46°35'00"N ⁵¹**50**⁰⁰⁰m**N** 68°52'30"W SCALE 1:24,000 Base map features from Maine Office of GIS - 1:24,000 USGS contour lines, E911 roads, 1:24,000 National Hydrography Dataset, USGS GNIS SOURCE OF GEOLOGIC INFORMATION placenames and 1:24,000 political boundaries. Additional unpaved Field work by Chunzeng Wang, assisted by roads digitized from aerial imagery by Chunzeng Wang, 2016. Map 1000 0 1000 2000 3000 4000 5000 6000 Caleb Ward (2016-2017) and Daniel Swallow (2016). projection Universal Transverse Mercator, North American Datum, 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

REFERENCES

Billings, M.P., 1935, Geology of the Littleton and Moosilauke quadrangles: New Hampshire Planning and Development Commission, Concord, New Hampshire, 51 p. Fyffe, L.R., Johnson, S.C., and Van Staal, C.R., 2011, A review of Proterozoic to Early Paleozoic lithotectonic terranes in the northeastern Appalachian orogen of New Brunswick, Canada, and their tectonic evolution during Penobscot, Taconic, Salinic, and Acadian orogenesis: Atlantic Geology, Volume 47, p. 211-249. Hall, B.A., 1970, Stratigraphy of the southern end of the Munsungun anticlinorium, Maine: Maine Geological Survey (Department of Economic Development), Bulletin 22, scale 1:62,500,

van Staal, C.R., Wilson, R.A., Kamo, S.L., McClelland, W.C., and McNicoll, V., 2016, Evolution of the Early to Middle Ordovician Popelogan arc in New Brunswick, Canada, and adjacent Maine, USA: Record of arc-trench migration and multiple phases of rifting: Geological Society of America Bulletin, v. 128, no. 1/2, p. 122-146 van Staal, C.R., Whalen, J.B., Valverde-Vaquero, P., Zagorevski, A., and Rogers, N., 2009, Pre-Carboniferous, episodic accretion-related, orogenesis along the Laurentian margin of the northern Appalachians, in Murphy, J. B., Keppie, J. D., and Hynes, A. J., eds., Ancient Orogens and Modern Analogues: Geological Society of London, Special Publications, v.

Waldron, J., McNicoll, V., and van Staal, C.R., 2012, Laurentia-derived detritus in the Badger Group of central Newfoundland: deposition during closing of the Iapetus Ocean: Canadian Journal of Earth Sciences, 49, p. 207-221.

ACKNOWLEDGEMENTS

or potential effects on the natural resources.

This project is funded by the U. S. Geological Survey StateMap Program through the Maine Geological Survey and by the Maine Historic Preservation Commission. Robert Marvinney and Arthur Spiess are thanked for their support and guidance. Special thanks to David Putnam for his many years of mentoring and partnership in the North Maine Woods and his assistance in this project, to Amanda Barker for her leading early trips to the area that started this mapping project, to Stephen Pollock for his guidance and partnership in the project, and to Brandon Boucher and Christopher McFarlane for providing assistance in U-Pb dating. Caleb Ward and Daniel Swallow served as field assistants and are much appreciated for their hard fieldwork. Gary Boone is thanked for his constructive discussion and suggestions. Chuck Johnston and Jason Johnston are thanked for allowing my team using their camp and motor boat.

EXPLANATION OF UNITS

STRATIFIED ROCKS

Silurian(?) [S]

Spider Lake Formation. This volcanic suite is largely composed of basalt flows with minor volcaniclastics (mostly gray tuff), and is characterized by widespread pillow basalt and peperite. The basalt is mainly aphyric; vesicular or amygdaloidal textures are common. In the Round Mountain quadrangle, it is present only in a small area in the northwest corner. Regionally, this suite is widespread on the northwest flank of the Munsungun inlier.

Samples collected in neighboring quadrangles are geochemically tholeitic with relative enrichment of large-ion lithophile elements (LILE) and depletion of high field strength elements (HFSE) such as tantalum, niobium, and titanium, indicating a volcanic arc environment.

