DEPARTMENT OF AGRICULTURE, CONSERVATION AND FORESTRY

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Title: *Geology of Mount Blue State Park*

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Author Note: The New England Intercollegiate Geologic Conference (http://neigc.info/) is an annual field gathering of geologists in New England that has been taking place since 1901, with the exception of war and the recent pandemic years. The purpose of the conference is to present geology in the field during a series of trips that cover a wide range of topics within a selected region, hosted by an academic institution and/or government agency. The 2021 conference was much less formal than usual, with the simple goal of giving geologists a chance to meet again in the field – especially students that had been learning online during much of the pandemic, so the trips and guides were created with them in mind.

Contents: 15 p. report

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Geology of Mount Blue State Park
NEIGC 2021 Field Trip

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Maine Geological Survey

Introduction

Purpose

Mount Blue State Park and Tumbledown Public Lands offer more than 18,000 acres (7,284 hectares) of accessible land centered in Weld, Maine. Thousands visit each year to hike the very popular Tumbledown Mountain and Mount Blue trails, or to relax at Webb Beach. Along with Center Hill, these park locations offer excellent examples of local surficial and bedrock geologic features. *The Geology of Mount Blue State Park* was published 56 years ago and is focused on bedrock geology that was mapped in 1959-1962 for dissertation work that resulted in the Dixfield 1:62,500-scale bedrock map (Pankiwskyj, 1964; Pankiwskyj, 1965; Pankiwskyj, 1978). While the geology is certainly the same, terminology, technology, and the size of the park have changed a lot since the 1960s. This trip is based on surficial geology mapping conducted in 2018-19 (Spigel, 2018; Spigel, 2020b; Spigel, 2021b) and will focus on surficial features at Webb Beach and Weld (Webb) Corner, with discussion of both surficial and bedrock geology at Center Hill. Participants are encouraged to hike either Tumbledown or Mount Blue on their own if they have time before heading home from the conference. Fig. 1 provides an overview of the area with trip stops and other features mentioned in the text.

Physiography and Recent History Overview

The Weld, Maine and Mount Blue State Park region lies within the Central Maine Highlands, east of the Mahoosuc and southeast of the Blue (Longfellow) Mountain ranges. Local topography is a product of the Devonian Acadian orogeny and subsequent erosion, with most of the higher topography underlain by deformed metasedimentary rocks, and lowlands that tend to be underlain by more easily eroded plutons (Hanson and Caldwell, 1989). The most significant lowland in the area is now occupied by Webb Lake and is presumed to be underlain by granodiorite, although outcrops are rare due to thick glacial deposits (Pankiwskyj, 1978; Spigel, 2021b). Webb Lake is approximately 2,146 acres (868 hectares), is fed by several inlet streams that drain the surrounding ring of mountains, and has a southern outlet that becomes the Webb River which flows south to meet the Androscoggin River in Dixfield, Maine. The highest local peak is Jackson Mountain (3,568 ft/1,088 m), but Mount Blue (3,192 ft/973 m) has always been the iconic Weld region landmark with its lone asymmetric profile and summit fire/communications tower (Fig. 2). Peaks surrounding the Webb Lake lowland include (clockwise from west) Spruce, Walker, Tumbledown, Little Jackson, Jackson, Blueberry, Pope, Hurricane, Mount Blue, Bald, and Saddleback Mountains (Fig. 1). The area is easily accessed via Maine Route 142 from Dixfield or Maine Route 156 from Wilton.

The Androscoggin band of the Eastern Abenaki First Nation originally inhabited the Androscoggin Valley region of western Maine and eastern New Hampshire until they were forced north by Euro-American settlement during the early to mid-1700s. Like much of western Maine, Euro-American settlers came to the Weld area for timber followed by agriculture and supporting trades, summarized here from Weld Historical Society (1993). Much of the area's timber was harvested in the

