Bedrock Geology of the
Kittery 1:100,000 Quadrangle, Maine and New Hampshire

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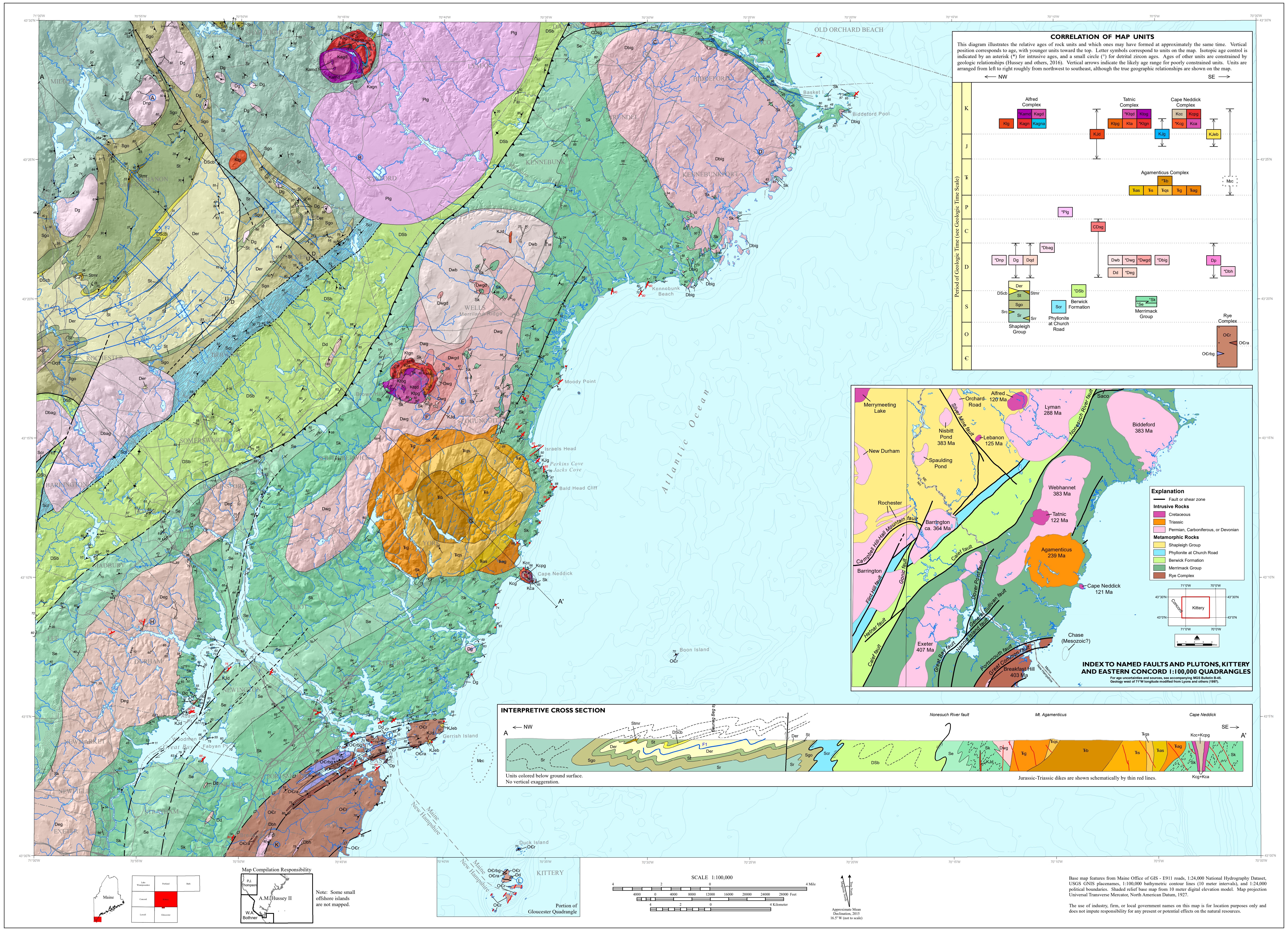
Geologic Map 16-6
2016 (Corrected 2019)
For additional information, see Bulletin 45 (Hussey and others, 2016).
This map supersedes
Geologic Map 08-78.



CORRELATION OF MAP UNITS

This diagram illustrates the relative ages of rock units and which ones may have formed at approximately the same time. Vertical position corresponds to age, with younger units toward the top. Letter symbols correspond to units on the map. Isotopic age control is indicated by an asterisk (*) for intrusive ages, and a small circle (°) for detrital zircon ages. Ages of other units are constrained by geologic relationships (Hussey and others, 2016). Vertical arrows indicate the likely age range for poorly constrained units. Units are arranged from left to right roughly from northwest to southeast, although the true geographic relationships are shown on the map.

