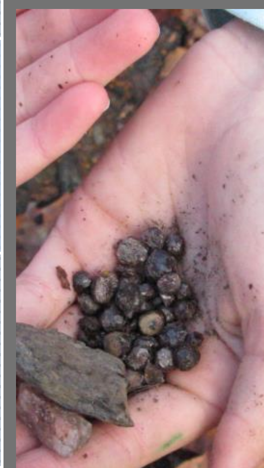
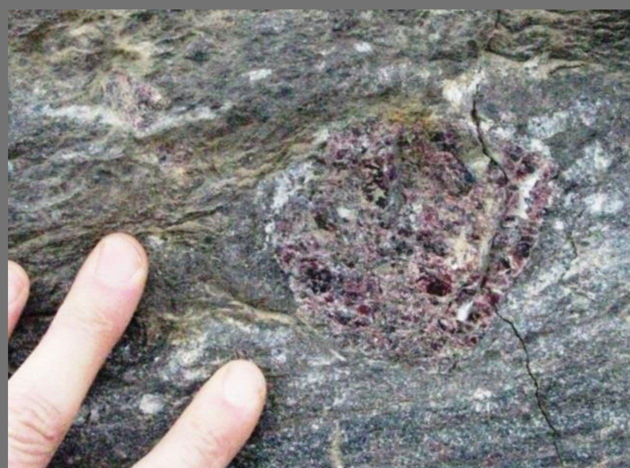




A Guide to some of Connecticut's Best Public Sites to find Garnet.

Brief descriptions of the minerals and geology found at each site, as well as directions and information about each of the trails.

Created by the Connecticut Geological Survey - Department of Energy and Environmental Protection. 2015.

Almandine garnet is the state mineral of Connecticut. We have developed a trail highlighting locations where the state mineral may be found easily. These sites are within state parks and forests (and may require an entrance or parking fee during the season) or other lands that are accessible to the general public such as municipal parks, conservancy land, and privately-owned land to which the public has been given right-of-way access. Most include a short hike in a recreational area. The Connecticut Garnet Trail is designed to increase public understand-ding of local mineralogical and geological features. A brief illustrated report describes the features of each locality and includes a map.

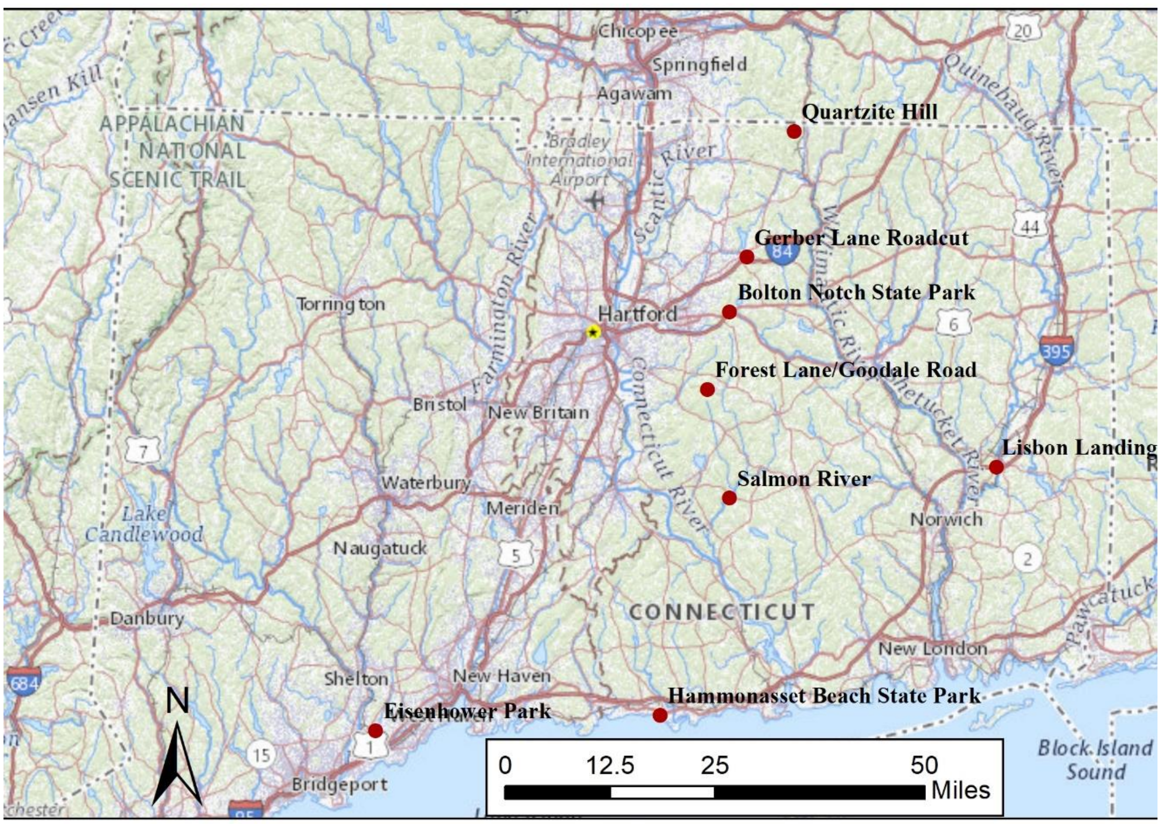
Almandine garnet is a mineral that may occur in igneous, metamorphic or sedimentary rocks, but in Connecticut it is most commonly found in a metamorphic rock called schist. Schists can form when sedimentary pelitic rocks (known as shale) are exposed to high temperatures and pressure (metamorphism). Garnets are commonly found in rocks that have been through strong to intense metamorphism (medium- to high-grade metamorphism). The composition of the original rock or "protolith" can vary, but if there is enough aluminum in the composition during metamorphism, garnet will form. This composition can be provided by rocks abundant with aluminum-rich clay minerals. Sediments deposited in the deep oceans (pelitic sediments) are clay rich and can form shale. Pelitic shale is thought to be the protolith for most of the garnet bearing schist found in Connecticut.

Garnets are not an uncommon mineral in metamorphic rocks, especially in those that have subjected to higher temperatures and pressures during metamorphism. They are found commonly in rocks that were rich in aluminum before metamorphism. Their sizes can vary, and are commonly found to be as small as a grain of sand or as large as a marble. Besides their use as gemstones, garnets are commonly used in abrasive materials such as sandpaper and nail files, due to their hardness.

THE CONNECTICUT GARNET TRAIL: INTRODUCTION

In eastern Connecticut, garnet is found in abundance in certain layers of rocks that are Siluro-Devonian[1] in age (rock formations such as the Littleton Formation and Clough Quartzite formation). In southern Connecticut, garnet is found in layers of the same age in the Wepawaug Formation. In western Connecticut, it is found in rocks from the Cambro-Ordovician period[2] in the Rowe Schist Formation. It is also found as a detrital mineral[3] in some modern streams and beaches. Garnet also may be found in other rocks that were not originally peletic shale. The "Geology of State Parks" section[4] on the State Geological Survey of Connecticut and Department of Energy and Environmental Protection website indicates that garnet can be observed at many of the state parks and forests of Connecticut. We have picked out some of the better localities for the Connecticut Garnet Trail (see map and following descriptions).

IMPORTANT: Please do not collect the minerals. Collecting minerals is prohibited on state land. These minerals are for all of the citizens of Connecticut to enjoy. Please be considerate of others and take nothing but photos. Thank you for your cooperation!



1. Siluro-Devonian: A period of the Paleozoic Era, ~400 million years ago.
2. Cambro-Ordovician period: A period of the Paleozoic Era, ~550 million years ago.
3. Loose fragments or grains that have been worn away from rocks.
4. Go to www.ct.gov/deep/geology and click "Geology of State Parks"

Quartzite Hill: Garnets in the Clough Quartzite.

The outcrop belt of the Clough Quartzite and Littleton Schist extends from Cobalt, Connecticut, well north into Massachusetts and New Hampshire. In most places, the base of the Clough contains a metamorphosed (changed by heat/pressure) quartz-pebble conglomerate[1] which is overlain by beds of quartzite. The quartzite beds become progressively thinner and gradually become interbedded with mica schist as the Clough grades upward into the overlying Littleton Formation (mica schist). The schist was originally formed as mud on the sea-floor. The sea-floor mud later lithified (hardened) to form shale before being metamorphosed into schist.

Quartzite does not usually produce garnets during metamorphism because the rock composition normally does not contain enough aluminum and iron to form the garnet. The Clough however *is* garnet bearing. Indeed the garnets exceed a centimeter in diameter in some places. The iron and aluminum needed to form garnets most likely were derived from the interbedded schist (schist layered between the layers of quartzite). In places the schist apparently dissolved during the metamorphism, leaving only the garnets to bear testimony of its former presence.

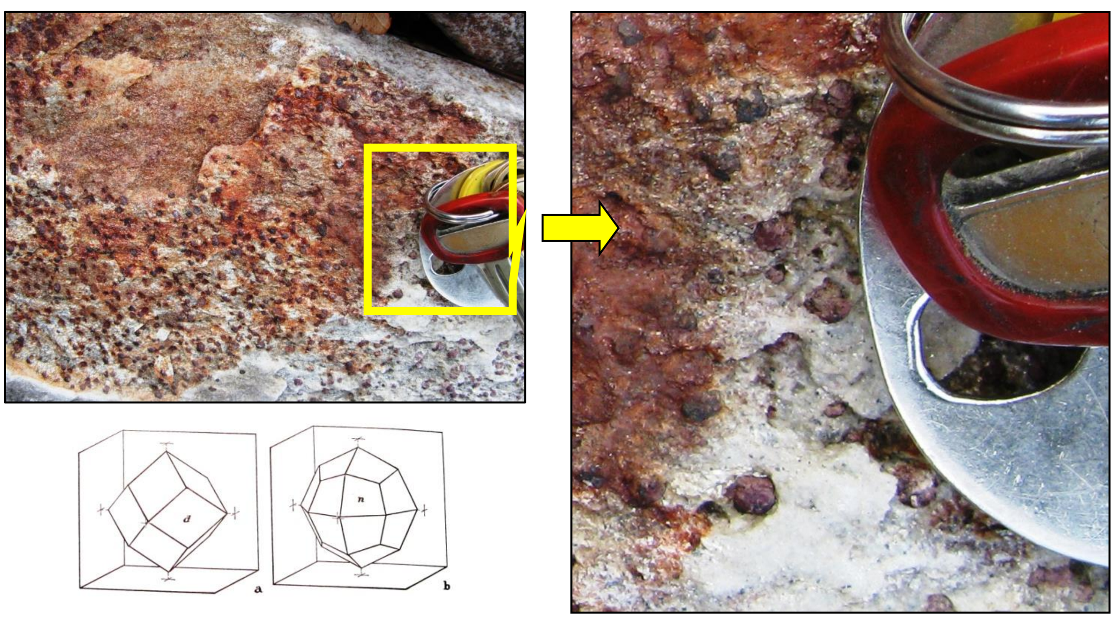


Figure 1. Rusty weathering garnet-bearing quartzite found at the top of Quartzite Hill. Garnet crystals are 1-2 mm in diameter. Garnets are associated with muscovite mica (pale orangish-brown color in upper left quarter of both the figure and the enlargement)) where the rock weathers rusty. Muscovite is absent in lower right view and the rock does not weather rusty. Disc partially visible beneath keys is 2" in diameter. Image on right is enlargement to show morphology of garnet crystals. Most appear to be trapezohedrons (labeled b. on diagram) rather than dodecahedrons (a. on diagram). No diamond shaped faces characteristic of the dodecahedron is seen.

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1. **Conglomerate:** A sedimentary rock composed of many clasts (pieces of other rocks) "stuck" together as the matrix (glue: ie mud) hardens.

Quartzite Hill

The name "Quartzite Hill" was given to this area in the 1990's by University of Connecticut geology students who were taught geologic field methods there. The Clough Quartzite underlies several hills including this one (Figure 2). These hills have steep (locally cliffed) east facing slopes and gentler west facing slopes. The hills stand high because the quartzite here resisted erosion from the glaciers during the last Ice Age better than the schist and gneiss of the overlying and underlying formations. This garnet trail involves a hike of about a mile and three-quarters over trails that locally are moderately rough and moderately steep. Cliffs, some more than 50 feet high, are present in the area and ***young children should be carefully supervised***. *NOTE*: *Neither water nor sanitary facilities are found in the area.*

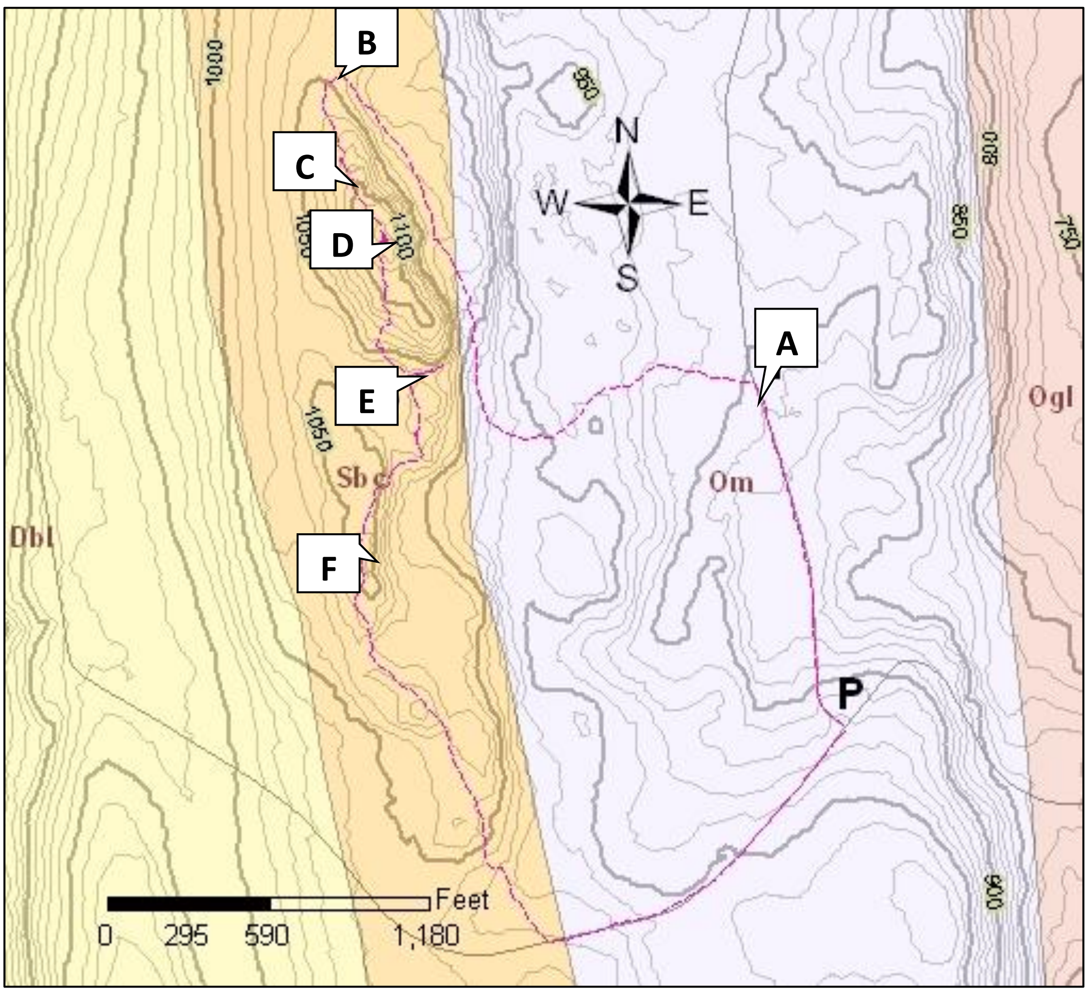

Figure 2. Geologic map (Rodgers, 1985) showing the trail and underlying geologic formations. The Monson Gneiss (very light grey, Om) and Glastonbury Gneiss (pink, Ogl) are the oldest rocks. They are unconformably overlain by the Clough Quartzite (orange, Sbc) which grades upward to the Littleton Formation (yellow, Dbl). P is the parking area off Crow Hill Road; the numbers refer to the way-points mentioned in the Trail Guide. Contour interval: 10 feet.