Ordovician [0]

Rowe Lake Formation (new unit). This formation is mainly composed of massive and widespread pebble conglomerate and black argillitic slate. Excellent exposures in and around Rowe Lake, for which the formation is named, constitute the type locality for this new unit. There are three conformable members of the formation: the lower slate member, the conglomerate member, and the upper slate member. These members form a northwest-dipping homocline with an average strike at 200 to 225° and an average dip angle at 30°. It is fault bounded with the Blind Brook and Spider Lake volcanics to the northwest, and with the Chase Brook and Round Mountain Volcanic Suite to the southeast.

Fossil records (Hall, 1970) and correlation with similar black slate and shale units, for example, the Popelogan Formation black shale in Popelogan inlier in New Brunswick (Fyffe and others, 2012), the Badger Group black shale in Victoria arc in Newfoundland (Waldron and others, 2012), and the Partridge Formation black shale in Bronson Hill arc in New Hampshire (Billings, 1935), suggest that the Rowe Lake Formation was deposited in a post-arc-collision successor basin in Late Ordovician

Orlus Upper slate member. This member is predominantly a black or dark gray, lithologically homogenous argillic and pelitic slate, and is characterized by thin (0.3 to 2 centimeter) layers or seams of brown siltstone that repeat in 5 to 15 centimeter intervals. It contains several graptolite genera which point to a Late Ordovician age. It is also strongly foliated with the regional prevailing northwest-dipping foliation attributed to the Acadian orogeny. The upper slate member contains abundant graptolite fossils. Recent identification of the fossils categorized them as Sandbian/Caradocian and possibly Katian-aged Orthograptus calcaratus group (Stephen Pollock, personal communication, 2018).

Orlc Conglomerate member. This unit is predominantly a massive and very thickly layered, clast-supported, pebble or cobble conglomerate, with minor intercalated layers of sandstone. This intra-formational conglomerate is relatively poorly sorted except where sandstone layers exist. This member is polymictic but dominated by light gray or gray "chert" clasts (which are actually cherty fine-grained tuff). Because very few red, cherty, fine-grained tuff have been found within the conglomerate member, it is suggested that these "chert" clasts were derived from the Munsungun Lake Formation as seen at the Mule Brook Mountains in the Mooseleuk Lake quadrangle to the west, which contains little red tuff but voluminous gray, cherty, fine-grained tuff, rather than the Round Mountain and Center Mountain volcanic suites, which contain numerous layers of red tuff. The conglomerate is locally foliated, in particular where there are layers of sandstone. The foliation is consistent with the regional prevailing northwest-dipping foliation.

Lower slate member. This unit is predominantly a black, lithologically homogenous argillic and pelitic slate with a distinct yellowish brown weathering color, making it easily distinguishable from other slate. It is strongly foliated, consistent with the regional, prevailing, penetrative foliation. Likely displaced by faulting, the lower slate member pinches out on the east side of Bartlett Brook.

Blind Brook Formation. The Blind Brook Formation is largely exposed in the neighboring Mooseleuk Obb Lake quadrangle. Within the Round Mountain quadrangle, however, it occurs only in the northwest corner. This flysch formation consists of dark gray-black graptolitic slate and thin- to medium-layered sandstone with several intercalated layers of volcaniclastics.

sequence made of alternating layers of eruptive-facies pyroclastics (fine-grained tuff, coarse-grained tuff, lapilli tuff, lapillistone, and tuffaceous breccia) and effusive-facies basalt (dominantly porphyritic basalt), with pillow basalt only observed in the area southeast of Rowe Lake. The formation formed from multiple cycles of submarine volcanic eruptions during which each cycle began with explosive eruption and ended with effusive basaltic lava flows. The unit also includes similar rocks exposed at Bartlett Mountain. This volcanic suite is divided into three separately mapped units:

Round Mountain Volcanic Suite (new unit). The Round Mountain Volcanic Suite is a volcanic

