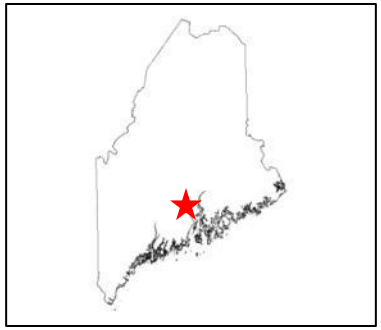
Geologic Site of the Month

July, 2006

Mosquito Mountain Granite Quarry, Frankfort, Maine



44° 34‘ 0.85“ N, 68° 52‘ 1.04“ W

Text by
Henry Berry

Introduction

The Mount Waldo Granite underlies an area south of Winterport and west of Bucksport, near the mouth of the Penobscot River, mid-coast Maine. The granite body is named for Mount Waldo in the town of Frankfort, the highest of a small group of hills underlain by the granite (Figure 1). Other hills include Mosquito Mountain, Mack Mountain, Heagan Mountain, and Treat Hill. The local topography is a result of the way this particular granite has eroded over geologic time.

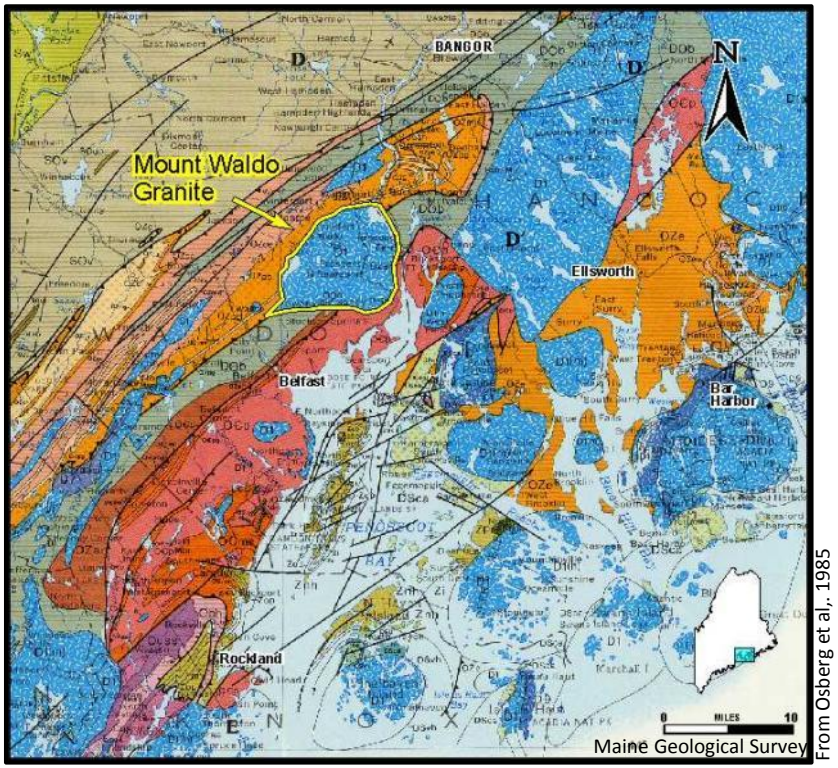
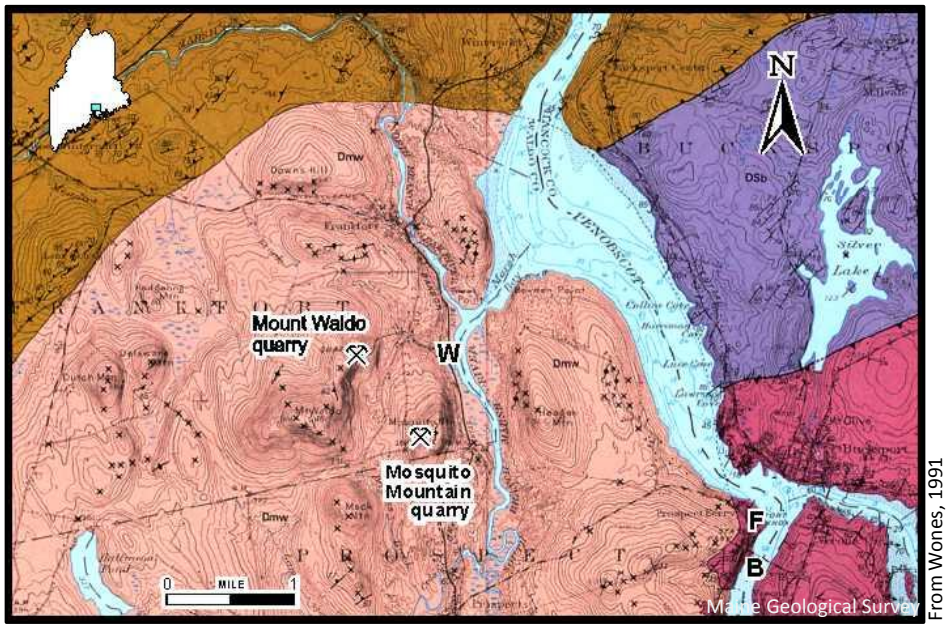


Figure 1. Geologic bedrock map of the Penobscot Bay region, mid-coast Maine.

