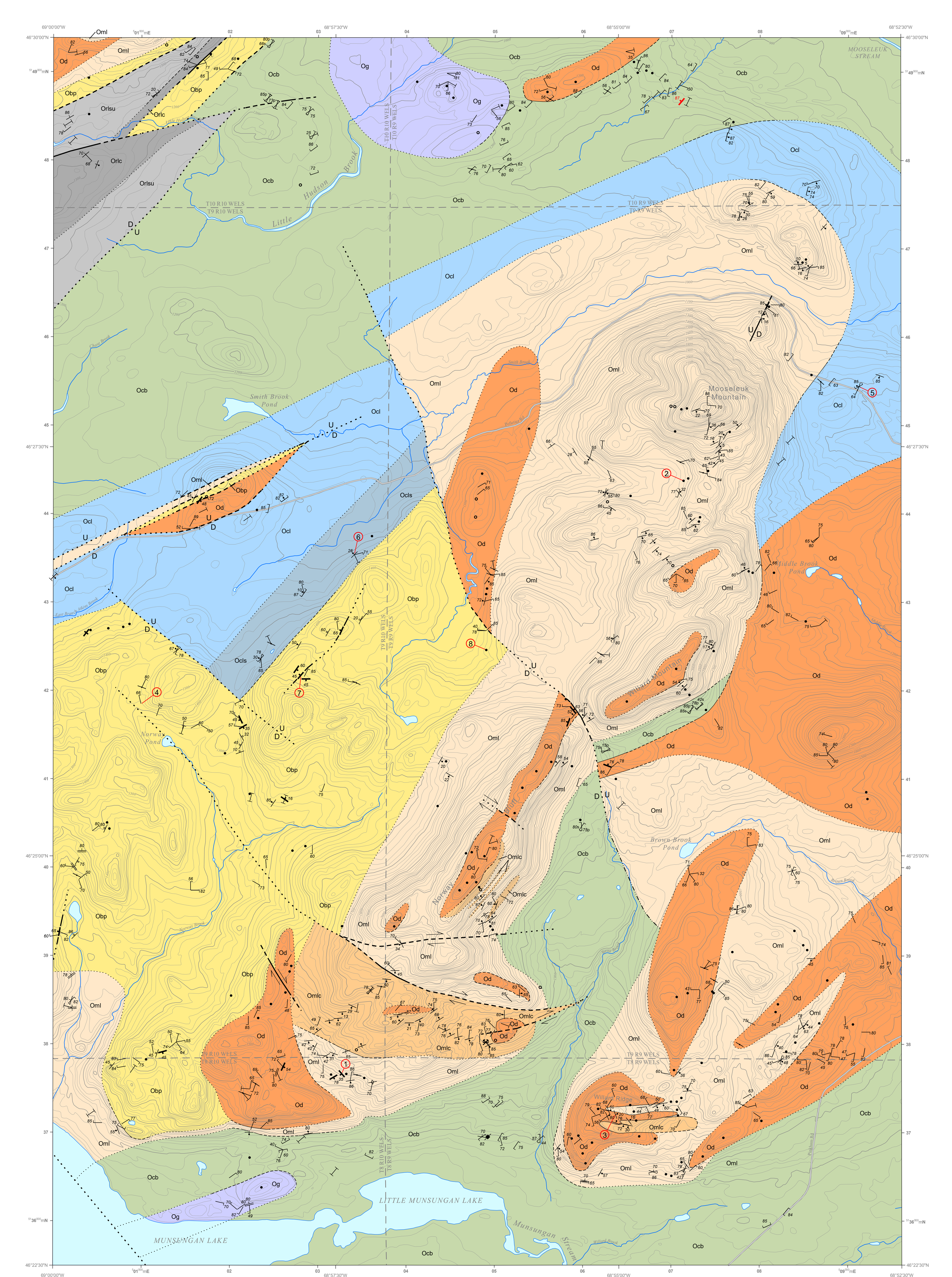
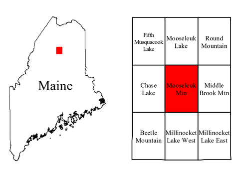


SOURCE OF GEOLOGIC INFORMATION

Field work by Stephen G. Pollock, 2014, 2016, 2018, assisted by Dingyi Qian (2016), Chandler Harris (2018), and Ethan Pollock (2018).



