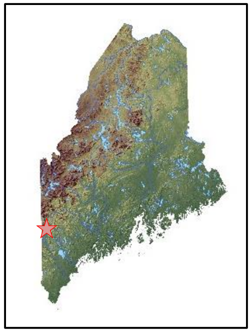
Maine Geologic Facts and Localities

November, 2017

The Rock Garden at the Maine Mineral and Gem Museum, Bethel, Maine



44° 24' 27.8" N, 70° 47' 19.1" W

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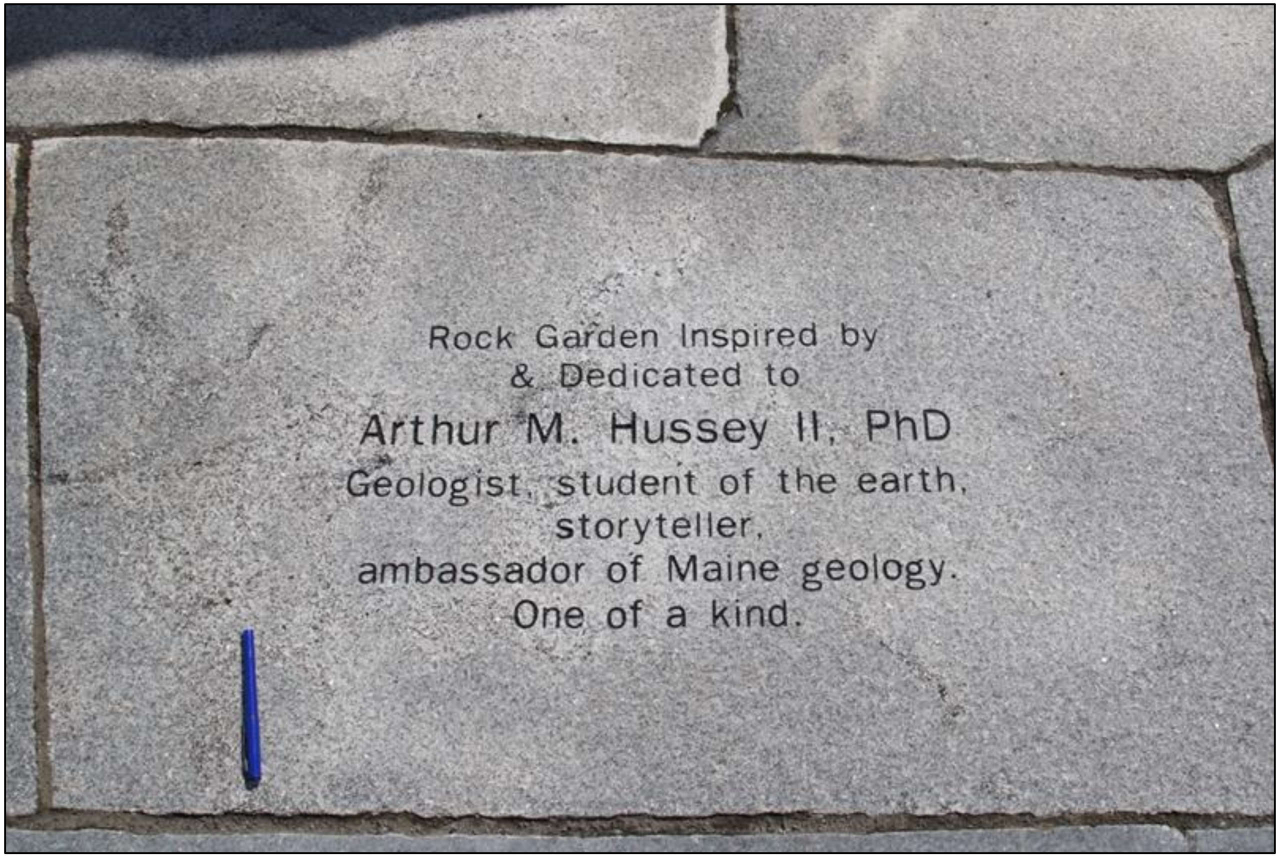
Introduction

The Maine Mineral & Gem Museum (MMGM) welcomes all visitors to explore its Rock Garden exhibit. The exhibit introduces a variety of rock types from many different parts of Maine, and one mammoth specimen from outer space. Each specimen has an interesting story to tell, and access to this exhibit is available 24/7.

Dedication

The MMGM Rock Garden is dedicated to Arthur M. Hussey, PhD., who was a founding trustee and whose inspiration led to the development of this exhibit.