Mining History

The combination of bare rock ledges and proximity to tidewater made this granite amenable to quarrying in the early 1800's. The two significant quarries in the Mount Waldo Granite in the 1800's were on the northeast flank of Mount Waldo itself, and near the top of Mosquito Mountain. According to a description of the operations from the early 1900's, the quarried stone was taken over graded tracks, operated by gravity, to cutting sheds and wharfs on Marsh River. From there it was taken on the Penobscot River and distributed to eastern ports in Massachusetts, New York, and Philadelphia, and to "western" cities of Chicago, Milwaukee, and Cleveland (Dale, 1907).



From Wones, 1991

Figure 2. Topographic map of the northern part of the Mount Waldo Granite, showing the group of hills held up by the granite bedrock (pink area labeled Dmw). Black X's and other symbols indicate natural outcrops of the granite. The W shows the location of the old wharf used for shipping granite in the 1800's and early 1900's. F is Fort Knox, and B is the site of the new Penobscot Narrows bridge to Verona Island.

Modern Mining

After lying dormant for years, the quarry on Mosquito Mountain was recently reactivated by Freshwater Stone, a local small business that designs and crafts stone products, mostly for in-state projects. As with most Maine granite quarries, there is plenty of quality stone left in the ground for the entrepreneur who can carve out a market. The Mount Waldo quarry is currently owned by the town of Frankfort, which sells granite blocks from the tailings piles on a contract basis. The Mount Waldo quarry is open to the general public, whereas the Mosquito Mountain quarry is an active construction area (Figure 3) that requires special permission of the owner for access.

Figure 3. Quarrying at Mosquito Mountain, May, 2006. A line of holes is being started on the top surface of the granite, generating the plume of dust. The vertical drill rig will then be used to drill holes to the desired depth to split blocks.

The Mount Waldo Granite

The Mount Waldo Granite has a coarse-grained texture (Figure 4), which gives it a more patchy, mottled look than the finer-grained granites.

