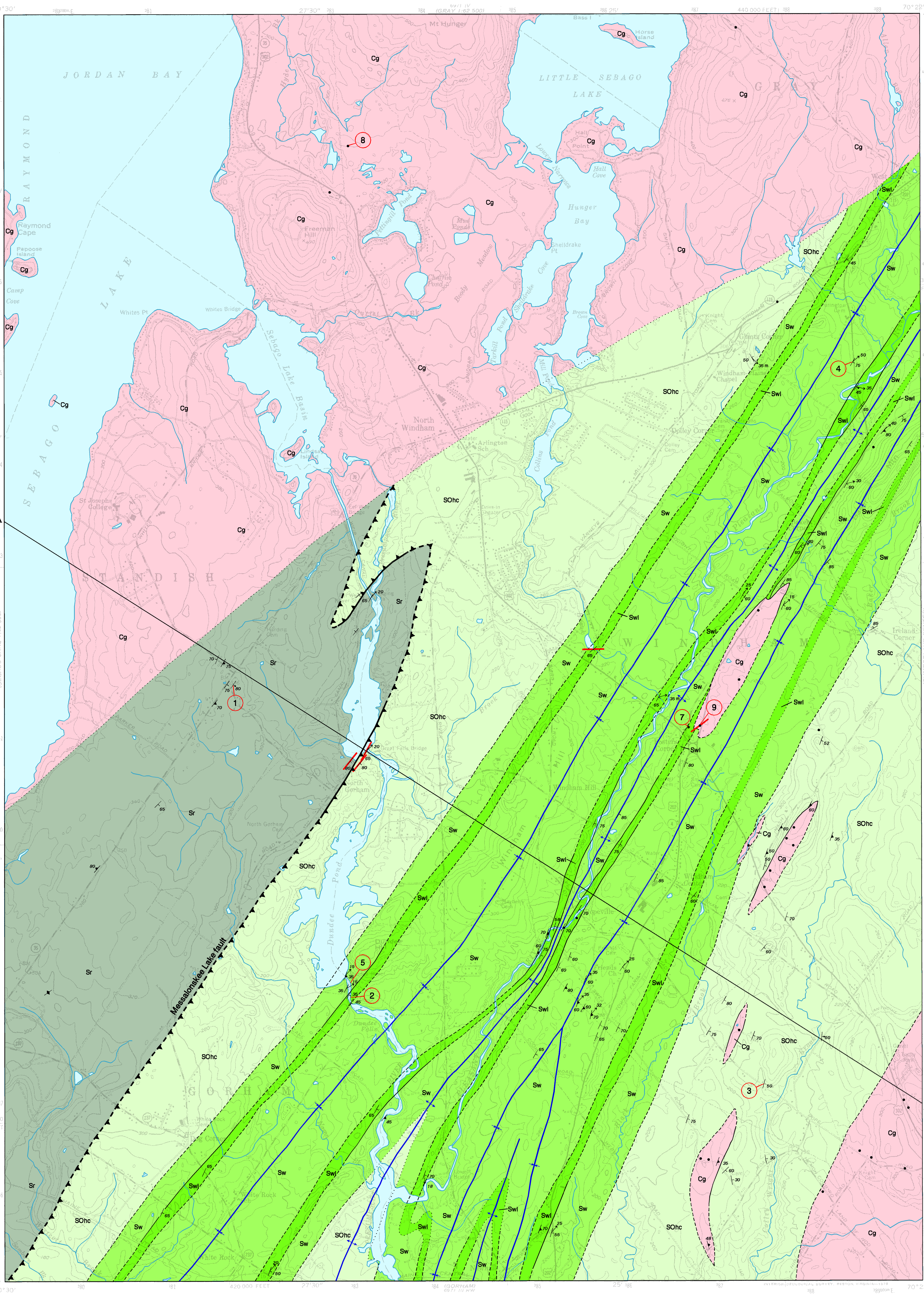
Bedrock Geology



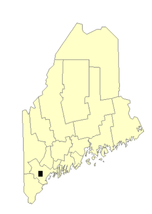
SOURCES OF INFORMATION

Bedrock mapping by Arthur M. Hussey II completed during the 1996 field season. Explanatory text by Henry N. Berry. Photographs by H. N. Berry and J. B. Poisson.