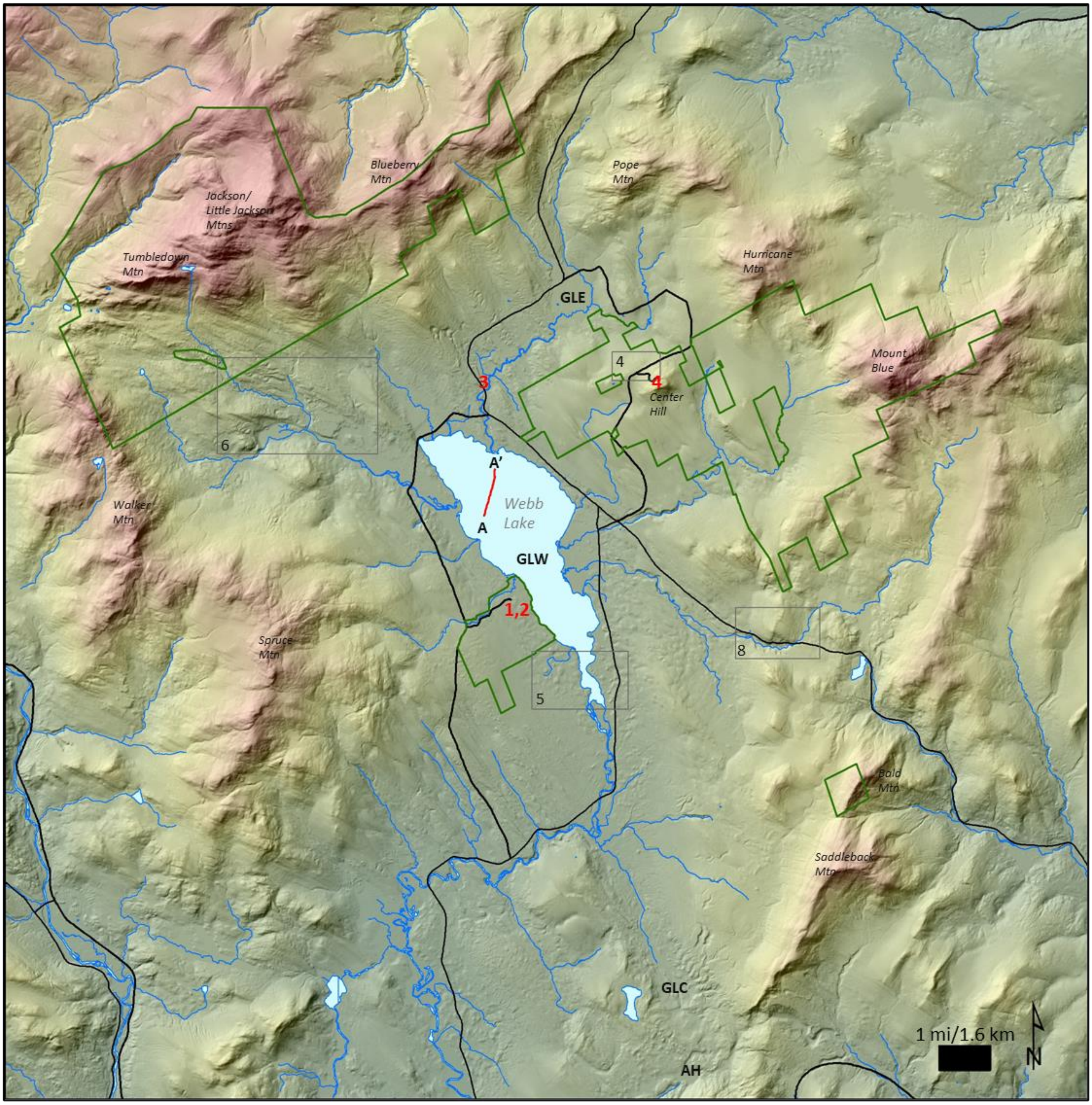

Fig. 1: Lidar hillshade image of the Weld/Mount Blue State Park region. Red numbers = field trip stop locations; black lines = major roads; blue lines/polygons = water; green polygons = Mount Blue State Park and Tumbledown Public Land parcel boundaries; numbered grey polygons = extent of corresponding numbered figure in text; red line = seismic survey line. Features mentioned in text: AH = Aunt Hannah Brook spillway; GLC = general location of Glacial Lake Carthage basin; GLW = general location of Glacial Lake Webb basin; GLE = general location of Glacial Lake East Brook basin.

1800s, including the steep slopes of Tumbledown and Mount Blue, and open farmland dotted the hillsides. Sawmills were present on almost every stream and logs were driven into Webb Lake and sluiced down the Webb River from an outlet dam that washed out by the 1930s. A wooden spool factory was the largest local industry for many years into the early 1900s. In 1934, the federal government purchased 5,000 acres (2,023 hectares) of marginal farmland in the Weld area through the U.S. Resettlement Administration Land Utilization Project. Families were relocated from these farms and the property was eventually transferred to the State of Maine to form Mount Blue State Park. The Civilian Conservation Corps (CCC) completed much of the preliminary work to establish the park, with the Center Hill area opening in 1938. Additional land acquisitions over time have increased Mount Blue State Park to 7,489 acres (3,031 hectares) and nearby Tumbledown Public Lands to 10,555 acres (4,271 hectares; Maine Bureau of Parks and Lands, 2020). Logging remains an important local industry, but tourism related to public lands recreation and private lake or mountain vacation camps is now firmly established as part of Weld’s identity.

Fig. 2: View of Mount Blue (center peak) from Webb Lake. Photo: MGS.

Bedrock Geology Overview

Bedrock in the Weld, Maine area was first mapped in detail by Pankiwskyj (1964) and this work was later updated and published as the reconnaissance Dixfield 1:62,500 bedrock geology map (Pankiwskyj, 1978). Units from the Dixfield map were adapted for use in the statewide bedrock geologic map and in later regional compilations (Osberg and others, 1985; Moench and Pankiwskyj, 1988a; Moench and others, 1995). Published map unit extents and general characteristics in the field trip area of interest have essentially remained the same throughout these iterations, although naming conventions and interpretations of some features have varied. On a broad scale, the Weld region lies within the Central Maine Trough, which is an area of Silurian to Devonian marine sedimentary sequences that were deformed, metamorphosed, and intruded during the Devonian Acadian orogeny. Within the field trip area, rocks were metamorphosed up to sillimanite grade or amphibolite facies (Moench and Pankiwskyj, 1988a; Guidotti, 1989). Structural measurements are lacking from all published maps but metamorphic units in the Dixfield 1:62,500 quadrangle are described as striking roughly north-northeast with steeply dipping beds that vary in direction based on their location within a series of larger/major folds (Pankiwskyj, 1960; Pankiwskyj, 1964).