Ormd Diabase. Diabase occurs as eliner sins of uncos. They are typical ophitic texture. Diabase is composed of plagioclase feldspar and augite. **Diabase.** Diabase occurs as either sills or dikes. They are medium- to coarse-grained with

Tuff. This unit is dominated by tuff and lapillistone with relatively minor tuffaceous breccia. Layers of fine-grained or very fine-grained tuff can be very silica rich and approach "chert" quality, thus archaeologically called "chert." The cherty tuff layers are mostly gray or dark gray in color. Some cherty layers of fine-grained or very fine-grained tuff are red or pink or purple. Color may change gradually between both gray and red/pink/purple varieties. Field mapping has discovered several suspected archaeologic sites (quarries) in the high-quality

"chert" where Paleoindians may have sourced materials for lithic tools. **Basalt.** The basalt flows are mostly porphyritic with plagioclase as major phenocrysts; some also have augite and olivine as phenocrysts. Some basalt flows show amygdaloidal texture and the amygdales are mostly calcite or zeolite. Pillow basalt of this unit is only observed at the northeast terminus of the Suite, east of Rowe Lake.

The Round Mountain Volcanic Suite was developed within a well-preserved half-graben. The alternating pyroclastic and basaltic layers within the half-graben form a homocline with an average strike at 235° and dip angle between 35° and 75°. The volcanic suite is pervasively foliated (except for the basalt flows and diabase dikes and sills) with the foliation dipping towards the northwest at a dip angle around 75°, which is consistent with the regional prevailing foliation. Basalt and diabase of the Round Mountain Volcanic Suite share the same geochemical characteristics and belong to a co-magmatic tholeitic series. They show compositions similar to primitive, enriched mid-ocean ridge basalts with enriched light rare earth elements (LREE) and LILE. In tectonic discrimination diagrams, they fall in a non-arc, within-plate setting. The half-graben structure confirms a rifting, extensional environment for the formation of the Round Mountain Volcanic Suite, which is consistent with the geochemical characteristics of the volcanics. This extensional environment might be related to an arc-rifting phase during arc evolution.

Center Mountain Volcanic Suite (new unit). The Center Mountain Volcanic Suite is exposed in the southeast of the quadrangle, in the areas around Spectacle Mountain and Center Mountain. It is part of the northeast-striking Munsungun - Center Mountain - Bald Mountain volcanic belt and includes voluminous volcaniclastics (tuff, lapillistone, and breccia), andesite-dacite, and diabase, each of them mapped separately. In the neighboring quadrangles, the suite also contains basalt flows.

Ocmt Tuff. This unit is dominated by fine-grained tuff, coarse-grained tuff, and lapillistone of lithic and crystal types. About 65% of the tuff is gray in color and the rest is red or purplish red in and crystal types. About 65% of the tuff is gray in color and the rest is red or purplish red in color, with changes between the colors either knife sharp or gradational. Several layers of volcanic breccia also occur within the unit, including jasper-bearing breccia. Some of the fine-grained tuff are very cherty and toolable.

Andesite-dacite (Ocma) and dacite (Ocmda). The gray to dark greenish gray andesite is porphyritic or hyalopilitic with mainly plagioclase feldspar and minor quartz phenocrysts (as well as some pseudomorphic hornblende which is replaced by chlorite or biotite). The matrix Ocmda is composed of aphanitic feldspar, chlorite, minor quartz, and opaque iron oxides. The gray to pale gray dacite is also porphyritic with more quartz phenocrysts than the andesite. Some quartz phenocrysts are embayed due to dissolution. Some dacite outcrops show spherulitic texture. The most prominent feature in the andesite-dacite and dacite units is the andesitedacite body that occurs in the area between Jack Mountain (located within the Jack Mountain quadrangle to the east) and Spectacle Mountain. It is largely an andesite body with lesser dacite that occurs along its margin. Another layer of dacite is exposed on the southeast side of

Diabase. About eight diabase dikes and sills of the Center Mountain Volcanic Suite are exposed within the quadrangle. Due to their relative higher resistance to weathering, they form hill tops such as the summits of Spectacle Mountain and Center Mountain. They are texturally ophitic and composed predominantly of plagioclase feldspar and augite.