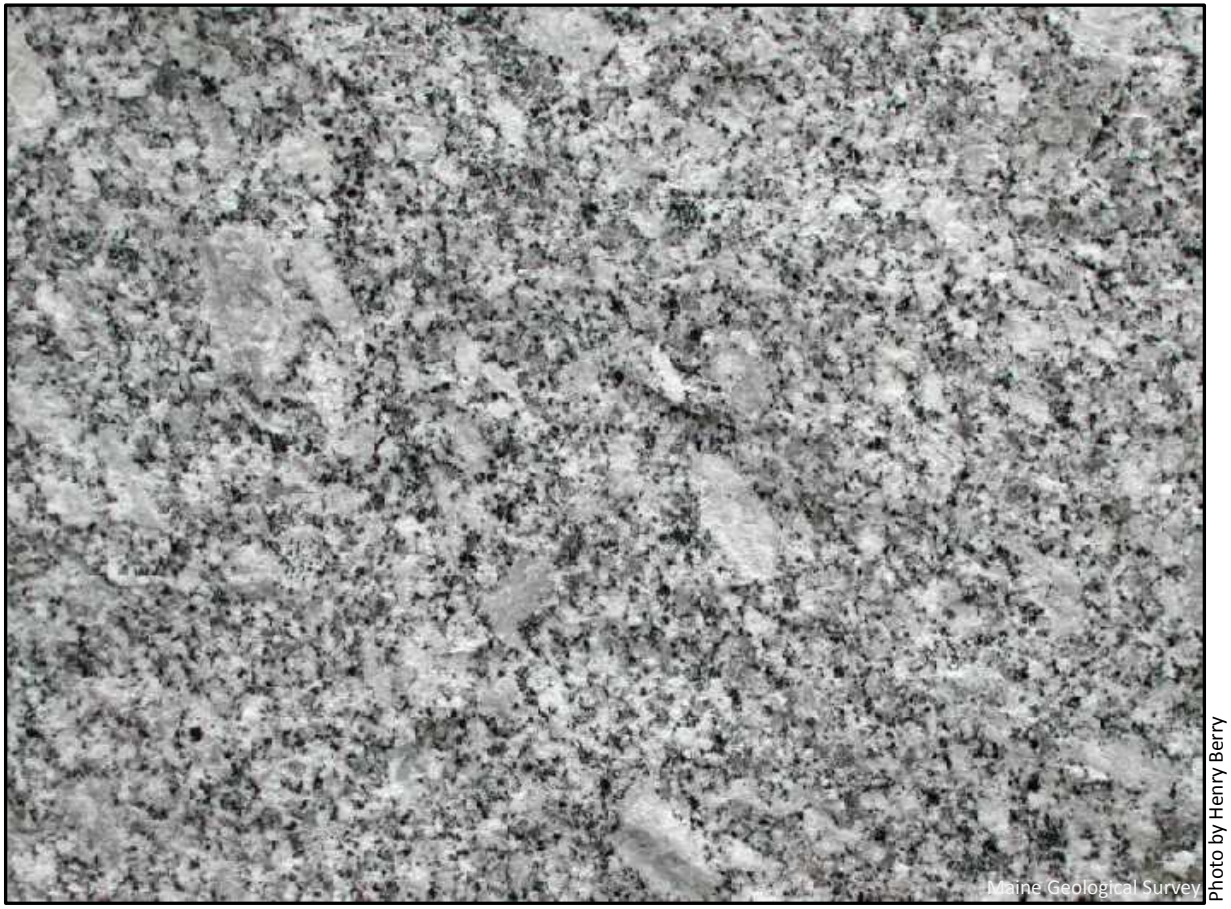


Figure 4. Mount Waldo Granite from the Mosquito Mountain quarry. Scattered larger grains of feldspar are characteristic. Note the approximate alignment of the large feldspar grains from upper left to lower right in this photo.

The Mount Waldo Granite

According to its mineral content it qualifies as a true granite, with approximately equal proportions of quartz, alkali feldspar, and plagioclase feldspar (Gibson and others, 2003). Black specks are scattered through the rock, consisting mostly of black mica (biotite) but also with minor hornblende in some places.

Its distinctive aspect is the presence of occasional large grains of white alkali feldspar up to an inch long. The large feldspar grains are more common in the Mosquito Mountain quarry than at the Mount Waldo quarry, though their abundance is variable across the dozens of square miles of the granite body.

Some of the larger, slightly grayish alkali feldspar grains are enclosed by rims of white plagioclase feldspar, a feature with the peculiar name of rapakivi texture, a name first used for granites in Finland over a century ago (by Sederholm, 1891, cited in the Timetable of Petrology).

The Mount Waldo Granite

The large, elongate feldspar grains are more or less aligned in many places, giving a subtle sense of direction to the stone (Figure 5). This characteristic was called "flow structure" by Dale (1907), because it reflects the flow of the molten mass before it solidified into granite.