Time Scale References:

Palmer, A. R., 1983, The Decade of North American Geology 1983 time scale: Geology, v. 11, p. 503-504.

Tucker, R. D., and McKerrow, W. S., 1995, Early Paleozoic chronology: a review in light of new U-Pb zircon ages from Newfoundland and Britain: Canadian Journal of Earth Sciences, v. 32, no. 4, p. 368-379.



Quadrangle Location

SCALE 1 : 24,000

1 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 0 1 KILOMETER

CONTOUR INTERVAL 20 FEET

TRUE NORTH

Topographic base from U.S. Geological Survey North Windham 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

Mesozoic — **Basalt and diabase.** Occurs as dikes and sills up to 3 feet (1 meter) thick. Symbol is parallel to strike of dike or sill.

Carboniferous to Permian — Cg — **Granitoid rocks.** Includes two-mica granite, granodiorite, quartz diorite and granitic pegmatite.

STRATIFIED ROCKS

Silurian

Sr — **Rindgemere Formation.** Rusty and non-rusty-weathering muscovite-biotite-quartz schist (locally with sillimanite, staurolite, garnet, and kyanite, depending on metamorphic grade), and quartz-plagioclase-biotite-muscovite granofels and schist.

Sw — **Windham Formation.** Non-rusty- and rusty-weathering biotite-muscovite-quartz schist (with kyanite, staurolite, sillimanite, and garnet depending on metamorphic grade), with thin interbeds of calc-silicate granofels and rare quartz-plagioclase-biotite granofels.

Swl — **Metalimestone member.** Impure marble, calc-silicate granofels, and calcite-rich quartz-plagioclase-biotite granofels and schist.

Late Ordovician or Silurian — SOhc — **Hutchins Corner Formation.** Mostly purplish-gray biotite-quartz-plagioclase granofels with thin interbeds of greenish calc-silicate granofels.

EXPLANATION OF SYMBOLS

- Outcrop with no structural data.
- Bedding, topping sense unknown (inclined, vertical).
- Upright bedding.
- Overturned bedding.
- Schistosity (inclined, vertical). Foliation in granitoid rocks.
- Lineation (combined with bedding or schistosity symbol). Not annotated: crenulation axis or cleavage-bedding intersection. Annotated with m: mineral lineation.
- Location of numbered photo shown at right.

Note: Symbols are parallel to strike or trend of structural feature. Symbols are annotated with dip or plunge angles. Middle of symbol or tail of arrow is at outcrop location.

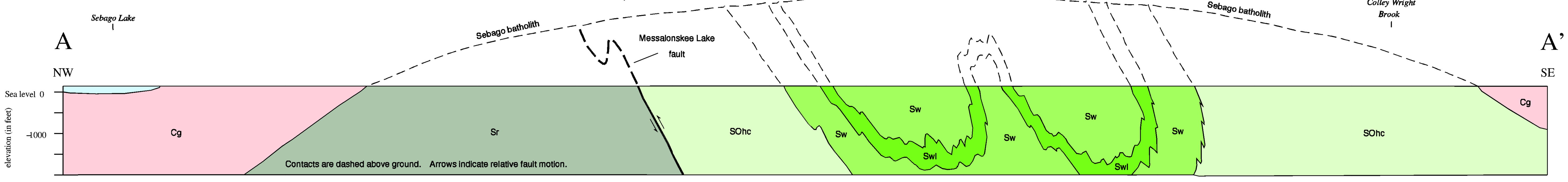
- Intrusive or stratigraphic contact
- Thrust fault
- Axial trace of syncline
- Axial trace of anticline
- A — A' Line of cross section.

Note: Lines on the map are solid where approximately placed, dashed where inferred, and dotted where uncertain.