The Garnets

Garnets are found on many of the outcrops at the top of the cliffs. The best garnet locality we have found is the very top of the hill. A prominent mid-sized fold in the bedrock can be seen that is a product of the same metamorphism that formed these garnets (Figure 3a). These conditions allowed for the garnets and muscovite to grow along the fold. The garnets are up to 3mm in diameter (Figures 1 and 3c) and found in bands parallel to the foliation (layering) that is seen in the fold (Figure 3c and d). Muscovite is illustrated in the enlarged Figure 1 but may be easily seen by close inspection of the outcrop (see enlargement of Figure 1).

The garnets at the top of Quartzite Hill have a unique crystal shape. They appear to be "trapezohedral[2]" rather than the normal "dodecahedral" (or diamond) shape. Most of the garnets at Connecticut Garnet Trail localities elsewhere are "dodecahedral" and are different from these.

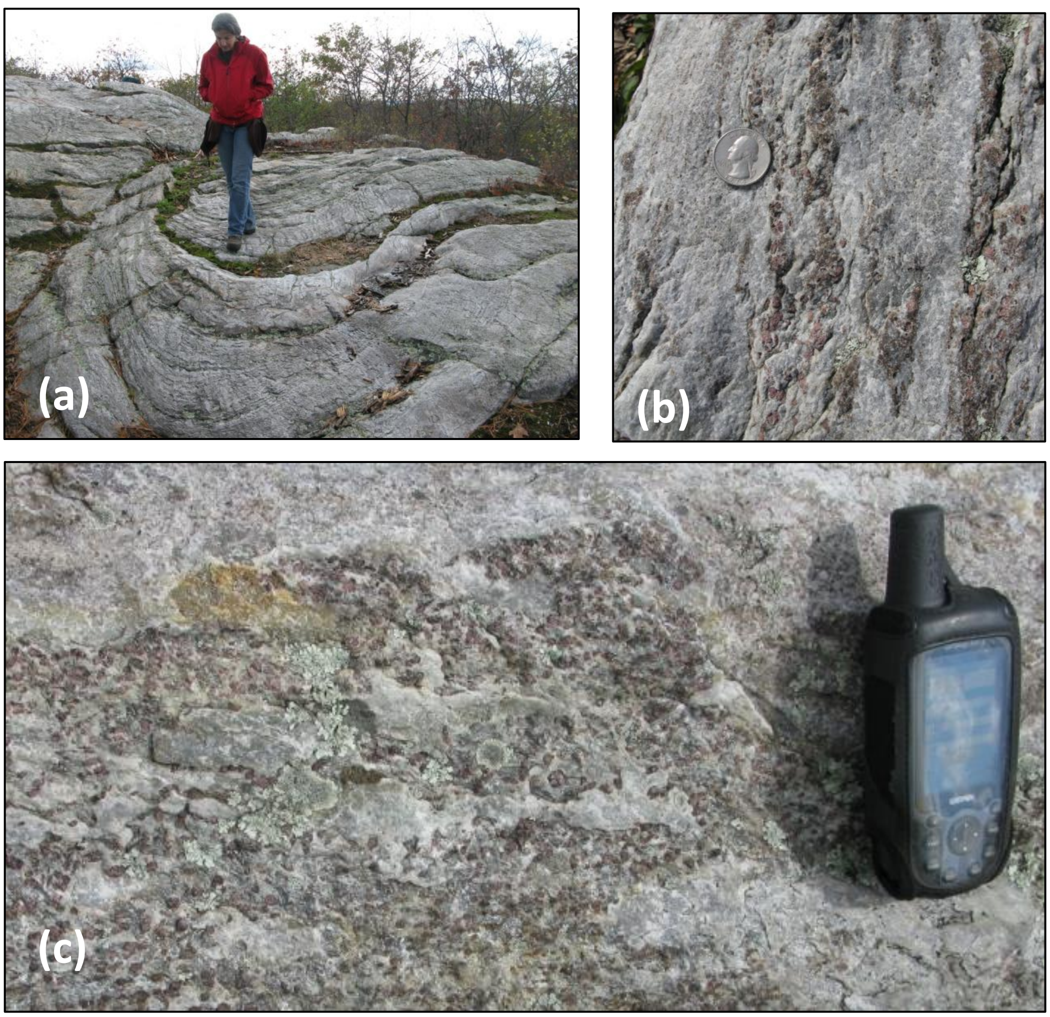

Figure 3. (a) The bedrock fold in quartzite near top of Quartzite Hill. The foliation ("layering") is visible below geologist's feet. (b,c) Detail of foliation. Garnets are 1-3 mm in diameter and line up with the foliation.

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2. **Trapezoid:** a shape that has 1 set of long/short parallel sides and 2 sides that open away from each other; a half hexagon).

Trail Guide

The parking area (labeled P on Figure 2) is located in front of a locked gate (at the following coordinates for those of you with a GPS unit: **N. 42º01.254', -072º20.322'**). Be sure to park out of the way as some days several cars may use this area. **Note* The area is open to hunting during the various seasons and bright clothing is recommended*. Figure 2 is a map of the area showing the trail. Follow the forestry service road north about a quarter mile to an intersection on the left with another service road (**way-point (A)**; Figure 2). Follow this second road west. It will gradually climb a gentle hill and the road will get rough in places. Do not take the small trails that branch to the left. In about a quarter mile the road will swing around to the north. If the trees are bare of their leaves you will notice cliffs (see Figure 4a) to your west (left). These cliffs are composed of Clough Quartzite. Eventually this trail will go around the end of the cliffs and climb a hundred feet to get to the top.

First, continue going north on this road for a little more than a quarter mile where the trail will branch. Turn sharply left at the branch (**way-point (B)**) and begin climbing the hill. The trail will swing around and head south as it climbs. A little more than 100 yards up the hill (**way-point (C)**) you will pass a huge boulder composed of Glastonbury Gneiss. It sits on top of the Clough Quartzite. This is a *glacial erratic*, or a bolder left out of place by the glaciers. It looks precarious but several groups of students have not found a lever sufficient to topple it.

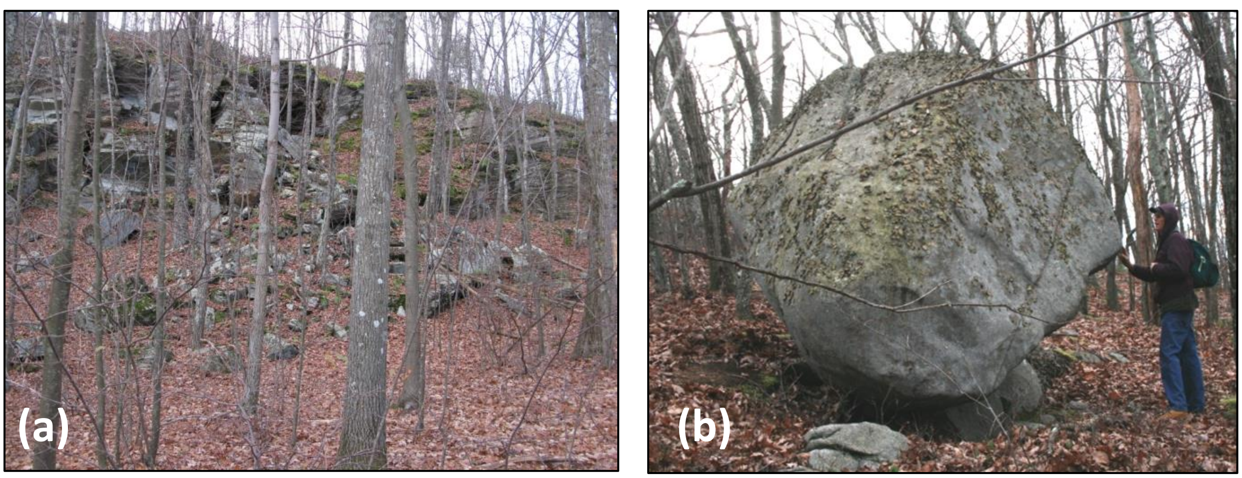

Figure 4. (a) Cliffs to west of trail prior to reaching way-point (B). This is near the northern end of the Quartzite Hill segment. Note rubble strewn at base of cliff, likely the result of a rock fall after the Ice Age glaciers had melted. (b) Glacial erratic composed of Glastonbury Gneiss perched on top of Clough Quartzite. Figure 4b by Gary Robbins.

Continue past the *erratic* and notice that the ledge is composed of quartzite. You may be able to find some with garnet and/or staurolite. You are near the top. Straight ahead you will notice the rock layers have been folded into a U-shape (see Figure 3a; **way-point (D)) N.**

42º01.535', -072º20.698'. This fold formed when the rock layers were deeply buried, allowing them to reach high temperatures. Because they were hot, instead of breaking or crumbling, they buckled. If you look carefully at the ledge in this area, you will find there are many small and mid-sized folds in the rock.

Here you will find garnets in abundance. Some of the concentrations have mica with the garnets, others do not. Although not confirmed at this time, it is possible that alternating beds of shale and schist once existed along many of the bedding planes of this rock but were dissolved during the metamorphic event. Original clay minerals in the shale could have provided the necessary chemical ingredients to form garnet (and muscovite mica), including iron and aluminum.

At this location the elevation is about 1125ft and there are cliffs to the east and steep hills to the west. To the west (Figure 5a) you can make out the Connecticut River Valley in the distance; it is about 30 miles away. The valley is underlain by sedimentary rocks that were more easily eroded by the glaciers and the river and hence form a low area in the landscape. Note that the highlands both east (closer) and west (further) of the valley have about the same general level (elevation). They are underlain by metamorphic rocks. To the east, you can look out over rolling hills (Figure 5b). On a clear day you can see faintly a distant gray mountain standing slightly higher than the near hills. This is Wachusetts Mountain (elev. 2006ft) which is about 40 miles away.

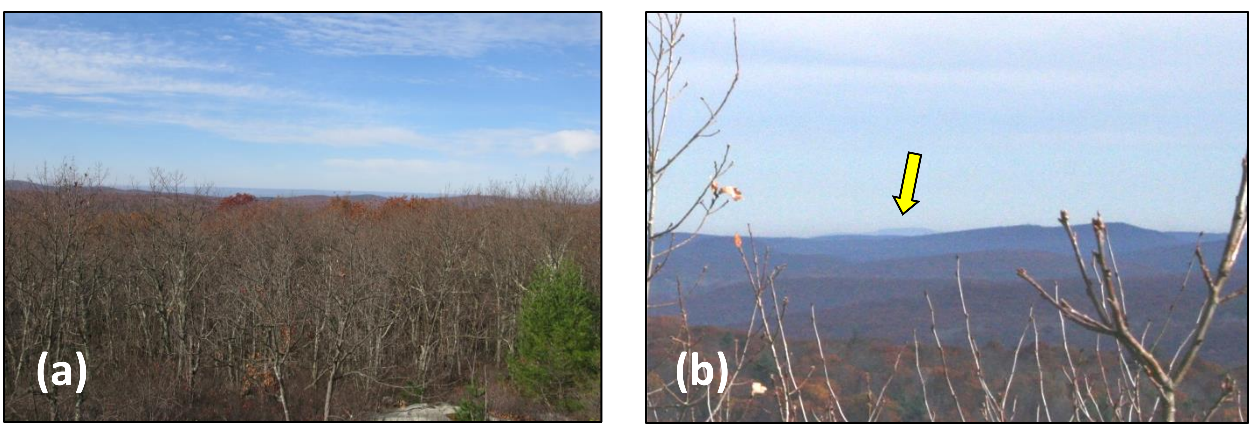

Figure 5. (a) View from Quartzite Hill to the west-southwest in the general direction of Windsor Locks. Soapstone Mountain is out of view on the left. The grey hills forming the distant skyline are the hills just east of Barkhamstead. The Connecticut Valley occupies the lowland west of Soapstone and east of Barkhamstead. (b) View toward the east-northeast in the general direction of Wachusetts Mountain in Massachusetts. The gray mountain peeking over the skyline in the middle is Wachusetts Mountain (yellow arrow). Figure 5b photograph by Gary Robbins.

When you continue south along the trail you will see the outcrops to your east. It is worth looking at some of these ledges, although the garnets included in the rock are neither as large nor as plentiful as at the top of the hill. You will find the layers are folded, but not as dramatically.

Continue southward about 150 yards (**way-point (E)**) to where the hills to your east become lower (this may be difficult to see when the trees have leaves on them) and turn toward the east. There should be a path that goes east on nearly level ground and then drops off. There you will be at the base of 15-25' high cliffs that become higher toward the north. The layers exposed on the edge of the cliff have been folded into a broad mid-sized fold (Figure 4). The quartzite beds here are massive and several feet thick, suggesting it is near the bottom of the formation. Although the grain-size (size of individual "pieces") is medium-to coarse-grained, the rocks do not appear to be conglomerate or even pebbly (like the original rocks that the quartzite came from), so the lowest layers seen here are not the base of the formation.

Here you can take one of two routes, one is shorter, the other has more interesting features:

Shorter Route: Continue down the steep hill (note that the path loses its definition when the slope increases) and intersect the logging road that you came on from the parking area. This will be a little quicker, but you will miss seeing the pebble quartzite-conglomerate. This route requires caution because the hill is very steep and may be slippery when icy or muddy. It may also be rocky and this route is not recommended if you do not have sturdy foot wear. Turn south (right) when you get to the service road and retrace the trail back to the parking area.

