

Bowdoinham Quadrangle, Maine

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see accompanying 17 p. report.

THE BEDROCK MAP

The geologic map at left shows features of the bedrock, the solid rock that makes up the Earth's crust. Although the bedrock is covered in most places by sediment related to the last continental glacier, this map depicts only the underlying bedrock, according to the geologists' interpretation. Symbols on the map show locations where bedrock was observed at the surface. Rocks of similar type are grouped together into

rock units (see map Explanation). These rock units are shown by colors on the map, and identified by letter symbols that indicate their geologic age and unit name. Boundaries between units are shown by either solid, dashed, or dotted lines to indicate how well their locations are known. The following text summarizes the major rock types present in each unit, and reflects our current understanding of how they formed.

GEOLOGY OF THE BOWDOINHAM QUADRANGLE

STRATIFIED ROCKS

The stratified, or layered, rocks of the Bowdoinham quadrangle are metamorphic rocks, primarily schist, gneiss, and granofels. Schist contains abundant thin, shiny flakes of mica which are arranged parallel to each other such that the rock splits into splinters or sheets. Gneiss has different minerals concentrated in streaks or layers. Granofels has a grainy texture somewhat like sugar. Varieties of schist, gneiss, or granofels may be further distinguished on the basis of their color, mineral content, grain size, or other characteristics.

The stratified rocks in the Bowdoinham quadrangle are grouped into two sequences. The older Falmouth-Brunswick sequence is dominated by gneisses of the Nehumkeag Pond Formation (**Photo 1**) and the Mt. Ararat Gneiss (**Photo 2**). Their compositions suggest they originated as igneous rocks, perhaps volcanic rocks, or as sediment eroded from nearby igneous rocks. The Nehumkeag Pond Formation also contains small amounts of rusty rocks (**Photo 3**) and impure marble which were probably muddy sediments and dirty limestone, respectively, deposited in the volcanic environment. While the details remain obscure, rocks of the Falmouth-Brunswick sequence are interpreted collectively to have been deposited in an active volcanic arc in Ordovician time (see Geologic Time Scale below). Similar geologic environments are found today in the islands of the southwestern Pacific. The Central Maine sequence is younger than the Ordovician volcanic arc. These rocks consist of layered granofels (**Photos 4 and 5**), that was originally sandstone and siltstone deposited in a marine sedimentary basin of Silurian age.



Photo 1. Light-colored gneiss of the Nehumkeag Pond Formation (**Onp**). The telltale streaks running through the rock are an alignment of minerals called **foliation**, a characteristic of gneiss produced by metamorphism. Light colored patches in the upper part of the photo, and the thicker white band across the lower part are igneous rock (granite) that was molten rock that flowed into the hot gneiss. *Route 138, south of Richmond Corner.*



Photo 2. Folded gneiss of the Mount Ararat Gneiss (**Oma**), with dark and light layers. In this case, the color of the layers reflects their composition. The layers were folded like putty during the metamorphic episode, probably in the Devonian Period of geologic time. *Road cut beside I-295, south of Route 197 exit, just east of the map area.*



Photo 3. Highly rusty-weathering rocks of the Richmond Corner Formation (**Onprc**). The dark purplish coating is thought to consist partly of oxidized manganese compounds, produced by exposure of the rock to the weather over geologic time. *Southeastern corner of the intersection of Route 201 and Route 197, near Richmond Corner.*



Photo 4. Typical natural outcrop of the Vassalboro Formation (**Sv**) showing a slightly rusty weathered surface and a tendency of the rock to split naturally into sheets because of its internal layering. *Off the Burrough Road in the southwestern portion of the quadrangle, in the church parking lot approximately 300 feet north of the South Bowdoin Cemetery.*



Photo 5. Fresh exposure of the Vassalboro Formation (**Sv**) showing greenish-gray layers alternating with medium gray layers. These layers are thought to have originated as silty and limy mud in Silurian time. The heat of metamorphism later changed them into the hard, granular rock we see today. *Quarry, approximately one-half mile northeast of Bowdoin Center.*