Significant units within the field trip area include (from oldest to youngest) the Carrabassett Formation, Hildreths Formation, Mount Blue Member of the Seboomook Formation, a portion of the Phillips batholith described as biotite and hornblende-biotite quartz diorite to granodiorite, and pegmatite intrusions throughout (Fig. 3). The more recent compilation maps (Moench and Pankiwskyj, 1988a; Moench and others, 1995) cover large areas and this is reflected in the wide range of characteristics noted in unit descriptions, so it is reasonable to combine these with the older but more local descriptions of Pankiwskyj (1965) and Pankiwskyj (1978) for the general purposes of this field trip.

The Carrabassett Formation (Dc) began as cyclically bedded mud and clayey sand turbidites deposited in a deep ocean environment which lithified to form shale and micaceous sandstone and were then metamorphosed to pelitic schist or metasiltstone and metasandstone. The Hildreths Formation (Dh) is named for exposures along Maine Route 156 between Weld and Wilton, about 4 miles (6 km) southeast of Center Hill at Hildreths Mill. This unit may represent a period of reduced erosion and marine deposition that resulted in more calcareous rocks, but the presence of sandy layers conflict with this theory. Another possibility is that the sandy beds represent higher velocity volcanic turbidity flows that also transported reef materials into deeper waters. Layers of limy sediments, mud, and clayey sand lithified to form limestone, sandy limestone, shale, and micaceous sandstone, which were then metamorphosed to marble, schist, metasandstone, and calc-silicate rocks. The Mount Blue Member of the Seboomook Formation (Dsm) is named for exposures at the summit of Mount Blue and represents depositional conditions similar to those of the Carrabassett Formation. Cyclically bedded mud and clayey sand turbidites lithified to form shale and micaceous sandstone that were subsequently metamorphosed to schist or metasiltstone and metasandstone. Only Carrabassett Formation exposures will be seen on this trip, with a relatively large and vegetation-free outcrop at Center Hill (Stop 4).

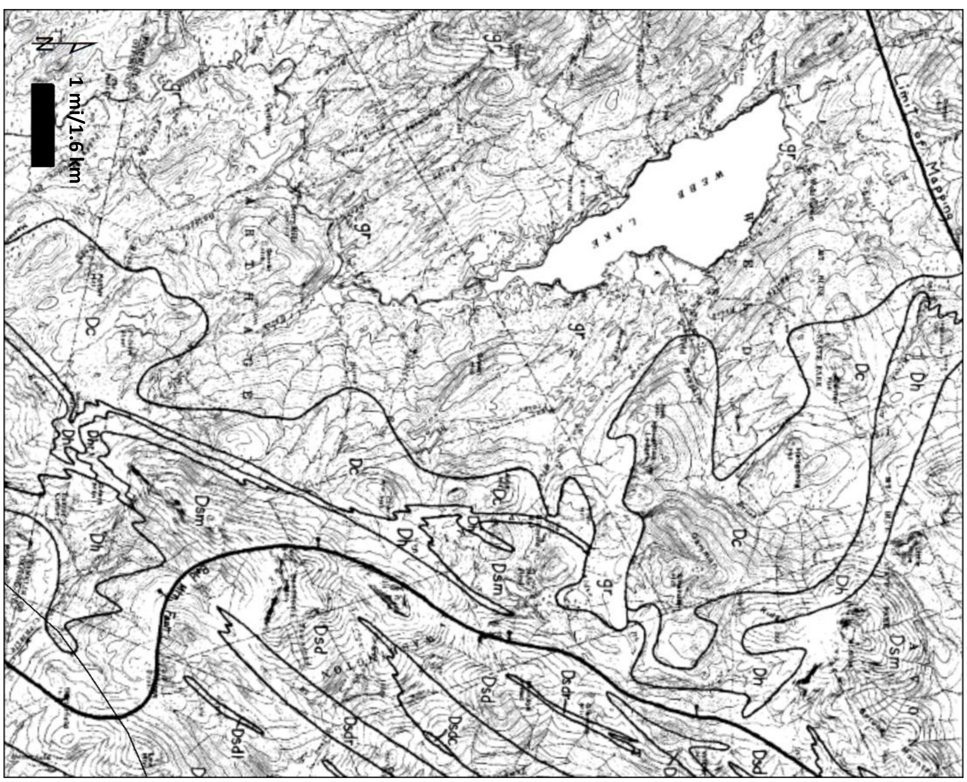

Fig. 3: Bedrock geology in the field trip area, modified from Pankiwskyj (1978). Units discussed in text are (from oldest to youngest) the Carrabassett Formation (Dc), Hildreths Formation (Dh), Mount Blue Member of the Seboomook Formation (Dsm).