Alternate Route: Go back (west) to the main ridge-top trail and turn south (left). Follow this trail about 50 yards over a gentle hill. Eventually you will come to a low ledge (large, flat exposed rock) that drops steeply down to the right. Leave the main trail and cross down the ledge. Another trail is at the bottom. Follow that trail west, down across small bridge over a seasonal brook and steeply up the next ridge. Once on top of the next ridge, head southward. In about another 100 yards the trail will traverse rockier quartzite ledges (**way-point (F)**). Notice, that these rocks are much more "pebbly" than those at the top of the hill (Figure 6). This quartzite is made up of quartz pebbles up to 2.5 inches in length that are shaped like stretched, oblong footballs. Quartz pebbles found on beaches and in rivers are not normally as oblong as these. We infer that they were stretched during deformation of the rocks here rather than deposition.

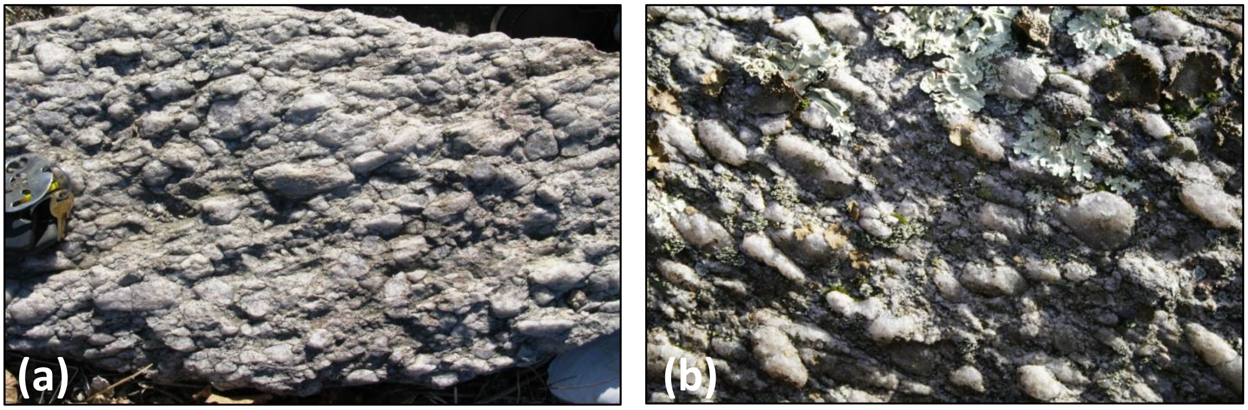

Figure 6. Quartz-pebble conglomerate. (a) Quartz pebbles are elongate to a greater amount than normally found in streams or along beaches. This in interpreted to be a result of the deformation undergone by this rock. Disc on key chain (left center) is approximately 2" in diameter. (b) Pebbles in this image are about 2" in length (maximum) and have up to a 3:1 ratio in the long:short axes of the grains. (Photograph 6b by Gary Robbins).

Follow the trail southward through mountain laurel forests, past a local quarry that produced a limited number of foundation and stoop stones, across a wet area that after rainfall and during the spring is practically swamp-like and eventually to Crow Hill Road. Your feet may get wet. Turn east (left) on Crow Hill Road and follow it back to the parking area.

Directions

The Quartzite Hill garnet location is north of Stafford Springs near the CT/MA border in part of the Shenipsit State Forest. To get there, take Rte. 32 N (exit 70 off I-84), through Stafford Springs, where it merges with Rte. 190 after the second exit off of the rotary. About a mile after merging, Rte. 190 bears left and Rte. 32 right: stay right on Rte 32. Continue about 3.75 mi north on Rte. 32 and look for Crow Hill Road on the left. It is immediately on your left when you first see State Line Pond on your right. If you miss it, take a left on State Line Road, which is about a long city block farther north: it will intersect Crow Hill Road. If you cross the state line and go into Massachusetts, turn around and come back. Follow Crow Hill Road about 1.25 miles and, nearing the top of a grade after a sharp left curve, find a parking area on the right at a Forestry Department service road. The trail initially follows service roads but later ascends a steep ridge and follows the ridge-top (there will be some spectacular views).

Reference:

Pepper, J.D., 1977, Bedrock Geologic map of the Monson Quadrangle, Massachusetts and Connecticut (1:24,000). U.S. Geological Survey. Geol. Quad. Map GQ-1374

Rodgers, John, 1985, Bedrock Geological Map of Connecticut (1:125,000). State Geological and Natural History Survey of Connecticut, Nat'l. Resource Atlas Series

Stone, J.R., Schafer, J.P., London, E.H., DiGiacomo-Cohen, M.L., Lewis, R.S., and Thompson, W.B., 2005, Quaternary Geologic Map of Connecticut and Long Island Sound Basin (1:125,000). U.S. Geological Survey. Sci. Invest. Map # 2784.

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Garnet Trail funded through DEEP Greenways program (National Recreational Trails Program funding) to develop educational information on the Connecticut State Mineral, Almandine garnet. Locations chosen to promote a greater awareness of our State Mineral and showcase the variety of garnet occurrences on State Land.

Written by Randolph Steinen (Connecticut Geological Survey - Department of Energy and Environmental Protection), 2009. Edited by Lindsey C. Belliveau (Connecticut Geological Survey - DEEP) and Gary Robbins (University of Connecticut), 2013.

Connecticut Garnet Trail

Garnets in the Gerber Lane Roadcut, Tolland.

The Littleton Schist is garnet bearing almost wherever it is encountered. This is one of three Connecticut Garnet Trail locations that look at the Littleton Schist (Glastonbury Park off Birch Mountain Road in Glastonbury, and off Forrest Lane in Glastonbury). In addition, another location (Quartzite Hill) looks at the Clough Quartzite, which underlies the Littleton Formation. The protolith[1] of the Littleton Schist was shale that accumulated during the Devonian period (some 350 million years ago) in the Iapetos Ocean, which was off the east coast of the ancestral North American Continent.

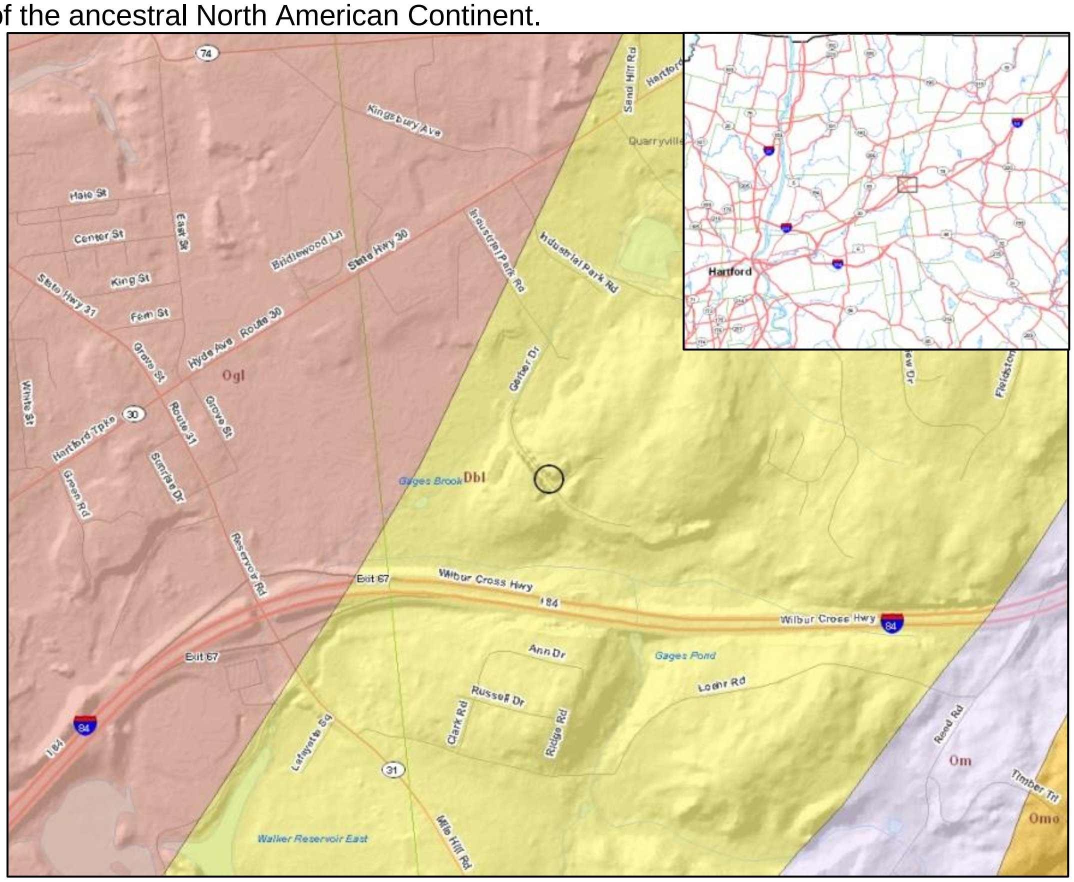

Figure 1. Map shows area underlain by Littleton Schist in yellow. Circle indicates east end of outcrop. Inset map shows northeastern part of Connecticut and location of this geologic map (box) with reference to the greater Hartford area. Although most of the road-cut outcrops contain small garnets, the far east end of outcrop is of most interest for this trail-site.

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1. **Protolith:** Term for the rock as it was before metamorphism (a process where rock is changed by heat/pressure)

Pelitic shale is an ocean-bottom deposit formed of clay minerals that are derived by weathering of preexisting rocks. The weathering process removes silica from the mineral, leaving aluminum behind, and in effect, increases the aluminum content of the weathered material. This is just what is needed for the creation of garnets during medium to high grade metamorphism.

Bedrock - Littleton Schist

The Littleton Schist is a silvery-gray garnet-bearing mica-schist. In many places it contains abundant staurolite crystals. However, except for the uphill (east) end of the outcrop, staurolite is not particularly prominent at this location. Throughout most of the outcrop, the garnet crystals are 1-2 mm in diameter and relatively equally dispersed throughout the rock. The size to which an individual garnet grows is determined by how much time is available for growth and how fast chemical constituents can be transported to the growing mineral. Transport of aluminum by chemical diffusion is a slow process, so most of the garnet crystals did not grow very large during the time the rocks were subject to the required temperatures.

At the far uphill (east) end of the outcrop there are abundant staurolite crystals (Figure 2). The staurolite crystals are large and brownish to dark gray in cross-section, with a fairly typical diamond-shape. They are of interest here because they engulf the 1-2 mm garnet crystals. It appears that the staurolite crystals grew after the garnet crystals had attained their current size.

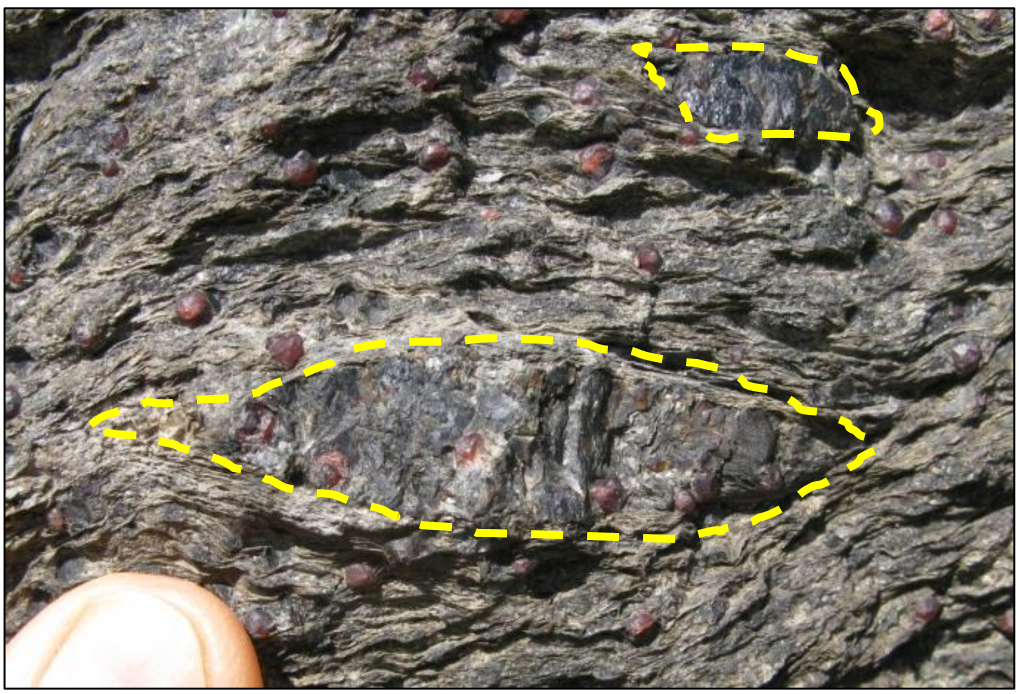

Figure 2. Staurolite (yellow dashed line) cross-section near the north end of the outcrop. It is shaped like an elongate diamond. This is a typical cross-section shape for staurolite. Note that the staurolite has grown around several small garnets. The garnets are same size as garnets in the matrix. Gray matrix surrounding the staurolite is composed of very fine-grained muscovite mica. Note small garnets scattered throughout the gray mica schist.

Professor Robert Wintsch (University of Indiana) suggests that the garnets may have grown during the Acadian Mountain building event (400-350 million years ago). The staurolites formed during the later Alleghanian event (300-250 million years ago) that heated the rocks to almost 600^{o}C when they were buried 30-40 km below the surface.

An interesting aspect of the Littleton Schist is that it easily gives-up its garnets during physical weathering. If you look carefully at places along the outcrop where rainwater washes down and onto the soil you will find numerous small garnets on top of the soil (Figure 3). Notice that these are about the same size as the garnets on the outcrop. They are easy to find because rainwater has washed away the smaller soil particles leaving behind garnets and small rock fragments. This concentration mechanism is similar to the processes that concentrate garnet on beaches and in river beds (see the Salmon River garnet site and the Hammonasset Beach site; note also the concentration of garnet crystals in the soil at the Glastonbury Park garnet trail site).

Figure 3. 1-2 millimeter garnet crystals, weathered out from their mica schist matrix, are concentrated on the soil surface at the base of the outcrops. Here rainwater has washed away smaller soil particles leaving behind the garnet crystals, hence concentrating them on the surface. This is the same mechanism that concentrates placer mineral deposits (accumulated deposits) and garnets on beaches and streams.