Disclaimer

All specimens in this exhibit were obtained from private properties with the permission from landowners. If individuals seek to explore these localities it is ***highly advised*** that the individuals seek permission from landowners before accessing any property. We do not condone trespassing.

We also ask that visitors be respectful of the specimens so that they remain available for others to see, so please don't climb on or deface the rocks.

Rocks from Wells

Three completely different rocks come from the town of Wells, two are from the same locality and the third from a nearby locality. The hornfels and gabbro are from the Pike Quarry, an aggregate rock quarry (the quarry is the lighter colored area in the top center of the map, outlined in yellow). The granite with the basaltic dike are from the nearby Bald Hill Quarry, just north of the Pike Quarry. By taking a look at the bedrock map of the area we can see what relationship these rocks have to one another.

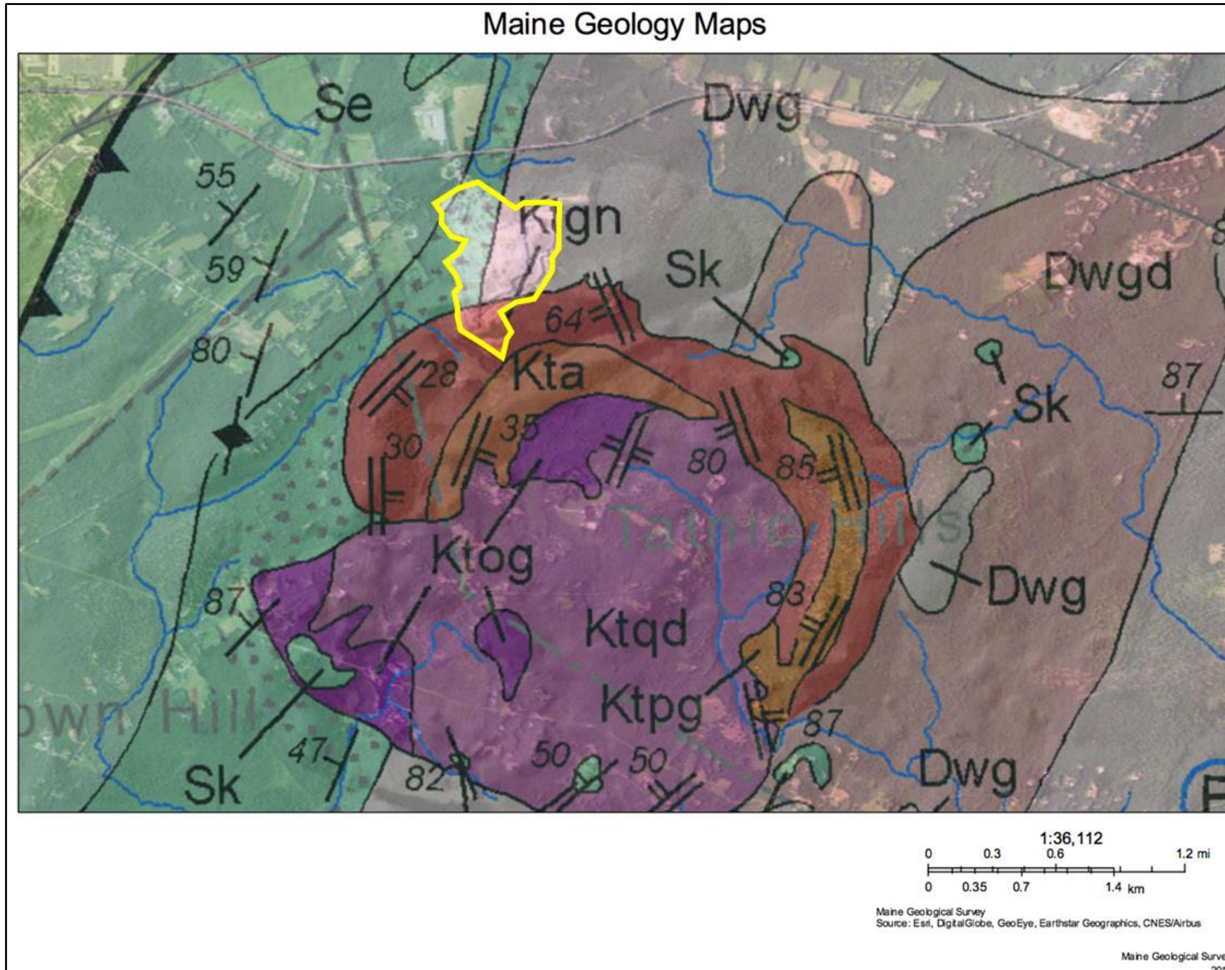


Figure 1. Cretaceous age Tatnic gabbro complex center. Devonian age Webhannett pluton (Dwg, Dwgd) center right. Silurian age Kittery formation (Sk-green) center left. Map from Hussey et. al 2008.

