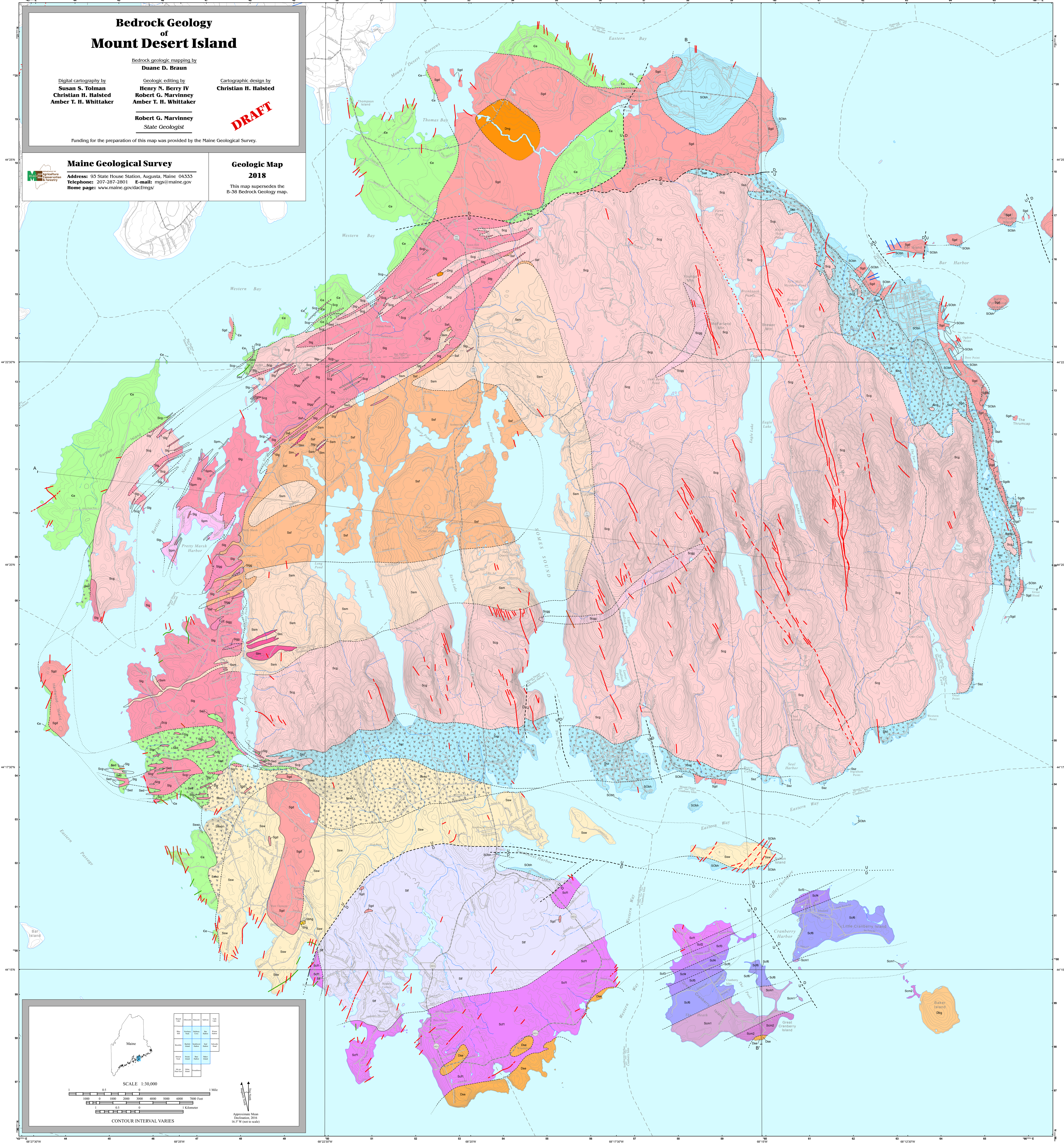

Bedrock Geology of Mount Desert Island

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Geologic Map
2018

This map supersedes the B-38 Bedrock Geology map.

EXPLANATION OF UNITS

INTRUSIVE ROCKS

Devonian(?) [D]

Dng — **Northeast Creek Granite.** Pinkish gray to lavender, medium-grained to porphyritic biotite granite, with light lavender phenocrysts (0.5 to 1.0 centimeter [cm]) of alkali feldspar.