Directions

The location of this Garnet Trail is a relatively new road cut exposure of the Littleton Schist off Rte. 30 in Tolland (Figure 1). Take Rte. 31 (exit 67) from I-84 and go north about a quarter mile to the intersection with Rte 30. Turn east (right) on Rte. 30 and proceed about a half mile to Industrial Park Road on the right. Bear right onto Gerber Drive and go up the hill to prominent road cut outcrops of Littleton Schist. Park at or just past the far end of the outcrop and make sure your car is off the road. No-parking signs are posted all along Gerber Dr. For those of you with GPS units, the east end of the outcrop is located at **N. 41.857773º, -72.420990º.**

Reference:

Rodgers, John, 1985, Bedrock Geological Map of Connecticut. Connecticut Geological Survey National Resource Atlas Series.

Skehan, James W., 2008, *Roadside Geology of Connecticut and Rhode Island.* Mountain Press, Missoula, MT., 288p.

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The Mohegan Trail at Bolton Notch State Park.

This State Park, home to a US Greenway trail, was once a railroad in the 1850s that transported both passengers and freight for over 100 years. A major use for the railroad in this location was from the historic Bolton Notch quarry located just east of the park. An interesting railroad feature that can be found at this site is the impressive rock cuts that you can see along the trail. Garnets can be found in these outcrops with a trained eye, but since it is very weathered and wet they may be difficult to find. The primary focus of this stop is a side trail known as the “Mohegan Trail”.

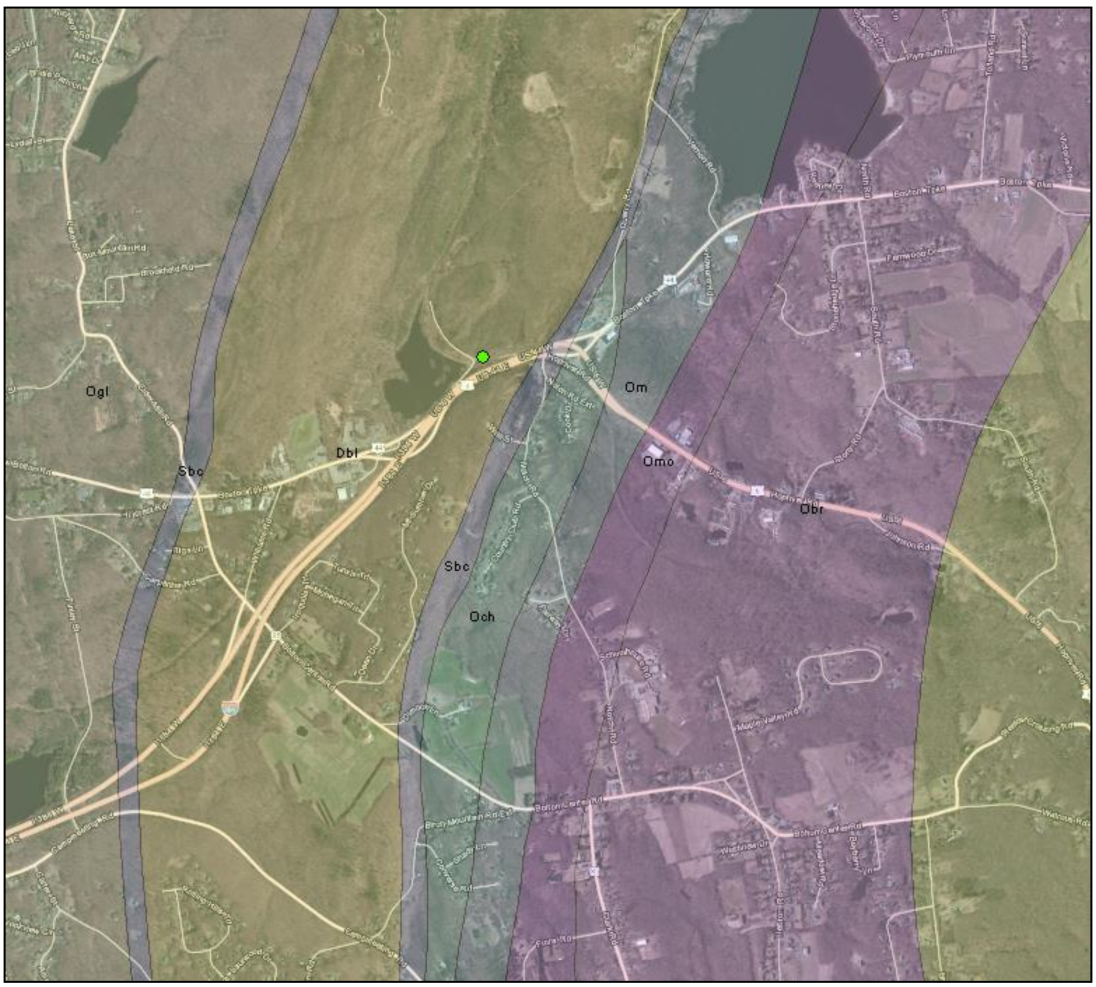

Figure 1. Aerial photograph taken in 2010 overlain by the bedrock in the area of the site. The park is represented by a green dot. This site is located primarily on Littleton Schist (Dbl) which overlies the Clough Quartzite (Sbc) that is exposed in some areas in the park. The garnets are found in Littleton Schist.

Figure 2. Abundant garnet in the Littleton Schist.

Begin your walk by taking a left on the trail from the parking lot (going toward the rock cut). After walking a short distance, you will see a sign on your right for the “Mohegan Trail”. The garnets are located along this trail. Immediately at its start, there are outcrops exposed on the ground with abundant garnets in Littleton Schist (Figure 2). Continue going up the trail and you will see more of this exposed schist as well as a lot of loose rock in the trail that presents garnet (Figure 3). If you continue to the top of this trail you will reach a large rock covered in spray paint. This is a pegmatite, or a coarse-grained rock formed when magma intruded rock deep beneath the earth’s surface and has since been exposed. Continue to the top of this paint covered rock for a nice view (watch young children near the edge).

Figure 3. Garnet can be readily found in the outcrop exposed along the Mohegan Trail as well as the loose rock surrounding

Bedrock – Littleton Schist

The Littleton Schist is a metamorphic rock that was originally formed by the lithification (hardening) of mud on an ancient seafloor. It was nearly flat lying when it formed but has since been deformed to the tilted rock we see today. The deformation occurred when the rock was deep (several km) underground and very hot. The heat and pressure of overlying rocks caused the original mud to metamorphose into the schist we see today. Garnet and staurolite are indicator minerals (Figure 4) that tell us the temperature and pressure during metamorphism and deformation was moderately high.

Figure 4. A close up of the garnet and staurolite in the Littleton Schist along the trail. Garnet is seen as the faint purplish spots (white arrow), staurolite is the thin, black mineral (yellow arrow).

In Connecticut, the Littleton Schist is found in the core (middle) of a long syncline (U-shaped fold in the bedrock) that is overturned toward the east. The east limb of the syncline dips (is tilted) toward the west. The west limb of the syncline is overturned, and because of that it also dips toward the west. In cross section, the syncline looks like a large letter U leaning, or tipped toward the east. The rock layers were originally formed in a near horizontal orientation. The tilted layers thus show deformation of the rocks during the plate tectonic processes to which they have been subjected. The syncline extends from Great Hill near Portland, Conn. northeast into Massachusetts and New Hampshire.

Directions

Parking is readily available at this site at the Bolton Park and Ride Commuter lot off the Rt-44 exit of I-384 (Yellow B arrow in Figure 5). A recent construction project has added a safe walking path from the Park and Ride lot past Bolton Pond (green star) to the entrance of Bolton Notch State Park (labelled in Figure 5). The entrance to Bolton Notch State Park is also accessible via a turn-off on I-384. It is suggested visitors do not use this entrance as the fast-moving traffic on I-384 and the lack of proper signage designating the entrance to the park can pose a hazard. **From Hartford:** Take I-84E to I-384E via exit 59.

Figure 5. Google Earth image of Bolton Notch State Park and Bolton Park and Ride, the suggested parking area to access the park.

Reference:

Rodgers, John, 1985, Bedrock Geological Map of Connecticut. Connecticut Geological Survey National Resource Atlas Series.

Geology of Connecticut State Parks: Bolton Notch. http:/www.ct.gov/deep/geology

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Written by Lindsey C. Belliveau (Connecticut Geological Survey - Department of Energy and Environmental Protection), 2014.

Forest Lane/Goodale Hill Road, Glastonbury.

Small clear maroon garnets are found scattered in the Littleton Formation. This location is along a gas transmission line right-of-way accessed by an unimproved/dirt road through a part of Meshomasic State Forest. The outcrop with the best garnets is just outside the state forest on land owned by the Town of Glastonbury. Land farther east is privately owned. We do not have permission to trespass on the privately owned land, so please stay on the trail. This locality is similar to the garnet locality on Birch Mountain Road in Glastonbury which is less than 2 miles to the northeast.

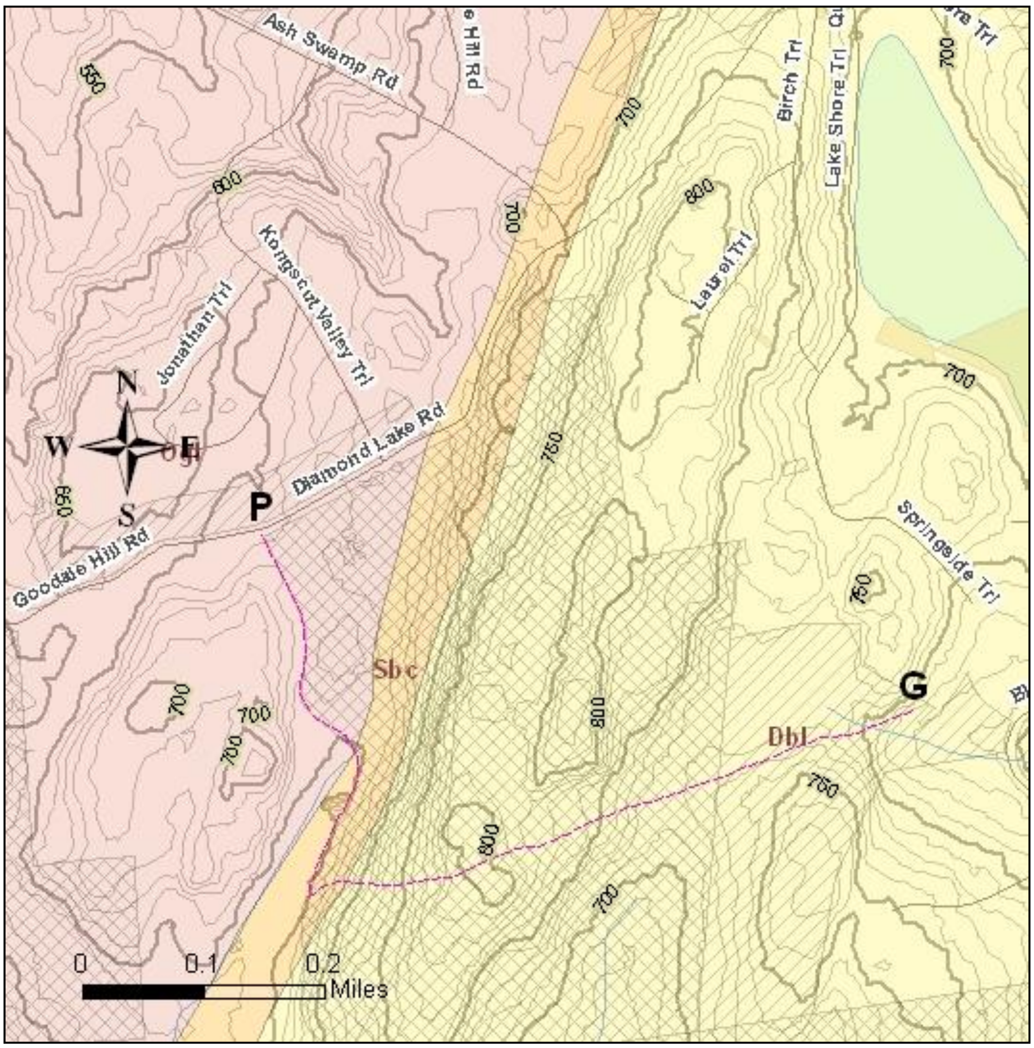

Figure 1. Topographic map (contour interval = 10') of area showing geologic formation boundaries. Area of Meshomasic State Forest is cross-hatched, open space owned by the city of Glastonbury is shown by diagonally ruled lines. Ogl (pink) = Glastonbury Gneiss; Sbc (orange) = Clough Quartzite; Dbl (yellow) = Littleton Formation. G marks location of garnet-bearing layers of Littleton Formation. P is the parking area and the trail is shown in pink. The road name changes from Goodale Hill Road to Forest Road a mile or so to the west of the map edge. Forest Road continues westward to its intersection with Rte. 83.

Bedrock-Glastonbury Gneiss

The trail begins on the metamorphic Glastonbury Gneiss (metamorphic, or “changed” by heat and pressure). Outcrops may be found off-trail on both sides just before crossing the Dark Hollow Brook. The contact of the Glastonbury Gneiss with the younger Clough Quartzite (metamorphic rock that is mostly quartz) is not well exposed at this locality but it is approximately where the brook crosses the road. Fragments of quartzite are abundant along the right-of-way on the west-facing slope of the first hill encountered. While you are trekking up that hill, keep your eyes open. The quartzite may contain garnets.

A short distance up the hill, you will cross the contact of the Clough Quartzite with the Littleton Formation. The Littleton is a silvery-gray to dark gray mica schist which contains garnet (small and somewhat spherical-shaped) and staurolite (elongate black mineral). Outcrops of the Littleton will be seen along the right of way and you should take time to look at them. The garnets are not particularly noteworthy although in some places they may be as much as a centimeter in diameter (see figure 4b) and they are sparse in most of the outcrops. Most of the rock does contain staurolilte crystals, however, and some may be a centimeter or two in length.

The View

From the top of the hill two nice vistas may be enjoyed. Toward the west one looks into the valley of the Connecticut River. The valley is underlain by Mesozoic[1] sedimentary and igneous rocks. Beyond the valley (faint grey hills forming the distant skyline) are the Western Highlands. The sedimentary rocks of the valley were easy to erode by the glaciers of the last ice age: they form the lowlands in central Connecticut. Rocks in both the Eastern Highlands and the Western Highlands are more difficult to erode. Hence, they stand up forming the higher ground in the landscape. Volcanic rocks in the valley are likewise more difficult to erode. Meriden Mountain (which may be barely made out as the hills of a slightly darker shade of gray just to the left of center in the above picture) and other ridges within the central valley stand up in relief also. The hills of Southington are seen in the distance about 20 miles away - a pretty good vista for Connecticut!

1. **Mesozoic:** A geologic Era, or time period, that occurred between 250-65 million years ago. This time is commonly known for its periods such as the Jurassic period, and as being the “time of the dinosaurs”.