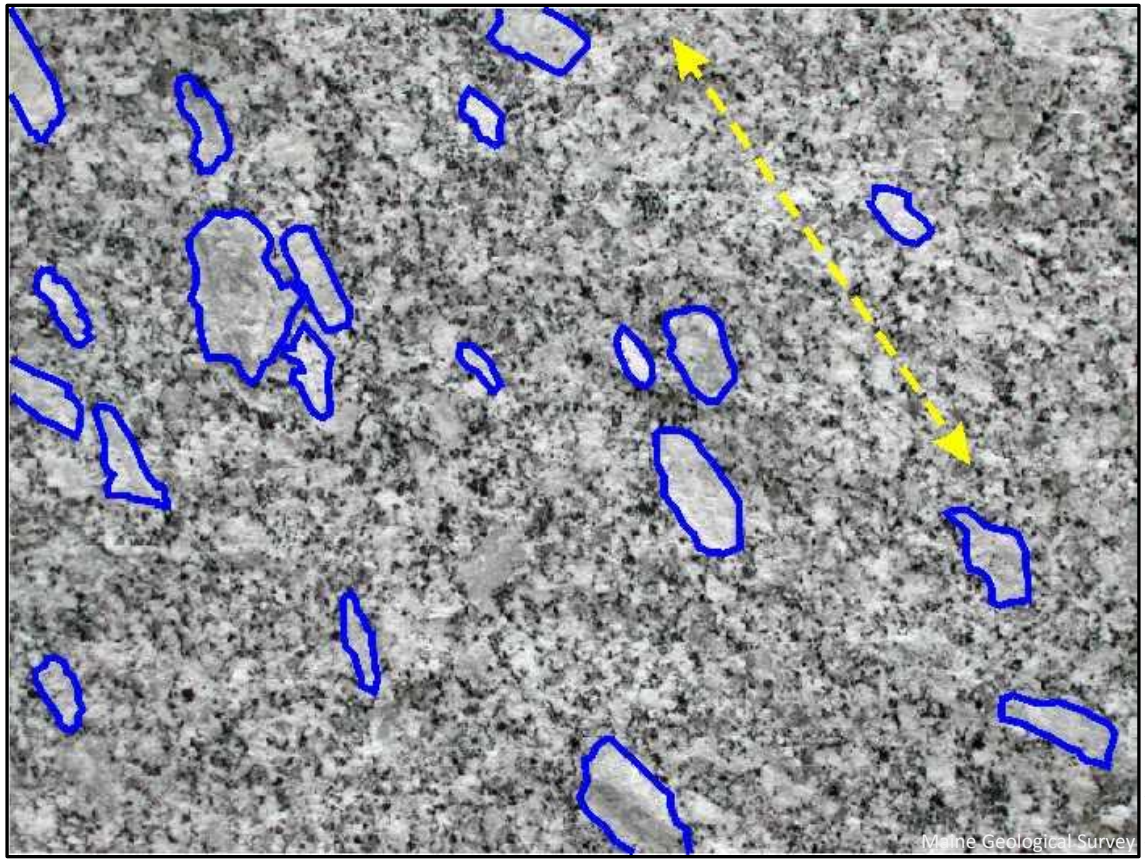


Figure 5. Mount Waldo Granite from the Mosquito Mountain quarry, with larger feldspars outlined. Arrow shows approximate alignment direction. This alignment was caused by flow in the magma before it was completely solidified.

Geologic History

The pattern of this internal structure was further investigated by Trefethen (1944) who mapped it across the granite body and found it to be parallel to the northern and eastern margins of the granite, while being at a high angle to the older fabric in the surrounding metamorphic rocks (Figure 6). These observations demonstrate that the feldspar alignment is a property of the granite itself, related to its process of formation, and that the granite was emplaced after the country rocks had been foliated.

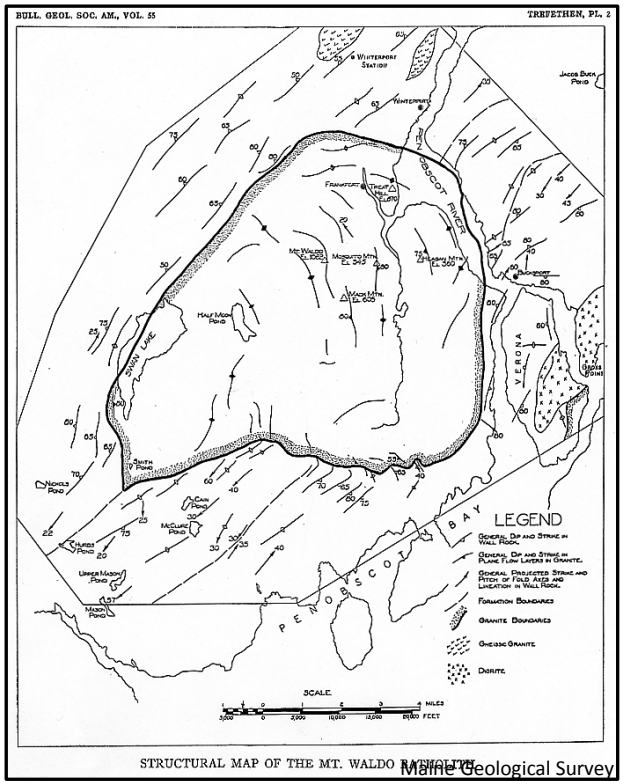


Figure 6. Structural map of the Mount Waldo batholith and neighboring country rocks. (Used by "Fair Use" provision of Geological Society of America policy.)

Solidification of the Mount Waldo Granite

The large rock exposures at the Mosquito Mountain quarry contain other clues to the formation of the granite. Thin dark layers (Figure 7-8) indicate the way in which the granite solidified, with successive layers being added to those already solidified. The thin, black streaks are concentrations of heavy mineral grains that accumulated on the side of the magma chamber as it was solidifying to form granite. The series of layers formed in sequence from left to right as the molten rock cooled, until eventually the entire body of magma had solidified to granite.

Figure 7. Layers in granite at the Mosquito Mountain quarry. Geologist Dan Lux of the University of Maine, shown here, has co-authored a paper describing some of the granite structure at this quarry.