Rocks from Wells

Moving backwards in time from youngest to oldest, we start with a gabbro of the Tatnic complex (gabbronorite, the red colored unit labelled Ktgn as mapped by Hussey et. al). It intruded the rocks of this area during the Cretaeous period, crosscutting the older Webhannet intrusion and the still older, Kittery formation.

Figure 2. Gabbro specimen from the Pike Quarry in Wells Maine. Specimen is approximately 40” long.

Rocks from Wells

Next we have an example of granite from the Webhannet Pluton (which itself has been intruded by a diabase dike, likely younger or similar in age to the gabbro). This granite intruded during the Devonian, and cross cuts the older stratified rocks of the Kittery formation (light pink colored unit, labelled Dwg).

Figure 3a. This granite specimen has been intruded by a basaltic dike. Specimen is approximately 4' long.

Figure 3b. Close-up view of the contact between the granite and the basaltic dike. Note how sharp the contact is and the variation of crystal sizes between the two rock types. The basalt cooled rapidly as indicated by the lack of visible crystals. Whereas the granite cooled more slowly, which is apparent from coarse texture. Width of the dike is approximately 1" wide.

Rocks from Wells

Lastly we have the hornfels, a rather simple looking rock with a very interesting story. This is an example of a contact metamorphic rock that was "cooked" by the heat that emanated outward from the molten magma of the intruding Webhannet Pluton. The Kittery formation is of Silurian age and is the oldest of the three rocks in the Rock Garden, from Wells (it is the darker green unit, labelled Sk on the map). A portion of the Kittery formation that is directly adjacent to the Webhannet granite is marked with gray spots, indicating the extent of the contact aureole.

Figure 4a. Despite its rather dull appearance the hornfels has an interesting metamorphic history. Heat that emanated from the nearby intrusion (the Webhannet Pluton) cooked the surrounding rocks of the Kittery Formation, forming the hornfels. Specimen is approximately 20" tall.

Figure 4b. The specimen is not entirely homogeneous. Upon close examination, it contains thin veinlets and pods of the green mineral epidote, which imply a hydrothermal event. Veinlet is approximately 0.5" wide.

Basaltic Rocks

Though the columnar jointing in this specimen is not as outstanding as examples seen out in the western United States like in Washington and Oregon, or even like those at the Giant's Causeway in County Antrim, Northern Ireland. The same principle remains for the formation of these jointed surfaces. Soon after the basaltic magma cooled and crystallized the rock began to contract, producing the hexagonal columnar jointed surfaces. This specimen is from Brooskville and is part of the Castine formation.

Figure 5a. View of two joint surfaces.

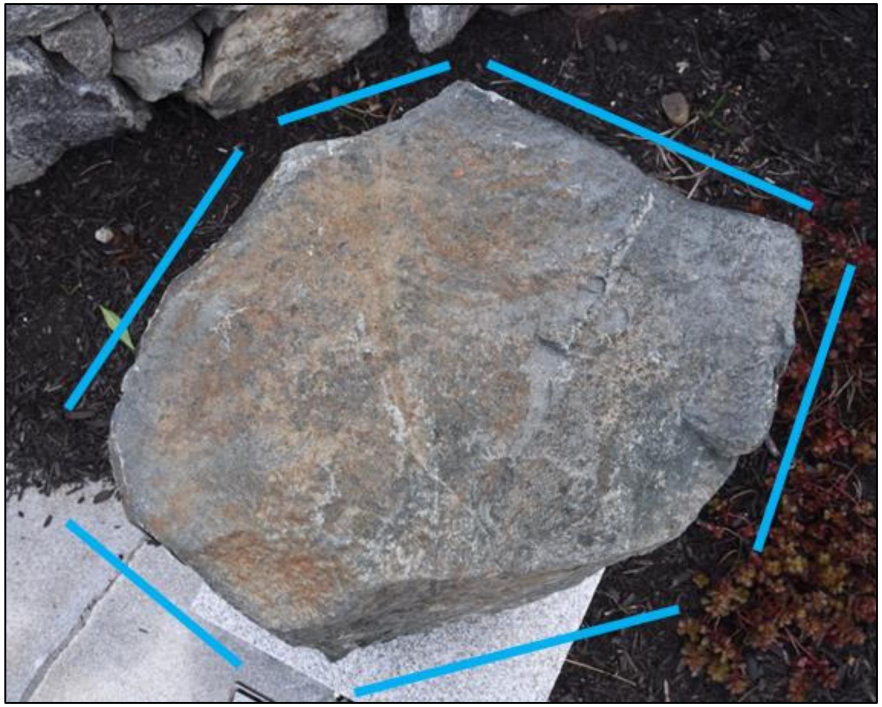


Figure 5b. View looking down the long axis of the column, note six jointed surfaces (highlighted by blue lines).