Figure 2. Vista toward west from top of hill. The image has been darkened so that the hills in the valley can be seen more easily.

Looking toward the east one can see parts of three ridge-lines, all at about the same elevation. There is a concordance of elevations of ridge-lines roughly parallel to lines of longitude in Connecticut. The elevation of the ridges gradually increases northward so that hill top elevations are about 1100-1200' above sea level at the Massachusetts/Connecticut boundary in eastern Connecticut. This is one of the reasons why huge vistas are rare in Connecticut: because each ridge is about the same elevation, it is difficult to see beyond the next ridge. It is generally thought that Connecticut had much less relief prior to the ice ages and that the landscape was a rather low-relief plain that sloped gradually toward the sea. Glacial and post-glacial erosion cut the valleys, but left the ridge tops. Hence, the ridge tops reflect the pre-glacial landscape… a gentle southward sloping plane.

Figure 3. View toward the east from top of hill.

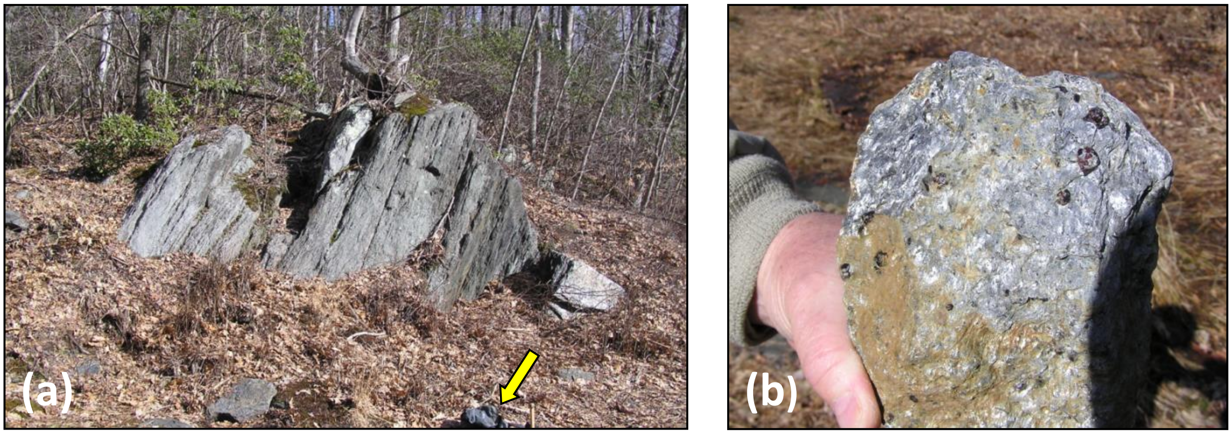

Figure 4. (a) Outcrop (left) with numerous small clear garnet crystals. Outcrop is about 4' high (backpack at bottom of picture shows scale; yellow arrow) and on north edge of right-of-way. (b) Garnet crystals in outcrop about size of smallest garnet crystals in hand sample (right). Hand sample was picked up along the right-of-way along the low, eastern-most hill. We have searched in vain for an outcrop that contains garnets this large.

State forest property ends at the bottom of the hill. The transmission line continues eastward through land owned by the Town of Glastonbury. A small intermittent stream crosses the right-of-way just the other side of the next small hill. An outcrop with both clear and opaque garnets is found just beyond the wet area of the stream on the north side of the right-of-way (see left hand picture above). The garnets are 1-3 mm in diameter and most exhibit nice dodecahedral (diamond-shaped) crystal faces. Note also that small staurolite crystals are found in the schist.

Directions

From CT Rte 83 (see index map above) in Glastonbury go east on Forest Road. Within about 1.5 – 2 miles the road surface turns to gravel and the name of the road changes to Goodale Hill Road. About a half mile further, the pavement returns and the road name changes to Diamond Lake Road. That is where to park; there is ample area just off the road (**N. 41.69082º, -072.49309º**).

A Forest Service road heads south behind a locked gate. This used to be a thoroughfare called Windham Road. Walk along that road a little more than a quarter mile until it intersects the pipeline right-of-way. The road usually is an easy walk although a small stream (Dark Hollow Brook) crosses it about half way in. Turn east and follow the right-of-way up a steep hill. Footing can be difficult because of loose rocks and erosion that formed shallow gullies. Follow the pipeline eastward another half mile to outcrops at the bottom of the hill on the north side of the right-of-way (**N. 41.68840º, -072.48302º**).

Reference:

Rodgers, J., 1985, *Bedrock Geological Map of Connecticut*. State Geological and Natural History Survey of Connecticut, Nat'l. Resource Atlas Series, 1:125,000, 2 sheets.

Skehan, James W., 2008, *Roadside Geology of Connecticut and Rhode Island.* Mountain Press, Missoula, MT., 288p.

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Written by Randolph Steinen (Connecticut Geological Survey - Department of Energy and Environmental Protection), 2009. Edited by Lindsey C. Belliveau (Connecticut Geological Survey - DEEP) and Gary Robbins (University of Connecticut), 2013.

CONNECTICUT Garnet Trail

Lisbon Landing: Garnets in the Tatnic Hill Formation.

These outcrops made of gneiss and schist were exposed during construction of an entrance to commercial buildings in Lisbon. They contain large garnets, faults (fractures along which rocks on opposite sides have moved under tectonic forces) and provide a safe accessible outdoor laboratory for geological observ-ations.

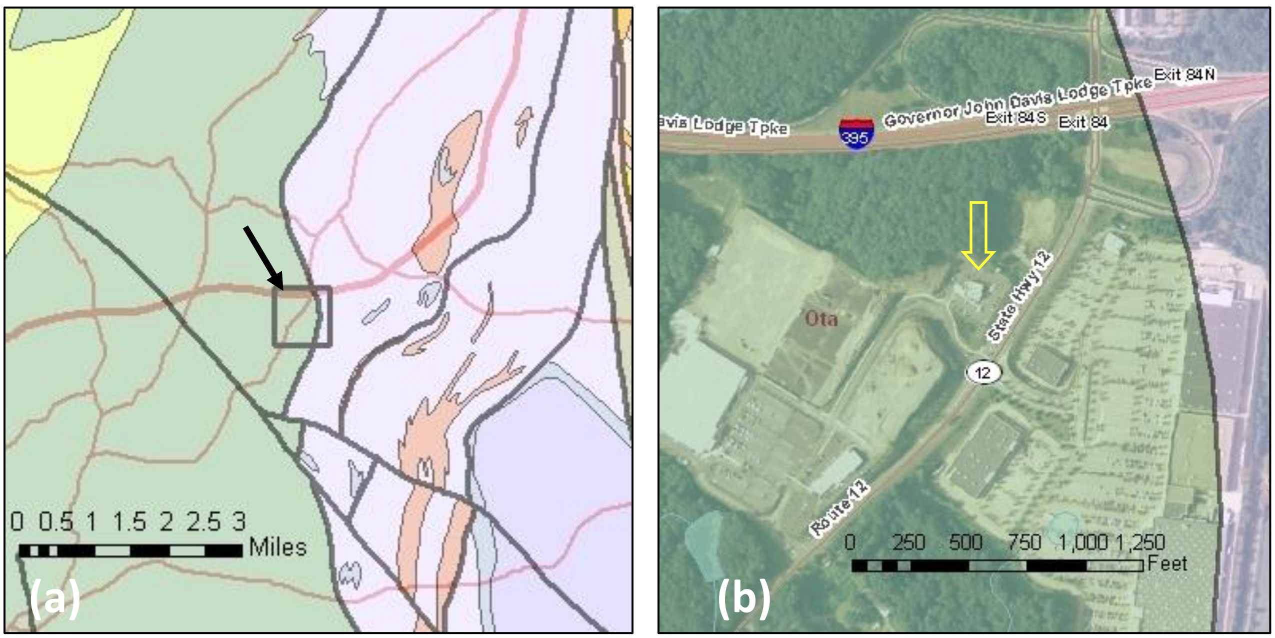

Figure 1. Geology and aerial photograph of the shopping area (Ota = Tatnic Hill – green colored area; Oq = Quinebaug Fm, pinkish color; both are gneiss). Inset on map (a) shows area of aerial photograph. Map on right (b) is an aerial photograph that is overprinted with bedrock data (Rodgers, 1985). The new outcrop is along the entrance to the shopping area north of Route 12 (yellow arrow).

Bedrock - Tatnic Hill Formation

Geologically, this area is near the middle of the Putnam-Nashoba Terrane (Figure 2) which originated as a long micro-continent (similar to modern day Japan) that welded onto the North American continent during or prior to the collision with Avalonia about 320 million years ago. The rocks are mapped as Tatnic Hill Formation. During peak metamorphism these rocks were buried between 30 and 40 km below the surface and reached temperatures of almost 600^{o}C (see Wintsch et al, 2001). At these temperatures and pressures the rock is "soft" and

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1. **Ductile:** can be bent or reshaped without breaking
2. **Shearing:** Extreme pressure causes two rock surfaces to slip against one another

"pliable", becoming ductile[1], and it deforms by shearing[2] and flowing. Concurrently, metamorphic reactions occur, releasing fluids that in effect "lubricate" the rock, making it even weaker (these fluids may also have been the medium that transported the iron, magnesium, and aluminum ions to the growing garnet crystals).This produced the wavy structures seen in the outcrops on both sides of the road.

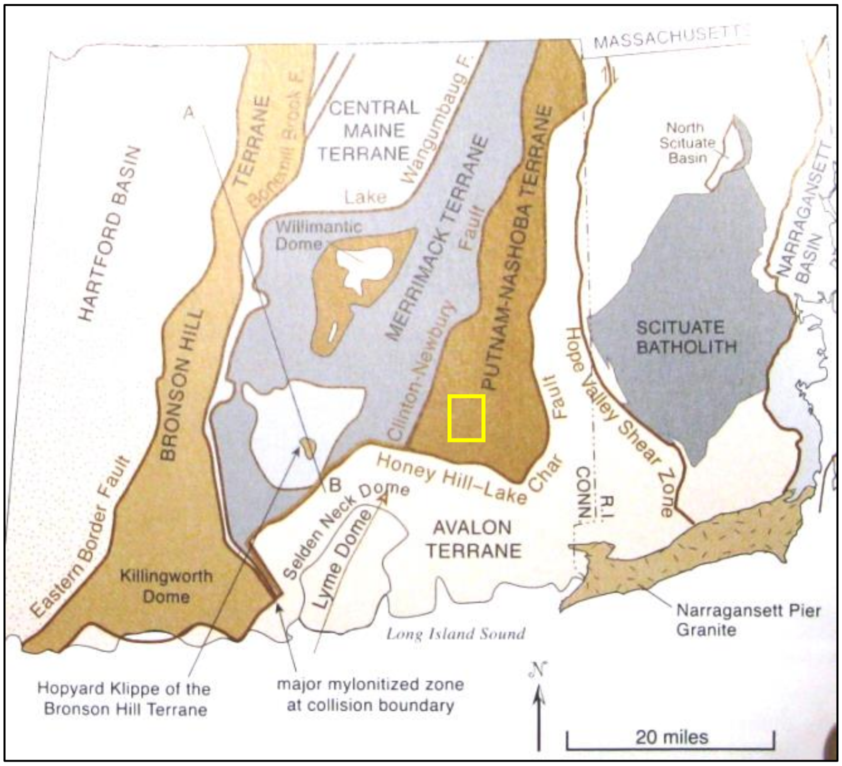

Figure 2. Terrane map of Skehan (2008, p. 32, after Wintsch and others, 2001). Location of new outcrop approximately under the letter "P" in Putnam-Nashoba (shown with box).

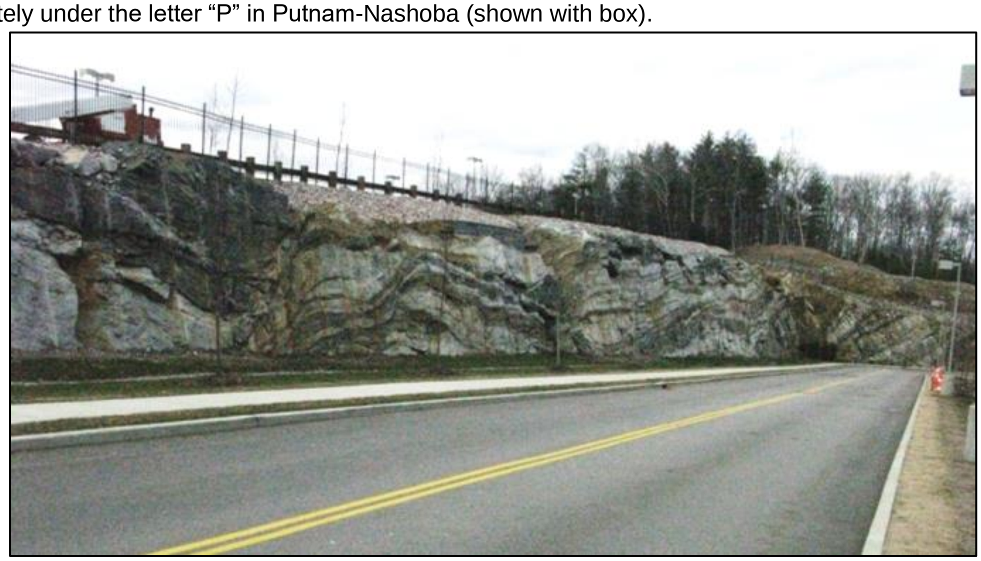

Figure 3. Typical appearance of garnet bearing rocks (Tatnic Hill Fm.) along west side of drive. Note the bands of white. These layers are rich in the mineral feldspar.

Garnets are found in most of the rock layers exposed. The white feldspathic layers (see Figure 3, and 4) tend to contain the fewest garnets and the smallest (1-5mm). They tend to be dark purple to black and pink (Figure 4b). Garnet in the biotite gneiss and schist tend to be much larger and are almost all maroon *almandine* garnets. They range in size up to 10 cm and locally compose up to 50% of the rock (Figure 6a). Many are euhedral[3] (Fig. 6c) and do not appear rotated or otherwise deformed, which suggests formation late in the metamorphism after shear stresses had relaxed.