Assumed Devonian ages of the field trip area units described above are based on correlation with similar rocks in northern Maine and New Hampshire. These strata are part of a larger 30 x 70-kilometer (19 x 43 mile) area in western Maine of Devonian rocks surrounded by Silurian rocks, bound by the Blueberry Mountain Fault to the northwest and the Winter Brook Fault to the southeast. These isolated Devonian units were first delineated as the Rumford Allochthon and later as the Rumford Outlier (Moench and Pankiwskyj, 1988a; Moench and Pankiwskyj, 1988b; Reusch and others, 2010). There is some disagreement among researchers working in the Rumford Outlier area as some believe that it does not exist and the Devonian strata are continuous with the surrounding Silurian strata (Solar and Brown, 2001). The various arguments are outside the scope of this trip but have been presented in previous NEIGC trips (Reusch and others, 2010; Solar and others, 2017).

Surficial Geology and Geomorphology

Previous Research

Many excellent early accounts of Maine's surficial geology come from *The Glacial Gravels of Maine* by Stone (1899), but Weld and the Webb River Valley are only mentioned briefly in this publication as having "considerable alluvium." The need for road aggregate increased in the 1930s, prompting a detailed town by town surficial materials inventory by Leavitt and Perkins (1935) who recognized the presence of hillside glacial lake deltas in the Webb Lake Valley. Some areas they noted as deltas are actually relatively flat bedrock terraces covered with thin glacial deposits, but other glaciofluvial features delineated at about 820 ft (250 m) have proved to be significant. Reconnaissance surficial geologic mapping was conducted by G.C. Prescott, Jr. and W.B. Thompson for contribution to the statewide map (Thompson and Borns, 1985). But unlike other areas of western and northern Maine, initial 1:62,500-scale maps for the Rumford and Dixfield quadrangles were never published. The lack of detailed maps in these portions of the Rumford 1:100,000-scale quadrangle initiated a five-year USGS STATEMAP project (2016-2020) during which the surficial geology for ten 1:24,000 quadrangles was mapped by Maine Geological Survey staff.

Overview of Landforms and Sediments

The Weld region and Mount Blue State Park contain a wide variety of glacial deposits and landforms that are delineated in Spigel (2018; 2020a; 2020b; 2021b). Lidar topographic data for the entire area has revealed many subtle features and has greatly improved mapping efficiency. Only a few examples will be illustrated here due to space, but readers can easily view referenced surficial maps and lidar hillshade for the entire area with the Maine Geological Survey WebMap. Glacial ice flow was generally northwest to southeast as indicated by many striation localities and streamlined topography (Stop 4; Fig. 1). Uplands are covered with stony, sandy glacial till and bedrock is frequently exposed on peaks and ridgelines. Compact lodgement till is common on up-ice (northwest) slopes, and one needs only a few encounters with "hardpan" to understand why much of the area was bought out as marginal farmland – working these dense, stony soils with the additional constraint of a short growing season must have been difficult. Rock walls comprised of glacial cobbles and boulders culled from plots that were once farm fields or pasture are prevalent throughout the modern forested landscape and are easy to spot on lidar topographic imagery, hinting at both glacial and human history (Fig. 4).

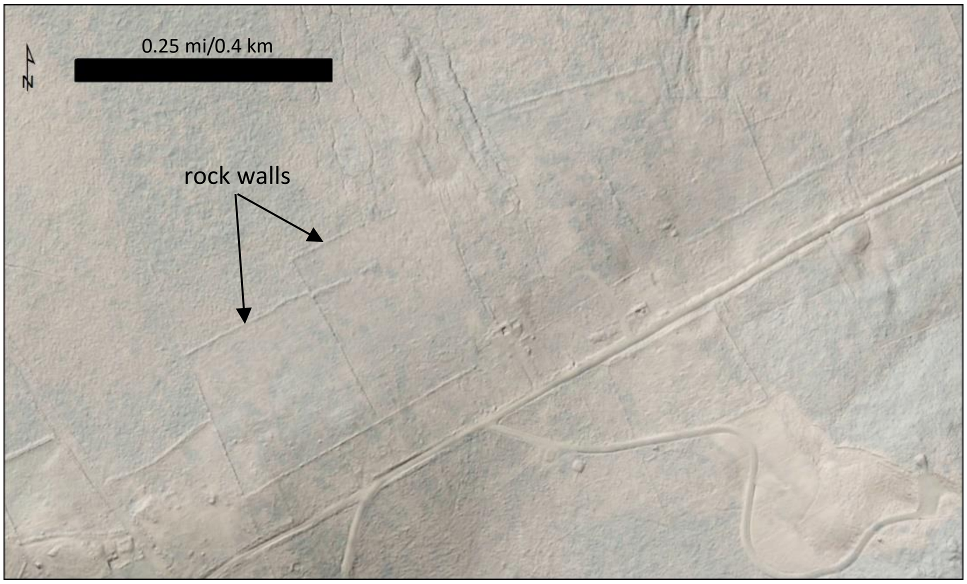

Fig. 4: Lidar hillshade and aerial imagery show a mosaic of old rock walls and cellar holes hidden under tree cover northwest of Center Hill (Stop 4). See Fig. 1 for location and extent of this figure in the Weld area. Map: MGS.

