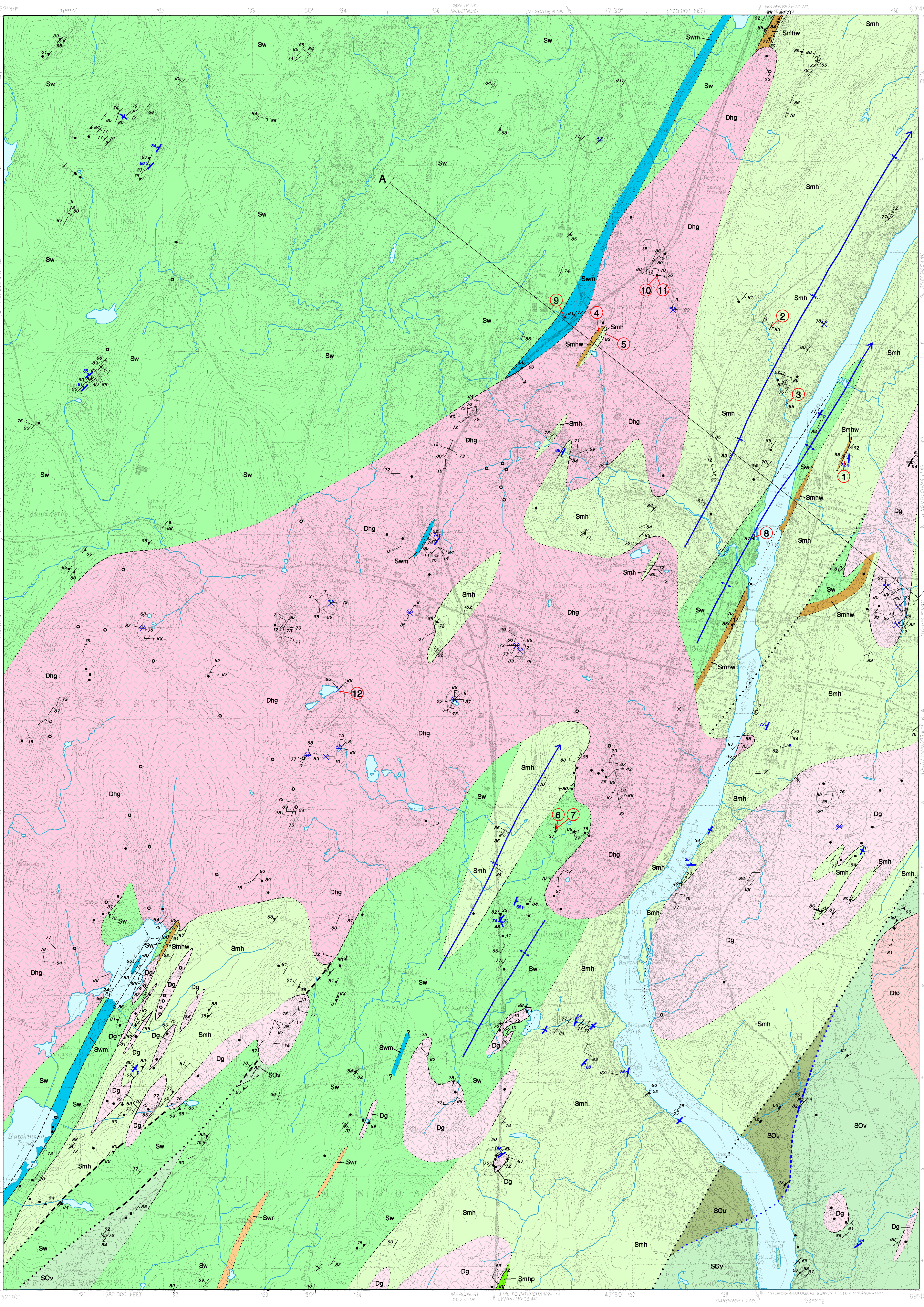
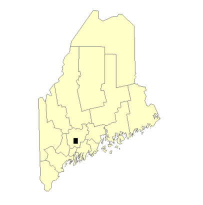
Bedrock Geology



SOURCES OF INFORMATION

Field work by R. G. Marvinney (2005-2007) and D. S. Barker (1959-1960). Published mapping by Barker (1961) and Barker (1964).