METAMORPHISM AND DEFORMATION

During middle to late Paleozoic time, the rocks were complexly deformed and metamorphosed by processes related to Appalachian mountain building. Rocks now exposed at the surface were subjected to temperatures in excess of 600 degrees Centigrade and pressures equivalent to 5 or 6 miles beneath the surface. These extreme conditions transformed the original igneous and sedimentary rocks into the

metamorphic rocks now exposed at the surface. Large scale deformation of the Earth's crust produced many effects preserved in the rocks, such as folds (**Photos 2 and 6**), alignment of minerals (**Photo 7**), and new mineral growth. Dates from metamorphic minerals indicate the main phase of metamorphism and deformation occurred about 380 million years ago.



Photo 6. Folds in layered rocks of the Mount Ararat Gneiss. The shapes of folds are curved around imaginary horizontal surfaces, as if they were squeezed vertically. This contrasts with the folds of photo 2, which have a steeper orientation. The reason for this apparent difference in rock structure is not yet understood. *I-295 road cut 1000 feet south of Sedgley Brook, Bowdoinham.*



Photo 7. The large, white mineral grains in this photo are feldspar. Feldspar is the most common mineral in the Earth's crust, and such large feldspar grains are typical of igneous rocks. Their alignment parallel to the knife, however, was caused when that original igneous rock was flattened during metamorphism. *Hornbeam Hill gneiss (Dhh), 0.9 miles west of Richmond Corner.*

INTRUSIVE ROCKS

At several times, melting occurred in the crust to produce batches of molten rock (magma). This magma forced its way into the stratified rocks and solidified slowly, still underground, to produce igneous rocks such as granite. The oldest and largest intrusive rock body is the Hornbeam Hill Gneiss (**Photo 7**). Rocks of the Hornbeam Hill Gneiss range in composition from light colored granite to a darker rock called diorite. Smaller lenses of foliated granitic rock (**Dfg**) are also present. These strongly deformed rocks must have intruded before the main phase of metamorphism.

During metamorphism, high temperatures caused partial melting of some rocks, producing granite layers within other rocks throughout the quadrangle (**Photo 1**, for example). After the main metamorphism, bodies of very coarse-grained granite, known as pegmatite, were emplaced. One variety, containing coarse-grained black tourmaline (**Photo 8**), is common in the northwest. These are interpreted to be Devonian in age. Another, intriguing variety has a graphic texture (**Photo 9**), and is common in the eastern portion of the quadrangle. These are similar to pegmatites in the Topsham area which have been dated as Permian (about 275 million years old). Many of these pegmatite bodies have been the sites of past, relatively small scale quarrying activity, presumably for feldspar.

The youngest rocks in the quadrangle are dark-colored diabase dikes (**Photo 10**). They formed in Mesozoic time (circa 200 million years ago), long after deformation and metamorphism had ceased. Magma was injected into extensional fractures produced during the continental rifting that ultimately led to opening of the Atlantic Ocean. Millions of years of uplift and erosion progressively exhumed the bedrock currently exposed at the surface.



Photo 8. The very large white crystals of the igneous rock called **pegmatite**. This particular variety of pegmatite (**Dtp**) has abundant black tourmaline crystals as well. *Blasted boulder, 0.6 miles northeast of Caesar Pond, Bowdoin.*



Photo 9. Another variety of pegmatite, in which the white feldspar is intergrown with translucent gray quartz. This peculiar intergrowth is called a graphic texture, from its similarity to ancient cuneiform writing. Pegmatites with this texture (**Pp**) are common in the eastern part of the map area. *4500 feet east-northeast of Stoddard Pond.*



Photo 10. The youngest rocks in the Bowdoinham quadrangle (about 200 million years old) are black igneous rocks like this one (**Mzd**). They formed when fluid magma rapidly up through cracks in the older rocks, and then solidified. In this case, the older rock is pegmatite. *At the end of the southbound entrance ramp to I-295 at the Bowdoinham Exit.*