Basaltic Rocks

This pillow basalt specimen is from the same formation as the columnar basalt. Pillow basalts are evidence of underwater eruptions. This particular example shows an excellent example of 'tops' criteria. As the pillow structures form they cool with a rounded surface in the upward direction and have a concave shape on the underside resulting from the cooling on top of another pillow. More information about Maine pillow basalt.

Figure 6a. Front view of the rounded top of the single pillow. This specimen is from Condon Point in South Brooksville. Specimen is approximately 20" tall.

Figure 6b. Cross section view of pillow structure. Note the curved surface on right, and concave surface on left. These shapes form as lava erupts on the ocean floor forming a pillow, subsequent eruptions stack onto older ones beneath and as they cool they mold themselves over the rounded surfaces of the pillow below. This results in the concave-convex shape of pillow lavas, and is an indicator of the "way-up" direction. In this example the pillow has been mounted so that "up" is to the right (note blue arrow).

Granitic Pegmatite Specimens

Granitic pegmatite mining in Maine began in c. 1850 in Topsham and lasted to the mid-1970s marked by the closure of the West Paris feldspar mill. Initially these deposits were mined solely for feldspar. Mining them for mica, beryl and gemstones would come much later.

Microcline is a variety of potassium-rich feldspar. It was primarily used in the ceramics industry. This particular specimen is a single crystal, large crystals like this are characteristic of pegmatites. As a pure crystal, free of intergrowths of other minerals, this type of feldspar was referred to as “No. 1 Spar” by local pegmatite miners, indicating it is the highest quality of feldspar.

Figures 7a & b. A large microcline crystal from the Albany Rose Quarry in Albany Township. This is the mineral upon which most of Maine pegmatites mining was based. The specimen is approximately 3’ tall and is twinned after the Baveno law, one of five twin laws for feldspars. Several smaller feldspar crystals are also intergrown with the larger crystal, quartz and muscovite mica are also present.

Granitic Pegmatite Specimens

Graphic Granite is a texture that is specific to granitic pegmatites. It is a graphic intergrowth of feldspar and quartz, though the texture does occur with other mineral pairs in pegmatites. Material like this was also quarried by feldspar miners. However, this material was less desirable due to the high proportion of quartz. This material was referred to as “No. 2 Spar” by local miners, indicating the lower quality of the ore.

Figure 8b. Close-up of lower right side of boulder seen in pervious figure. The graphic granite texture is composed of two minerals, quartz (gray) and feldspar (tan).

Figure 8a. Graphic granite specimen from the Havey Quarry in Poland, ME. Specimen is approximately 60” tall. Blue box highlights the area seen in the next figure.

Granitic Pegmatite Specimens

Pegmatite a very coarse grained intrusive igneous rock composed of interlocking crystals larger than 2.5 cm (1 inch). Most pegmatites are composed of quartz, feldspar and mica. However, many of the granitic pegmatites in Oxford County contain a wide range of accessory minerals including tourmaline, garnet, lepidolite, columbite-tantalite minerals, and pollucite. Some of the textures from these rocks are unusual and quite remarkable. This example from the Mt. Marie quarry has a particularly interesting texture. Schorl tourmaline crystals circle around two clusters of dark green apatite.

Figure 9a. Pegmatite specimen from Mt. Marie in Paris, ME. Several pegmatites quarries are located on Mt. Marie, where commercial feldspar was originally sought. Today the quarries on Mt. Marie are worked for specimens and gem rough. Specimen is approximately 5' in length. Note the two circular pods boarder by black tourmaline (schorl).