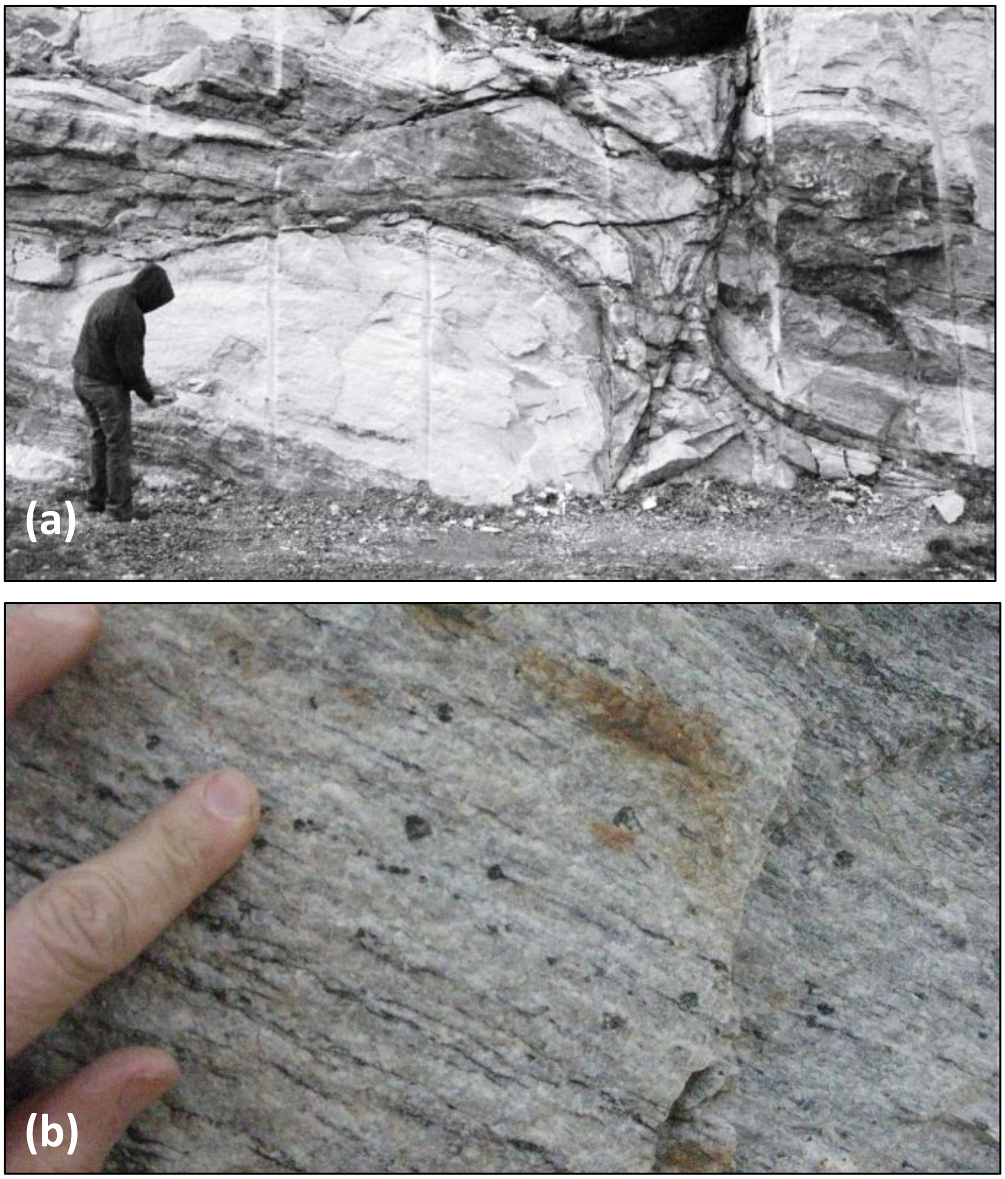

Figure 4 (a). Detail of picture above showing brittle fault cutting structures formed when the rock was hot and ductile: it deformed by flowing rather than breaking. Feldspathic gneiss surrounded by dark biotite gneiss. (b) Detail of light colored layers. Finger is about 15 mm in width (~5/8"). Composition mostly plagioclase feldspar. Slight variations in amount of quartz produces a faint foliation (or banding) in the light colored rocks. Small 1-2 mm euhedral garnets scattered throughout. Garnets are pink or maroon. They all appear granulated (crushed).

3. **Euhedral:** referring to well formed faces on a mineral grain giving that mineral a shape that reflects the crystal form (dodecahedral – 12 faces -- in this case).

Figure 5. Geologist points to garnet bearing biotite gneiss, schist and calc-silicate gneiss (rock types that host garnets). Layers are folded and sheared, and later cut by brittle faults. Dark layers are biotite-garnet schist.. Light colored layers are composed mainly of plagioclase feldspar with small amounts of quartz and garnet.

Garnets are very abundant and easy to find at this site. The dark layers of the Tatnic Hill formation exposed in the outcrops consists of garnet bearing biotite schist, calc-silicate gneiss, and feldspathic biotite schist or gneiss. Garnets in these layers may be large and locally abundant, some are as large as 10cm! Figure 6 shows the various arrangements and sizes of garnets that can be found in the different layers of the rock.

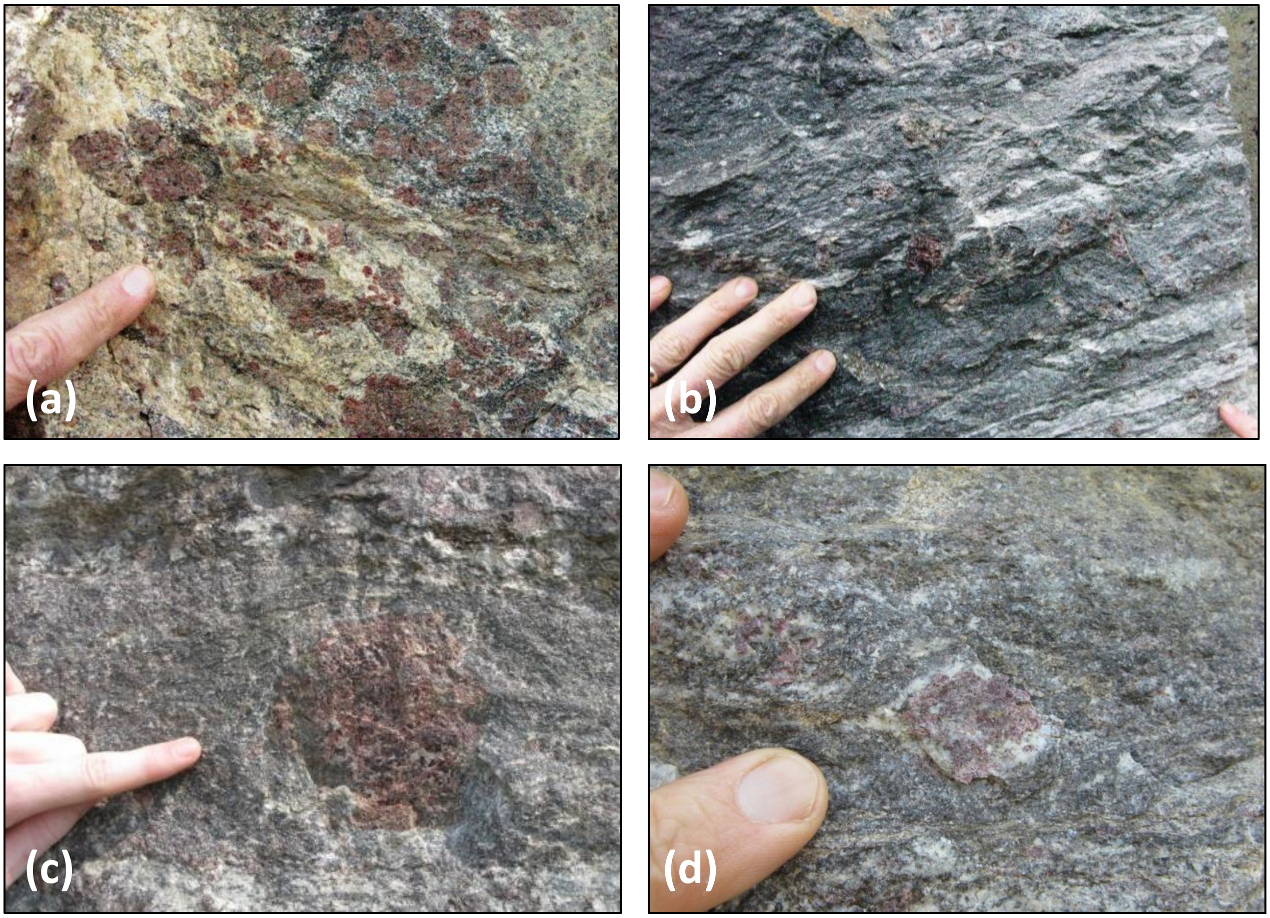

Figure 6. (a) shows concentration of garnet that locally approaches 50% of the rock. (b) Garnet-bearing calc-silicate gneiss (a gneiss containing calcium-bearing minerals) with *augen* (large almond shaped crystals) of andesine plagioclase (white). They indicate shearing during and/or after formation of the feldspar. Garnets appear undeformed but have been crushed and appear to be granular. (c) Large euhedral crystals (called porphyroblasts) of granulated garnet (~10 cm) in biotite gneiss. (d) Light colored feldspathic rim surrounding pink-colored garnet that forms "wisps" trailing off the edge of garnet in the plane of foliation. This area (at edge of rigid garnet grain) probably had slightly lower pressure which allowed growth of the "wisps"

Directions

The commercial area is on the northwest side of Rte. 12 just south of the interchange with I-395 in Lisbon. The outcrop is located in the vicinity of a shopping complex called "Lisbon Landing". The site is located along the driveway for "Target" and "Lowes Home Improvement". Parking is best at the Target/Lowes complex at the top of the hill or at the "Chili's Grill & Bar" restaurant (if it is not a busy time for the restaurant). For those of you with GPS units, it is located at **N.41.6111º, -072.0008º**. The address of the shopping complex is 160 River Road Lisbon, CT. From the Hartford area: Take I-84E to Rte. 2E and merge is I-395N. Take the Exit for Rte. 12 and turn left.

Reference:

Dixon, H.R., and Felmlee, J.K., 1986, Bedrock Geologic Map of the Jewett City Quadrangle, New London County, CT. U.S. Geol Surv., Geol. Quad. Map GQ-1575

Rodgers, J., 1985, *Bedrock Geological Map of Connecticut*. State Geological and Natural History Survey of Connecticut, Nat'l. Resource Atlas Series, 1:125,000, 2 sheets.

Skehan, J.W. 2008, *Roadside Geology of Connecticut and Rhode Island.* Mountain Press Pub. Co, Misoula, MT, 288p.

Wintsch, R. W., et al, 2001, "A new look at the Alleghanian overprint of Acadian metamorphic rocks in southern New England: Evidence from structure, petrology and thermo-chronology". *Guidebook for Geological; Field Trips in New England,* ed. D.P. West and R.H. Bailey. Geological Society of America Annual Meeting, Boston.

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Salmon River: *A Garnet Placer Deposit*.

The sand and gravel in the bed of the Salmon River contains scattered concentrations of tiny sand grains composed of garnet. The small garnet grains are about a millimeter in diameter. They occur in small concentrations in the lee (or quieter side) of cobbles in the stream bed. The garnet concentrations are easier to find when the river flows at a low stage; when it flows at a high stage they are submerged.

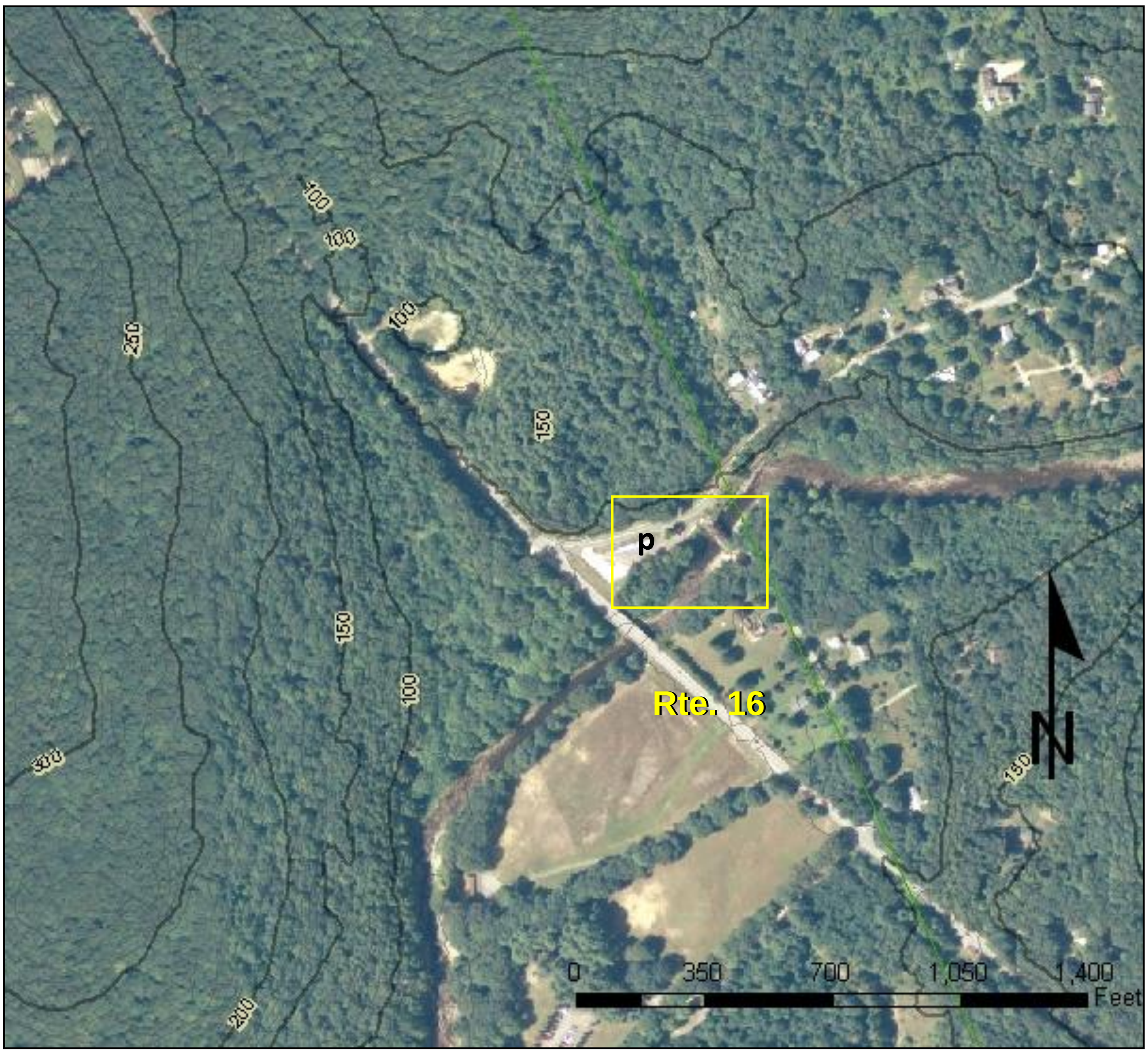

Figure 1. Aerial photograph taken in 2010 showing the Comstock Covered Bridge on Rte. 16 just upstream (east) of highway bridge. Boundary of East Hampton and Colchester (faint green line trending NNW/SSE across photo) immediately east of covered bridge. Yellow box shows area of interest/parking (p).

