, bends north to Rumford, then southeast through Lewiston and mixes with the Kennebec River waters in Merrymeeting Bay and ultimately into the Gulf of Maine (Fig. 4). The Androscoggin is the third largest river in Maine and drops more than 1500 vertical feet over a 169 mile distance from Lake Umbagog to Merrymeeting Bay. This river was once known for its plentiful fish populations, inspiring my grandfather to write a story about a giant salmon that lived in the headwaters of Lake Umbagog:

"The Magalloway River has its birth within the sylvan mountains at the northwest corner of out great state of Maine, where it has a common meeting place with New Hampshire and Canada. Craggy mountains with gray granite ledges surmounted by tangles of spruce, fir, and cedars lead downward along hardwood ridges to valleys of hidden ponds and cascading crystal clear streams. This country of

magnificent splendor and serenity, far from the din of cities and madding crowds, is the setting for the story of MAGALLOWAY SAM!"

-Excerpt from Magalloway Sam by Dr. Lowell E. Barnes

The Androscoggin was a vital pathway for many fish species, including the Atlantic Salmon (Watts, 2017). After years of intense fishing, settlers built textile, lumber, and pulp and paper mills along the river and dumped pollutants, such as sewage, wastewater, phosphorous, dioxin, chlorine byproducts, lead and others into the river. By the 1960s, the Androscoggin had become one of the most polluted rivers in the United States, with dissolved oxygen levels reaching zero in the summer. At present, the Androscoggin has over 100 dams (32 for recreation, 16 for hydropower generation, 9 for flood control and storm water, 9 for reservoir storage, and 28 for 'other' purposes).

U.S. Senator Ed Muskie (a.k.a. 'Mr. Clean'; native of Rumford, Maine; Bates alum '36) was instrumental in the 1970 Clean Air Act and 1972 Clean Water Act. The Clean Water Act provided funding and legal mandates for sewage treatment plants along the Androscoggin and the river health and clarity have improved dramatically. The river is almost up to Class C standards (the lowest allowed in Maine) because the Gulf Island Pond section still has oxygen levels that are too low for fish (Watts, 2017). Recreation on and near the Androscoggin thrives now that the river looks and smells cleaner.

Research questions to ponder:

- How have dissolved oxygen levels changed over time (years and seasons)?
- Does flooding and erosion cause contaminated sediment to 'reenter' the environmental system?
- What are the research opportunities for water quality on Maine rivers?

STOP 1: SCREW AUGER FALLS. (1 hour)

(UTM 348900 m E 4937100 m N, outhouse available) Turn right out of rest area, drive north on Rt. 26 for 2.7 mi, turn left onto Bear River Road, which is a continuation of Rt. 26. Continue driving north on Rt 26 and at 12.1 mi, turn left into the Screw Auger Falls parking area. Please remember to pay your $3 park fee here.

Figure 5. Screw Auger Falls, Grafton Notch State Park, Maine (people for scale in both photos).

This location includes a 23-foot waterfall in a narrow, twisting gorge along the Bear River. Water levels in the spring are high and the gorge become louder and more dangerous to viewers in flood conditions. There are many pothole features within mountain streams in New England, and at this location we can see where two potholes connected forming a natural bridge. If the water is low, we may be able to see well-rounded stones of local and foreign origin.

The waterworn bedrock above the waterfall shows pegmatite vein intrusions in the granite. It is likely that the gorges follow a weakness in the bedrock, whether that weakness is a fault, pegmatite vein, joint, or something else, is uncertain. There are two main hypotheses regarding the formation of these gorges. They may have formed while the ice sheet retreated north of the region and contributed a large quantity of meltwater, or, more likely, they formed while the ice sheet covered the area and the subglacial water was under very high pressure. Either way, the stream was likely sediment laden (as evidenced by local eskers and outwash deposits), which causes more intense erosion than the modern stream.