Solidification of the Mount Waldo Granite

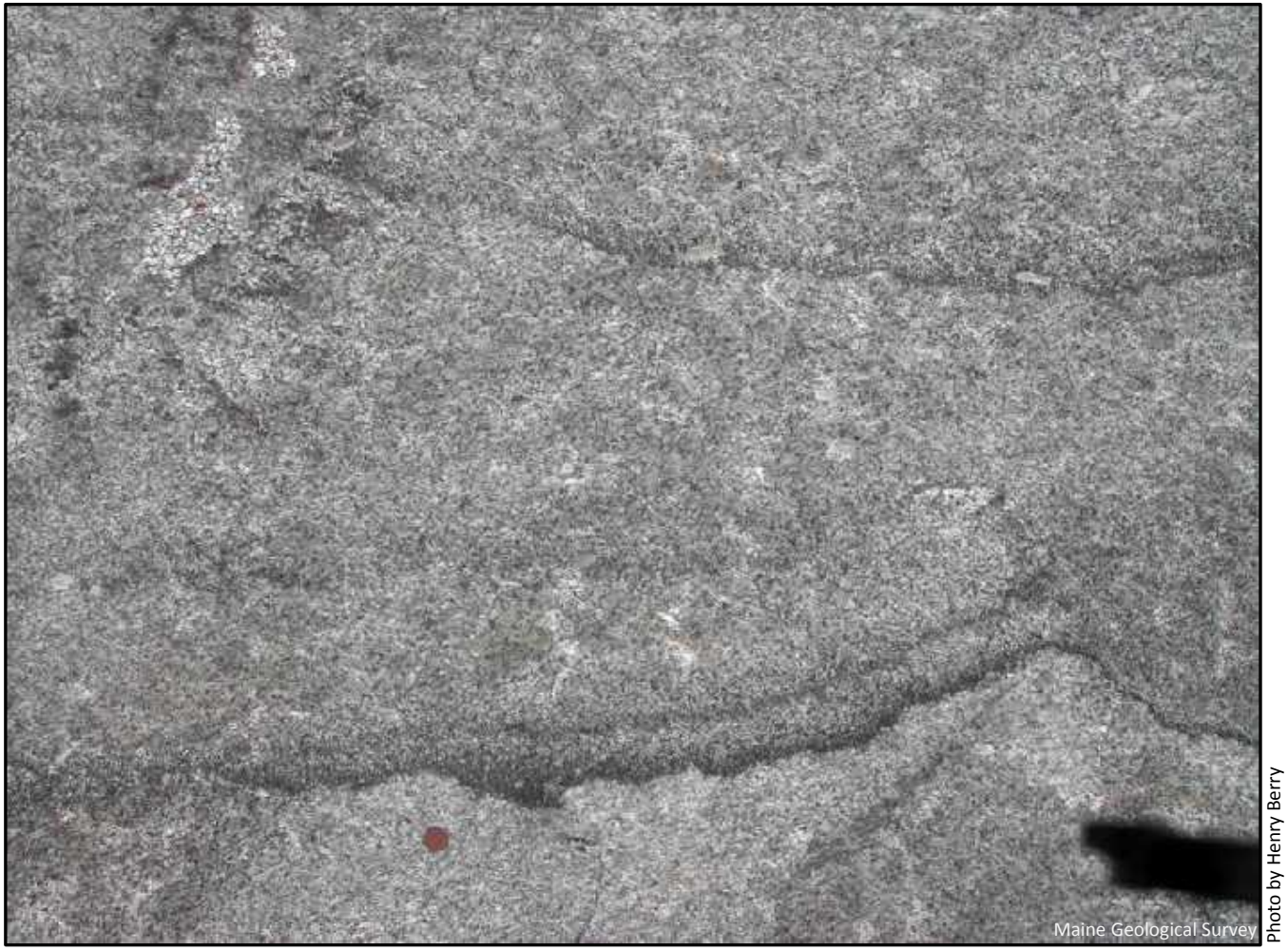


Figure 8. Close-up of the layers showing a wavy pattern that formed when the rock was still partly molten.

Solidification of the Mount Waldo Granite

Scattered blobs of finer-grained rock (Figure 9-10) are remnants of small batches of different magma that were stirred into the main granite magma, yet not completely mixed before it solidified. These features all testify to the movement of molten rock within the large magma chamber as the Mount Waldo Granite was emplaced in a molten state and gradually solidified into rock.