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 10 FEET

TRUE NORTH

Topographic base from U.S. Geological Survey Augusta 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.

Augusta Quadrangle, Maine

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Funding for the preparation of this map was provided in part by the U.S. Geological Survey STATEMAP Program, Cooperative Agreements No. 05HQAG0044 and 06HQAG0026.

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Open-File No. 12-36
2012

This map supersedes Open-File Map 08-83.

Photo 1. Folds in medium-bedded granofels, Mayflower Hill Formation (**Smh**). The folds are outlined by a bed of rusty schist near the center of the photograph. Beds dip steeply to the southeast on the left side of the photo. They are folded into an anticline in front of the person with the backpack. To the right, they are folded into a V-shaped syncline, as highlighted by the rusty schist. *View toward the southwest.*

Photo 2. Graded bed, Mayflower Hill Formation (**Smh**). Bedding is parallel to the bottom of the photo, which spans the thickness of one full bed and parts of two others. The sharp base of one bed is just below the pencil eraser. The lighter colored base of the bed contains more relatively coarse quartz grains. As the quartz content decreases upward in the bed (toward the top of the photo), the color gradually gets darker, owing to a greater content of darker biotite mica. The top of the bed is about 5 cm (2 in) above the tip of the pencil. Pencil is 15 cm (6 in) long. *Nearly horizontal outcrop surface.*

Photo 3. Calc-silicate layers, Mayflower Hill Formation (**Smh**). When metamorphosed, layers rich in calcium carbonate and clay minerals generate calcium-bearing silicate minerals such as actinolite, epidote, and grossular garnet. Zones where these minerals are concentrated are light blue-green in color (green of actinolite and epidote), sometimes with orange spots (garnet). Layers and lenses of calc-silicate rock are abundant in the Mayflower Hill Fm. *Vertical roadcut, looking northeast.*

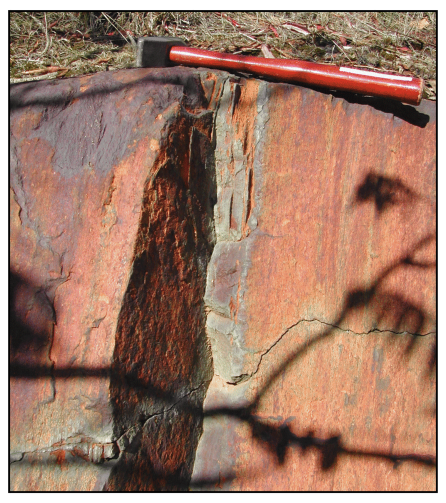

Photo 4. Rusty-weathering, sulfidic schist, Woodbury Member of the Mayflower Hill Formation (**Smhw**). This schist locally marks the lower contact of the Mayflower Hill Formation where it rests on the Waterville Formation. Its distinctive rusty weathering comes from the abundance of iron-sulfide minerals, including pyrite and pyrrhotite, in the rock. *Vertical outcrop surface looking northeast.*

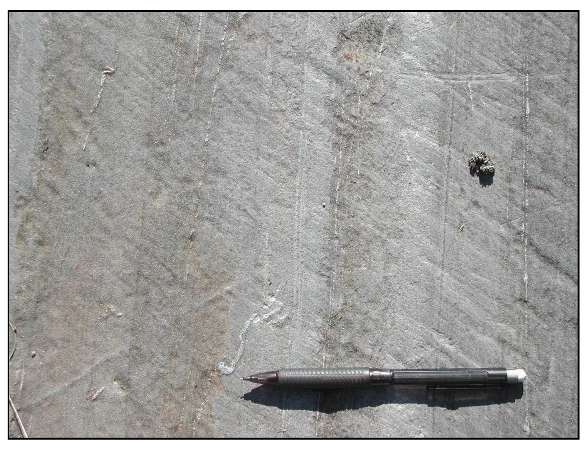

Photo 5. Graded beds and glacial grooves, Mayflower Hill Formation (**Smh**). Graded beds similar to those in Photo 2 are present, but in thinner beds of granofels. The tops of beds are toward the left of the photo (southeast). The bases of the beds are lighter colored; a particularly sharp bed base is about 4 cm (1.5 in) to the right of the pencil tip. Shallow glacial striations cross-cut the outcrop from lower right to upper left. *Horizontal outcrop surface, southeast to the left.*