Research questions to ponder:

- Do the gorges follow some type of weakness in the bedrock? If so, what is that weakness (fault, joint, pegmatite, etc.)?
- Does pegmatite erode more easily than granite?
- To form a gorge, does there need to be an overburden of thick ice to increase water pressure or could the sediment-laden streams create gorges without the pressure of an ice sheet?
- How long would it take to form a gorge of this depth under different scenarios of sediment content and pressure conditions of the water if we assume all of the erosion happened during the most recent ice age (~20,000 years ago).

STOP 2: MOTHER WALKER FALLS (40 min)

(UTM 3472700 m E 4937700 m N) Turn left out of the parking lot. Drive north on Rt. 26 for 1.2 mi and pull into the Mother Walker Falls turn off on the right. If possible, park at a slight diagonal to accommodate more vehicles.

If the weather is good from the parking lot, look south to the tree line and bald top of the nearby mountain. We are at a higher altitude now and these mountains support boreal plant and animal species. If possible, view the nearby cliffs from the parking area. The steep cliffs and somewhat flat and wide valley floor are indicative of glacial erosion. The classic U-Shaped glacial valley can be seen in many mountainous regions in the middle-latitudes, but typically due to mountain glaciers. Was this valley carved by relatively thin ice that was confined by the valley walls, or can ice sheets carve U-Shaped valleys while overtopping the peaks? The terminus of an ice sheet may appear lobate and confined by topography (e.g. Greenland Ice Sheet), and these lobes would appear to erode and flow more like mountain glaciers. Alternatively, when the Laurentide Ice Sheet covered Grafton Notch during the Last Glacial Maximum, ice would have been thicker in the valleys than over the mountain peaks, potentially leading to more erosion in the valley bottoms. Subglacial meltwaters might have funneled through these lower areas and caused more substantial erosion to the bedrock compared with glacial erosion on the peaks.

As we walk down to Mother Walker Falls, notice the abandoned carriage road. This early passageway was more dangerous and difficult than transporting materials along the Androscoggin River.

Mother Walker Falls is a narrow gorge more than 40 ft deep and 980 ft long. There is a series of cascading pools with a total drop of 100 ft. Along the path, if you find pegmatite outcrops, notice the crumbly feldspar.

Research questions to ponder:

- Could feldspar be the weak underbelly of the pegmatite?
- Is the bedrock weakness that the stream exploited here the same weakness at Screw Auger Falls?

STOP 3: MOOSE CAVE (40 min)

(UTM 346300 m E 4938500 m N) Please use caution while pulling back onto Rt. 26 north (right). Drive north 0.8 mi and pull into Moose Cave parking area on the right.

From the parking lot, you may be able to see the glacially eroded cliffs on both sides of the valley, including Table Rock (STOP 6) above. Along the path, note several large boulders (probably left by the ice sheet, but some could be rock fall). The gorge in Moose Cave was created in part by sub-glacial rivers under pressure, and the ceiling of the cave is a large granite slab that fell onto the gorge. Moose Cave is about 600 ft long and 50 ft deep. Brewer (1978) speculated that the gorge may have developed along a fault in the granitic bedrock, but this origin has not been confirmed. Major faults in Maine are sometimes marked by prominent quartz veins or zones in which the rock is broken or contorted. Perhaps these gorges follow other types of weaknesses in the bedrock, such as pegmatite veins.

Research questions to ponder:

- What is the age and origin of the Moose Cave gorge?
- Is there evidence for past stream erosion across the valley floor or is it confined to the gorges? Look for striations on quartz veins, determine direction (east) parallel to the river and the valley.

STOP 4: SPRUCE MEADOWS PICNIC AREA (1 hour)
(UTM 345600 m E 4940800 m N, outhouse available) Please use caution while pulling back onto Rt. 26 north (right). Drive north 1.7 mi and turn left into the Spruce Meadows Picnic Area.