SCALE 1:24,000

1 | 0.5 | 0 | 1 Mile

1000 | 0 | 1000 | 2000 | 3000 | 4000 | 5000 | 6000 | 7000 Feet

1 | 0.5 | 0 | 1 Kilometer

CONTOUR INTERVAL 20 FEET

True North / Magnetic North. Approximate Mean Declination, 2016 17° W

Base map features from Maine Office of GIS - 1:24,000 USGS contour lines, E911 roads, 1:24,000 National Hydrography Dataset, USGS GNIS placenames and 1:24,000 political boundaries. Map projection Universal Transverse Mercator, North American Datum, 1927.

The use of industry, firm, or local government names on this map is for location purposes only and does not impute responsibility for any present or potential effects on the natural resources.

Photo 1: Peperite is a rock type commonly formed through the interaction of lava and wet sediment. In this image a basalt flow in the Munsungun Lake Formation (**Oml**) flowed over, and then incorporated, grayish-black chert into the flow. Chert with a grayish-white-weathering surface is common in this map area. *North of Munsungan Lake, T8 R10 WELS.*

Photo 2: This is an excavated block of mottled grayish-red Munsungun Lake Formation (**Oml**) chert in a recent borrow pit. Much of the chert in the Munsungun Lake Formation is highly fractured and because of this it is used as road bed material. Large natural outcrops of this particular color variety are practically nonexistent today, but Native American apparently prized this variety. The Spiller Farm archaeological site in Wells, Maine, has several artifacts of mottled red chert. *Just south of Mooseleuk Mountain, T9 R9 WELS.*

Photo 3: Color-laminated chert, consisting of alternating medium-gray and gray-black laminae, is the most common variety in the Munsungun Lake Formation (**Omlc**). The distinct weathering pattern with alternating black or gray-black laminae and light-gray to grayish-white lamina is a hallmark, and occurs in numerous archaeological artifacts found at sites throughout New England. *Willard Ridge, T8 R9 WELS.*

Photo 4: The Bluffer Pond Formation (**Obp**) is chiefly characterized by pillow basalts like the ones seen in this photo. Loaf-like, oval, and circular pillows range in size from approximately 15 to 75 centimeters. *Northwest of Norway Pond, T9 R10 WELS.*

Photo 5: Example of Chase Lake Formation (**Ocl**) pebble conglomerate. *East of Mooseleuk Mountain, T9 R9 WELS.*

Photo 6: A rare exposure of the siltstone member of the Chase Lake Formation (**Ocls**). This unit crops out poorly and is only recognized in borrow pits and road pavements. *Southeast of Smith Brook Pond, T9 R10 WELS.*

Photo 7: There are numerous small cohesive fault breccias throughout the Mooseleuk Mountain quadrangle. This example demonstrates the small-scale nature of the breccia fragments, which consist of angular, altered, fine-grained basalt derived from the Bluffer Pond Formation. The fragments are enclosed in a fine-grained matrix within a silicified fault less than 40 centimeters wide. Slickenlines, seen in the lower right of the image, are common. The fault is exposed in a large excavated area near the end of a recently constructed (2016) logging road. *Northeast of Norway Pond, T9 R10 WELS.*

Photo 8: The complex pseudotachylyte network shown here is hosted in diabase. Part of the network exhibits a ladder network pattern consisting of two parallel fault veins linked by perpendicular veinlets. An angular pull apart is in upper right of the image and an angular breccia is seen in the lower left quadrant of the image. Classifications are from Rowe and others (2018). *Center of the quadrangle, T9 R9 WELS.*

EXPLANATION OF UNITS

Late Ordovician(?) [O]

Rowe Lake Formation.

Orlc — **Conglomerate member.** Conglomerate varies between clast supported and matrix supported. Clast-supported conglomerates have clasts in contact with one another. Matrix-supported conglomerates have clasts in minimal contact that are enclosed within a matrix of granules, very coarse, coarse-, and medium-grained sand. Matrix-supported granule and very small pebble conglomerates usually have very fine and fine-grained sand supporting the granules. Locally these can be described as conglomeratic sandstone and/or pebbly sandstone. Clast shapes are dominantly oval to subspherical and subrounded to well rounded and preferred clast orientation such as imbrication is absent. Pebble-size clasts are most common, but sizes range from granule through boulder. While most outcrops show conglomerate that is very poorly sorted, containing a complete range of sizes, some localities are pebble or cobble conglomerate. Outcrops of both varieties commonly lack bedding. Where present, bedding ranges from approximately 30 centimeters (cm) to more than one meter (m).