USES OF BEDROCK MAPS

In most of Maine the bedrock is within a few tens of feet below the ground surface. Any significant subsurface activity, such as excavating for building foundations, installing bridge footings or power poles, quarrying gravel, or drilling water wells may encounter bedrock. A bedrock map is the geologist's prediction of what kind of rock will be encountered below the surface based on observed surface exposures. Quarries, whether for dimension stone such as granite or for crushed rock aggregate with particular strength characteristics, are best sited in appropriate rock types. Exploration geologists or mineral collectors looking for metal ores, industrial minerals, or gemstones may be interested in specific rock types likely to contain the minerals of interest. Engineers planning roads or transmission line routes may use bedrock maps in conjunction with surficial geology maps to see where valleys, ridges, and hills are controlled structurally by shallow bedrock rather than by unconsolidated deposits. Soil chemistry, important to agriculture and natural plant ecology, is related to bedrock composition because rock weathering contributes to soil formation. Water from wells drilled into bedrock may contain dissolved iron, manganese, calcium, or other undesirable constituents that occur naturally in higher concentrations in some rocks than in others. Groundwater flow in bedrock, relevant to water supply and contaminant transport issues, is controlled in a complicated way by the rock structure, including lithologic layering, metamorphic foliation, folds, dikes, and fractures, any of which may be indicated by symbols on the map. The distribution of rock units, their geometric relationships on the map, and the map explanation together indicate the origin of each unit and the sequence of geologic events that occurred in the map area. This provides a regional context that allows information from one area to be applied to another if the bedrock is sufficiently similar.

INTERPRETIVE CROSS SECTION



North Windham Quadrangle, Maine

Bedrock geologic mapping by
Arthur M. Hussey II
Department of Geology
Bowdoin College
Brunswick, Maine 04011

Digital cartography by:
Robert A. Johnston
Bennett J. Wilson, Jr.

Robert G. Marvinney
State Geologist

Cartographic design and editing by:
Robert D. Tucker

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Maine Geological Survey

Address: 22 State House Station, Augusta, Maine 04333
Telephone: 207-287-2801 **E-mail:** mgs@maine.gov
Home page: http://www.maine.gov/doc/nrimc/nrimc.htm

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For additional information, see Open-File Report 96-16.

THE BEDROCK MAP

The geologic map at left shows features of the bedrock, the solid rock that makes up the earth's crust. The overlying sediment, which is shown on surficial geologic maps, is disregarded here. Symbols on the map show locations where bedrock is exposed at the land surface. Closely related or distinctive rock types are grouped together into formations and other rock units (see Explanation). Boundaries between these units are shown as either solid, dashed, or dotted lines on the map to indicate how well their locations are known. The cross section illustrates the inferred relationships among rock units that would be seen along a vertical slice through the earth.

STRATIFIED ROCKS

The stratified, or layered, rocks of the North Windham quadrangle are metamorphic rocks, primarily schist and granofels. Schist is a rock composed of small, flat minerals such as mica that are aligned to give the rock a sheet-like structure so that it splits easily. Granofels is a more uniform rock made up of equant minerals, such as quartz and feldspar, which are not elongated in any particular direction so that the rock breaks into chunks. A schist or granofels may have a variety of distinguishing characteristics, such as different mineral contents or different grain sizes. For example, calc-silcate granofels is a granofels that contains minerals with calcium and silica such as diopside and plagioclase.

The stratified rocks were originally sediments that accumulated in an ocean basin during the late Ordovician to Silurian Periods (see Geologic Time Scale below). Geologic processes gradually turned these sediments into rock so that sedimentary characteristics such as layering are preserved, but in a modified form. Beds of sand, silt, and mud became layers of granofels and schist of the Rindgemere Formation **(Photo 1)**. Limestone and limy sand became marble and calc-silicate granofels in parts of the Windham Formation **(Photo 2)**. Beds of muddy silt or limy silt became biotite-bearing or calc-silicate granofels layers, respectively, of the Hutchins Corner Formation **(Photo 3)**. The map distribution of these rocks as thin, parallel units also suggest that they form regionally continuous layers.