Dse — **Seawall Granite.** Reddish gray to light gray, fine-grained to medium-grained biotite granite with sugary texture. Red hematite grains are common. Irregular veins of coarse-grained to pegmatitic granite containing abundant quartz and locally amazonite. (Revised from "Seawall Metafelsite" of Chadwick, 1944)

Dbg — **Baker Island Granite.** Pink to pinkish gray, medium-grained biotite granite. Biotite grains are aligned to produce a faint "grain" or foliation in places.

Silurian [S]

Cadillac Mountain Plutonic-Volcanic Complex

Diabase dike or sill. Dark gray to greenish gray, fine-grained to medium-grained diabase with ophitic texture, commonly with secondary chlorite and epidote. Some dikes in the Bar Harbor area are medium-grained gabbro with weak to no ophitic texture. Diabase dikes are present on the Cranberry Islands but were not mapped.

Felsite dike. Pinkish gray to light gray to tan, very fine-grained felsite to fine-grained homogeneous granite, with few visible mafic grains.

Composite felsite-diabase dike. Pinkish gray, very fine-grained felsite bounded on both sides by dark gray diabase with chilled margins or zones of rounded to irregular diabase enclaves with chilled margins.

Granite dike. Reddish to pinkish gray, medium-grained to coarse-grained hornblende granite or hornblende-biotite granite.

Somesville Granite (new name).

Ssf — **Fine-grained granite.** Pink to light gray, fine-grained to porphyritic biotite granite. It contains varying proportions of quartz and equant, perthitic alkali-feldspar phenocrysts up to 10 millimeters (mm) in size. It also has scarce phenocrysts (up to 10 mm) of complexly zoned plagioclase (30 to 15% anorthite [An_{30-15}]) with patchy and oscillatory zoning, and abundant small (0.1 to 0.3 mm), tabular plagioclase crystals with strong normal and oscillatory zoning (An_{45-15}). Biotite is the dominant mafic mineral; hornblende is scarce to absent. Accessory minerals include apatite, titanite, zircon, allanite, fluorite, and opaque minerals. The fine-grained granite is found from the village of Somesville westward to the Pretty Marsh area. In the northern part of the outcrop area there are commonly strips or masses a few meters across of medium-grained granite within the fine-grained granite. Type locality at the road cut at the intersection of the northern end of the Hall Quarry road with State Route 102.

Ssm — **Medium grained granite.** Pink to light gray, medium-grained to coarse-grained two-feldspar granite dominated by large, equant, perthitic alkali-feldspar phenocrysts (up to 10 mm) with smaller (1-4 mm) equant quartz and subordinate, complexly zoned plagioclase (An_{30-15}) with patchy and oscillatory zoning. Biotite is the dominant mafic mineral; hornblende is scarce to absent. Accessory minerals include apatite, titanite, zircon, allanite, fluorite, and opaque minerals. The medium-grained granite is exposed in a belt from the north of Somes Sound south to Acadia Mountain and then west to Hodgdon Pond. Type locality at the road cut at the intersection of State Route 198 and 233 (Eagle Lake Road).

Slm — **Mafic enclave layers within Somesville Granite.** Dark gray, fine-grained to coarse-grained gabbro or medium gray, medium-grained diorite arranged in layers of rounded enclaves mingled with or surrounded by pinkish gray medium-grained two-feldspar biotite granite.

Spm — **Pretty Marsh Granite.** Pink to pinkish gray medium-grained two-feldspar biotite granite. Perthitic alkali-feldspar is commonly equant and up to several mm in diameter; plagioclase is much smaller, tabular, and typically zoned from small cores of about An_{40} to broad rims of An_{15}. Hornblende occurs sporadically. Accessory minerals include apatite, allanite, zircon, titanite, and opaque minerals.