The Salmon River

The Salmon River flows over a fairly coarse-grained bed composed of cobbles and small boulders of gneiss and granitic rocks. Most of the sand has been washed up onto the river bank at locations where the bank is not too steep. There are few sand accumulations within the river. The sand on the bank is variable in its texture, but most is medium-grained. It is composed of feldspar and quartz grains. In places it contains small granules of gneiss and other rock fragments. Garnet is not apparent in the typical river-bank sand in the Salmon River.

River-bed sand accumulates in a few sheltered places on the downstream sides of small boulders and cobbles. Most are coarse-grained and have unusual concentrations of garnet. Locally, garnet comprises almost 100% of the sand. In most places, however, it comprises 20-40% (maybe even less in some locations) of the sand. The garnet grains are pink, purple and maroon in color. Many are translucent, but most are opaque. Most garnet grains are sub-rounded; very few are either well-rounded or angular. They are 1-2 mm in diameter and are associated with coarser non-garnetiferous (non-garnet bearing) grains. This is a clue to their concentration process. They are affected by the river currents in the same manner as grains that are coarser (larger) than themselves.

Figure 2. Garnet concentrations illustrated in images obtained during low-flow conditions of Salmon River just upstream from covered bridge. Note the variable concentration and that the small garnet grains are associated with coarser-grains of quartz and feldspar and pebble-sized rock fragments. Pen is 5.5 inches in length.

Most of the sand grains in the river are composed of feldspar, quartz, and rock fragments. All three have a relatively low density (~2.5-2.8 g/cm^3). Garnet is denser (~4 g/cm^3). Therefore, for the same size sand grain, garnet is heavier. Heavy mineral concentrations occur where less dense (lighter) sand grains wash away, leaving behind more dense (heavier) sand grains. They are heavier and harder to move, (i.e. it takes a stronger current to move them). During high water, the currents are markedly stronger (higher velocity). Sand and gravel of all sizes are moved by fast currents. As the current subsides, the heavier material settles out in the lee of protruding rocks while the finer-grained sand is carried on. Much of the finer material washes onto the banks where the current is weaker: there they get deposited. Garnets are too heavy to get washed up on to the bank. Hence, it accumulates on the river bed. Many of the gold deposits out in the western US are found in stream gravels where the lighter quartz and feldspar grains were washed away, leaving heavier gold nuggets behind. They are referred to as *placer deposits* (pronounce that with a long “A” as in “plastic” rather than the short “A” in “place”).

A similar process can occur on the beach. Storm waves deposit both light and heavy minerals together. After the storm, wind and calmer waves remove the lighter minerals, leaving a concentration of the heavy minerals. Perhaps you have noticed pink/purple sands at Hammonasset or other Connecticut beaches. Gem concentrations that form in the same manner are found in some African and South American beaches as well.

The source of these garnets is of some interest. The Salmon River watershed drains about 150 square miles. Hebron Gneiss, which is not particularly garnetiferous, and the Brimfield Schist, which contains garnet in some places, both underlie more than 80% of the drainage basin. The Bolton Group, and especially the Littleton Formation, consists of garnet-bearing rocks. They underlie less than 20% of the drainage basin and crop out along the northwestern drainage divide. Sand from many of the tributary streams of the Salmon River was monitored for garnet concentrations. Those streams, such as Pine Brook and Meadow Brook, which drain areas underlain by the Brimfield Schist contain little if any garnet. Streams, such as the Jeremy River, which drain areas underlain by the Hebron Formation, contain small, dilute concentrations of very fine-grained garnet. Tributary streams that drain the Bolton Group or areas immediately to the south-southeast of the Bolton Group outcrop-belt, contain concentrations of coarse-grained garnet like what is found in the Salmon River.

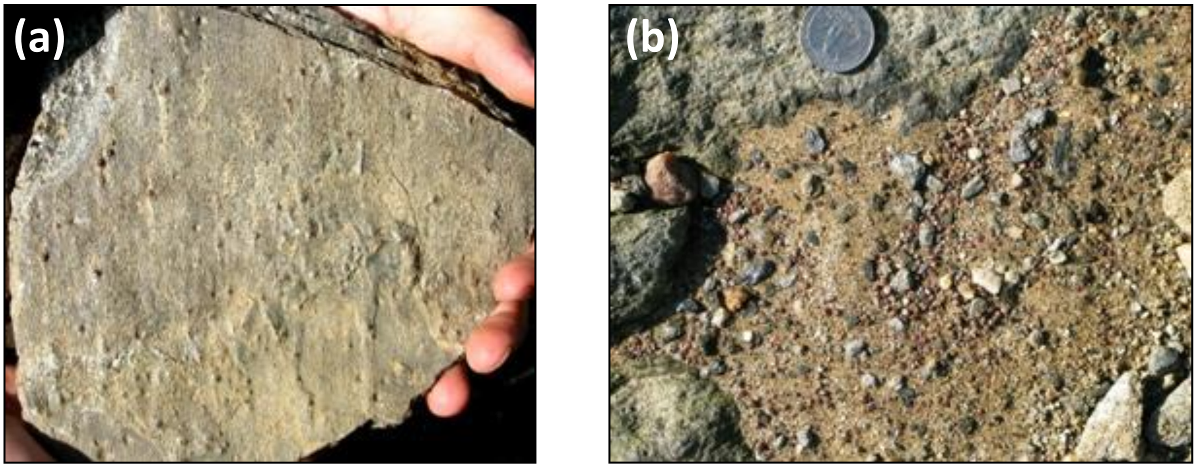

Figure 3. (a) Hand sample of Littleton Schist found at Bolton Notch State Park, showing 1-2 mm sized garnet grains set in a silvery colored mica-schist. Small staurolite grains also present in this sample. (b) Pocket of soil on an outcrop of Littleton Formation in Glastonbury showing garnets left behind after rainwater washed away lighter soil components (mud and lighter sand grains composed of quartz and feldspar).

The garnet-bearing river-bed sand was traced upstream into tributary streams that drain the western half of the Salmon River watershed (Safstrom Brook, Dickenson Creek and Blackledge River). The headwaters of these tributaries are areas that are underlain by the Littleton Formation, which is a garnet-bearing mica-schist. Glacial erosion of this formation during the last ice age likely liberated the garnets from their host rock (see Figure 3b). The garnet grains were then transported by glacial ice and later by meltwater streams, and finally modern streams and deposited in the Salmon River and some of its western tributaries. Recycling of the sand and gravel from the glacial terraces may also be a source for these garnet grains in the river-bottom concentrations.

Directions

The site is located in the Salmon River State Forest where Connecticut Route 16 crosses the Salmon River (about 8 miles east of Middletown and 5 miles west of Colchester). There is a parking lot adjacent to Comstock covered bridge off of Comstock Bridge Rd, directly off of CT-Rte 16 (coordinates given below). Best places to find garnets are along the river bank on the southeast side of historic covered bridge: **N. 41º33.2166’, -072º26.8836’**), cross the bridge from the parking lot and look for garnets in and around the area directly beneath the bridge. Location: **N.41º 33.1926’, -072º 26.9382’** (Parking Lot)

References

Rodgers, John, 1985, Bedrock Geological Map of Connecticut. Connecticut Geological Survey National Resource Atlas Series.

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The Pink Sands of Hammonasset State Park.

Hammonasset State Park has almost two miles of sandy beach (see Figure 1). It is oriented northwest/southeast and waves that hit the beach tend to move sand toward the east. This can be seen at the jetties at both ends of the beach. At Meigs Point sand has piled up on its western side but a sand-starved shoreline is on its eastern side. The sand is somewhat coarser at the east end of the beach compared to the west end. In addition, the sand in the west end tends to have concentrations of garnet along the upper shore face. At times the concentrations of garnet result in the beach having an intense pink color (see Figure 2).

Figure 1. Air photo taken during the early summer, 2010. This is the western end of beach where upper beach face has a distinct pinkish hue because of the garnet concentrations on the surface. Notice off-shore sand bars.

The Hammonasset Sand

The sand at Hammonasset Beach is eroding (CTGEOSURVEY, 2007) and it has been replenished numerous times as part of a beach stabilization program that began in 1954 (Patton and Kent, 1992). Thus, the origins of the sand is unknown. Part of the sand was pumped onshore from submerged sand deposits off shore. It is likely that all the sand was ultimately derived from deposits from streams that occurred as the glaciers were melting at the end of the last ice age.

Note that the upper part of the beach is finer grained than the surf (wave) zone and may have pink sand on its surface and layers of pink sand just below the surface (see Figure 2). In some places a black mineral(s) will be mixed in with the pink. The pink sand is composed of abundant grains of garnet, some of it very clear and gem-quality (except for its tiny size). The black mineral is magnetite (and/or possibly ilmenite) (Figure 3). Both of these black minerals are magnetic, which you can prove to yourself by taking along a small magnet and running it through the sand. Children love this fun activity, especially if you collect the minerals and place them on a piece of paper. These black grains can be made to "dance" on the paper by moving the magnet around under the paper. During some conditions black streaks will form by the same process in the swash zone.

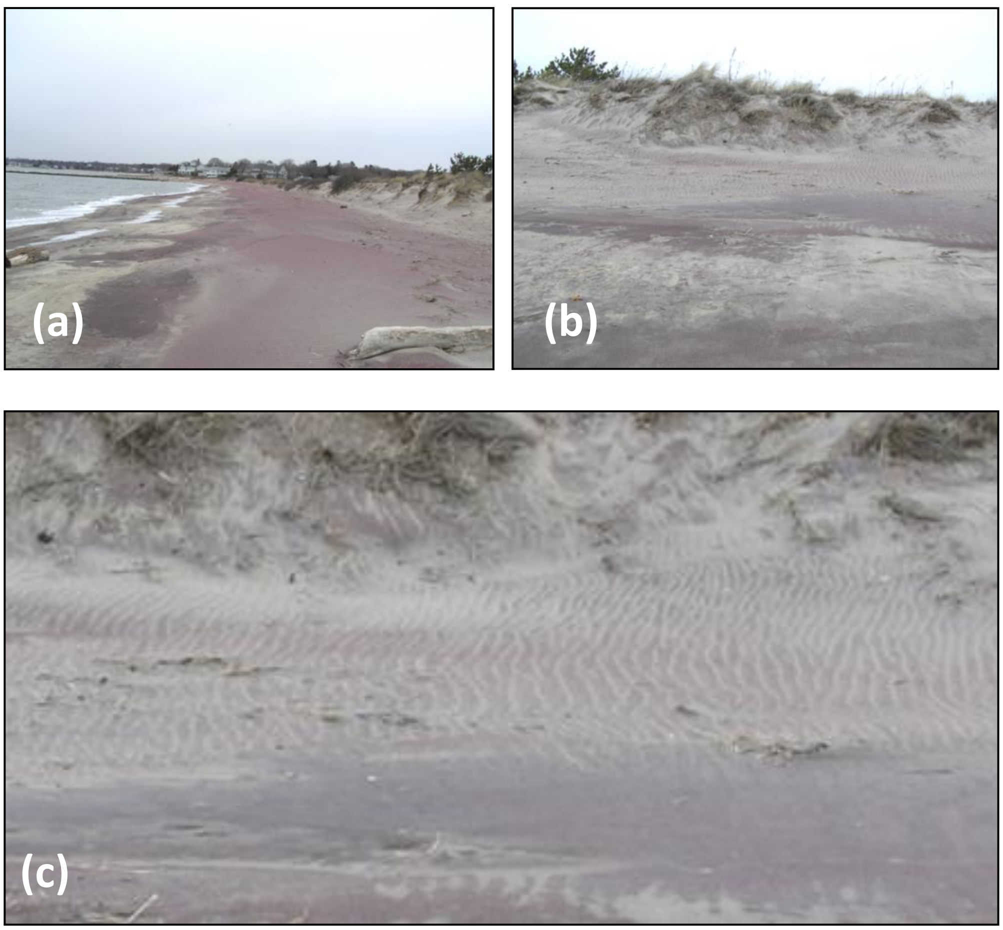

Figure 2. West end of Hammonasset Beach in April 2007. Garnet-rich sand covers the beach. (a) Looking west along-shore toward the jetty at western boundary of Hammonasset State Park. (b) Looking onshore toward the sand dunes near location in (a). (c) Detail of garnet concentration. Notice the windblown ripples below the dune line. The crests of the ripples are composed of lighter colored quartz and feldspar grains that are lighter in weight. When the wind blows, the lighter grains get blown away and the heavier grains are left, forming a coating on top of the beach.

The garnet and magnetite are concentrated because they are denser than most of the sand grains on the beach. For the same size sand grain, garnet and the black minerals are heavier. Heavy mineral concentrations (pink and black) occur where less dense (lighter) sand grains blow or wash away, leaving more dense (heavier) sand grains behind. Storm waves deposit both light and heavy minerals together. After the storm, the wind and less energetic waves remove the lighter minerals, leaving a concentration of the heavier, harder to move mineral grains (Figure 2c). The same process occurs at most Connecticut beaches (see CTGEOSURVEY, 2008, activity 3). The same process can occur in river currents or water waves (particularly in the swash zone). This is the same method that forms gem concentrations on some African beaches. Many of the gold deposits out west are found in stream gravels where the lighter quartz and feldspar grains were washed away, leaving heavier gold nuggets behind. They are referred to as *placer deposits* (pronounce that with a long “A” as in “plastic” rather than the short “A” in “place”).

Figure 3. A close up of the individual grains on the beach from one of the dunes. Notice the lighter and darker grains. The red/pink grains are the garnets.