INDEX TO NAMED FAULTS AND PLUTONS, KITTERY AND EASTERN CONCORD 1:100,000 QUADRANGLES

For age uncertainties and sources, see accompanying MGS Bulletin B-45. Geology west of 71°W longitude modified from Lyons and others (1997).

INTERPRETIVE CROSS SECTION

Units colored below ground surface.
No vertical exaggeration.

Jurassic-Triassic dikes are shown schematically by thin red lines.

Map Compilation Responsibility

Note: Some small offshore islands are not mapped.

Portion of Gloucester Quadrangle

SCALE 1:100,000

Approximate Mean Declination, 2015
16.5° W (not to scale)

Base map features from Maine Office of GIS - E911 roads, 1:24,000 National Hydrography Dataset, USGS GNIS placenames, 1:100,000 bathymetric contour lines (10 meter intervals), and 1:24,000 political boundaries. Shaded relief base map from 10 meter digital elevation model. Map projection Universal Transverse Mercator, North American Datum, 1927.

BEDROCK GEOLOGY OF THE KITTERY 1:100,000 QUADRANGLE

Bedrock exposed in the Kittery 1:100,000 quadrangle includes metamorphosed sedimentary rocks and intrusive igneous rocks. Sedimentary rocks are accumulations of particles of gravel, sand, silt, and clay in distinct beds, or precipitation of minerals from solution in layers or strata. Recrystallization of the sedimentary rocks by heat and pressure transforms them into metamorphic rocks, frequently developing minerals that are quite different from the originally deposited particles and changing the rock structure. Intrusive igneous rocks are those rocks formed by the crystallization of masses of molten rock material (magma) that were entrapped within the Earth's crust.

STRATIFIED ROCKS

Stratified, or layered rocks in the Kittery quadrangle are metamorphosed deposits of shale, siltstone, and sandstone that accumulated in two ancient ocean basins, the Merrimack Basin to the east and the Central Maine Basin to the west. (Note that present day orientations are used here for reference, even though the continents have moved significantly since the basins formed in Paleozoic time.) Deposition occurred during latest Ordovician through Middle Silurian time in the Merrimack Basin, and from latest Ordovician through Early Devonian time in the Central Maine Basin. These rocks were derived from weathering and erosion from exposed landmasses surrounding the basins. Stratified rocks are separated into formations of closely similar rock types that can be mapped over a broad area. Within the Kittery quadrangle these formations include the Eliot (**Se**) and Kittery (**Sk**) formations deposited in the Merrimack Basin, and formations of the Shapleigh Group (Rindgemere, **Sr**, Gully Oven, **Sgo**, Towow, **St**, and East Rochester, **Der**) deposited in the Central Maine Basin. The Berwick Formation (**DSb**) and the Phyllonite at Church Road (**Scr**) may have been deposited also in the Central Maine Basin, but the Phyllonite at Church road is so strongly deformed that its original rock is difficult to recognize, and the Berwick Formation is isolated from the other formations by faults.

The Eliot Formation consists of metamorphosed thin beds of alternating tan-weathering limy siltstone, and dark gray shale (**Photos 1** and **2**). The Kittery Formation consists of variably thin to very thick-bedded metamorphosed limy sandstone, siltstone, and shale that preserve a variety of sedimentary features similar to those found today in deep-sea sediments that accumulate at the base of continental slopes. Graded bedding (**Photo 3**) and flute casts (**Photo 4**) are common and enable us to determine the stratigraphic order and the direction from which the sediments were derived and transported. The Kittery Formation was derived from a continental land mass lying to the east of the Merrimack Basin.

The Berwick Formation consists of metamorphosed calcareous sandstone, siltstone, and shale much like the Kittery Formation but with generally thicker beds (**Photo 5**). The Rindgemere, Gully Oven, and East Rochester Formations consist of gray, metamorphosed shale, siltstone, and sandstone. Bedding of the Rindgemere Formation is weakly developed and variable, and primary sedimentary structures are rare. On the contrary, bedding in the Gully Oven (**Photo 6**) and East Rochester (**Photo 7**) formations is characteristically well developed, with rhythmic alternations of shale and siltstone which are commonly graded. The Gully Oven Formation includes thin beds of reddish garnet-quartz granofels that help identify the formation (**Photo 8**). The Towow Formation is a distinctive alternation of rusty-weathering, sulfidic, poorly bedded to massive metamorphosed shale and siltstone. The Merchants Row Grits (**Stmr**) occurs locally at the top of the Towow Formation, characterized by granule-sized clasts up to 4 mm in size consisting of white and blue quartz, quartzite and rare metashale chips, perhaps representing a minor episode of erosion. Between the Towow and the East Rochester Formations lies an unnamed thin, possibly discontinuous, unit (**DScb**) of metamorphosed calcareous sandstone, similar to a widespread unit in central New Hampshire and western Maine.