Slg — **Layered gabbro-diorite.** Interlayered gabbro, diorite, and granite. Much of the unit consists of thick layers (2 to 50 meters [m]) of medium to dark gray gabbro that occur in macrorhythmic series that grade upward from basally chilled fine-grained gabbro to coarser-grained gabbro, light gray to pinkish gray, medium-grained diorite, or pinkish gray, medium-grained to coarse-grained hornblende granite. Some parts of the unit have thinner (20 cm to 1 m) gabbroic layers that are chilled on both margins. Load-cast structures are common along the chilled bases of mafic layers, and silicic pipes commonly extend upward from the underlying silicic cumulates. Also common are relatively thin (50 to 75 cm) lensoid to sheet-like masses of gabbro and layers of gabbroic pillow-shaped enclaves, chilled on all margins, surrounded by dioritic to granitic cumulate material. Some thin gabbroic layers are composed of angular fragments surrounded by dioritic to granitic material.

Slgg — **Granite within the layered gabbro.** Pinkish gray, medium-grained granite that commonly has two feldspars, normally zoned plagioclase (An_{30-20}) and potassium-rich feldspar with white cores. Although hornblende is the dominant mafic mineral, biotite is common. It occurs as 10- to 100-m-thick masses within the layered gabbro-diorite unit (**Slg**). It is uncertain whether they are exceptionally thick granite layers in the layered complex or are intrusive into the layered complex.

Scg — **Cadillac Granite.** Reddish to greenish gray, homogeneous, massive, medium-grained to coarse-grained granite. Quartz and mesoperthitic alkali feldspar (65% albite, 35% orthoclase [$Ab_{65}Or_{35}$]) are equant and range from 2 to 7 mm in diameter. Hornblende is the dominant mafic mineral; scarce biotite occurs locally. Both minerals are typically interstitial. Opaque minerals, zircon, and apatite are ubiquitous accessory phases; allanite, titanite, and fluorite are common. Epidote, chlorite, stilpnomelane, carbonate, and sericite occur sparsely as alteration products and as fillings of primary interstitial cavities. In the northwestern and southwestern parts of the granite mass, feldspar typically contains white cores of ternary feldspar ($\sim An_{10}Ab_{70}Or_{20}$). Mafic enclaves and irregular concentrations of hornblende and plagioclase 1 to 10 cm across are sparsely but widely distributed throughout the granite. Near the shatter zone the granite is more mafic and varied in mineralogy and texture; some exposures show cumulate textures. Fluorite, zircon, and allanite are more abundant in this marginal zone. The granite on the west proximal to the layered gabbro-diorite unit (**Slg**) commonly has two feldspars, normally zoned plagioclase (An_{30-20}), and potassium-rich feldspar. Although hornblende is the dominant mafic mineral, biotite is common, and both minerals are commonly subhedral. Informally known as the Cadillac Mountain Granite.

Scgg — **Granophyre.** Pink to reddish gray, fine-grained granite with intergrown quartz and alkali feldspar crystals. Only the largest masses within the Cadillac Granite were mapped, although there are numerous smaller granophyre masses.

Stf — **Tremont felsite** (new name). Pinkish gray to light gray, very homogeneous, very fine-grained felsite to fine-grained biotite granite, with few visible mafic grains. Intrusive contact with the Cranberry Island Volcanics with blocks of ignimbrite and volcanic breccia surrounded by felsite near the contact. Was previously considered to be the upper part of the Cranberry Island Volcanics. Type locality is a road cut along Tremont Road just east of where the road crosses the head of the northwest arm of the Bass Harbor estuary.

Small intrusions at West Tremont.

Shg — **Hornblende granite.** Reddish yellow to brown, coarse-grained porphyritic hornblende granite, with 1- to 10-cm-long hornblende blades. A small intrusion within the Southwest Harbor granite or a late phase of the Southwest Harbor granite.

Sbhg — **Biotite-hornblende granite.** Lavender, fine-grained to medium-grained biotite-hornblende granite. A small intrusion within the Southwest Harbor granite or a late phase of the Southwest Harbor granite.

Ssw — **Southwest Harbor biotite-hornblende granite.** Pink to light gray, fine-grained to medium-grained biotite-hornblende granite. Very subtle mingling of slightly more grayish/more mafic and more pinkish/less mafic granite at scales of tens of centimeters to tens of meters is found in the western part of the outcrop and on Sutton Island. Mafic enclaves and irregular concentrations of hornblende and plagioclase 1 to 10 cm across are sparsely but widely distributed throughout the granite.