Hummocky glacial till, push moraines, glaciofluvial, and glaciolacustrine deposits in the Weld area depict an interesting deglaciation process, which is estimated to have occurred about 12,000 to 12,800 ^{14}C yrs BP (Borns and others, 2004). As ice retreated to the northwest, Glacial Lake Carthage was the first of three possible proglacial lakes to form, occupying the north-draining Green Brook Valley in the Dixfield and Weld quadrangles (Spigel, 2018; Spigel 2020a). Glacial Lake Carthage had three spillways, with the most prominent at about 840 ft (256 m) into the Aunt Hannah Brook Valley (Fig. 1). Lidar topography and field observations revealed an area of hummocky (mound and swale) topography to the northwest of Aunt Hannah Brook that was not apparent on the traditional topographic map. The hummocks likely represent an area of debris-rich stagnating ice that may have detached from the main glacier and continued to melt in an uneven fashion, resulting in the irregular topography.

Glacial Lake Carthage eventually drained as the glacier retreated into the upper Webb Valley lowland. Two areas of possible push moraines segue into more hummocky moraine deposits and meltwater channels to the northwest around the modern Webb Lake outlet (Fig. 5). After some activity that created the moraines, it is likely that another larger block of ice stagnated and separated from the main glacier, blocking drainage from the upper Webb Valley lowland area to create Glacial Lake Webb. Deltas and other possible glaciofluvial deposits along the northern extent of the valley indicate a maximum or longest-duration lake stage of about 800-820 feet (244-250 m), with a very prominent delta in the West Brook Valley (Fig. 6). Remnants of the hummocky moraine have been reworked over time by wave actions to form stony "reef" areas at the southern extent of Webb Lake. A large glacial erratic known as Bass Rock sits in one of these reef areas just off Webb Beach and is easy to observe via kayak (Spigel, 2021a; Stop 2). Limited mapping resources meant that more extensive investigation of the Glacial Lake Webb story was not possible, but unpublished research by Professor Tom Lowell has further proved its existence. Since the Weld area lies just northwest of the currently delineated limit of late-glacial marine incursion, there has been some interest in analyzing regional glaciolacustrine and glaciomarine sediments to better understand deglaciation history such as in Day (1980). Professor Lowell conducted seismic surveys of several Maine lakes in 2020 to better address this question, and his survey of Webb Lake clearly revealed the presence of Pleistocene and Holocene lake sediment deposits (Fig. 7).

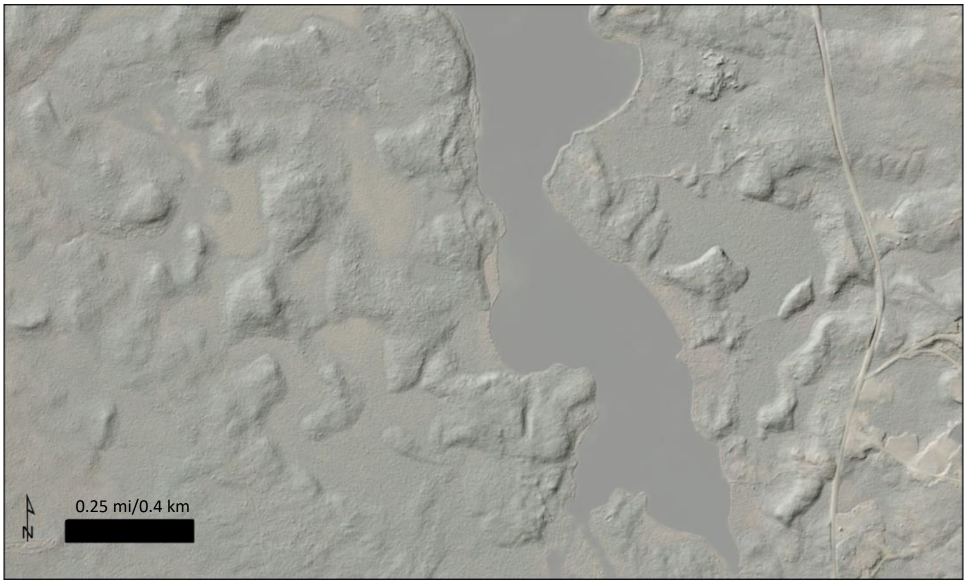

Fig. 5: Lidar hillshade and aerial imagery of hummocky topography at the southern end of Webb Lake. See Fig. 1 for location and extent of this figure in the Weld area. Map: MGS.