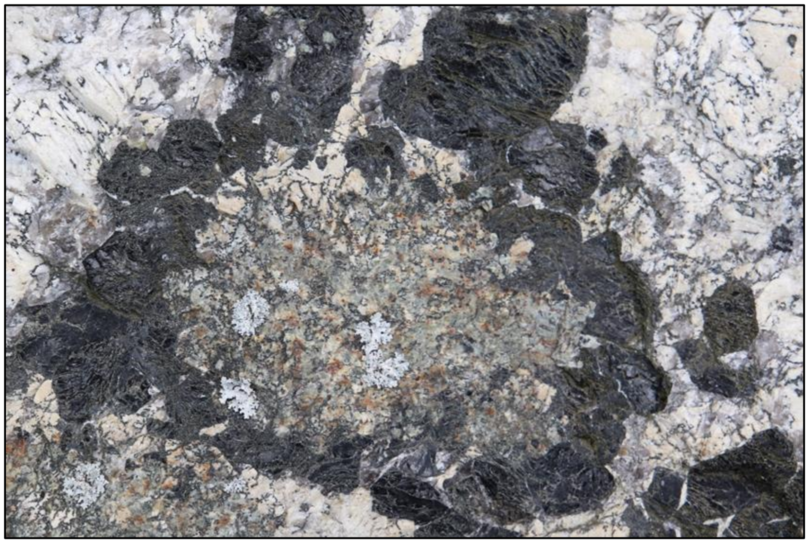


Figure 9b. Close-up of one of the circular pods bordered by schorl, pod is approximately 9" across. The core of the pod is composed primarily of green fluorapatite. Tan colored microcline is found between some of the schorl and apatite. Outside of the pod is light gray quartz and white colored plagioclase feldspar.

Granitic Pegmatite Specimens

This boulder from the Havey Quarry in Poland, ME, is an example of a rare element pegmatite. The presence of tourmaline (black, green, and pink) is evidence for an enrichment in boron, whereas the presence of lepidolite (purple) shows an enrichment in lithium.

Figure 10a. The Havey pegmatite is a type of zoned rare-element pegmatite, containing an abundance of boron (tourmaline) and lithium (lepidolite) minerals and miarolitic cavities (pockets). This boulder, approximately 9' long, is from an interior enriched region within the pegmatite. This is apparent given the mineralogy, tourmaline (schorl and elbaite), lepidolite, cleavelandite, microcline.

Figure 10b. Cluster of black tourmaline (schorl), approximately 10" across, surrounded by the platy variety of albite, cleavelandite. Purple lepidolite is seen to the left.

Figure 10c. Crumbly elbaite tourmaline (pink and green) in the center of figure. The green color is due to the presence of the element iron in the crystal structure, the pink is due to manganese. Cleavelandite and schorl to left. Field of view is approximately 18".

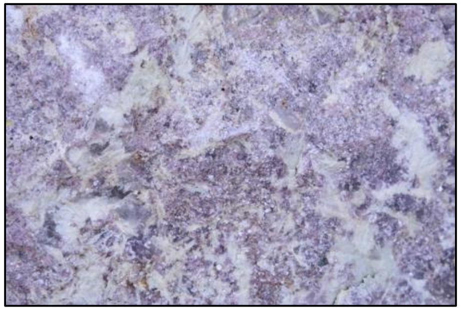


Figure 10d. Close-up of lepidolite, a micaceous mineral that commonly occurs as masses in pegmatite. The purple color is due to trace amounts of the element manganese in the crystal structure.

Jasper

Jasper is a common lapidary material composed of very fine-grained quartz and used to make cabochons for jewelry. The red coloration in this specimen is due to the presence of iron oxides, though jasper comes in many colors. This specimen comes from the town of Eustis, Franklin County. Jasper in this part of Maine has been associated with the pillow basalts of the Jim Pond Formation.

Figure 11a. The jasper specimen, about 30” tall, was recovered from a river bed and has been significantly rounded.

Figure 11b. Close-up area of the jasper specimen.

The Marbles

Marble mining in Maine began in the mid 1700's to produce lime, a key ingredient in the manufacture of mortar and concrete and to a lesser degree for agricultural purposes. The marble specimen is from the Dragon Cement quarry in Thomaston, Knox County. The thin bedding is due to variable amounts of graphite content.

Figure 12a. The banding in this specimen is inherited from compositional differences in the original sediment. The darker gray bands indicate the presence of graphite (carbon), which came from organic matter, likely plants living in the ocean during the Precambrian. The specimen is approximately 50" across.

Figure 12b. Close-up of the banding in the larger marble specimen. Note there are some white bands of pure calcite, these are generally quite coarse grained compared to the other bands.

The Marbles

This marble specimen is also from the Dragon Cement quarry in Thomaston, Knox County. Organic materials are also likely the cause of the black color. The folding records a compressional event.

Figure 13a. The smaller marble specimen displaying some dramatic folds between the highly contrasting sections. Both the dark and light portions of this specimen are marble. The darker colored portion is attributed to the presence and abundance of graphite (carbon), whereas graphite is nearly absent in the lighted colored portion. The specimen is about 20” tall.

Figure 13b. Close- up of the folds in the lighter colored portion. Note that the folded layers are generally thicker along the hinges and thinner along the limbs.