Sgd — **Gabbro.** Dark gray, medium-grained to coarse-grained gabbro. In places, there is a subtle mingling of darker gray, more mafic and lighter gray, less mafic (more plagioclase-rich) rounded masses of gabbro at a scale of tens of centimeters to several meters. Blocks of medium gray quartzite (Bar Harbor Formation) tens of centimeters to tens of meters across occur in patches within the gabbro. In the interior of thicker sill masses is medium gray to pinkish gray, medium-grained diorite. The thicker sills appear to have formed from multiple injection events. This unit represents the initial sills and dikes of the Cadillac Mountain Plutonic-Volcanic Complex.

STRATIFIED ROCKS

Silurian [S]

Cranberry Island volcanic series. Extrusive equivalent of the Southwest Harbor Granite and early part of the Cadillac Granite. (Seaman and others, 1999; Wiebe, 1994).

Scm2 — **Basaltic lava and tuff.** Dark gray, locally pillowed and vesiculated, fine-grained basaltic lavas discontinuously interbedded with dark gray, layered, fine-grained basaltic tuffs and thin layers of fine-grained, rippled, epiclastic tuff. The basalts contain fine-grained labradoritic plagioclase, epidote, hornblende, biotite, actinolite, chlorite, quartz, and locally garnet.

Scm1 — **Basaltic tuff.** Laminated green, red, and white water-lain tuffs with larger fragments disrupting the lamination. Grain size is silt to sand sized. Green layers contain epidote, hornblende, and/or actinolite (~70%), plagioclase (~20%), and chlorite (~10%). Red layers contain biotite (~75%), and plagioclase (~25%). White layers contain quartz (~90-95%) and plagioclase (~5-10%). Green and red layers show delicate cross-bedding and ripple structures. The unit is interpreted to be pyroclastic fallout and flow deposits.

Scf6 — **Rhyolitic ignimbrite, tuff, and breccia.** Gray, pumiceous, crystal-rich, rhyolitic, plagioclase-quartz-sanidine ignimbrite and volcanic breccia with brown discontinuous fine-grained clay-rich layers. Pumice clasts, typically 1 to 2 cm across, become less common upward in the unit, while rounded, dark gray mafic enclaves become more common. Breccia clasts are typically a few centimeters to tens of centimeters across.

Scf5 — **Andesitic ignimbrite.** Pinkish to reddish brown, fine-grained, crystal- and lithic-poor, dacitic to andesitic ignimbrite with undulatory and rippled bedding. It has an aphanitic, clay- and chlorite-rich matrix with abundant 1-3 mm phenocrysts of plagioclase and rare larger plagioclase and quartz phenocrysts (to 10 mm). Clusters of medium gray, small (~3 mm to 3 cm), rounded mafic enclaves consist of hornblende and/or epidote and minor plagioclase with white plagioclase-rich rims. There are also light gray, irregular, ellipsoidal rhyolitic segregations up to 1 m across with clusters of the small white-rimmed mafic enclaves.

Scf4 — **Pumiceous rhyolitic ignimbrite.** Dark gray, fine-grained, crystal- and lithic-poor rhyolitic ignimbrite with abundant flattened pumice lenses. There are two subunits, each showing an upward increase in the size of pumice fragments from a few centimeters at the base to 25 cm at the top.

Scf3 — **Rhyolite lava flows.** Light to medium gray high-silica rhyolite flows or sills, intricately flow banded and microporphyritic with small (~1 mm) plagioclase phenocrysts. The outrcop surface is ribbed due to more resistant quartz and feldspar layers alternating with less resistant quartz and hematite layers.

Scf2 — **Rhyolitic ignimbrite and tuff.** The lower part of the unit consists of gray epiclastic layers with graded bedding, scour surfaces, and truncated cross-bedding. The upper part of the unit consists of gray, fine-grained, lithic-poor rhyolitic ignimbrite interbedded with discontinuous tan-brown fine-grained layers containing broken euhedral crystals (< 1 mm) of quartz, plagioclase, and potassium feldspar in a

Scf1 — **Rhyolitic ignimbrite and breccia.** Light to medium gray, very fine-grained, lithic-rich rhyolitic ignimbrite interbedded with clast-supported volcanic breccia. The very fine-grained ignimbrite is characterized by broken, euhedral, pink potassium feldspar phenocrysts (~2 mm) in a matrix of 60-65% interlocking quartz and sanidine crystals (0.01 to 0.02 mm), secondary muscovite (10-15%), biotite and hornblende (10%), and blocky opaque minerals (10%). Abundant lithic fragments as large as a few centimeters across consist of brown siltstone, pink rhyolite, gray or pink granite, and basalt. Dark gray, rounded to lobate basaltic enclaves a few centimeters across are locally common. In places breccia layers grade into clast-free material 100 m or so along strike of the layering.