INTRUSIVE IGNEOUS ROCKS

The intrusive igneous rocks are generally even-textured, massive rocks with interlocking mineral grains. They are distinguished from each other by characteristics such as the size of the mineral grains (texture) and proportions of minerals (mineralogy). Intrusive rocks occur in bodies (called plutons) that range in size from large areas shown on the map to small bodies intruding other rocks within an outcrop. The major bodies include the following, listed approximately from oldest to youngest.

1) Exeter pluton (**Deg**) is medium-grained variably textured quartz-biotite diorite with minor irregular masses of gabbro to quartz monzonite. Similar small bodies of diorite (**Dd**) are also considered Early Devonian, and possibly the Rochester plutons (**Dqd**).

2) Biddeford pluton (**Dbig**) is medium-grained biotite granite (**Photo 9**). Webhannet pluton consists of three principal phases. The oldest is fine-grained to medium-grained biotite-hornblende granodiorite (**Dwgd**); the intermediate-aged phase is medium-grained to coarse-grained biotite granite with moderate amounts of sphene and epidote (**Dwg**); the youngest phase, forming the northern end of the pluton, is medium-grained biotite-muscovite granite (**Dwb**). The Nisbitt Pond pluton (**Dnp**) is biotite-muscovite granite with white feldspar grains up to 3 cm long, commonly aligned, which form a swirled foliation pattern in many outcrops. Ages obtained for all of these bodies are the same, at the Middle-Late Devonian boundary. Many bodies of similar granite (**Dg**) and pegmatite occurring as isolated bodies or in migmatite in the Ridgemere Formation may be of the same age.

3) Barrington pluton (**Dbag**) is medium-grained to coarse-grained biotite-muscovite granite of Late Devonian age.

4) Lyman pluton (**Plg**) is fine-grained to medium-grained, irregularly textured biotite and biotite-muscovite granite. Irregular masses of granite pegmatite are common in many parts of the pluton. It is Permian, approximately 100 million years younger than most other granites in the Kittery 1:100:000 sheet.

5) Agamenticus Complex is a roughly circular body consisting of several phases of pink, gray, or green granite and syenite closely associated in space and time. Syenite is similar to granite but with only small amounts of quartz. Several phases of granite and syenite contain very unusual varieties of dark minerals including riebeckite, arfvedsonite, enigmatite, aegirine-augite, and ferrohastingsite in place of biotite or hornblende of more typical granite. This reflects a higher than usual proportion of sodium in the magmas from which the rocks formed, a composition referred to as alkalic. The youngest phase of the complex is pinkish gray biotite granite of Triassic age (**Ꞧb**) that cuts across the other phases of the complex. The Chase Stock (**Mzc**), known only from sea floor grab samples, is also syenite so may be similar in age.

6) Several relatively small gabbro complexes (Alfred, Cape Neddick, Tatnic, and Lebanon plutons) consist primarily of gabbro and other dark gray to black, iron- and magnesium-rich igneous rocks. These are the youngest crustal rocks in the Kittery quadrangle, having intruded about 120 million years ago (Ma) in the Cretaceous Period.

7) Thin dikes of basalt intrude all the metamorphosed stratified rocks and all the igneous plutons except the gabbro complexes and the biotite granite of the Agamenticus Complex (**Ꞧb**). They occur in thin, nearly vertical sheets ranging from a few centimeters to 75 meters in thickness. The dikes are black to very dark green, predominantly basalt and diabase (a coarser grained variety of basalt), approximately the same composition as gabbro. They are especially common in the exposures of the Kittery Formation along the coast from Kittery to Biddeford Pool (**Photo 16**). A few larger occurrences are mapped (**KJd**), and some representative examples are shown by red symbols on the map.

DEFORMATION AND METAMORPHISM

The stratified rocks have been extensively folded and faulted. Two stages of folding are particularly well displayed in the Kittery Formation along the coast between Ogunquit and Kittery. Earlier folds are recumbent, that is, they are lying over on their side (**Photo 10**), whereas the later folds are upright, with both sides of the fold dipping steeply (**Photo 11**). Major faults in the map sheet include: the Phyllonite at Church Road (**Photo 12**), a shear zone which defines the boundary between the Shapleigh Group and the Berwick Formation; the Calef-Nonesuch River fault, separating the Berwick from the Merrimack Group; several faults cutting the Merrimack Group near the Great Bay, New Hampshire; the Portsmouth fault separating the Merrimack Group and Rye Complex; and the Great Common fault within the Rye Complex. Old silver mines and prospect pits of the Acton Silver District are located along a zone of white bull quartz, apparently marking the trace of a northwest-trending Mesozoic fault, the Silver Mine fault.