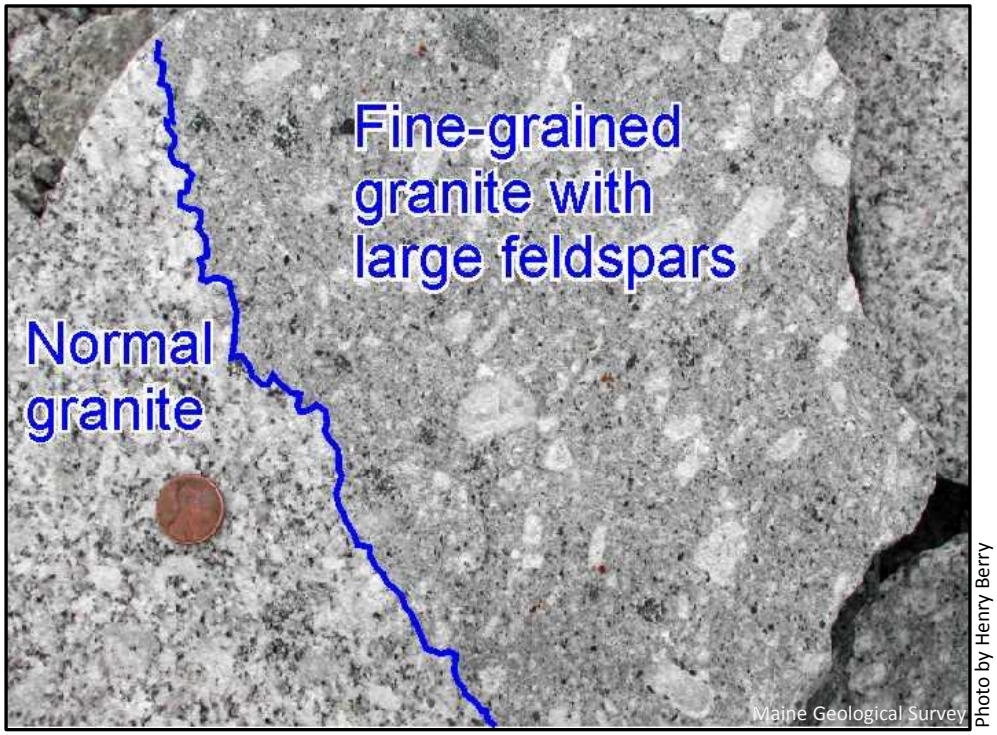


Figure 9. Large blob of fine-grained, medium gray granite on the right, enclosed by ordinary coarse-grained light gray granite on the left. The rocks have different composition, indicating that they solidified from different batches of magma.