Silurian-Ordovician [SO]

SObh — **Bar Harbor Formation.** Dark to light gray to lavender, 0.05- to 0.3-m-wide layers of quartzite and argillite with grain size ranging from sand to silt, intercalated with 0.1- to 10.0-m-wide layers of very light gray metarhyolite tuff. Along some bedding planes are a series of elliptical nodules of quartz.

Cambrian [Є]

Єe — **Ellsworth schist.** Gray to greenish gray chlorite schist interlayered with thin (1 to 10 mm), white, quartz- and feldspar-rich layers and grayish green, muscovite- and chlorite-rich layers, often highly contorted; intercalated with 0.1- to 3.0-m-wide layers of light gray metarhyolite tuff and medium gray to grayish green metabasalt tuff (greenstone). Some such layers have a bimodal alternation of metarhyolite and metabasalt.

EXPLANATION OF PATTERNS

COMPLEX CONTACT-ZONE ROCKS

Silurian [S]

Ssz — **Shatter zone.** Angular blocks from a few centimeters to hundreds of meters across of reddish gray to gray quartzite and medium to dark gray, fine-grained to medium-grained gabbro surrounded by light gray, fine-grained to medium-grained hornblende-biotite granite. The zone forms a belt around the eastern and southern margins of the Cadillac Granite. Most of the shatter zone can be divided into three zones: (A) An outer zone against the country rock which consists of extensively broken up, tightly packed (no more than about 20% matrix), deformed, layered Bar Harbor Formation (**SObh**) with or without angular blocks of diabase invaded by thin, irregular veins of felsite. Where not aphanitic, the matrix has very fine-grained quartz and biotite as well as small feldspar. (B) A central zone comprised predominantly of smaller blocks of Bar Harbor Formation (typically <1 m) and diabase blocks from less than one meters to tens of meters across. The matrix of this zone (20 to 40% of the rock) is composed of quartz, two feldspars, biotite, and minor hornblende. It is fine-grained to medium-grained and commonly has a strong flow fabric around blocks of country rock. (C) An inner zone of mainly larger blocks from 10 to 80 m across, commonly separated by large areas of homogeneous granite. The granitic matrix (>50%) is medium-grained and has blocky feldspars with white cores of ternary feldspar ($\sim An_{10}Ab_{70}Or_{20}$) and broad rims of mesoperthite, interstitial to equant quartz, iron-rich clinopyroxene, iron-rich hornblende, two oxides, and scarce fayalite. A unique character of the feldspar is a sequence of strong oscillatory zoning (albite-orthoclase) between the core of ternary feldspar and rim of alkali feldspar ($Ab_{65}Or_{35}$). This matrix grades to typical Cadillac Granite that lacks country rock inclusions and ternary feldspar cores.

Sed — **Disrupted Ellsworth schist.** Angular blocks a few meters to hundreds of meters across of greenish gray to gray chlorite schist or light gray felsic meta-rhyolite cut by and surrounded by pinkish gray to light gray, medium-grained to coarse-grained hornblende granite. The granite commonly has two feldspars, normally-zoned plagioclase (An_{30-20}) and potassium-rich feldspar often with white cores of ternary feldspar ($\sim An_{10}Ab_{70}Or_{20}$). Although hornblende is the dominant mafic mineral, biotite is common, and both minerals are commonly subhedral.

Sswz — **Southwest Harbor granite with many xenoliths.** Mix of angular 0.1- to 1.0-meter fragments of quartzite and rounded mafic inclusions surrounded by pinkish gray medium-grained biotite-hornblende granite. Inclusions are often in patches of tens to hundreds of meters across separated by granite with few inclusions that extends for hundreds of meters or more.