Clasts are overwhelmingly felsic volcanic rocks, possibly of rhyolite or dacite composition. They are white weathering, and may be porphyritic with quartz and/or feldspar phenocrysts up to 5 millimeters (mm). Biotite or amphibole phenocrysts are rare. These felsic clasts display textures identical to felsite tuffs in the Munsungun Lake Formation. Other clast compositions, in order of decreasing commonness, include chert, milky and smoky quartz, slate, and diabase. Chert pebbles are most commonly gray and black laminated; uniformly gray black or black; medium dark to dark gray; and very rarely red. These chert colors are indicative of the range of chert colorations observed in outcrop in the Munsungun Lake Formation. The rare diabase clasts are also identical to diabase intrusives in the Munsungun Lake Formation.

Orlsu — **Slate member, undifferentiated.** Thin-bedded siltstone and claystone slate. Slate beds range in thickness from approximately 1 to 30 cm. Coarse-grained siltstone and very fine grained sandstone laminae are common. Laminae are commonly less than 3 mm in thickness and are both continuous and discontinuous. Continuous lamina are traceable for greater than 1 m. Discontinuous laminae are traceable for distances less than 30 to 74 cm. Very fine and fine-grained sandstone beds up to 30 cm thick are locally present. These sandstone beds exhibit sharp bases and are commonly graded. Fine- to medium-grained lithic tuffs or lithic sandstone beds are rare. Tuff beds up to 75 cm thick are uncommon and are not widespread.

Poorly preserved graptolite fragments were recovered in the southwestern part of the Mooseleuk Lake Quadrangle, approximately 300 m north of the Mooseleuk Mountain quadrangle boundary. At this location a recent excavation for road material exposed slates interbedded with the Rowe Lake conglomerate. Written communication from Henry Williams, Professor Emeritus Memorial University of Newfoundland, suggests that these graptolites favor assignment to the Late Ordovician *Dicranograptus clingani* and the *Pleurograptus linearis* biozones.

TACONIC UNCONFORMITY(?)

Late Middle Ordovician to Early Late Ordovician [O]

Od — **Diabase.** Diabase is common as small stocks and sills. Diabase is dark gray, gray black, and black, fine grained (< 1 mm) to medium grained (1-5 mm). Weathered surfaces exhibit ophitic and subophitic textures of interlocking needle-like grains of plagioclase feldspar and pyroxene.

Oml — **Munsungun Lake Formation.** In the Mooseleuk Mountain quadrangle the formation is heterogeneous. It consists of volcanics, volcaniclastic sandstone, siliceous mudstone or argillite, slate, and chert of various colors. The volcanics are tuff, crystal-rich tuff, lapilli tuff, tuff breccia and pyroclastic flow deposits with blocks up to 45 cm in size. Tuffs are uniformly microcrystalline. Within this classification there is a range of textures from "grainy" or "sugary" tuffs through "cherty tuff" and "tuffaceous chert" to chert. Crystal-rich tuffs are porphyritic. Phenocrysts are most commonly euhedral feldspar up to 2 mm and/or subrounded to rounded grains of quartz up to 5 mm in diameter. Small biotite (and/or amphibole?) phenocrysts are rare. Lapilli tuffs contain subrounded to angular fine-grained aphanitic lithic grains up to 3 cm within an ash matrix. Mixed tuffs contain both phenocrysts and lithic grains. Tuff breccia contains angular grains of aphanitic volcanics. Breccia fragments are commonly 2 to 3 cm in size. Peperite, a mixture of basalt and sedimentary rock that forms through the interaction of lava with wet sediment, is rare (**Photo 1**).

Volcaniclastic sandstone interbedded with chert or argillite is a significant component in the Munsungun Lake Formation. Volcaniclastic sandstones range from very fine to very coarse grained. Grains are commonly angular to subrounded. Sorting is poor in coarser grained rocks. Sandstones are quartz poor. Lithic grains consist of very fine grained felsic volcanics. Feldspar is common. Granule and pebble conglomerate are minor components. Platy, elongated, or oval lithic grains are commonly imbricated in conglomerate beds. Angular to subangular pebbles of chert are locally common. Quartz pebbles are uncommon.