From the parking lot, walk along the path to the west side of the picnic area. Notice the abundance of sand and how flat this area is compared with what we've seen today. At the western edge of the picnic area, walk up onto a small ridge. This ridge is part of an esker. From one of the picnic sites, you can see views of Old Speck and the 'Eyebrow' cliffs on the mountain. From another picnic site, you can look out over the wetland, which is poorly drained, possibly due to fine sediments left by glacial meltwater.

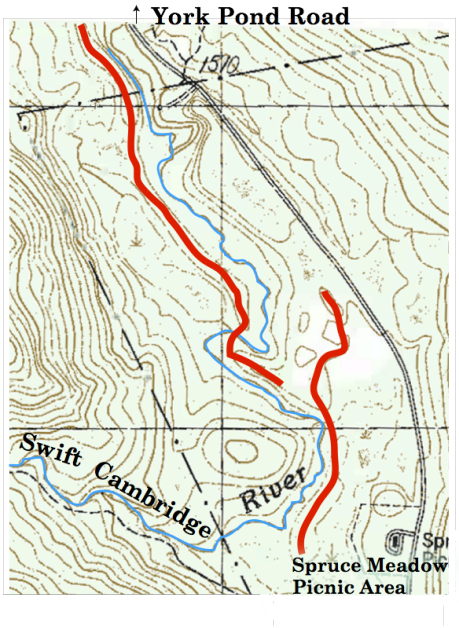

Figure 6. Topographic map of the Spruce Meadow Picnic Area, Rt. 26, the Swift Cambridge River and the red lines represent ridges of gravel deposits (eskers). Modified topographic map.

Research questions to ponder:

- What determines whether glacial meltwater will erode into bedrock or result in an esker deposit?
- What did the proglacial environment look like as the glacier retreated through this area?
- What do the wetland - fine sediment deposits relate to?
- Is the flat picnic area part of a level outwash surface? Or perhaps a delta?

STOP 5: SAND AND GRAVEL PIT (1 hour)
(UTM 344300 m E 4943000 m N) From the picnic area, turn left onto Rt. 26 north and drive 2.2 mi where you will turn left onto York Pond Road. Drive slowly on this dirt road as there may be other recreational drivers. The parking area is in a gravel pit on the left not far from the road.

This gravel pit is not in the park and we ask that you are respectful to the owners and others on the field trip while exploring these deposits. Please do not climb to the headwall and be careful of rocks rolling from the walls.

There are several features to notice in this pit:

1. Graded gravel beds
2. Finer, silty/sand deposits
3. Rounded cobbles

This sand and gravel pit (Fig. 6 & 7) is part of an esker deposit (Fig. 3, 6 & 7) that is probably a continuation of the Spruce Meadows esker seen at the previous stop. Here we can see a diversity of lithologies, and a relatively high concentration of sand as opposed to cobbles.

Figure 7. Sand pit on York Pond Road.

Research questions to ponder:

- Is there a way to tell the location of an esker within an ice sheet (subglacial, englacial, supraglacial)?
- Are eskers only likely to be deposited in areas of subdued topography and not in narrow valleys?
- Does the grain size distribution of sediment within an esker depend on water speed?
- What is the significance of the finer, laminated sediments near the top of the esker deposit?

STOP 6: OLD SPECK PARKING LOT AND TABLE ROCK TRAILHEAD (2-3 hours)
(UTM 345400 m E 4939200 m N, outhouse available) If you are not planning on participating in the hike, you may now return to Bethel by following Rt. 26 south. If you are joining us on the hike, turn right onto Rt. 26 south and drive 2.8 mi then turn right into the Old Speck parking lot.

The optional strenuous hike begins here. Cross the road to the east side of the valley (use caution while crossing the road) and follow the signs to Table Rock (Caution: Do not follow the Appalachian Trail). The loop hike is about 1.9 mi long with a 1000 ft elevation gain and takes ~2-3 hours (Fig. 8). This hike is best for experienced and adventurous hikers who enjoy lots of rock steps, bolted rebar steps and scenic views. The connection to the AT and return to the parking lot is relatively gentle and easy to walk down.