Sgdb — **Disrupted gabbro dike.** Dark gray, medium-grained to coarse-grained gabbro. The gabbro is cut by a number of hornblende-biotite granite dikes and is broken into a series of blocks from a few m to hundreds of m across. It is traceable as a continuous south-north zone bounded by more typical shatter zone with a mix of Bar Harbor Formation and gabbro blocks surrounded by granite.

EXPLANATION OF LINES

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

U
D

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

SOURCES OF MAP INFORMATION

Mineralogic and petrographic details of the Cadillac Mountain Intrusive Complex unit descriptions are paraphrased from an unpublished manuscript by R. Wiebe, Wiebe, 1994, and Wiebe et al, 1997 with some description from field observations by Braun.

Unit descriptions for the Cranberry Isles volcanic series are paraphrased from Seaman et al, 1999.

Descriptions for the other units are derived from Gilman et al., 1988, Chapman, 1970 & 1973, and field observations by the Brauns.

Bedrock geologic mapping of Mount Desert Island was conducted by Duane D. Braun during the 2013 through 2017 field seasons.

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.

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SOURCES OF ADDITIONAL INFORMATION

For more detailed information, please see the individual 1:24,000-scale bedrock geologic maps for each quadrangle represented in this composite map: Newbury Neck, Salsbury Cove, Bar Harbor, Bartlett Island, Southwest Harbor, Seal Harbor, Swans Island, Bass Harbor, and Baker Island. Publication availability may be determined by searching the Maine Geological Survey website (www.maine.gov/dacf/mgs/).

GEOLOGIC HISTORY OF MOUNT DESERT ISLAND

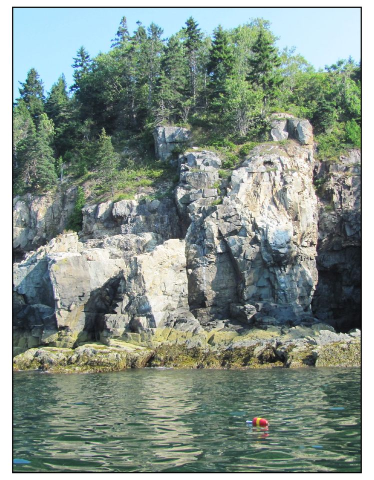
Mount Desert Island (MDI) is on the edge of the Gander terrane, a New Zealand-sized slice of continental crust that split from the southern continent of Gondwana about 550 million years ago (mya). Sediment deposited in the opening rift was later metamorphosed to form the Ellsworth Schist, found on the north and west side of MDI. Gander traveled north to collide at about 440 mya with Laurentia, the name for the geologically old core of North America, to form a substantial portion of what is now Maine. Sediments deposited on the trailing edge of Gander would become the Bar Harbor Formation on the east side of MDI. Following Gander was the Avalon terrane which collided with Gander starting at about 420 mya. At that time a line of volcanos formed along the collision zone that was offshore and parallel to what is today the coast of downeast Maine.

The rocks now exposed on MDI formed beneath one of those volcanos as a result of a series of magma intrusions and violent eruptions for several million years centered around 420 mya. These intrusions form most of MDI, including all the larger granite and gabbro masses shown on this geologic map. The Cadillac Mountain Granite was the largest intrusion and underlies the northwest-southeast trending mountains of MDI. The intrusive and volcanic rocks of MDI are a prime example of "bimodal volcanism," the alternating intrusions and extrusions of very hot, fluid basaltic magma and less hot, less fluid granitic magma. Especially violent eruptions occurred when basalt magma was injected into still-molten granite magma. Such violent eruptions formed a caldera 10 miles in diameter that occupied most of what is now MDI. The rim of the caldera is marked by the arcuate shatter zone of blocks of country rock in the granite (see map) and as wedge-shaped masses on the cross-sections below. That caldera was one-fourth the size of today's Yellowstone caldera in Wyoming and one-half the size of today's Long Valley caldera in California. Based on size of the caldera and volume of volcanic material, the volcano that formed the rocks of MDI might be classified as a "super volcano," similar to today's Yellowstone or Long Valley volcanos.