Solidification of the Mount Waldo Granite

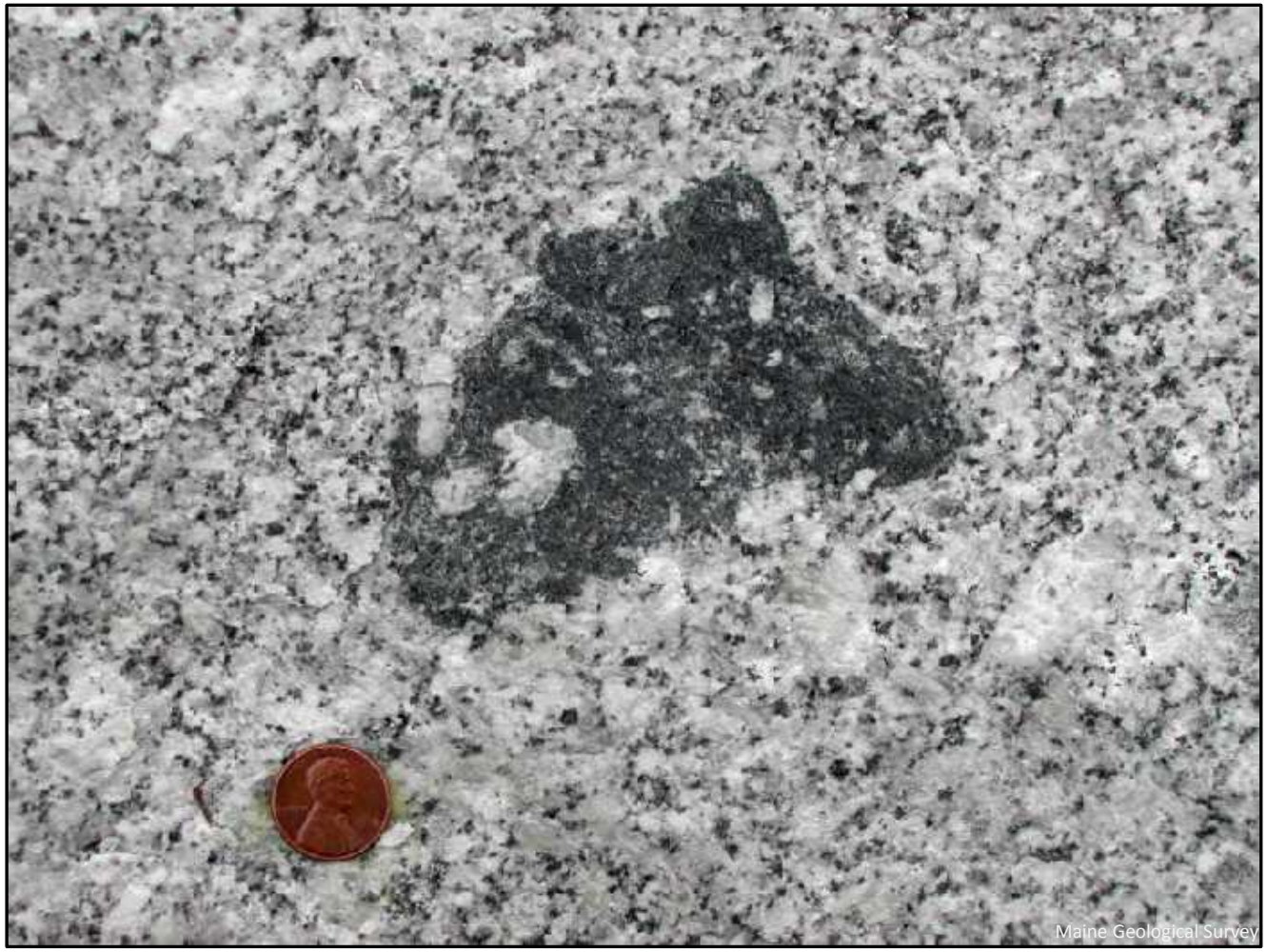


Figure 10. Small blob of dark gray rock enclosed by ordinary coarse-grained granite. Some large feldspar grains that had begun to form in the granite became detached from it and drifted into the molten blob of dark magma.

Solidification of the Mount Waldo Granite

Solidification happened in the Devonian Period of geologic time, as established by laboratory experiments on specimens of the granite that show it is 371 million years old, plus or minus 2 million years (by R. D. Tucker, reported by Stewart, 1998).

Not only did it happen a long time ago, but the process of granite formation took a long time to play out. In particular, it takes time for solid minerals to grow to the size we now see in the Mount Waldo Granite. Estimates from experimental and theoretical work are that it takes at least several tens of thousands of years and perhaps over a hundred thousand years for a sizable granite body to completely crystallize. Geologists have estimated that for the Mount Waldo Granite, this took place at a depth of about 7 miles below the surface at the time (Gibson and others, 2003).

Clearly, a significant amount of erosion has taken place since then to wear away the overlying rock and expose the middle of the granite to the modern land surface. Gravity surveys of the remaining granite (Sweeney, 1976) indicate that it continues for several miles below the ground surface still.

Mosquito Mountain Quarry

All the events of its geologic history combine to give the rock its character and structure. For quarrying, the most important features are the sheeting joints - long, nearly flat natural fractures that extend through the rock. These horizontal sheeting joints allow rock to be removed in blocks of appropriate thickness. At the Mosquito Mountain quarry, the vertical sides of the blocks are either cut by wire saws, or else broken apart by drilling a line of vertical holes and pouring in a water-based expansive mortar to push it apart (Figure 11). The orientations of the vertical faces are chosen to take into account the rift and grain of the rock, directions along which the rock has a natural preference to break on straight surfaces. These directions are not easy to see, and are discovered by experience