Photo 6. Thin beds, Waterville Formation (**Sw**). Bedding in this formation is typically one to a few cm thick (0.5 - 2 in). Beds are marked by thin quartz-rich layers (light gray in photo) and darker mica schist. *Horizontal outcrop surface, northeast to left.*

Photo 7. Small-scale fold, Waterville Formation (**Sw**). This fold deforms thinly bedded schist and quartz-rich beds, as described in Photo 6. The quartz-rich layers are more resistant to weathering and stand out in relief relative to the mica-rich schist. *Horizontal outcrop surface, northeast to left.*

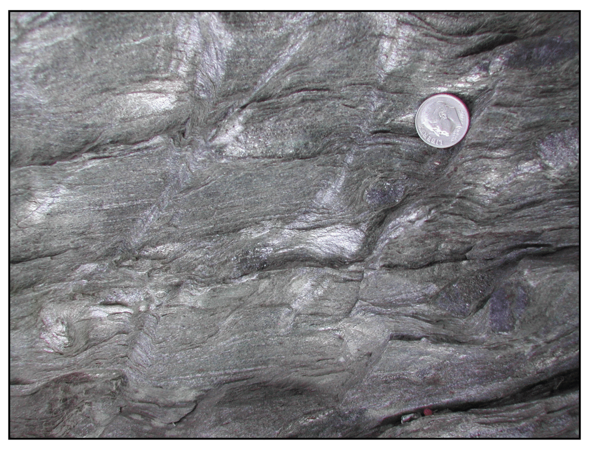

Photo 8. Mica schist, Waterville Formation (**Sw**). This schist is mostly muscovite mica which gives the rock a silvery sheen. The regional foliation cuts across this surface, and is cross-cut by a later foliation running from top right to lower left. Dark gray lumps in the rock (one just below and left of the dime) were formerly andalusite crystals that have been replaced with fine-grained muscovite. *Nearly horizontal outcrop surface, northeast to right.*

Photo 9. Marble and schist, limestone member of the Waterville Formation (**Swm**). Thin impure, light gray marble layers are separated by thinner, darker gray schist layers. The schist layers are more resistant to weathering and erosion and impart a ribbed appearance to the outcrop. *Horizontal outcrop surface, northeast to right.*

Photo 10. Joints in granite (**Dhg**). These sheeting joints, nearly parallel to the ground surface, are typical of the joints found in the numerous small granite bodies of the area. Here they have been accentuated by blasting for a retail center. Diffuse layering in the granite (from upper right to lower left of the photo) is due to mineral alignment, perhaps in response to flow in the original molten magma, or due to later tectonic compressional forces. *Vertical rock cut, looking south.*

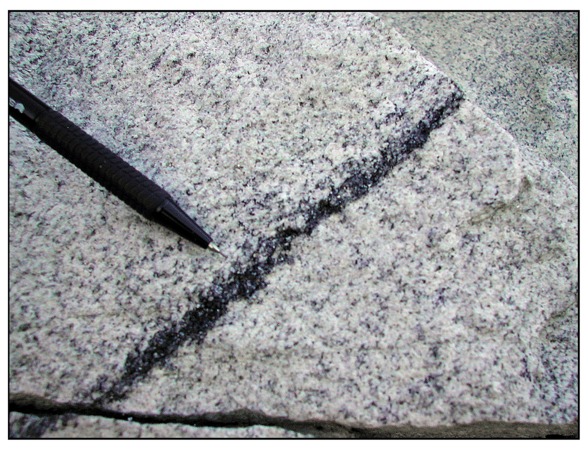

Photo 11. Close-up of granite from Photo 10. The dark layer contains abundant biotite mica. Such diffuse layers in igneous rocks are called schlieren.