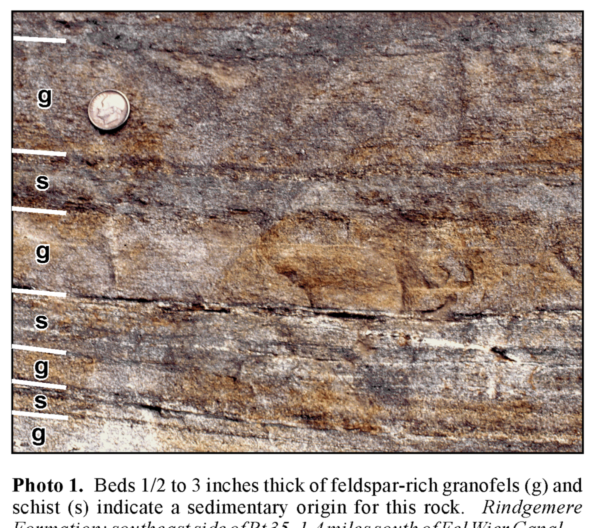

Photo 1. Beds 1/2 to 3 inches thick of feldspar-rich granofels (g) and schist (s) indicate a sedimentary origin for this rock. *Rindgemere Formation; southeast side of Rt 35, 1.4 miles south of Eel Wier Canal.*

Photo 2. Brown-weathered calcite marble weathers more deeply than the light green calc-silicate rock, accentuating the layering. The calc-silicate rock contains green diopside, white plagioclase, and quartz. *Metalimestone member, Windham Formation; Dundee Falls, Presumpscot River.*

Photo 3. Layered granofels of the Hutchins Corner Formation. Medium-grained biotite-quartz-feldspar granofels weathers to a brown, slightly crumbly surface. Light gray layers are calc-silicate granofels with much less biotite. Small, white granite veins cut across layers. Layers are tilted down to the right (southeast). *Northeast side of Pope Rd., 0.1 mile west of Colley Wright Brook.*

METAMORPHIC AND STRUCTURAL FEATURES

In the Devonian Period and again in the Carboniferous, central New England was geologically active. Rocks now at the earth's surface in southern Maine were then at depth, subjected to heat and pressure in the earth. These factors caused metamorphism (literally, a change in form) of the rocks. For example, the muddy sediments were recrystallized into mica schist **(Photo 4)**, typical of the Windham Formation. In rocks with the necessary chemical constituents, new minerals such as garnet, staurolite **(Photo 5)**, kyanite **(Photo 6)**, and sillimanite grew. The rock mass was deformed by folding and faulting in response to the pressure. Layers were distorted into folded shapes **(Photo 7)**, or tilted away from horizontal **(Photo 3)**. This deformation occurred on a regional scale, as indicated by the inclined bedding throughout the map area and by the structure shown on the interpretive cross section.

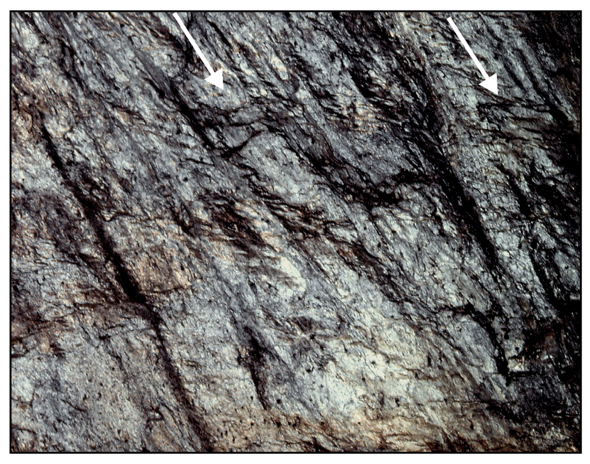

Photo 4. Schist that has split parallel to the foliation plane. The shiny, reflective surface is due to mica that grew during metamorphism. The schist has been crinkled, producing delicate lineations (parallel to arrows) on this surface. Field of view about 6". *West side of Rt. 202, 0.2 miles north of Pleasant River.*

Photo 5. Bedded staurolite schist of the Windham Formation. The "twinned" shape near the right edge is characteristic of the metamorphic mineral staurolite. Layers of thin, light gray quartzite and darker schist were sand and mud, respectively, in the original sediment prior to metamorphism. *Dundee Falls, Presumpscot River.*

Photo 6. Unusually large crystals of the pale blue, bladed mineral kyanite in a quartz pod from the Windham Formation. Kyanite occurs commonly as small grains in schist in the Windham Formation. Metamorphic conditions were not appropriate for kyanite to form in most of southern Maine. Field of view is 6 inches.

