Bedrock Geology of the Northern Part of the Small Point Quadrangle, Maine

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Open-File Map 12-1
2012

SCALE 1:12,000

0.5 0 0.5 MILE

500 0 1000 2000 3000 4000 FEET

0.5 0 0.5 KILOMETER

CONTOUR INTERVAL 20 FEET

Quadrangle Location

SOURCE OF INFORMATION

Field work by A. M. Hussey II (1970-2011).

Topographic base from U.S. Geological Survey Small Point quadrangle, scale 1:24,000, using standard U.S. Geological Survey topographic map symbols.

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.

EXPLANATION OF UNITS

INTRUSIVE ROCKS

Devonian to Late Silurian (?)

DSgp Biotite-muscovite granite with pegmatite lenses and segregations.

STRATIFIED ROCKS

Middle to Late Ordovician

Casco Bay Group *

Osh Non-rusty to moderately rusty-weathering schist containing muscovite, biotite, quartz, garnet, staurolite, andalusite and or sillimanite (possible correlative of the Scarboro Formation).

Ogr Moderately rusty-weathering quartz-graphite-muscovite schist and very rusty-weathering muscovite-graphite schist (possible correlative of the Diamond Island Formation).

Oma Association of rusty-weathering mica schist; rusty- and non rusty-weathering amphibolite; marble with abundant zoisite and diopside (possible correlative of the Spring Point Formation).

Units possibly correlative with the Cape Elizabeth Formation

Oqs Quartz-biotite-muscovite schist and minor biotite-muscovite-garnet schist with andalusite or sillimanite.

Opq Mostly non-rusty to slightly rusty-weathering biotite-muscovite-garnet-quartz schist with andalusite or sillimanite; includes some very rusty-weathering mica schist and minor quartz-biotite-muscovite schist.

Obc Non-rusty and very rusty-weathering quartz-biotite granular schist with interbeds of calc-silicate gneiss. Includes minor amphibolite and very rusty-weathering mica schist.

Ors Very rusty-weathering muscovite-biotite schist.

HIGHLY DEFORMED ROCKS

sz Shear zone with mixed rock types including mica schist, calc-silicate gneiss, quartz-biotite granofels, and rusty-weathering schist and granofels; truncates map units Oma, Ogr, and Osh against Oqs east of Small Point Road.

** The stratified rock units are assigned to the Casco Bay Group. Individual rock units are tentatively correlated with formations as indicated, because the rock types and stratigraphic sequences are similar to those in the Casco Bay area (Hussey, A. M., II, and Berry, H. N., IV, 2002, Bedrock geology of the Bath 1:100,000 map sheet, coastal Maine: Maine Geological Survey, Bull. 42, 50 p.).*

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. For planar features, symbol is centered at observation point. For linear features, tail of symbol is at observation point. Multiple measurements at a site are represented by combined symbols.

- Outcrop of mapped unit
- 20 — Bedding, tops unknown (inclined, vertical)
- 20 — Bedding, tops known (upright)
- 20 — Igneous foliation (inclined)
- 20 — Cleavage or schistosity (inclined, vertical)
- 20 — Axial plane of minor fold (inclined, vertical)
- 20 20 20 20 20 — Hinge of minor fold (rotation sense unknown, counterclockwise, clockwise, neutral)
- 20 — Lineation
- 20 — Diabase dike, of presumed Mesozoic age
- Inactive quarry

GEOLOGIC TIME SCALE

Geologic Age		Absolute Age*
Cenozoic Era		0-65
Mesozoic Era	Cretaceous Period	65-142
	Jurassic Period	142-200
	Triassic Period	200-253
Paleozoic Era	Permian Period	253-300
	Carboniferous Period	300-360
	Devonian Period	360-418
	Silurian Period	418-443
	Ordovician Period	443-489
	Cambrian Period	489-542
Precambrian time		Older than 542

* In millions of years before present. (Okulitch, A. V., 2004, Geological time chart, 2004: Geological Survey of Canada, Open File 3040 (National Earth Science Series, Geological Atlas) - REVISION.)