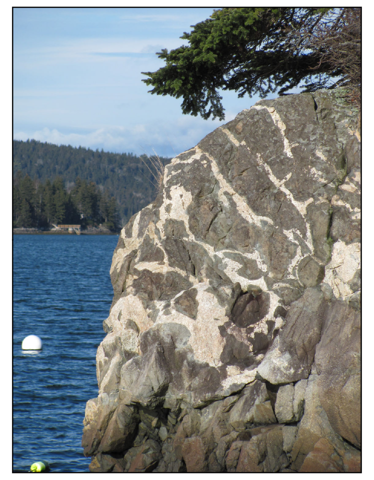
Long after volcanic activity ceased, collision of the Meguma terrane at around 360 mya probably uplifted the area and produced the smaller granite intrusions around the periphery of the 420 mya caldera. Finally, Gondwana collided with North America around 300 mya. All the terrane collisions contributed to the formation of the Appalachian Mountains, uplifting and tilting the landscape. The later mountain building events extensively fractured the rock, which had cooled considerably and become brittle. The MDI landscape today is dominated by linear valleys carved out of northwest-trending fracture zones. From around 420 mya when volcanic activity ceased to just a million years or so ago, streams deeply eroded the uplifted volcano. During that 400 million year or so period of erosion, three kilometers (two miles) of rock were eroded from the landscape. The volcanic landform was entirely removed, preserving only remnants of volcanic ash and lava flows on its down-tilted and down-faulted southeast side, now seen at the Cranberry Islands. At MDI today, the level one is standing on was originally at the center of the magma chamber three kilometers (two miles) beneath the volcano.

Over the last million years or so continental glaciers as much as 5000 feet thick flowed over MDI several times and sculpted the landscape into its present form. Immediately prior to glaciation the region was a gentle V-shaped ridge and ravine landscape formed by long-term stream erosion. The area that would become MDI was a northeast to southwest trending range of low mountains with V-shaped peaks separated by shallow V-shaped saddles. That mountain range was scoured and smoothed by the glaciers flowing across it from northwest to southeast. Ridge crests were rounded and valleys deepened into U-shape troughs. Today on MDI one is looking at a glacially sculpted landscape of rounded, streamlined peaks separated by elongate lakes in the glacial troughs. Offshore one sees rounded islands separated by glacial troughs flooded by the ocean.

Bar Harbor Formation. Layered rocks of the Bar Harbor Formation (**SObh**) with bedding slightly inclined toward the ocean. *Bar Harbor Shore Path, views of the harbor and Bar Island.*