Photo 7. Folded layers of quartzite and calc-silicate rock are cross-cut by a granite dike. Rocks can only be deformed this way at high temperatures. This particular granite intruded after the folds had already formed, since the dike is not folded. *Metalimestone member, Windham Formation; 0.1 mile north of Fosters Corner.*

INTRUSIVE ROCKS

During and after the metamorphism and deformation, melting occurred in parts of the crust to produce magma (molten rock). The magma forced its way into rocks of the region, cutting across the pre-existing layers. It cooled slowly underground to produce coarse-grained igneous rocks such as granite **(lower part of Photo 7)** and pegmatite. The northern part of the quadrangle is underlain by granite of the Sebago batholith, Maine's largest granite body, extending north to Norway and westward past Fryeburg. The Sebago granite **(Photo 8)** is of Carboniferous age, but the ages of the other small granite bodies in the quadrangle are not known.

The youngest rocks are thin dikes of black, fine-grained igneous rock **(Photo 9)**. They formed when magma intruded into relatively cool, solid rock along straight fractures. These northeast-trending dikes formed during the Mesozoic Era, at the time when Europe and Africa were rifting away from North America to begin forming the modern Atlantic Ocean.

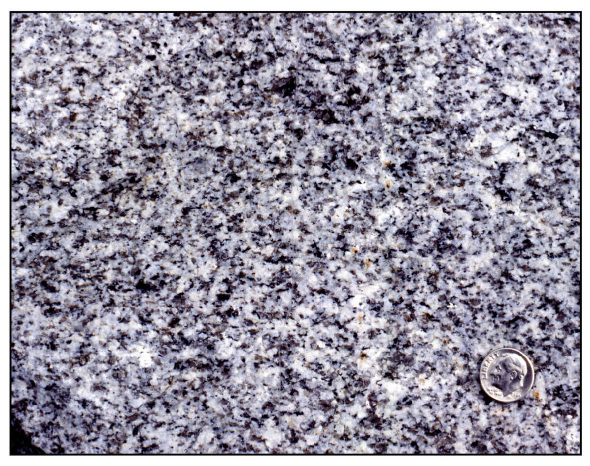

Photo 8. Granite of the Sebago batholith. Medium-sized grains are distributed randomly through the rock. The main minerals are feldspar (white) and quartz (light gray), with scattered flecks of the two micas biotite (black) and muscovite (pale yellow). *From outcrop 0.5 miles northwest of Pettengill Pond.*

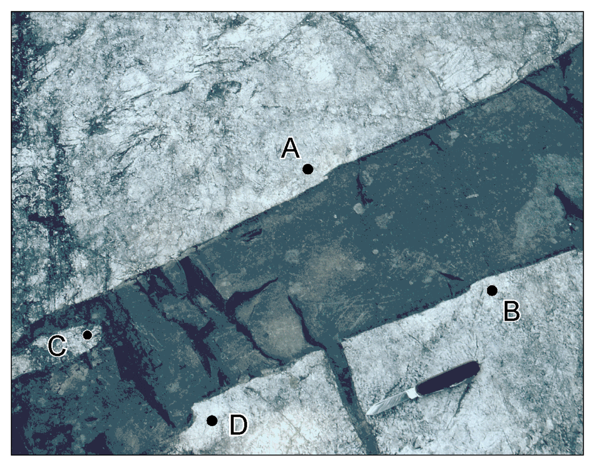

Photo 9. Dike of dark igneous rock cutting through granite. Black rim at edge of dike formed when hot magma was rapidly frozen against cold granite. Small grains are difficult to see without magnification. Before the granite split apart, point A was next to point B, and C was next to D. Magma also flowed into small crack by knife blade. *In small granite body, 0.1 mile north of Fosters Corner.*

GEOLOGIC TIME SCALE (in millions of years before present)

Geologic Age	Absolute Age*
Cenozoic Era	0-66
Mesozoic Era	66-245
Cretaceous Period	66-144
Jurassic Period	144-208
Triassic Period	208-245
Paleozoic Era	245-545
Permian Period	245-286
Carboniferous Period	286-360
Devonian Period	360-415
Silurian Period	415-443
Ordovician Period	443-495
Cambrian Period	495-545
Precambrian time	Older than 545

*From Palmer (1983) and Tucker and McKerrow (1995).