Along the hike, keep your eyes out for various bedrock and surficial features. You may notice large **erratic boulders** deposited by the Laurentide Ice Sheet or more recently dislodged from the valley wall. If you are a well-rounded naturalist, note the **boreal species** (e.g. White-throated sparrow, balsam fir) along the trail. Closer to the lookout, we will climb over a **scree slope**. Think about the size of these boulders and what might be causing the scree to form and why the boulders are a typical size (e.g. jointing). From the lookout, we may be able to see the Grafton Notch State Park in its entirety, as well as the **U-shaped** valley. View the summit of Old Speck (4170 ft, 1270 m elevation), the highest peak of the Mahoosuc Range, and the steep, glistening cliffs below it. Take a close look at the Table Rock lithology, note the wide pegmatite vein and how it is essentially flush with the granite surface.

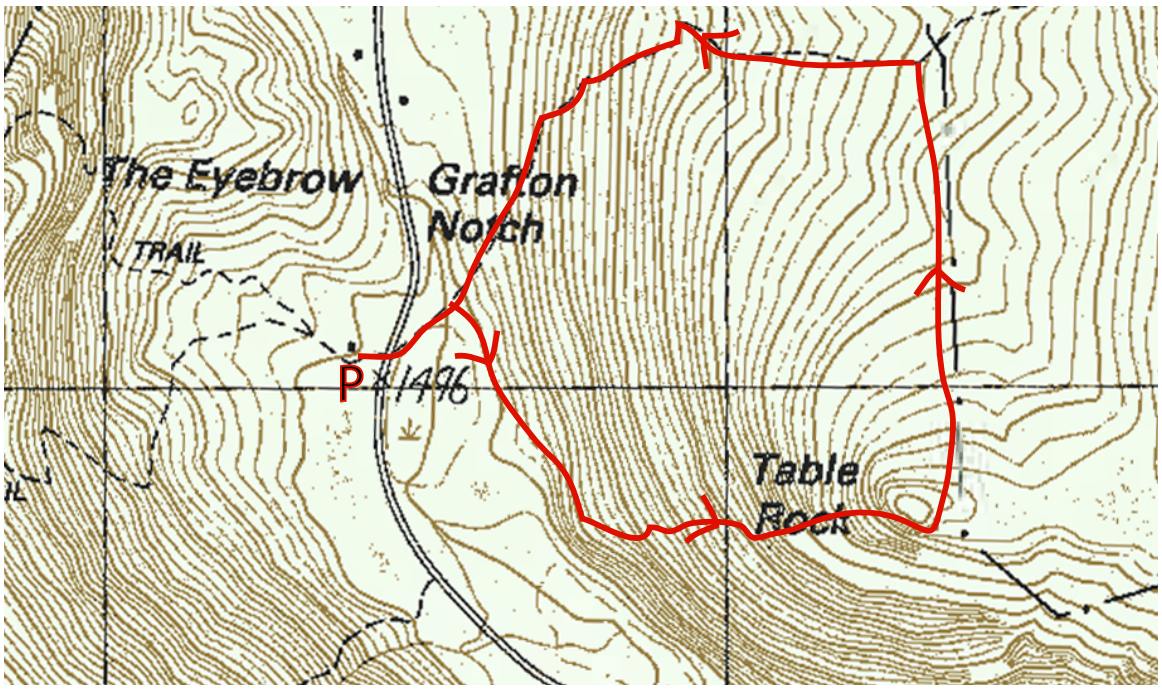

Figure 8. Topographic map of the Table Rock loop trail, contours are 20 foot increments, side of boxes represent 1 mile. From the parking lot on the west side of Rt. 26, we will cross the road to the east side and bear right onto the Table Rock trail. After summiting, we will connect with the Appalachian Trail and walk back to the parking lot. Modified topographic map.