The Gargantuan Metaconglomerate

This 13-ton boulder was recovered from Otisfield, Oxford County. It did not have any resemblance to the bedrock in the area, making it a glacial erratic (oddly, there was another boulder with matching characteristics found next to it). Without any obvious and definite source rock, there has been much speculation about the true origin of this boulder. However, it does share some likeness to parts of the Rangeley conglomerate unit. The conglomerate is polymict, meaning it contains a range of clast types. The clasts are well-rounded and include examples of mafic, intermediate, and felsic rock types. More work will need to be done to property classify this specimen.

Figure 14a. The massive 13-ton metaconglomerate is approximately 9' long. Note the heterogeneity of clast types, some regions primarily consist of dark clasts, some lighter colored, and other regions where there is a mixture.

Figure 14b. Close-up of a region of darker clasts, field of view is 16" long. Dark clasts are igneous and gabbroic in composition.

The Gargantuan Metaconglomerate (continued)

Figure 14c. Close-up of a region of primarily lighter colored clasts, field of view is approximately 2'. Note the range of rock types, primarily igneous compositions including granitic, dioritic, and gabbroic types. Some clasts are fine grained and others are quite coarse grained, even pegmatitic.

Figure 14d. Not all the clasts are igneous. Center of photo shows a gneissic clast, approximately 4" long.

The Granites – Stonington

Three granite localities are represented in the rock garden. The first two localities are a series of large boulders. Granite quarrying in Maine began over two centuries ago. An abundance of exposures along the coastline was particularly advantageous for loading the cargo on ships. The single lavender colored specimen is a coarse-grained biotite granite from Stonington, mapped as a phase of the Deer Isle Pluton. Within this specimen are rapakivi feldspar phenocrysts (larger grains in a finer matrix). These grains show a distinct core of reddish colored orthoclase rimmed with white plagioclase feldspar. This texture is usually associated with an anorogenic settings (extensional tectonic settings).

Figure 15a. Granite from the Church Quarry in Stonington. Note the drill marks along the edge left by quarry workers splitting the stone.

Figure 15b. Close-up of a rapakivi feldspar phenocryst. Note the reddish colored potassium feldspar core surrounded by a white rim of plagioclase (yellow arrow points to crystal). Crystal is approximately 1” long.

The Granites – Hallowell

The two taller specimens are light gray, medium grained two-mica granites with accessory garnet from the Hallowell pluton. The Hallowell pluton covers a large area along the western side of the Kennebec river near Augusta. Granite quarrying in the Hallowell area began in the late 1800's, and although the location is some distance from the coast, the nearby Kennebec river was quite accessible for transportation. One surface of the larger of the two specimens has many parallel lines that appear like striations. This is a slickenside surface, which developed from friction along a fault surface. A fault is a fracture in rock where displacement has occurred. Along a few surfaces on the smaller specimen is a good example of a weathering surface. Compare this to the fresher surface on the granite specimen.

Figure 16a. The two Hallowell granite specimens at center and left (the two tallest in the photo) are from the Stinchfield Quarry in Hallowell. Note the series of drill marks along the edge of the tallest specimen. These drill marks are left by quarry works splitting the stones.

Figure 16b. Slickenside surface on larger specimen. Note the striations trending from left to right, these indicate the relative movement along the faulted surface. Field of view is approximately 2' across.

The Granites – Hallowell (continued)

Figure 16c. Weathered surface on smaller granite specimen.

Figure 16d. Fresh, unweathered surface of larger granite specimen. Note the garnet grain in the top center of photograph (yellow arrow points to crystal).

The Granites – North Jay

While you're walking around the rock garden looking for the third granite locality you might look down at your feet! The garden is paved with slabs of a light gray (almost white colored), medium grained two-mica granite with abundant accessory garnet, from the North Jay Pluton in North Jay. Some of them contain pegmatite veins, and some have inclusions called xenoliths.

Figure 17a. Close up of medium grained two-mica (biotite and muscovite) granite from North Jay. Note the blue arrows pointing to garnet crystals. The association of biotite, muscovite, and garnet indicate that this granite formed from a magma that was produced from melting of sedimentary rocks. Geologists refer to this as an S-type granite.

Figure 17b. Xenolith (foreign rock) in the North Jay granite paver. Note the foliation (layers produced from the alignment of mineral grains) in the xenolith, suggesting that it is of a metamorphic origin.

The Granites – North Jay (continued)

Figure 17c. Coarser grained pegmatite vein cross-cutting a paver of North Jay granite. Blue box indicates magnified area in next figure.

Figure 17d. Close-up of the pegmatite vein from previous figure. Note that there is not a sharp contact between the vein and the granite, this is called a gradational contact. The pegmatite consists primarily of feldspar, quartz, muscovite, and biotite. Many of the biotite laths and feldspar crystals are oriented perpendicular to the contact, suggesting a preferred growth orientation inward toward the center of the vein (a unidirectional solidification texture, or comb texture).