The andesite, dacite, tuff, and most of the diabase are geochemically calc-alkaline, depleted in titanium, tantalum, and niobium, and enriched in LILE with a negative europium anomaly. Their spider and REE patterns suggest intra-oceanic arc or island-arc environment. Tectonic discrimination diagrams

A red tuff sample collected from south of Center Mountain was used to select zircon grains for uranium-lead (U-Pb) geochronological analysis at the University of New Brunswick. The selected zircon grains were euhedral in shape with magmatic origin. The result yielded a concordia age of 468.0±2.0 million years before present (Ma) and a weighted mean age ²⁰⁷Pb/²⁰⁶Pb of 467.0±2.2 Ma, indicating a Middle Ordovician age for the Center Mountain Volcanic Suite.

Chase Brook Formation. The Chase Brook Formation consists of predominantly slate with siltstone, graywacke, conglomerate, and minor limestone. Slate is mostly pyritic and characterized by the occurrence of pyrite balls. The formation is pervasively and strongly foliated and the foliation has a dominant southwest strike and northwest dip (at around 75°). Primary bedding is nearly completely eliminated at most of the exposures and replaced with this prevailing Acadian foliation. The formation is metamorphosed at lower-greenschist facies. The weathering color of the slate varies depending on content of sulfides such as pyrite.

Conglomerate member. A predominantly polymictic, matrix-supported, small-pebble and granule conglomerate has been mapped in several locations. It occurs as an intra-formational deposit and is moderately to strongly foliated. Clasts are moderately to poorly sorted, and include chert, quartz, rhyolite, and cherty slate.

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. D (down) and U (up) indicate sense of dip-slip motion (well located, approximately located, poorly located).

TABLE I. GEOCHRONOLOGY

Zircon LA-ICP-MS U-Pb 468.0 ± 2.0 University of New Brunswick, Canada

Location is shown on the map by a letter in a blue circle. Concordia age shown.

suggest a calc-alkaline arc setting as well.

Bedrock Geology of the Round Mountain Quadrangle, Maine

Bedrock geologic mapping by **Chunzeng Wang**

Digital cartography by Amber T. H. Whittaker

Geologic editing by **Robert G. Marvinney**

Cartographic design by **Christian H. Halsted**

Robert G. Marvinney State Geologist

Funding for the preparation of this map was provided in part by the U.S. Geological Survey STATEMAP Program,

Cooperative Agreement Nos. G16AC00162 and G17AC00163.



Maine Geological Survey

Address: 93 State House Station, Augusta, Maine 04333 **Telephone:** 207-287-2801 **E-mail:** mgs@maine.gov **Home page:** www.maine.gov/dacf/mgs/

Open-File No. 18-8 2018



Photo 1: Pillow basalt in the Spider Lake Formation (**Ssl**).



Photo 2: Conglomerate member (Orlc) of the Rowe Lake Formation



Photo 3: Lower slate member (**Orlls**) of the Rowe Lake Formation.



Photo 4: Very fine-grained cherty tuff ("gray chert") in the tuff member (Ormt) of the Round Mountain Volcanic Suite.



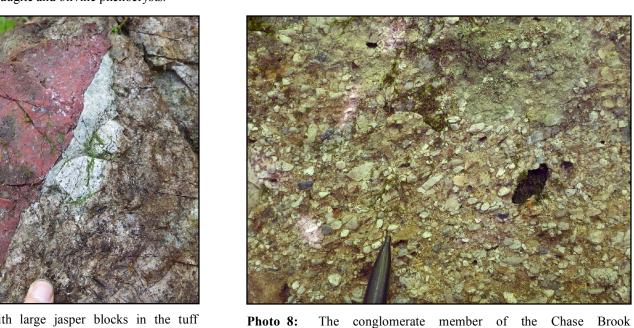
Photo 5: Porphyritic basalt in the basalt flow member of the Round Mountain Volcanic Suite (Ormb). Plagioclase feldspar comprise the



Photo 6: Diabase made of predominantly augite and plagioclase in the Round Mountain Volcanic Suite (Ormd).