The formation is well bedded almost everywhere. Tuff beds range in thickness from approximately 1 m to more than 4 m. Concentrations or horizons of chert rip-up clasts, subparallel to bedding surfaces, are common. Chert fragments to 15 cm, and chert blocks with well-preserved bedding or lamination up to 1 m by 15 cm may be randomly distributed throughout the bed. These concentrations most commonly occur near the base of any particular tuff bed, but may also be present at any level in the bed. Lapilli is randomly distributed throughout lapilli tuff beds. However, lapilli grains may concentrate in the upper portions of beds. Sandstone beds range in thickness from 1 cm to more than 1 m. These beds exhibit sedimentary structures common to turbidites. Grading is common, but texturally uniform beds are also widespread. Parallel lamination is common to abundant while ripple cross lamination is uncommon. Medium to very thick (30 cm to > 1 m) beds of very poorly sorted granule and pebble conglomerate with reverse grading are uncommon. Chert rip-up clasts in thicker beds range in size from 3 cm to more than 1 m long. These are commonly near the base of the bed.

Dark-gray to grayish-black argillite and slate are minor components. These rock types usually are found as thin beds (< 10 cm) between volcaniclastic sandstones.

Hall (1970) reported an early late Ordovician age for the Munsungun Lake Formation. Graptolites consistent with those identified and reported by Hall (1970) from his Norway Brook location were found at two localities during the 2018 field season.

Omlc — **Chert.** Chert is an important part of the Munsungun Lake Formation. Chert outcrops in this quadrangle have been intermittently mined by Native Americans beginning approximately 11,500 B.P. and continuing through European contact. Artifacts of chert mined from Munsungun Lake Formation outcrops have been recovered from numerous archaeological sites in Maine, New England, and other locations in northeastern North America (Pollock and others, 1999). Chert may be found throughout the Munsungun Lake Formation, but overall chert is concentrated in three areas in the Mooseleuk Mountain quadrangle: the southeast-facing slope of Norway Bluff, on Willard Ridge, and on slopes north of Munsungun Lake. Chert sediment was volcanogenically derived (Pollock, 1987). The rocks are cryptocrystalline and well bedded. Beds vary in thickness, but at most locations beds are less than 30 cm thick. Chert occurs in two main physical types. The first type is a sequence of chert beds several meters to tens of meters in thickness. This type generally lacks argillite, slate, volcaniclastic sandstone, or tuff interbeds. It is this type that was extensively quarried by early Native Americans. The second type occurs as thin (<15 cm) interbeds with volcaniclastic sandstone and more rarely interbedded with slate or argillite. The chert is remarkable for its color varieties. These are: 1) structureless, grayish-red chert; 2) laminated grayish-red chert; 3) grayish-red chert interlaminated with dark-gray or greenish-gray chert, or with irregular color mottles of grayish-red and grayish-black or dark-greenish-gray to greenish-black chert (**Photo 2**); 4) color-laminated chert consisting of alternating medium-gray and gray-black laminae (**Photo 3**). Burrow structures in this color variety are commonly round to oval and black in color. This variety has a distinct weathering pattern with alternating black or gray-black laminae and light-gray to grayish-white lamina; 5) dark-gray to black laminated chert; and 6) structureless grayish-black chert. In addition to these dominant colors, the following colors are recognized: greenish black, brownish black, olive black, olive gray, and grayish green. Thin parallel laminations are common in these minor color varieties. Small circular structures interpreted as radiolarian fossils are locally common to all varieties. The gray-black chert is similar or identical to gray-black chert in Vermont and eastern New York, and the greenish-gray varieties are similar or nearly identical to greenish-gray varieties in the Hudson Valley of New York at Flint Mine Hill and West Athens Hill near Coxsackie and West Athens New York, respectively.

Obp — **Bluffer Pond Formation.** The formation consists primarily of metabasalt which exhibits very well developed pillow structures (**Photo 4**), and to a lesser extent of basaltic agglomerate as well as outcrops without pillow or agglomerate structures. Outcrops lacking pillow or agglomerate features may be sills or large dikes, but current exposures do not permit classification. Whitish-weathering fine-grained felsic tuffs similar to those of the Munsungun Lake Formation are locally present. Current outcrop size and distribution do not allow these tuffs to be shown as separate map units. Peperite is rare. Metabasalts are typically dark greenish gray to greenish black with amygdaloidal texture. Porphyritic textures and amygdules are rare features. Phenocrysts of plagioclase feldspar exhibit maximum lengths of 4 mm by 1 mm, but most are approximately 1 mm long. Amygdules are circular, less than 2 mm in diameter, and are filled with calcite or chlorite.