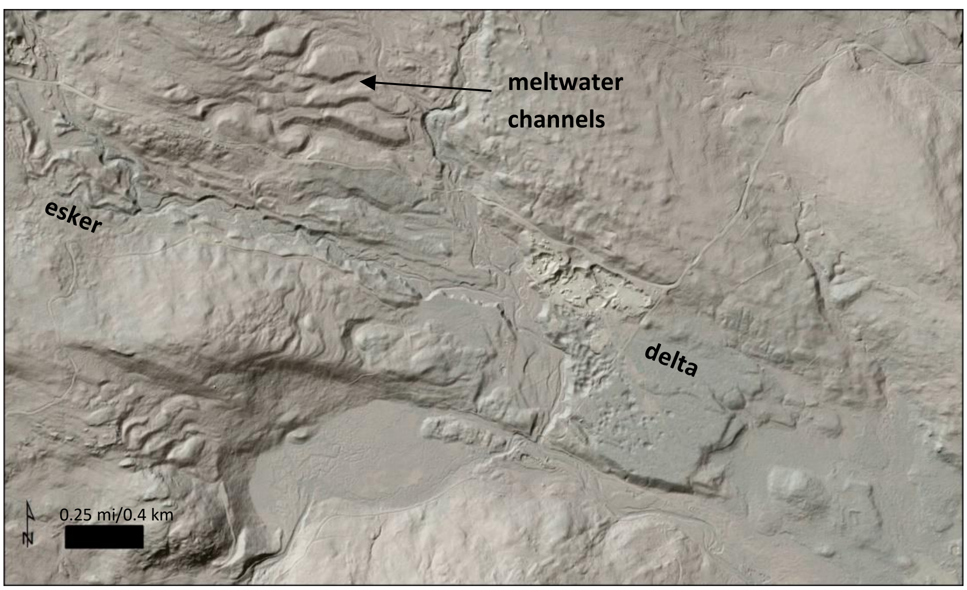

Fig. 6: Lidar hillshade and aerial imagery of the most prominent Glacial Lake Webb delta in the West Brook Valley (center of image with gravel pit on north edge). Small esker segments and ice-contact deposits extend up the West Brook Valley to the west-northwest and a series of meltwater channels extend up the hillside. See Fig. 1 for location and extent of this figure in the Weld area. Map: MGS.

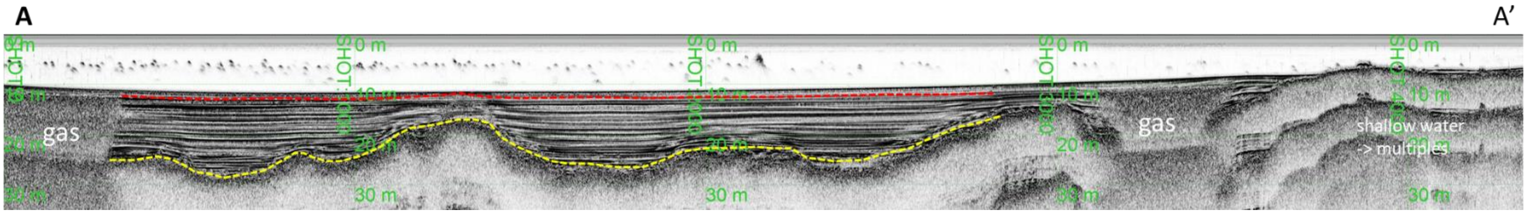

Fig. 7: Seismic survey image from Webb Lake. See Fig. 1 for location and extent of this figure. The line runs roughly SSW (A) to NNE (A') and is about 1,500 m (~1 mi) long. Depth from lake surface is noted in green. The survey was obscured by methane gas bubbles from organic sediments in fuzzy areas marked as "gas." This problem was especially common in the northwest section of the lake. Shallow water at the end of the survey line (image right) produced multiple reflections. The red dashed line indicates approximate boundary between thin Holocene and thick, layered Pleistocene lake sediments. The yellow dashed line indicates approximate extent of Pleistocene lake sediments, which are more than 10 m (33 ft) thick in some areas. Image courtesy of Tom Lowell.

Another series of push moraines extend upslope from the northwest corner of Webb Lake, indicating the possibility of an actively retreating ice tongue flowing into Glacial Lake Webb since many ridges are below 820 ft (250 m) and adjacent to other ice-contact and glaciolacustrine deposits (Fig. 11). However, it should be noted that any of the delineated push moraine ridges may have formed by other processes such as sediment forcing into crevasses or cavities in the ice base (Bennett and Glasser, 2009). Excavation into several of the ridges would be required to determine their true origin.

A third area of hummocky moraine exists to the northeast of Webb Lake in the East Brook Valley and likely represents yet another area of stagnant ice that blocked drainage to form Glacial Lake East Brook with a possible stage of about 960 feet (293 m), indicated by a small delta on the Weld-Madrid quadrangle boundary. The relatively flat area southeast of Maine Route 142 at Chase Corner represents the former lake bottom (Fig. 1), and fine-grained sediments were sampled from this location to compare with other glaciolacustrine and glaciomarine sediments in the region (Day, 1980).

Other notable surficial deposits include large areas of Holocene alluvium that extend into Webb Lake from several tributaries - these could be considered Holocene lake deltas but more subsurface information is needed to rule out a veneer of alluvium over till and/or Glacial Lake Webb deposits. The alluvium along with reworked lake deposits stand out as sandy lake shorelines, and the influence of geology on shoreline morphology will be apparent at locations throughout the trip. Lidar has revealed many glacial meltwater channels and post-glacial features such as periglacial remnants and landslides (Fig. 8). Surficial mapping seems to have prompted more questions than answers for the Mount Blue State Park region, and there are several interesting projects that could greatly improve understanding of local natural history and glacial processes such as: Webb Lake sediment analysis; push moraine excavation and analysis; periglacial feature analysis; deglaciation timing and manner; causes of possible ice stagnation.