Photo 7: Tuffaceous breccia with large jasper blocks in the tuff member of the Center Mountain Volcanic Suite (Ocmt).



Formation (Ocbc). It is mainly a small-pebble and granule conglomerate, polymictic, and moderately to poorly sorted.



Photo 9: Pyrite ball formed in the rusty-weathering, pyritic slate is a

typical feature in the Chase Brook Formation (Ocb).

GEOLOGICTIME SCALE Geologic Age Absolute Age * Cenozoic Era (Cz) Mesozoic Era (Mz) Cretaceous Period (**K**) 145-201 Jurassic Period (**J**) Triassic Period (**T**) 201-252 Paleozoic Era (Pz) 252-299 Permian Period (**P**) Carboniferous Period (**C**) 299-359 Devonian Period (**D**) 359-419 419-444 Silurian Period (**S**) Ordovician Period (**O**) 444-485 Cambrian Period (€) Precambrian time (**p€**) 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.

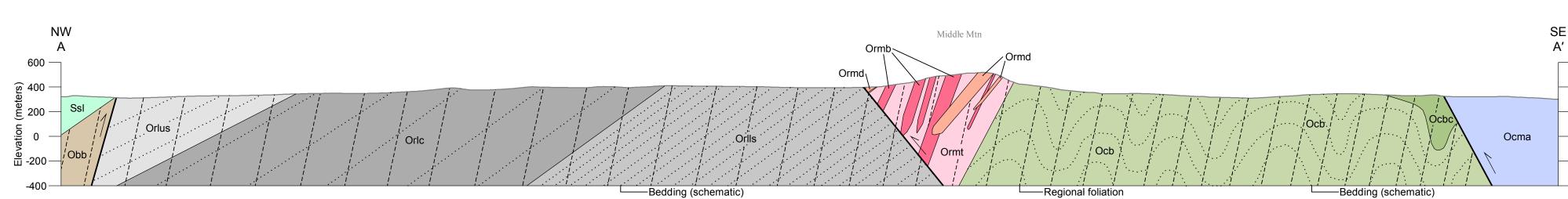
4.0: Geological Society of America, doi: 10.1130/2012.CTS004R3C.)

EXPLANATION OF SYMBOLS

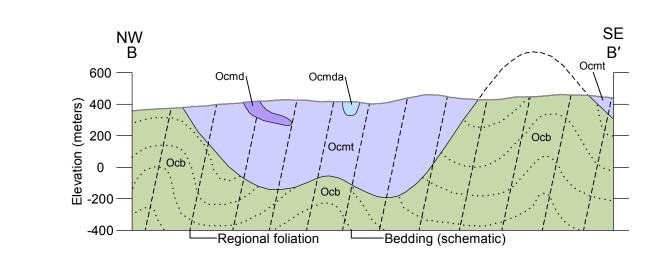
Note: Structural symbols are drawn parallel to strike or trend of measured structural feature. Barb or tick indicates direction of dip, if known. Annotation gives dip or plunge angle, if known. For most planar features, symbol is centered at observation point; for joints, observation point is at end 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, no structural information available.
- Bedding or contact between basalt flow and tuff, tops toward ball (inclined, vertical). Foliation, metamorphic (inclined, vertical).
- Fault (inclined).
- Photo location.
- Geochronology sample location (see **Table 1**).

INTERPRETIVE CROSS SECTIONS



CONTOUR INTERVAL 20 FEET



CROSS SECTION NOTES

Contact lines are solid where projected below ground, and dashed above the ground surface. Dotted lines represent bedding orientation. Dashed lines represent the regional prevailing foliation that overprints bedding. No vertical exaggeration.