Pillow structure is nearly ubiquitous. Pillow length ranges from 10 to 75 cm. Chill rinds are well preserved and are less than 3 cm thick. Surface features or textures on the pillows surfaces consist of a mosaic of irregular polygons. Pillows most commonly occur in close-packed arrangements of loaf-like pillows. Interarea fills are mostly lacking, but where seen interareas are small breccias. Bombs in agglomerates are generally less than 20 cm. Fill between the bombs range from coarse ash to fine lapilli. Volume of ash and lapilli-sized fragments varies on a bed by bed basis, but does not exceed 20% of the rock. Where seen agglomerates commonly define a stratigraphic horizon.

The unit includes very minor occurrences of chert, found as rip-up clasts incorporated in pyroclastic flows and as clasts in peperite.

Fossils were not found in the Mooseleuk Mountain quadrangle. To the south, Hall (1970) collected several from localities which formed the basis for assigning the Bluffer Pond to the late Middle Ordovician at the time of Hall's publication.

Ocl — **Chase Lake Formation.** The Chase Lake Formation is a mix of conglomerate, sandstone, and slate. Conglomerate is poorly to moderately well sorted with pebbles from 1 to approximately 6 cm (**Photo 5**). Pebbles are well rounded and consist of fine-grained sandstone and siltstone. Basalt pebbles are moderately common. These display amygdaloidal textures and where amygdules have weathered out, the pebble resembles a vesicular basalt. Slate pebbles are uncommon and are rectangular in cross section. The pebbles are not white weathering as in the Rowe Lake Formation conglomerate. Another difference is the granules, pebbles, and cobbles in the Chase Lake are predominantly sedimentary. Conglomerate beds are 50 cm to 1.5 m thick. Chase Lake Formation sandstones are predominantly gray-black, fine- to medium-grained, moderately well sorted lithic sandstones. The lithic grains are dark gray and rounded. Quartz comprises less than 25% of the rock and is present as rounded to well-rounded grains. Sandstone beds range between 10 and 30 cm thick and generally lack textural grading and other sedimentary structures.

Brachiopod fragments were collected from conglomerate at one location. Several of these pieces can be assigned to the genus Dalmanella. One collection reported by Hall (1970) also contains this genera. At this time the Chase Lake Formation is considered late Middle or early Late Ordovician based upon previous collections and assignment made by Hall (1970).

Ocls — **Metasiltstone.** The metasiltstone member is characterized by thin beds of rusty-weathering gray-black siltstone and argillite. Pyrite is disseminated throughout the beds as submillimeter-sized grains. Beds range between 2 and 10 cm in thickness. Parallel lamination is abundant. Spaced cleavage or very closely spaced joints is the main secondary structure. Cleavage or joint spacing ranges between approximately 2 and 4 cm.

This distinctive variant of the Chase Lake Formation was exposed in a series of borrow pits and pavements during the 2018 field season (**Photo 6**). The member has similarities to the Blind Brook Formation in the northern half of the adjacent Mooseleuk Lake quadrangle. There are approximately 13 kilometers separating outcrops of the metasiltstone assigned to the Chase Lake and outcrops of the Blind Brook Formation. While there are lithologic similarities between the two, there is nothing to suggest a temporal, stratigraphic or structural connection between the two at this time.

PENOBSCOT UNCONFORMITY

Early Ordovician [O]

Og — **Gabbro.** Two small gabbro stocks intrude the Chase Brook Formation. One crops out in the southwestern part of the quadrangle and one crops out in the north central part of the quadrangle. The gabbro is a medium-grained, equigranular gabbro. Plagioclase predominates over pyroxene. No layering has been recognized. In thin section the rock shows alteration of all minerals. Both augite and hypersthene are present. Olivine, or pseudomorphs after olivine, have not been recognized in thin section.