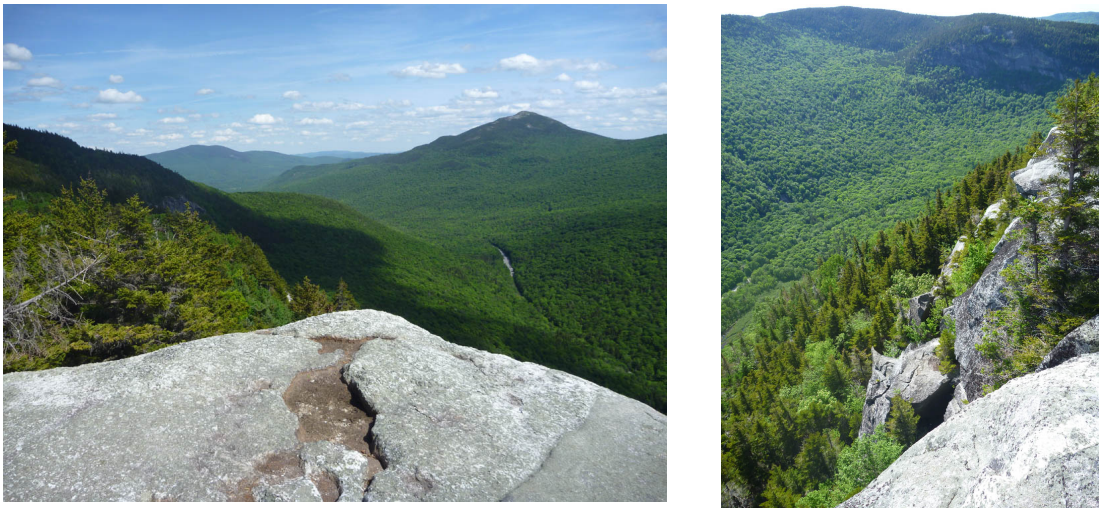

Figure 9. Left image shows Grafton Notch from Table Rock and right image shows 'the Eyebrow', Rt 26, and the steep drop off from Table Rock.

Research questions to ponder:

- Does the prominent pegmatite vein in Table Rock suggest that pegmatite is as strong as granite?
- Does a U-shaped valley only form when 'thin' ice is constrained by the valley walls and does not overtop them? Or can U-shaped valleys form while under a mile-thick ice sheet?
- What caused the valley to be in this orientation (fault, contact, weaker lithology, etc)?
- Where there mountain glaciers in this area and if so, when did they melt away completely?

REFERENCES

Caldwell, D.W. (1975) Reconnaissance Surficial Geology of the Old Speck Mtn. Quadrangle, Maine. Open-file No. 75-15. Maine Geological Survey, Augusta, Maine.

Eusden, J.D., Thompson, W.B., Fowler, B.K., Davis, P.T., Bothner, W.A., Boisvert, R.A., Creasy, J.W. (2013) The Geology of New Hampshire's White Mountains. Durand Press, Lyme, NH.

Marvinney, R.G. and Thompson, W.B., 2000, A geologic history of Maine, in King, V.T. (editor), Mineralogy f Maine, Volume 2: Mining history, gems, and geology: Maine Geological Survey, p. 1-8.

Milton, D.J., 1961, Geology of the Old Speck quadrangle, Maine: Ph.D. Thesis, Harvard University, 190 p.

Moench, R.H., Boone, G.M., Bothner, W.A., Boudette, E.L., Hatch, N.L., Jr., Hussey, A.M., II, and Marvinney, R.G., 1995, Geologic map of the Sherbrooke-Lewiston area, Maine, New Hampshire, and Vermont, United States, and Quebec, Canada: U.S. Geological Survey, Map I-1898-D.

Thompson, W.B., 2001, Glacial and Postglacial Geology of Grafton Notch State Park. Maine Geological Survey, http://digitalmaine.com/cgi/viewcontent.cgi?article=1346&context=mgs_publications

Watts, Doug, accessed 2017, A brief history on the Androscoggin River. Maine Rivers. http://mainerivers.org/watershed-profiles/androscoggin-watershed/

All photographs were taken by A. Doughty between 2015 and 2017.