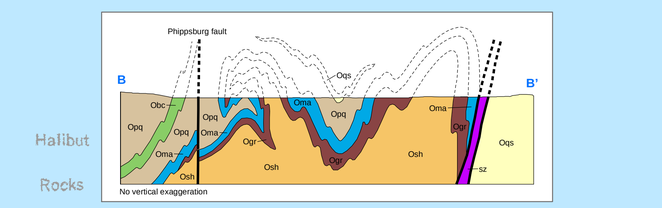
EXPLANATION OF LINES

Contact between mapped units, interpreted to be of stratigraphic or intrusive origin. Location is constrained by bedrock outcrops indicated by symbols on the map, or by projecting rock units from adjacent areas. Additional information may have been used. (well located, approximately located, poorly located)

Inferred fault.

A ——— A' Line of cross-section.

INTERPRETIVE CROSS SECTIONS



OVERVIEW OF THE GEOLOGY OF THE SMALL POINT QUADRANGLE

On the geologic map, different bedrock units are indicated by colors and identified by letter symbols that indicate age and rock type or unit name. The contacts between rock units are indicated by thin black lines and inferred faults by heavier dashed lines.

MAJOR ROCK TYPES

Two major groups of rocks are present in the Small Point 7 1/2' quadrangle: stratified metamorphic rocks, and igneous rocks. The stratified, or layered, rocks include schist, gneiss, granofels, impure marble, and amphibolite. These were originally sedimentary and minor volcanic rocks before they were transformed (metamorphosed) by heat and pressure deep within the Earth's crust into the rocks we observe now. Schist consists mostly of thin flat flakes of mica which are arranged parallel to each other such that the rock splits into sheets. The minerals that make them up further characterize schists, as for example muscovite-biotite-garnet schist. Gneiss is a type of layered rock in which different minerals are concentrated in separate irregular streaks or layers. Granofels, usually made up of the minerals quartz and feldspar, has grainy texture somewhat like sugar. In contrast with schist, gneiss and granofels tend to break into irregular blocks. Amphibolite is a rock named for dark grains of the amphibole minerals which are its principal constituents. Marble is composed mostly of calcite, but commonly contains other minerals, mostly calcium silicates. Varieties of gneiss, schist, granofels, marble, and amphibolite may be further distinguished by their particular mineral content, grain size, color, or other distinguishing characteristics.

Igneous rocks, formed from molten rock material from deep within the Earth's crust, are present as (1) large bodies of granite composed of quartz, feldspar, and minor amounts of biotite and muscovite, and (2) very coarse-grained feldspar and quartz rock called pegmatite, similar in composition to granite. Pegmatite commonly intrudes the metamorphic rocks and granite as lenses and irregular masses. One dike of dark basalt is present.

ORIGIN OF THE STRATIFIED ROCKS

The rocks of the Small Point quadrangle belong to the Casco Bay Group, a diverse assortment of metamorphosed sandstone, shale, impure limestone, and mafic volcanic rocks deposited during the Ordovician Period. The oldest rocks (possibly of the Cape Elizabeth Formation) consist of (1) quartz-feldspar-biotite-schist and gneiss, with interbeds of biotite-muscovite-quartz schist with or without sillimanite, garnet, and staurolite (map unit Oqs); (2) non-rusty to moderately rusty-weathering quartz-mica-staurolite-garnet schist containing andalusite or sillimanite, and minor quartz-feldspar-mica schist (Opq); (3) rusty and non-rusty weathering quartz-feldspar-biotite granofels interbedded with greenish calc-silicate granofels (Obc); and (4) rusty-weathering schist (Ors). These rocks were deposited in Ordovician time as feldspathic sandstone and shale in an ancient ocean, Iapetus, which bordered an island arc much like that of Japan today. Next, a period of volcanism resulted in deposition of basaltic lava and ash now metamorphosed to dark amphibolite (Oma). Associated with this amphibolite is abundant calc-silicate gneiss, impure marble, and very rusty-weathering mica schist. The presence of a significant amount of amphibolite suggests a correlation with the Spring Point Formation of the Casco Bay Group. The calcareous rocks and rusty schist are, however, not typical and cast some doubt on the correlation. Dark sulfidic and carbonaceous shale, now metamorphosed to graphite-quartz-pyrite-muscovite schist (Ogr), accumulated in the basin after cessation of basaltic volcanism. Because of its strikingly similar rock type, this unit is tentatively correlated with the Diamond Island Formation. More shale, metamorphosed to rusty and non-rusty mica schist, accumulated on top of the carbonaceous schist, and these rocks (Osh) are tentatively correlated with the Scarboro Formation of the Casco Bay Group.