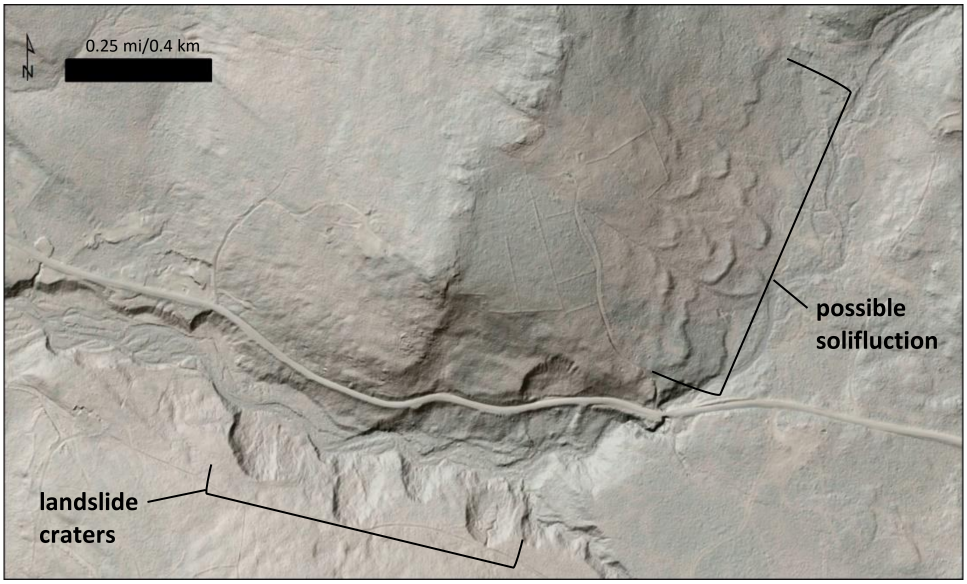

Fig. 8: Lidar hillshade and aerial imagery of prehistoric landslide craters along Maine Route 156 and Bowley Brook (bottom center). Possible solifluction lobes are present on a southeast facing slope (right side of image). See Fig. 1 for location and extent of this figure in the Weld area. Map: MGS.

Road Log

MEETING PLACE: Saturday, October 16 at 9 AM, Webb Beach Gatehouse, Mount Blue State Park (385087 m E, 4948648 m N)

The Webb Beach portion of Mount Blue State Park is located off West Side Road (a.k.a. W Side Road) in Weld, Maine. *Please be aware that the park has several separate locations in the Weld area so if you just enter Mount Blue State Park into your GPS or Maps App, you may be directed to the wrong location.* Directions from the Grafton/Newry, Maine area: From the intersection of Maine Route 26 and U.S. Route 2, take Route 2 east towards Rumford. Drive about 20 miles (32 km), passing through Rumford. In Dixfield, turn left on Maine Route 142 (at stoplight). Drive about 8 miles (13 km) to Carthage village. Turn left on West Side Road (look for Mount Blue State Park sign). Drive about 3.5 miles (6 km) to park entrance on right and follow access road to the gatehouse. Webb Beach may be closed for the season so trip participants might need to park at the gatehouse and walk in. Day entrance fees still apply ($5 Maine resident, $7 non-resident). All walking will be on relatively easy, flat to rolling trails. Please bring enough food, water, clothing, etc. for the day. Latrines are available in several locations at Webb Beach and at Center Hill. Cell service is extremely limited so please plan accordingly.

Stop 1: Mount Blue State Park Nature Trail (1-1.5 hours)

From the gatehouse, we will walk about 0.2 miles (0.3 km) to the Nature Center. We will walk the Nature Trail (about 0.75-1 mile/1.2-1.6 km roundtrip) to observe a variety of sediments and landforms (Fig. 9).

Fig. 9: Lidar hillshade and aerial imagery for Stop 1. G = Gatehouse; N = Nature Center; red dashed line = Nature Trail. Map: MGS.

Discussion:

- As we descend the slope towards Webb Lake, note the landscape and apparent surficial materials. Can you pick out the transition from glacial till to alluvium?
- At the trail loop intersection, two large tree throws expose the surficial sediments. Observe these sediments for evidence of fluvial transport.
- Stay right at the trail loop intersection. As we descend closer to the lake, the trail traverses several small ridges. How did these ridges form? What do they tell us about Webb Lake? How might we estimate their ages?
- Near post seven and at the overlook bench, there is an excellent view of Mount Blue. Walk out onto the beach and note its morphology and sediments for comparison with later stops.
- The trail follows Swett Brook before looping back. This is a great place to observe floodplain morphology as the trail traverses old stream paths.

Stop 2: Webb Lake Shoreline from Nature Center to South Shelter (1-1.5 hours)

From the Nature Center, we will follow informal trails to the beach and south shelter area with several short stops to look at sediments and landforms (about 1.25 miles/2 km roundtrip; Fig. 10). We may break for lunch at Webb Beach depending on weather and timing.

Fig. 10: Lidar hillshade and aerial imagery for Stop 2. N = Nature Center; W = Webb Beach; red dashed line = approximate shoreline trail; yellow circle = Bass Rock erratic. Map: MGS.

Discussion:

- When the trail first meets the lake, note the shoreline morphology. How is it different from the shoreline along the Nature Trail and why?
- Do you think Webb Beach is naturally sandy? Why or why not?
- Note Bass Rock from Webb Beach. This large glacial erratic sits in one of several "reef" areas described in the overview. For comparison, the lone boulder on Webb Beach is likely representative of the local bedrock. Is there anything else about Bass Rock that hints at glacial transport?
- The South Shelter area is located in the hummocky moraine zone. We will walk off trail in this area to get a sense of the hill/mound vs. swale areas.