Most of the large scale folding is probably the result of the Acadian orogeny, a major period of middle Paleozoic crustal compression driven by plate tectonic movements. An additional effect of this event was the recrystallization of the stratified rocks to form schists out of shales and siltstones, and granofels and gneisses from sandstones. The degree of heating during this compression is expressed in the variety of new minerals that formed, particularly in the schists. Lower temperature, for example, is indicated by the presence of chlorite, medium temperature by garnet, and higher temperature by sillimanite and andalusite. In general, rocks of the Rye Complex and Shapleigh Group are at higher metamorphic grade than those of the Berwick Formation and Merrimack Group, although the regional metamorphic pattern is complicated. Heat carried by intrusion of the large plutons caused contact metamorphism of the adjacent rocks.

GEOLOGIC HISTORY

The oldest stratified rocks are those of the Rye Complex. Dating of tiny zircon grains in metasedimentary rocks of the Rye indicates an origin as sedimentary and perhaps minor volcanic(?) rocks (**Photos 13** and **14**) that accumulated in Cambrian–Early Ordovician time. We suspect this assemblage was deposited on Ganderian basement. The Rye Complex was metamorphosed and deformed (**Photo 15**) during and after Ordovician intrusion, perhaps multiple times.

The Merrimack Group was deposited during Silurian time along the eastern edge of the Merrimack Basin, derived from peri-Gondwanan source areas to the east. Rapid deposition of sediments, a major regional deformation (Salinic), and associated metamorphism are strongly implied before post-tectonic intrusion of the Exeter pluton in Early Devonian time. To the west, in the Central Maine Basin, sediments of the Shapleigh Group accumulated in Silurian to Early Devonian time. Silurian and older formations were derived from the Laurentian continent and Bronson Hill island-arc complex to the west. By the time of deposition of the East Rochester Formation, however, the source area had shifted to the east, probably the uplifted and deformed rocks of the Merrimack Basin.

Rocks of the Central Maine Basin were multiply deformed and metamorphosed during the main Acadian event and intruded by Devonian plutons such as the Biddeford, Webhannet, Nisbitt Pond, and Barrington. The Acadian deformations included thrusting of the Merrimack Group over the Berwick and Shapleigh Group to the west, and regional folding toward the east. Another episode of magmatic intrusion is represented by the Lyman pluton in the north part of the Kittery 1:100,000 map sheet, probably related to the Sebago batholith to the north of Permian age. This age suggests a relationship to the Alleghanian orogeny, the terminal compressional event of the Appalachian Mountains that formed the supercontinent Pangea. Although major deformational features of this age have not been confirmed in the area of the Kittery map sheet, it is possible that some of the major faults and shear zones are Alleghanian.

The last major event recorded in the bedrock of the Kittery sheet is the intrusion of rocks of the White Mountain Plutonic-Volcanic Series of Mesozoic age, related to the opening of the Atlantic Ocean. These rocks comprise a northwest-trending chain of eroded volcanic centers from the New England Seamounts across central New England into southern Quebec. The rift and drift-related magmatism spanned more than 100 million years. The Agamenticus ring complex is of Triassic age, one of the oldest intrusive bodies of the series. The last vestiges of this activity are represented by the Cretaceous gabbroic complexes. In addition to these complexes, the area is crosscut by abundant basalt and diabase dikes (**Photo 16**), some of them tens of meters thick and traceable for tens of kilometers across the map area, and hundreds of kilometers to the northeast and southwest. They maintain an orientation roughly parallel to the edge of the North American plate where it split and separated from the Eurasian plate. A majority of these dikes are of Jurassic age, intruded after the Agamenticus Complex but before the gabbro complexes. Minor faults, such as the Silver Mine fault and some of the faults in New Hampshire may also be of Mesozoic age.


Photo 1: Thin, folded beds of the Eliot Formation at the type locality at Lee Five Corners, New Hampshire.


Photo 2: Glacially polished Eliot Formation, gravel pit in Saco, Maine.