Photo 12. Inactive granite quarry. This quarry on Granite Hill, Hallowell, is typical of the small quarries that abound in almost every mappable granite body in the area. Blocks cut from this quarry were used to construct Maine's Statehouse in 1829-1831.

EXPLANATION OF UNITS

INTRUSIVE ROCKS

Devonian (?)

Dto — **Togus pluton.** Biotite-muscovite ± garnet granite, granodiorite, and tonalite.

Dhg — **Hallowell granite.** This unit includes several varieties of granite, but is dominated by light gray, medium-grained, equigranular two-mica granite consisting of feldspar, quartz, biotite, and muscovite. Minor pink garnet and minor black tourmaline are present locally. Locally porphyritic with feldspar phenocrysts up to 1 cm. Locally lacks muscovite. Pegmatite veins are common.

Dg — **Granite.** Similar in lithology to Hallowell granite, but in small discontinuous bodies. Pegmatite veins are common in all bodies.

STRATIFIED ROCKS

Silurian - Ordovician (?)

SOv — **Vassalboro Group, undifferentiated.** Rocks which may belong either to the Mayflower Hill Formation or to the Silurian-Ordovician(?) Hutchins Corner Formation, which are indistinguishable on the basis of rock type. Mapped where the stratigraphic position with respect to the Waterville Formation is uncertain, or where the Waterville is absent (Marvinney and others, 2010).

Silurian

Smh — **Mayflower Hill Formation.** Purplish brown, fine-grained to medium-grained quartz-feldspar-biotite granofels and minor schist. Bedding is pronounced with granofels beds ranging from a few centimeters to over a meter in thickness. Graded beds with sharp bases are common. Thin biotite schist, locally rusty-weathering, forms the tops of beds. In most sections, granofels predominates over schist. Granofels also contains thin greenish-blue layers and small lenses of calc-silicate granofels, commonly containing grossular garnet.

Smhp — **Granofels and pelite.** Interbedded quartz-plagioclase-biotite granofels and pelitic schist. A thin unit at the south edge of the map, projected from exposures in the Gardiner quadrangle to the south (West and Berry, in preparation).

Smhw — **Woodbury Member.** Dark gray, rusty-weathering schist containing abundant sulfide minerals. Some exposures are thinly bedded biotite-muscovite schist with abundant pyrite. Present intermittently at the base of the Mayflower Hill Formation.

Sw — **Waterville Formation.** Thinly bedded, purplish-gray granofels and schist. Beds are typically 1 centimeter (cm) thick. Thick sections of schist are common. Schist is composed of biotite, quartz, and feldspar, with minor muscovite. Some sections have thicker granofels beds up to 10 cm. In the northwest portion of the outcrop belt, in particular, some layers have abundant small lavender-pink garnets, imparting a knobby appearance to the rock. Thin (1-10 mm) brown-weathering limestone layers are common. Thin (up to 1 cm) greenish-blue calc-silicate layers are abundant. In the southern part of the outcrop belt and near the contact with granite elsewhere, patches of fibrous sillimanite are common. Along the Kennebec River, the Waterville includes a section of massive silvery-gray muscovite schist with pseudomorphs after andalusite.

Swr — **Sulfide-rich schist.** Mapped by Barker (1961).

Swm — **Marble and limestone member.** Brown-weathering gray limestone with thin phyllite interbeds. Bedding 2-5 cm. In granite contact zones, becomes thinly bedded marble and schist.

(SOv through Swm: Vassalboro Group)

Silurian - Ordovician (?)

SOu — **Unnamed quartzite, gneiss, and schist.** Undifferentiated rocks, including buff colored, angular-weathering quartzite and quartz-biotite gneiss, with some chlorite-rich schist. Interpreted to be older than the Vassalboro Group, but its contact relationships are uncertain.