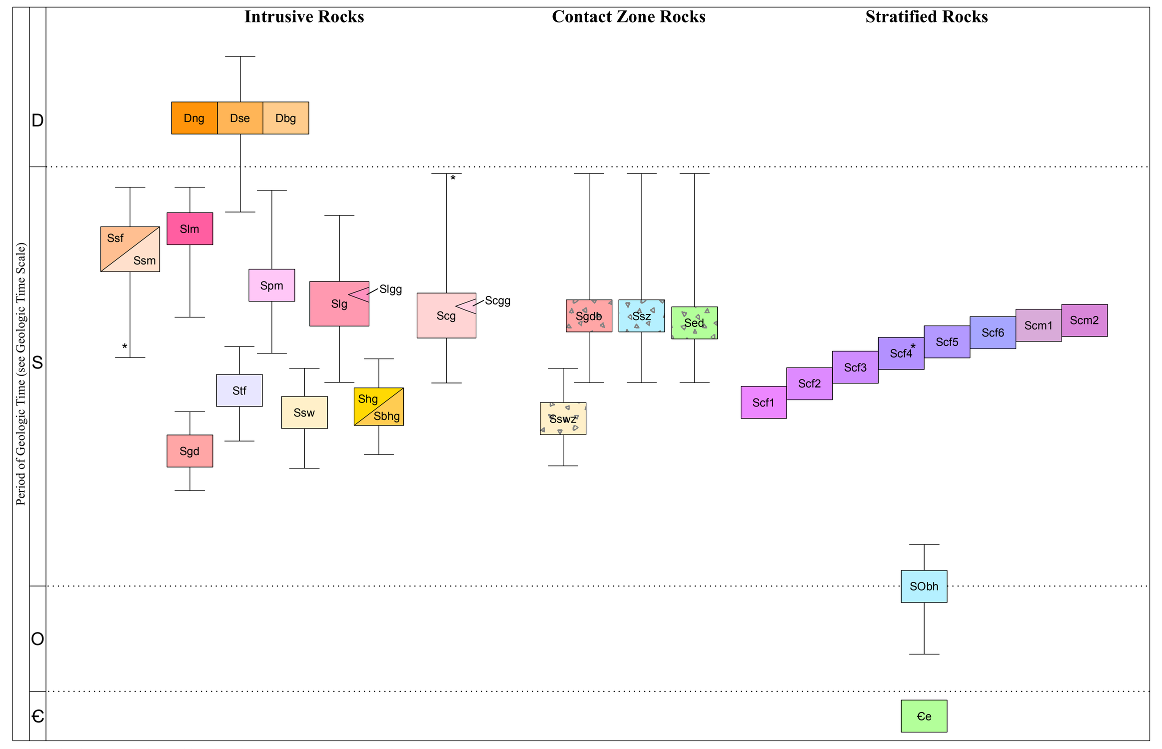


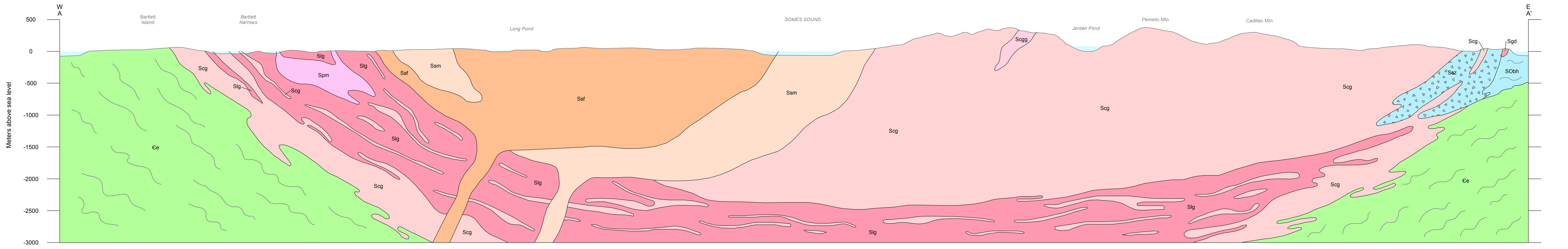
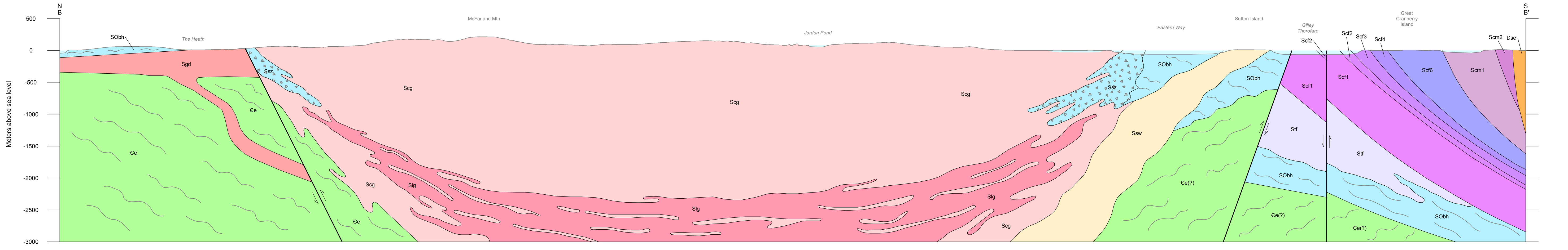
Diabase dike intruding Cadillac Granite. Dramatic cliffs of Cadillac Granite (**Scg**) meet the ocean. A dark-colored diabase dike cuts vertically through the granite near the center of the image and disappears into the treeline. *Just east of Ingraham Point near Seal Harbor.*



Interlayered gabbro and granite. Dark gray irregularly-shaped masses of gabbro mingle with pink granite (**Slg**). *Coastal exposure on the east side of the mouth of Pretty Marsh Harbor, Mount Desert.*

STRATIGRAPHIC RELATIONSHIPS



Unit blocks shown in relative positions based on observed geological relationships.
* Radiometric date

INTERPRETIVE CROSS SECTIONS