Photo 3: Graded beds in the Kittery Formation along the shoreline in York, Maine. A graded bed (two of which are well shown) has a light gray metasandstone lower part that grades upward into a dark metashale, which is in sharp contact with the overlying metasandstone. These beds top to the right of the photo and are inclined because of folding. The graded bed marked by the arrow is approximately eight centimeters thick.


Photo 4: Flute casts in Kittery Formation at Moody Point, Wells, Maine.


Photo 5: Berwick Formation at type location, South Berwick, Maine, Salmon Falls River. Note typical medium bedded characteristic of the formation.

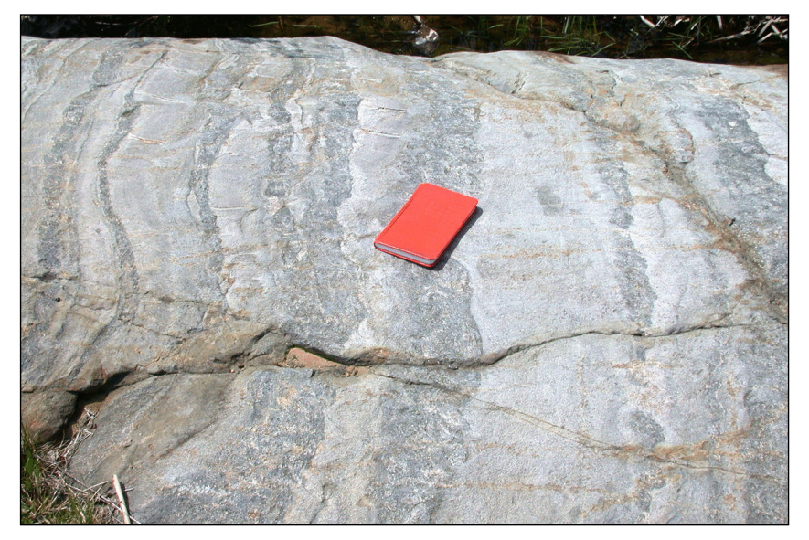


Photo 6: Bedding typical of the Gully Oven Formation at an exposure along Goding Road, Sanford, Maine. Note the conspicuous graded bed under the notebook (light colored metasiltstone grading upward into dark colored metashale. The beds are steeply inclined because of folding during the Acadian orogeny.


Photo 7: Bedding typical of the East Rochester Formation exposed in Little River, Lebanon, Maine. Arrow points to a graded bed that indicates these beds are overturned.

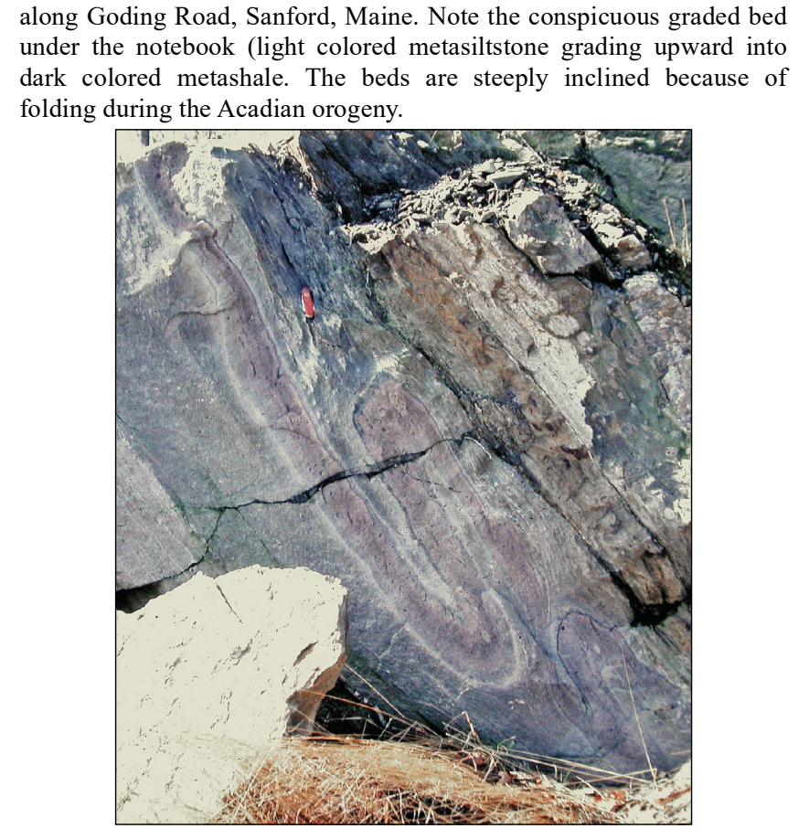


Photo 8: Thin garnet-quartz granofels (coticule) bed in the Gully Oven Formation, Route 16 road cut, Rochester, New Hampshire.