Mileage

0.0 At the intersection of Webb Beach Road and West Side Road, turn right.
3.4 Stay right onto Byron/Number 6 Road.
3.9 Turn left on Maine Route 142/Phillips Road.
4.4 Turn right into sand pit pull-off. Use caution with low clearance vehicles.

Stop 3: Skolfield Sand Pit (384462 m E, 4953549 m N; 0.5 hour)

This sand pit is one of several inactive glaciofluvial/glaciolacustrine exposures north of Webb Lake (Fig. 11). Take a few minutes to observe the sediments. Thank you to the Skolfield family for allowing access for this trip. ***NOTE: This pit is on private property – please do not access outside of this field trip without landowner consent.***

Fig. 11: Lidar hillshade and aerial imagery for Stop 3. P = Parking area on east side of Route 142. Map: MGS.

Discussion:

- What landform is visible here and what does it tell us?
- The sediments are relatively fine-grained – what might this tell us about the environment in which it formed?

Mileage

0.0 Turn left on Maine Route 142/Phillips Road (use caution – limited visibility and fast traffic).
2.8 Turn left on Center Hill Road.
5.4 Turn right at Center Hill Picnic Area. Follow access road up to parking area.

Stop 4: Center Hill Picnic Area and Loop Trail (388425 m E, 4953701 m N)

Depending on timing, this will be an alternate lunch stop area. We will make some observations in the picnic area, and then walk the Center Hill Loop Trail (about 0.75 mile/1.2 km roundtrip; Fig. 12). Center Hill offers excellent views of Webb Lake, Byron Notch, Tumbledown Mountain, Jackson Mountain, and Mount Blue.

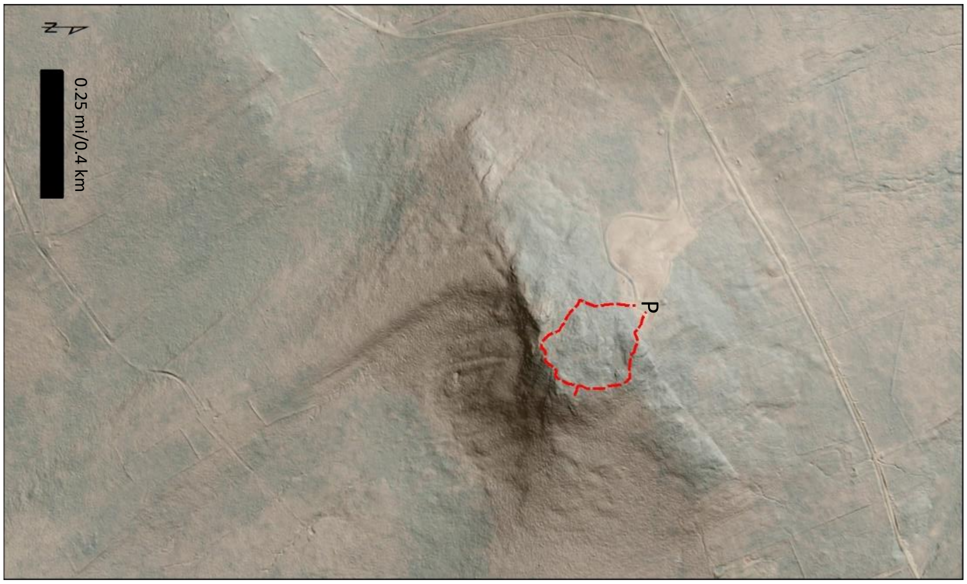

Fig. 12: Lidar hillshade and aerial imagery for Stop 4. P = Parking/picnic area; red dashed line = trail. Map: MGS.

Discussion:

- Can any of the boulders in the picnic area be classified as glacial erratics?
- Bedrock exposures are common on the Center Hill Trail. Look for features such as calc-silicate pods and pegmatite dikes.
- At the ledges overlook, there are many features to observe:
  - What do the rocks tell us about their original depositional environment?
  - The rocks look pocked – which mineral is weathering out?
  - The ledges have excellent glacial striations – what do they tell us about ice flow direction?
  - What other glacial process is evident here?
  - There is a nice view of the Byron Notch area from the ledges and picnic area. It is likely that ice plucked the south side of Tumbledown Mountain as it flowed around the area and/or directly scoured the area as it flowed through the notch during retreat. The south slope is covered with talus, and small rockfalls occasionally occur on the cliff exposures, hence the name Tumbledown.
  - Can you pick out the variation in Webb Lake shoreline that we saw at Stops 1 and 2? Inlet areas are easy to pick out, especially the extensive alluvium at Dummer's Beach.
- A side trail leads to the Mount Blue overlook. How does the shape of Mount Blue indicate former ice flow direction? Look for evidence of a shallow landslide scar.

End of trip. To return to the Grafton Notch area, turn left on Center Hill Road and follow into Weld village. Continue straight at the stop sign to follow Maine Route 142 to Dixfield. Turn right on U.S. Route 2 at the stoplight. Follow Route 2 through Rumford. Turn right on Maine Route 26 and follow north to Grafton.

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