Rhyolite Drill Core

There are currently no metallic mineral mines operating in Maine. In the past there have been dozens of mines opened in Hancock County, many for relatively short periods of time. The Harborside Mine in Brooksville was operational from 1968 to 1972. A necessity of mining underground is ventilation. To achieve this, the Callahan Mining Corporation drilled a 48-inch diameter shaft though the subsurface. This sample is small section of the drill core extracted from this process.

Figures 18a & b. Note the parallel grooves on the sides of the cylinder left from the drill bit. The rusty color is a feature of weathering; a fresh surface of the rhyolite reveals a light gray color. The core is 48 inches in diameter.

Slate

Slate is a fine grained metamorphic rock that commonly displays a distinct 'slaty' cleavage due to the alignment of platy minerals, called foliation. This specimen is from the Carrabassett Formation. The towns of Blanchard, Brownfield, and Monson were large producers of slate in the late 1800s and early 1900s. Slate has a range of applications ranging from pool tables, insulators for capacitors to building materials like slate roofing and sinks and counter tops.

Figure 19a. Two slabs of slate from Monson. The specimen on the left is approximately 90" on its long axis.

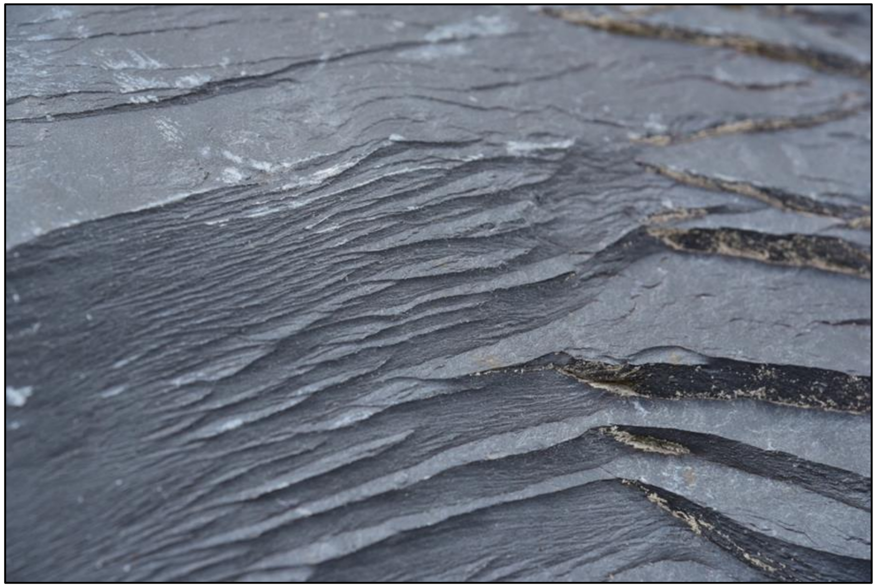


Figure 19b. Close-up of the slaty cleavage, the foliation developed from the alignment of platy mineral grains of mica.

Gneiss

This specimen of gneiss is from the Mt. Ararat Formation. The lighter colored bands are composed of feldspar and quartz, whereas the darker colored bands contain an amphibole. These different compositional layers may represent layers of volcanic ash that have since been metamorphosed into the minerals now present in this specimen. The layers in this were likely deformed during the course of metamorphism, the resulting folds are evidence of this process. To see this rock in outcrop, visit the Androscoggin Brunswick-Topsham Riverwalk.

Figure 20a. The bulls-eye on the top right of the specimen marks the core of a series of folded layers. The specimen is approximately 30” tall.

Figure 20b. Close-up of alternating layers of darker (amphibole-rich) and lighter (quartz and feldspar-rich) layers. The field of view is approximately 8” wide.

Schist and Granofels

This specimen from the Benner Hill formation consists of thin layers of interbedded biotite schist and quartzo-feldspathic granofels. The schist layers have been weathered out whereas the granofels layers (being more resistant to weathering) stand out prominently, which reveals the intricate folding in this specimen. Note the large z-fold in this specimen, and the smaller folding in some of the individual granofels layers.

Figure 21a. The darker schistose layers have been weathered out revealing the complex folding in the granofels layers, which are more resistant to weathering. Specimen is approximately 30” tall.

Figure 21b. Note the ptygmatic folds in the lighter gray granofels layers, on right of specimen. A ptygmatic fold is where the amplitude of the fold (distance from crest to trough) is nearly equal or equal to its wavelength (distance from crest to crest). The darker schistose layers have been weathered out revealing the complex folding in the granofels layers, which are more resistant to weathering. Specimen in approximately 20” wide at base.