Photo 9: Stringers of the Biddeford granite (light colored, g) cutting the Kittery Formation (dark, k), Biddeford Pool, Maine.


Photo 10: Earlier recumbent folds of the Kittery Formation, Marginal Way footpath, Ogunquit, Maine.


Photo 11: Upright folds of the Kittery Formation along York, Maine, shoreline.


Photo 12: Phyllonite at Church Road along Turkey Street, North Berwick, Maine.


Photo 13: Sheared beds of metasiltstone (medium gray) and metashale (dark gray) typical of the Rye Complex at Fort Foster, Kittery, Maine.


Photo 14: Thinly laminated amphibolite, possibly representing mafic volcanic rocks in the Rye Complex at Sewards Point, Kittery, Maine.


Photo 15: Quartz-feldspar gneiss, Rye Complex, New Castle, New Hampshire, Coast Guard station. The blastomylonitic texture in the gneiss is the product of extreme early shearing. This exposure also contains late pseudotachylite (frictional melt rock) in S-shaped gashes formed by late shearing.


Photo 16: A 2-meter-thick, brown-weathering diabase dike cutting the Kittery Formation, in turn cut by a thinner basalt dike. Shoreline north of Bald Head Cliff, York, Maine.

EXPLANATION OF UNITS

INTRUSIVE ROCKS

Cretaceous [**K**]

ALFRED COMPLEX
- **Kagd** Fine-grained to medium-grained gray granodiorite.
- **Kamd** Medium-grained buff monzodiorite.
- **Kagn** Dark brownish gray gabbronorite.
  - **Kagna** Medium gray, medium-grained, anorthositic gabbronorite (as thin layers within **Kagn**.

CAPE NEDDICK COMPLEX
Younger Funnel
- **Kcpg** Poikilitic gabbro, gradational from **Kcc**.
- **Kcc** Cortlandtitic gabbro. Dark gray mafic-rich gabbro with large poikilitic hornblende phenocrysts.

Older Funnel
- **Kca** Medium gray anorthositic gabbro.
- **Kcg** Medium dark gray gabbro, commonly with thin lighter gray gabbro layers. Some layers are pegmatitic gabbro. Thin unit of breccia along south and east margins of the complex.

TATNIC COMPLEX
Younger Funnel
- **Ktqd** Medium olive-gray to light buff quartz diorite, commonly with abundant inclusions of dark gray porphyritic and aphanitic basalt.
- **Ktog** Dark gray olivine gabbro with abundant hornblende and biotite.

Older Funnel
- **Ktpg** Dark gray gabbronorite with large, elongate poikilitic hornblende phenocrysts.
- **Kta** Medium gray coarse-grained anorthositic gabbronorite.
- **Ktgn** Dark brownish-gray gabbronorite.

Klg **LEBANON PLUTON**. Deeply weathered, dark gray, magnetite-bearing gabbro-diorite.

Cretaceous-Jurassic(?) [**KJ**]

KJd **Diabase**. Large dikes are mapped to scale. Numerous smaller dikes, some of which are shown by red lines or symbols on the map, intrude all stratified rocks and older intrusive rocks.

KJg **JACKS COVE GABBRO**. Dark gray, coarse diabase with swirled layering.

KJeb **Breccia**. Two areas of explosion breccia on Gerrish Island, Kittery. Includes fragments of the Rye Complex and older felsic and basalt dike rocks.

Triassic [**Ꞧ**]

AGAMENTICUS COMPLEX
- **Ꞧb** Fine-grained to medium-grained, pink biotite granite.
- **Ꞧag** Gray to light pinkish-gray, medium-grained aegirine alkalic granite.
- **Ꞧg** Light gray to light buff, fine-grained to medium-grained, alkaline granite.
- **Ꞧqs** Light buff, alkaline quartz syenite with irregular texture.
- **Ꞧs** Medium to dark olive green, medium-grained to coarse-grained, alkaline syenite.
- **Ꞧas** Dark to medium green, porphyritic aenigmatite syenite.

Mesozoic(?) [**Mz**]

Mzc **CHASE STOCK**. Gray, medium-grained olivine-pyroxene-amphibole-biotite quartz syenite discovered by sampling the sea floor. Contact of submerged body is inferred.

Permian [**P**]

Plg **LYMAN PLUTON**. Biotite-muscovite-garnet granite and pegmatite.

Carboniferous-Devonian(?) [**CD**]

CDsg **SACO PLUTON**. Dark greenish-gray, foliated and metamorphosed gabbro.

Devonian [**D**]

Dbag **BARRINGTON PLUTON**. Biotite-muscovite granite and pegmatite.