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)

Contact between mapped units, interpreted to be a fault because of discontinuities or dislocations of stratigraphic contacts or the stratigraphic sequence. (approximately located, poorly located)

Contact of uncertain nature, between units SOu and SOv in the southeast corner of the map. Might be an unconformity or a fault. (well located, approximately located, poorly located)

Axial trace of map-scale fold. Fold shape and location are interpreted from the pattern of mapped units, together with observed minor folds, bedding and cleavage orientations, and stratigraphic facing directions as determined from relict tops indicators in bedding. Most of the large scale folding is probably of Acadian (Devonian) age (Tucker and others, 2001). Arrow at end of line indicates direction of plunge, if known. (anticline, syncline)

A — A'
Line of cross-section.

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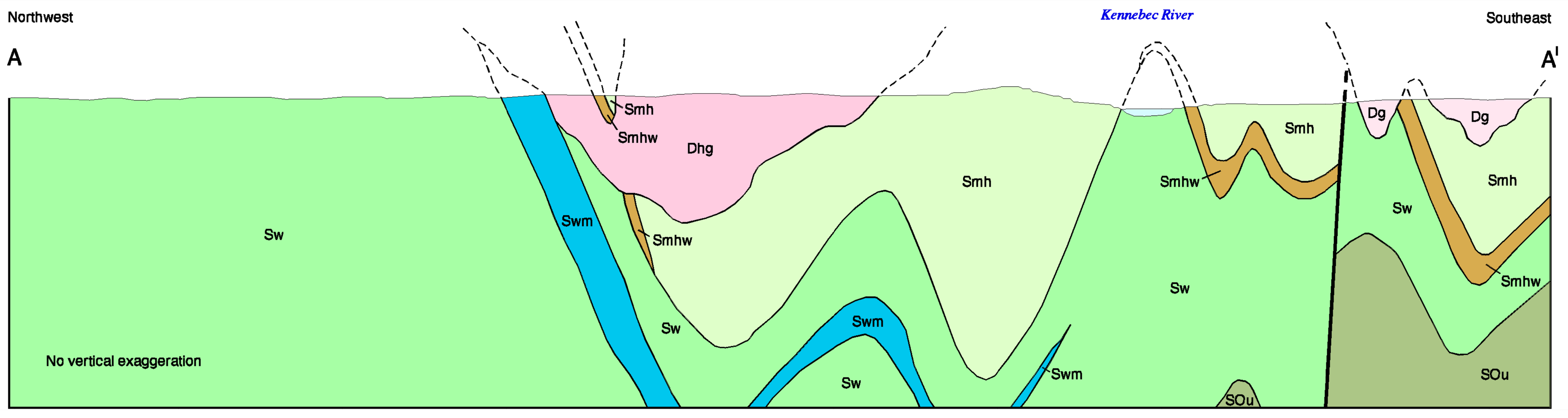
EXPLANATION OF SYMBOLS

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 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.

- Outcrop of mapped unit (small exposure, large outcrop or area of abundant outcrop)
- Outcrop of mapped unit, visible during construction but now obscured
- Float block presumed to represent underlying bedrock
- Dike of felsic igneous rock. Medium-grained granitic texture unless indicated otherwise by letter: a = aplite, p = pegmatite (inclined, vertical, orientation unknown)
- Bedding, tops unknown (inclined, vertical)
- Bedding, tops known (tops up, tops down, vertical - tops toward ball)
- Metamorphic foliation (inclined, vertical)
- Gneissic layering (inclined)
- Hinge of minor fold with asymmetry indicated by symbol (left-handed, right-handed, neutral)
- Axial plane of minor fold (inclined, vertical)
- Crenulation cleavage (inclined)
- Minor fault, unknown displacement
- Joint (inclined, vertical)
- Quarry (active, inactive)
- Location of photo shown in sidebar

INTERPRETIVE CROSS-SECTION



GEOLOGIC TIME SCALE

Geologic Age		Absolute Age*
Cenozoic Era		0-65
Mesozoic Era	Cretaceous Period	65-253
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.)