Hydrothermal Vein Quartz

This specimen is from a hydrothermal quartz vein. There are several interesting qualities to this rock. Starting with the texture, light green subrounded fragments are surrounded by concentric oscillating, color zoned, bands of quartz. We believe that these fragments represent portions of the surrounding rock (country rock) that were incorporated into the hydrothermal melt. The fragments worked as nucleation sites for the quartz, which crystallized on and around the piece of country rock. Local changes in melt composition around the fragments led to the development of the alternating color banding. Some other interesting features are the cavities located throughout the specimen. Small quartz crystals are found lining the walls of the cavities. These represent pockets of an aqueous fluid that were unable to escape from the crystallizing hydrothermal solution. Quartz crystals were able to grow unobstructed into this fluid, forming euhedral (well-formed) crystals.

Figure 22a. Hydrothermal quartz vein boulder from Ellsworth, specimen is approximately 2’ tall. Note the brown rounded clasts surrounded by concentric growth bands and two cavities; close-up of lower cavity seen in next figure.

Figure 22b. Close-up of cavity, approximately 2” wide. Lining the inside of the cavity are euhedral (well-formed) quartz crystals.

Metasandstone and Metashale

This specimen is composed of alternating sandstone and shale layers. These layers have been slightly metamorphosed, hence the prefix 'meta'. The evidence for metamorphism is noted by the presence of mica flakes in some of the beds. An important observation to make for sedimentary rocks is to determine the "up" direction, the order in which the layers of sediment were initially deposited. This particular sample is a little tricky, but the slight degree of metamorphism this rock has endured is a key to identifying this "way up criteria". Remember those little mica grains? Mica grains are produced from the metamorphism of pelitic sediment, which is normally finer grained than the sandy, quartz-rich sediment. However, the mica grains appear to be coarser than the sandy materials.

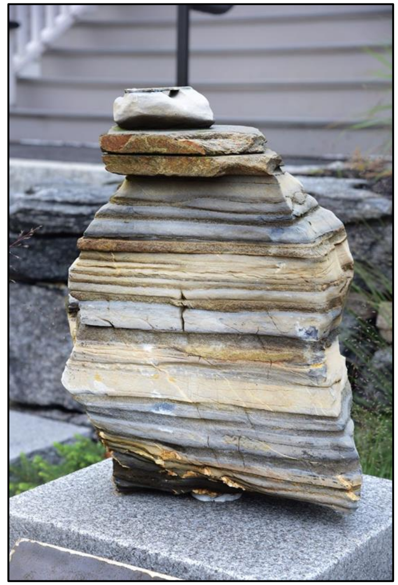


Figure 23a. Alternating metashale and metasandstone layers in this specimen from Avon, specimen is approximately 20" tall. Note that some layers are more resistant to weathering than others this is called differential weathering. It is the result of differences in composition between the layers where some materials are more susceptible to weathering than others.

Figure 23b. Close-up of thickest, lighter colored metasandstone layer in center, approximately 1.5" thick. Note the darker gray at the top of the bed, this is a "way-up" indicator. Finer grained material would have settled out last from a turbidity current. Finer grained material tends to be darker in color, whereas coarser grained material tends to be lighter colored.

The Seymchan Meteorite

This 3-ton meteorite is from northern Siberia, near the Seymchan River. It is one of numerous masses found from this locality, the first of which was discovered in 1967 by a geologist during field work. This particular specimen was discovered c. 2008 and is one of the largest on display in North America. This specimen is an example of an iron meteorite. The Widmanstätten pattern (a common feature of iron meteorites) is present on surface of this specimen, which is caused by the interlocking of two compositionally different iron-nickel minerals. Some surfaces consist of olivine suspended in an iron-nickel matrix which is typical of pallasites.

Figure 24a. The 3-ton Seymchan meteorite.

The Seymchan Meteorite (continued)

Figure 24b. A surface of the Seymchan meteorite showing the Widmanstätten pattern and regmaglypts displaying the the scalloped texture. Regmaglypts form on the surface of a meteorite as it is entering the Earth's atmosphere.

Figure 24c. A pallasitic portion of the Seymchan meteorite specimen in the middle and foreground of the image. The lighter colored, yellowish-green-brown portions are the olivine crystals. The dark brown-black portions are the iron-nickel matrix.

Additional Information

For more information about MMGM we encourage you to visit our website at https://www.mainemineralmuseum.org/ and also check out our Facebook page at https://www.facebook.com/mainemineralmuseum/.

References

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