Dnp **NISBITT POND PLUTON**. Light gray, porphyritic muscovite-biotite granite.

WEBHANNET PLUTON
- **Dwb** Light gray to pink, biotite-muscovite granite and rare pegmatite.
- **Dwg** Light gray, medium-grained to coarse-grained biotite granite with sphene and epidote.
- **Dwgd** Medium gray, fine-grained, porphyritic biotite-hornblende granodiorite and quartz diorite.

Dbig **BIDDEFORD PLUTON**. Light gray, medium-grained biotite granite and rare pegmatite.

Dbh **BREAKFAST HILL GRANITE**. Foliated muscovite-biotite granite which intrudes the Rye Complex.

Deg **EXETER PLUTON**. Medium gray, medium-grained quartz diorite and diorite; minor gabbro.

Devonian(?) [**D**]

Dg **Granite and pegmatite**. Biotite-muscovite granite and pegmatite.

Dp **Pegmatite**. On New Castle Island, New Hampshire.

Dqd **ROCHESTER PLUTONS**. Medium-grained to coarse-grained biotite quartz diorite.

Dd **Diorite**. Medium-grained, weakly to strongly foliated hornblende-biotite diorite.

STRATIFIED ROCKS

Shapleigh Group

Devonian [**D**]

Der **EAST ROCHESTER FORMATION** (new name). Well-bedded muscovite-biotite-garnet-sillimanite (or andalusite)-staurolite schist and micaceous quartzite. Probably equivalent to the Littleton Formation (New Hampshire) and the Carrabassett Formation (Maine).

Devonian-Silurian [**DS**]

DScb **Calc-silicate and biotite granofels** (unnamed). Probably equivalent to the Madrid Formation (Maine) and the Warner Formation (central New Hampshire).

Silurian [**S**]

St **TOWOW FORMATION**. Rusty-weathering schist and graphitic schist. Probably equivalent to the Smalls Falls Formation (Maine and New Hampshire).
- **Stmr** **MERCHANTS ROW GRITS** (new name). Quartz granule grit in rusty-weathering schist matrix, some blue quartz grains. Probably equivalent to the Wild Goose Grit, Strafford, New Hampshire (Eusden and others, 1987).

Sgo **GULLY OVEN FORMATION** (Thompson, 2004). Well-bedded muscovite-biotite-staurolite-andalusite-garnet schist and micaceous quartzite with rare pink quartz-garnet granofels (coticule). Probably equivalent to the Perry Mountain Formation (Maine and New Hampshire).

Sr **RINDGEMERE FORMATION**. Poorly-bedded to moderately well-bedded biotite-muscovite-garnet-staurolite-andalusite (or sillimanite) schist. Probably equivalent to the Rangeley Formation (Maine and New Hampshire).
- **Srr** Rusty-weathering muscovite-biotite schist.
- **Src** Calc-silicate granofels and marble.

---------------------------- fault ----------------------------

Silurian(?) [**S**]

Scr **PHYLLONITE AT CHURCH ROAD**. Silvery-gray muscovite-biotite-garnet-staurolite phyllonite with abundant deformed quartz veins. Schematic pattern of wavy lines in the map unit indicates the rocks are strongly sheared.

---------------------------- fault ----------------------------

Devonian-Silurian [**DS**]

DSb **BERWICK FORMATION**. Medium-bedded, medium brownish gray, feldspathic quartz-biotite granofels, greenish calc-silicate granofels, and subordinate quartz-biotite schist.

---------------------------- fault ----------------------------

Merrimack Group

Silurian [**S**]

Sk **KITTERY FORMATION**. Variably thin- to thick-bedded, buff-weathering, feldspathic and calcarous metawacke. Characterized by well-developed primary structures including graded bedding, channel cuts-and-fills, small scale cross-bedding, flame structure, and flute casts.
- **Skr** Rusty-weathering hornfels or granofels and phyllite.

Se **ELIOT FORMATION**. Generally thin-bedded gray calcareous and ankeritic quartz-biotite-chlorite phyllite and metasiltstone, and dark gray biotite-chlorite-muscovite phyllite.

STRONGLY DEFORMED ROCKS

Ordovician-Cambrian [**OЄ**]

OЄr **RYE COMPLEX**. Strongly mylonitic, complex association of quartz-plagioclase-biotite gneiss, calc-silicate gneiss and biotite gneiss, biotite-muscovite-staurolite-sillimanite (or andalusite) gneiss, and extensively migmatitic equivalents of these rock types. Minor dark gray graphitic schist and impure marble.
- **OЄra** Amphibolite.
- **OЄrbg** Blastomylonitic quartzo-feldspathic gneiss.