DEFORMATION, METAMORPHISM, FAULTING, AND IGNEOUS INTRUSION

Rocks of all stratified sequences were intensely folded during two major stages of regional deformation and mountain building known as the Acadian orogeny in Late Silurian to Early Devonian time. The earlier stage resulted in regional, large scale recumbent folds, which are, so to speak, lying on their sides. The stratified rock sequence as a whole is interpreted to be upside down, on the inverted limb of a major anticlinal fold (nappe), so that the youngest unit (Osh) is the deepest (see cross sections). The later stage of folding deformed these rocks into upright to slightly overturned anticlines and synclines tilted (plunging) gently to the south. Minor folds related to both of these stages can be seen in outcrop.

During these two deformations, the rocks were forced into deep levels of the Earth's crust where heat and pressure transformed them into the metamorphic rocks we see now. Shale was transformed into schist; feldspathic and muddy sandstone became schist or gneiss; limestone and impure limestone were recrystallized into marble and calc-silicate rock; basaltic ash became amphibolite. Some of the rocks rich in quartz and feldspar may have undergone partial melting to supply some of the molten rock that was injected into the stratigraphic pile as the large granite and pegmatite masses in the quadrangle (DSgp), as well as the numerous quartz-feldspar stringers seen in the stratified rocks.

After the Acadian orogeny, the rocks of the quadrangle were subjected to major faulting and shearing (the Phippsburg fault and the unnamed fault on the east side of Small Point). Movement on these faults was minor and they may be better characterized as shear zones, accounting for severe attenuation of map units in such areas as the small island southwest of Small Point Hill.

Diabase and basalt dikes which are numerous in the Casco Bay region and coastal areas to the south are virtually absent in the Small Point quadrangle. One basalt dike, 2 feet in thickness, was observed on the east shore of Hermit Island. This represents the youngest bedrock of the area, probably intruded into vertical fissures in the Cape Elizabeth Formation during Mesozoic time after all deformational events had ceased.

Photo 1. Broad coastal exposure of non-rusty mica-rich schist of map unit Opq. The mica grains are aligned to produce a strong schistosity in the rock, which gives the weathered outcrop a rough surface. Minerals present are biotite, muscovite, andalusite of two metamorphic stages, staurolite, garnet, and minor quartz. This is the most aluminous unit in the Small Point quadrangle.

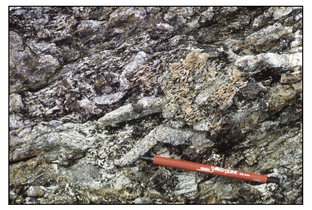


Photo 2. Masses of muscovite grains mimic the shape of chiastolite crystals of the early metamorphic stage. Fresh andalusite of the second metamorphic stage lies adjacent to the muscovite grains. Bending of the muscovite grains suggests they were developed during an early stage of metamorphism associated with recumbent folding and were deformed in the later stage of upright folding.

Photo 3. Mica-rich schist of Opq. The well shaped crystals of dark brown staurolite formed during the second metamorphic stage, associated with upright folding.

Photo 4. The shape of this thin bed of calc-silicate gneiss is produced by recumbent folds refolded by gentle upright folds. Yellow line highlights one contact of the bed.

Photo 5. Tightly folded fracture cleavage. Same locality as Photo 4.

Photo 6. Upright relatively tight folding of gneissic foliation (darker portion of the photo) and fracture cleavage related to the earlier recumbent folding. Same locality as Photo 4.

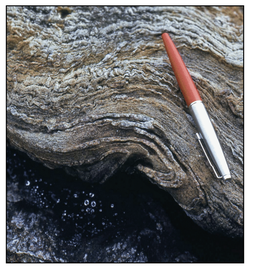


Photo 7. Tight folds in repeatedly folded quartz vein (to the left of the silver portion of the pen). In quartz-mica schist.

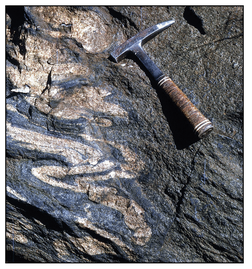


Photo 8. Recumbently folded garnet-quartz-magnetite (coticule) beds. In biotite-rich schist.