Ocb — **Chase Brook Formation.** Almost everywhere the Chase Brook Formation is an olistostromal deposit consisting of slate and phyllite with inclusions of calcareous siltstone, sandstone, greenish-black and black slate and phyllite, grayish-red siltstone slate, and micrite. Rare outcrops demonstrate that the original rock of the Chase Brook consisted of thinly bedded dark-gray to grayish-black mudstone, with bedding thicknesses less than 10 cm. The unit commonly consists of a matrix of a mildly rusty to rusty-weathering black to gray-black to black phyllite and slate. Locally the gray phyllite/slate contains discontinuous layers of greenish-gray slate or phyllite that are characteristically less than 5 cm wide and less than 20 cm long. The greenish-gray phyllite/slate also occurs as small subangular blocks. Grayish-red siltstone slate was seen in one area only, and was mapped in the adjacent Mooseleuk Lake quadrangle (Pollock, 2019) and to the south by Hall (1970). Thin, discontinuous, calcareous metasiltstone beds are locally present. These may be present as fold hinges, while fold limbs are absent. Additionally, small (< 10 cm) isolated blocks of thinly bedded calcareous metasiltstone are found within the black slate. Beds and bed fragments suggest that original bedding was thin (< 10 cm) in most cases. Blocks of poorly sorted quartz-rich sandstone are rare. These blocks range from a few centimeters to more than a meter. The Chase Brook Formation is pervasively cleaved. Cleavages are of two types: a planar slaty cleavage and an irregular biconvex cleavage producing lens-like or phacoidal fragments. Phacoidal fragments range from 2 by 0.5 cm to more than 10 by 4 cm.

Secondary pyrite concentrations and concretions are moderately common. Concretions are characteristically subspherical to oval in shape and are commonly less than 8 cm on the longest dimension. In addition, pyrite occurs as small, finely disseminated grains. These may be present in thin layers up to 10 cm long by 0.5 cm thick. These layer-like concentrations may be preserved disaggregated fold hinges.

Conodonts previously recovered from the Chase Brook Formation from the southern portion of the Mooseleuk Mountain quadrangle confirmed a middle to late Arenig age (Pollock, 1993). Hall (1970) mapped green and red phyllite and slate in the vicinity of Chamberlain Lake at the south end of the Munsungun anticlinorium. Hall (1970) placed this stratigraphically above the Chase Brook Formation. Stratigraphic position in the Mooseleuk Lake quadrangle has not been established due to limited exposure. The outcrop located in the Mooseleuk Lake quadrangle is surrounded by the Chase Brook Formation and is cross cut by a small gabbro stock.

Bedrock Geology of the Mooseleuk Mountain Quadrangle, Maine

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Digital cartography by
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EXPLANATION OF LINES

Contact between rock units, of stratigraphic or intrusive origin (well located, approximately located, poorly located).

High-angle fault, interpreted from truncation of units on the map or from disruption of stratigraphic sequence. Arrows indicate sense of strike-slip motion. D (down) and U (up) indicate sense of dip-slip motion (well located, approximately located, poorly located).

Contact of uncertain origin. May represent a stratigraphic contact or a fault.

EXPLANATION OF SYMBOLS

Note: Structural symbols are drawn parallel to strike or trend of measured structural feature. Barb or tick indicates direction of dip, if known. Annotation gives dip or plunge angle, if known. For most planar features, symbol is centered at observation point; for joints, observation point is at end of strike line opposite dip tick. For linear features, tail of symbol is at observation point. Multiple measurements at a site are represented by combined symbols. Symbols on the map are graphical representations of information stored in a bedrock database at the Maine Geological Survey. The database contains additional information that is not displayed on this map.

- Outcrop of mapped unit.
- Float, presumed to represent underlying bedrock.
- Vein (inclined, vertical).
- Dike (inclined).
- Basalt flow top (inclined).
- Compositional layering in igneous rocks, possible bedding or flow surface (inclined, vertical).
- Bedding, ball indicates tops direction, if known (inclined, inclined with tops, overturned inclined, vertical with tops).
- Cleavage in slate or phyllite (inclined, vertical).
- Axial plane of fold (vertical).
- Fault (inclined, vertical).
- Joint or joint set (inclined, vertical).
- Trend of glacial striae.
- Possible archaeological quarry.
- ① Photo location.

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GEOLOGIC TIME SCALE

Geologic Age	Absolute Age*
Cenozoic Era (Cz)	0-66
Mesozoic Era (Mz)	
Cretaceous Period (K)	66-145
Jurassic Period (J)	145-201
Triassic Period (Tr)	201-252
Paleozoic Era (Pz)	
Permian Period (P)	252-299
Carboniferous Period (C)	299-359
Devonian Period (D)	359-419
Silurian Period (S)	419-444
Ordovician Period (O)	444-485
Cambrian Period (Є)	485-541
Precambrian time (pЄ)	Older than 541

* In millions of years before present. (Walker, J.D., Geissman, J.W., Bowring, S.A., and Babcock, L.E., compilers, 2012 Geologic Time Scale v. 4.0: Geological Society of America, doi: 10.1130/2012.CTS004R3C.)