EXPLANATION OF PATTERNS

▨ Hornfels or granofels, in contact metamorphic aureole near a pluton.

EXPLANATION OF LINES

Contact between mapped units. Interpreted to be of stratigraphic or intrusive origin.

Approximate outline of submerged Chase Stock. Inferred from bathymetry and submarine backscatter imagery (see Bulletin 45).

Brittle, high-angle fault. Commonly marked by bull quartz, breccia, or offset map units. U = upthrown side, D = downthrown side, if known. Interpreted to be of Mesozoic age.

Ductile fault, ultramylonite present. Variably oriented. Last motion interpreted to be of Permian age.

Ductile fault, phyllonite present. Probably high-angle. Not well exposed. Arrows indicate sense of strike-slip motion, if known. Interpreted to be of Carboniferous-Devonian(?) age.

Shear zone boundary. Between intensely sheared and less sheared rocks. Arrows indicate dextral shear within zone. Of Carboniferous-Devonian(?) age.

Thrust fault. Teeth on upper plate. Fault plane dips to northwest at current level of exposure. Displays some late brittle displacement.

Fault of unknown type. Inferred from stratigraphic relationships. Of presumed Carboniferous-Devonian age.

Fault or shear zone extension. Projected into area of poor bedrock exposure.

F2 **Axial trace of upright fold**. Number indicates relative age from oldest (F1) to youngest (F3) (synform, antiform).

F1 **Axial trace of overturned fold**. Arrows indicate direction of dip. Number indicates relative age from oldest (F1) to youngest (F3) (synform, antiform).

A A' **Line of cross section**.

EXPLANATION OF SYMBOLS

PLANAR FEATURES. Symbol is oriented parallel to strike of feature. Dip direction indicated by tick or barb. Dip angle given in degrees.

- 20 Basalt, diabase, or mafic dike (inclined, vertical, orientation unknown).
- 20 Bedding, tops unknown (inclined, vertical).
- 20 Bedding, tops known (upright, vertical with tops toward ball, overturned).
- 20 Compositional layering in metamorphic rock (inclined).
- 20 Compositional layering in igneous rock (inclined, vertical).
- 20 Igneous foliation (inclined).
- 20 Metamorphic foliation or schistosity (inclined, vertical).
- 20 Cleavage (inclined).
- 20 Axial plane of minor fold (inclined).
- Shear zone (inclined, vertical).
- 20 20 Minor strike-slip fault (inclined dextral, inclined sinistral).
- 20 Joint (inclined, vertical).

LINEAR FEATURES. Symbol is oriented parallel to trend of feature. Plunge direction toward head of arrow. Plunge angle given in degrees.

- 20 Intersection lineation.
- 20 Mineral lineation.
- 20 20 20 20 Fold hinge (rotational sense clockwise, neutral, counterclockwise, unknown).
- Ⓐ Geochronology sample location.

AGE INFORMATION DETERMINED IN THIS STUDY

Rock sample descriptions as well as analytical methods, data, and interpretation of high-precision U-Pb zircon geochronology are presented in the accompanying Bulletin B-45. Age results are given in millions of years ago (Ma). See Geologic Time Scale for relation of ages to periods of geologic time.

Rock unit and map symbol	Age (Ma $\pm 2\sigma$)	Sample	Map Locality
Pluton crystallization ages			
Agamenticus Complex, granite (Ꞧb)	238.9 ± 0.3	12JAB4	G
Lyman pluton, biotite granite (Plg)	287.6 ±0.4	MGS-032	B
Appledore diorite (within OЄr)	361.1 ±0.4	07SI-06B	L
Salamander Point diorite (Dd)	380.1 ±0.5	MGS-038	I
Nisbitt Pond pluton, granite (Dnp)	383.1 ±0.5	MGS-035	A
Webhannet pluton, granodiorite (Dwgd)	382.9 ±0.5	MGS-034	F
Webhannet pluton, granite (Dwg)	383.1 ±0.5	MGS-033	E
Biddeford pluton, granite (Dbig)	382.7 ±0.5	ME-25	D
Biddeford pluton, granite (Dbig)	383.3 ±0.5	ME-10	C
Breakfast Hill granite (Dbh)	402.9 ±0.5	BH-1	K
Exeter pluton, diorite (Deg)	407.4 ±0.5	89ex-7	H
Age of youngest detrital zircon			
Rye Complex, granitoid gneiss (OЄr)	451.1 ±0.7	MGS-039J	J

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 (Ꞧ)	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 (**p**Є)	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.)

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