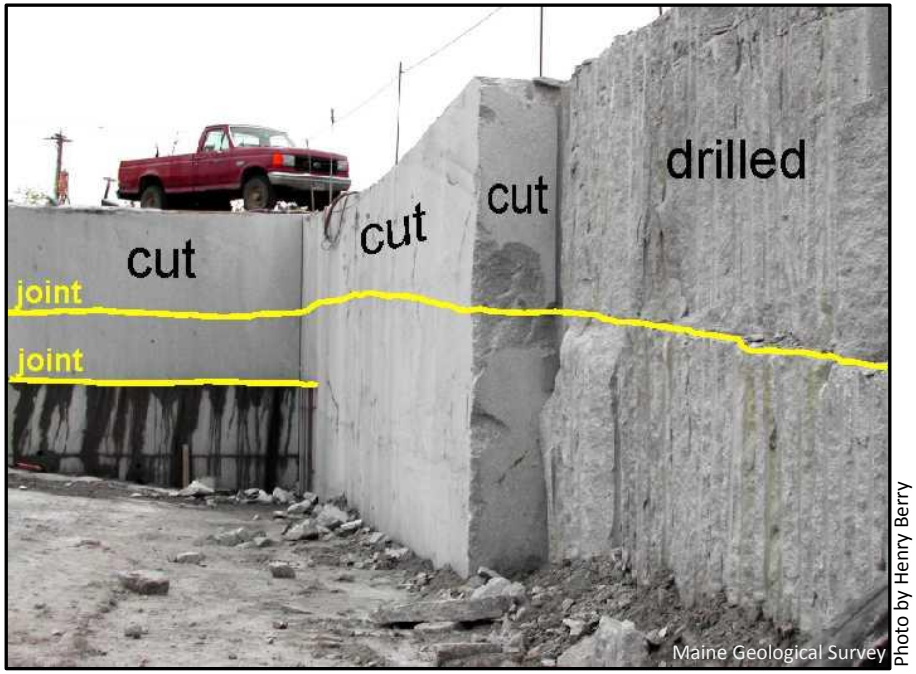


Figure 11. Wall of active quarry at Mosquito Mountain. Sheeting joints, cut surfaces, and drilled surfaces are labeled.

Uses for the Stone through the Years: Fort Knox, Prospect (1851-1869)

After suffering humiliation at the hands of the British Navy on the lower Penobscot River in the War of 1812, the U. S. government decided to build defensive installations along the Maine coast. The first and grandest of these was Fort Knox, in the town of Prospect, across the river from Bucksport. Over the course of 18 years, block after block was taken from the Mount Waldo quarry, transported down the mountain, then carried by river barge the five miles to the fort.

Fort Knox painting (1870-1875) by Seth Eastman in the U. S. Senate collection

Examples of stonework in the Fort

Information about the Fort

Fort Knox History

Uses for the Stone through the Years: Augusta Post Office (1890)

One of many post offices and federal government buildings in the eastern U. S. constructed of Maine granite in the late 1800's, the Augusta Post Office was built of granite from the Mount Waldo quarry (Rand, 1958).

Archival post card circa 1907

Archival post card circa 1920

Figure 12. Front of the old post office as it now stands on the east side of Water Street, Augusta.

Uses for the Stone through the Years: Augusta Post Office (1890)

Figure 13. A variety of Mount Waldo stone surfaces (Left). Faces of the wall are rough hewn, edges and corner blocks are sawn, columns and arches are turned, chiseled, and sculpted. Close-up of the granite in one of the rough blocks (Right). Notice the large feldspar near the center of the photo, typical of the Mount Waldo Granite.

Uses for the Stone through the Years: Penobscot Narrows Bridge and Observatory (2006)

A new cable stay bridge is being constructed across the Penobscot River, to carry U.S. Route 1 to Verona Island. The western pylon of the bridge will contain an elevator to an observation deck at 420 feet, offering spectacular panoramic views. A large beam of Mount Waldo granite from the Mosquito Mountain quarry will rest over the entryway to the observation tower (Figure 14). Visitors to the tower will be able to see Mount Waldo, Mosquito Mountain, and Fort Knox, completing the granite connection between past and present.

Figure 14. Freshly quarried granite block over 20 feet long to be used over the observatory tower entryway (Left). Artist's rendition of the observation tower entrance (Right).

References and Additional Information

Dale, T. Nelson, 1907, The granites of Maine: U. S. Geological Survey, Bulletin 313, 202 p.

Gibson, D., Lux, D. R., and Choate, M. A., 2003, Petrography of a "cryptic" mixed magma system - the Mount Waldo granite, coastal Maine: Atlantic Geology, v. 39, p. 163-173.

Osberg, Philip H., Hussey, Arthur M., II, and Boone, Gary M. (editors), 1985, Bedrock geologic map of Maine: Maine Geological Survey, scale 1:500,000.

Rand, John R., 1958, Maine granite quarries and prospects: Maine Geological Survey, Minerals Resources Index No. 2, 50 p.

Sederholm, J. J., 1891, Über die finnlandishen Rapakiwigesteine: Tschermaks Mineralogische Petrographische, Mitteilungen 12, p. 1-31.

Stewart, David B., 1998, Geology of northern Penobscot Bay, Maine, with contributions to geochronology by Robert D. Tucker: U. S. Geological Survey, Miscellaneous Investigations Series Map I-2551, 2 sheets, map scale 1:62,500.

Sweeney, J. F., 1976, Subsurface distribution of granitic rocks, south-central Maine: Geological Society of America, Bulletin, v. 87, p. 241-249.

Trefethen, Joseph M., 1944, Mt. Waldo batholith and associated igneous rocks, Waldo County, Maine: Geological Society of America, Bulletin, v. 55, p. 895-904.

Wones, David R., 1991, Bedrock geologic map of the Bucksport quadrangle Waldo, Hancock, and Penobscot Counties, Maine: U. S. Geological Survey, Geologic quadrangle map GQ-1692, scale 1:62,500.

Thanks to Jeff Gammelin for allowing access to the Mosquito Mountain quarry