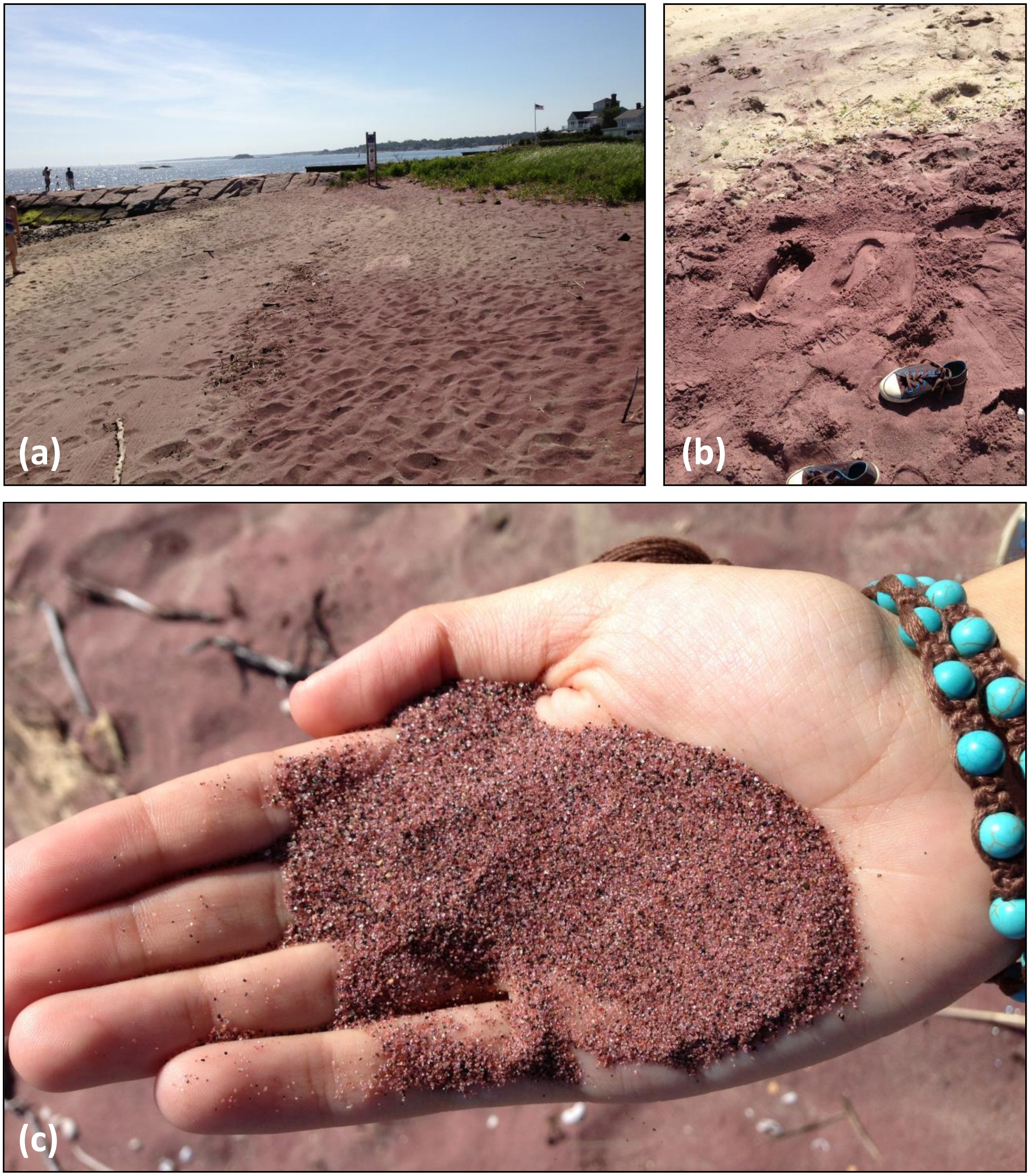

Figure 4. (a) The best location to find the pink sands, especially during the busy summer months. (b, c) Note the striking color contrast when compared to "normal" sand with lower garnet counts. The grains are mostly garnet at this end of the beach and are finer grained; shoes for scale.

Hammonasset Beach is a long beach (almost 2 miles), so it is important to note where the best pink sand is (depending on what time of year that you go, the areas with heavy beachgoer traffic may not show the pink sand well due to mixing). If you do not want to walk a distance on beach, park as close to the campground as possible. The entrance that is closest to the best pink sand is near the “Camp Store” in the vicinity of the long pier that people may be fishing off of (Figures 5,6). This is approximately 2000 feet west of the snack shack at “West Beach”.

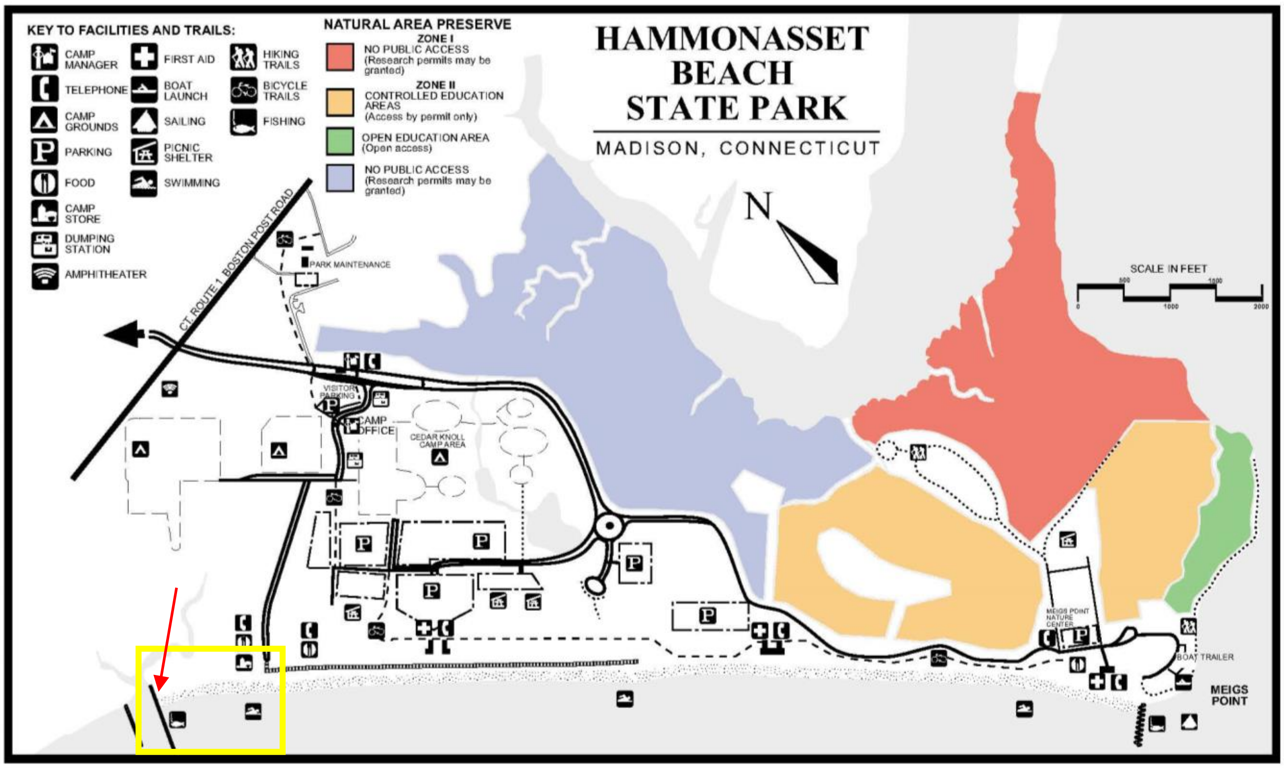

Figure 5. A map of the park. The best pink sand is found anytime of the year in the yellow box just west of the “Camp Store” (in the upper-right corner of the yellow box) and right before the pier (indicated by red arrow). For reference, the West Beach snack stand is just outside the upper-right corner of the yellow box.

Figure 6. A west-facing view of the beach just past the snack stand. Note the sand has a pink tint to it, but the garnets are better showcased at the furthest end of the beach.

Directions

N 41.268453º,-72.55896º. *From the north/Hartford*: take I-91 south to Route 9 south. Off Route 9, take Exit 9. Turn right (south) onto Route 81; continue down Route 81 until you run into I-95. Turn right onto I-95 south entrance ramp and go approximately 1 mile to Exit 62, then turn left off the exit. Head south 1 mile down Hammonasset connector, go straight through the light crossing Route 1 (Boston Post Road) into the park. *From the south area*: take I-95 north, Exit 62. Take a right off the exit ramp onto Hammonasset I-95 connector. Park entrance will be 1 mile ahead. *From the east area*: take I-395 south onto I-95 south, Exit 62. Take a left off the exit and go approximately 1 mile. Go straight through the traffic light crossing Route 1 (Boston Post Road). *From the west*: take I-95 north, Exit 62. Take a right off the exit and go approximately 1 mile. Go straight through the traffic light crossing Route 1 (Boston Post Road) into the park. It is suggested that visitors coming from all directions park in Lot B and use beach point 11 to access the beach and observe the garnets.

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Written by Randolph Steinen (Connecticut Geological Survey - Department of Energy and Environmental Protection), 2009. Edited by Lindsey C. Belliveau (Connecticut Geological Survey - DEEP) and Gary Robbins (University of Connecticut), 2013.

Garnets in the Wepawaug Schist at Eisenhower Park

This Garnet Trail is located in the town of Milford. Eisenhower Park is a town park located off State Highway 121 in the northern part of Milford. The eastern portion of the park is developed for various recreational activities. It is generally a lowland in the valley of the Wepawaug River. The western portion of Eisenhower Park, across the river from the recreational area, is undeveloped. It is an upland area underlain by garnet-bearing Wepawaug Schist. Access to the area is on River Street (see map, Figure 1). Parking is difficult but there are a couple of places, mainly north of the GPS location (but also under the power lines), that have shoulders wide enough to accommodate off-street parking.

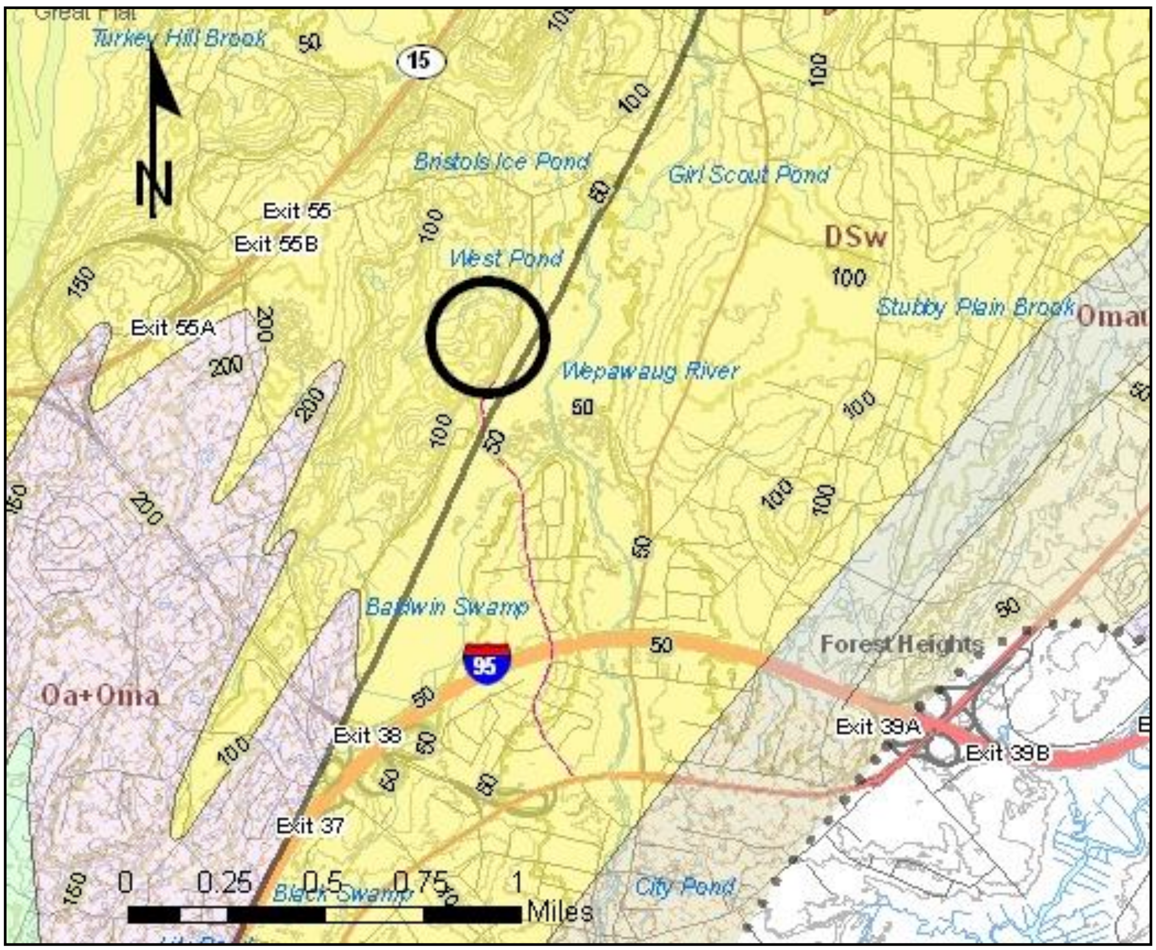

Figure 1. Bedrock geological map (after Rodgers, 1985). Yellow area is underlain by Wepawaug Schist (Siluro-Devonian in age). Pale purple area is underlain by Ordovician-aged metamorphosed volcanic rocks and the light blue and green areas are underlain by additional metavolcanic rocks. Red area is younger intrusion of diabase of Jurassic age. This diabase is a feeder dike for the youngest lava flow in the Hartford Basin to the east. Diagonal black line is trace of fault that uplifted the west side relative to the east side. Contour interval = 10'.

Bedrock: Wepawaug Schist

The western upland area consists of several hilltops with elevations reaching up to 180 feet above sea level. It is rugged with considerable area of relatively steep slopes that drop down to a roadside elevation of 50 feet above sea level. Thin glacial till covers the area with numerous bedrock (ledge) outcrops. Bedrock consists of the Wepawaug Schist (see Fig. 2). It is gray, dark gray and silvery gray. It consists of muscovite schist with zones of muscovite-garnet schist. It is composed of muscovite and garnet with lesser amounts of quartz and feldspar. Some layers contain small amounts of staurolite. Some places graphite is reported, but none was recognized during our field observations in the park. The schist is well foliated but indistinctly bedded. Bedding (or layers) may be recognized in many outcrops because of changes is grain-size and slight variations in the mineral content. Changes in mica and garnet crystal-size and abundance appear to be stratigraphically[1] controlled. Foliation is caused by alignment of fine- and medium-grained muscovite mica and is mostly a schistosity[2]. Gneissic foliation is local and not widespread. Foliation and bedding appear to be parallel over most, but not all, of the area.

Garnets are moderate in size; the largest are about 3-5 mm in diameter. They are dark colored and good crystal facets are difficult to find (i.e. they are not gem-quality garnets). They are most abundant in the outcrops just above the road and are not particularly abundant higher in the hills.

Regional mapping (Rodgers, 1985) has revealed a major fault that bisects the park. Neither the fault itself, nor fractures parallel to the fault were recognized during the field visit, but is shown on a bedrock geologic map (Figure 1 – shown as black line).

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1. **Stratigraphic control:** controlled or determined by the layer of rock that they occur in.
2. **Schistosity**: Scaly or flakey layering due to abundant micas

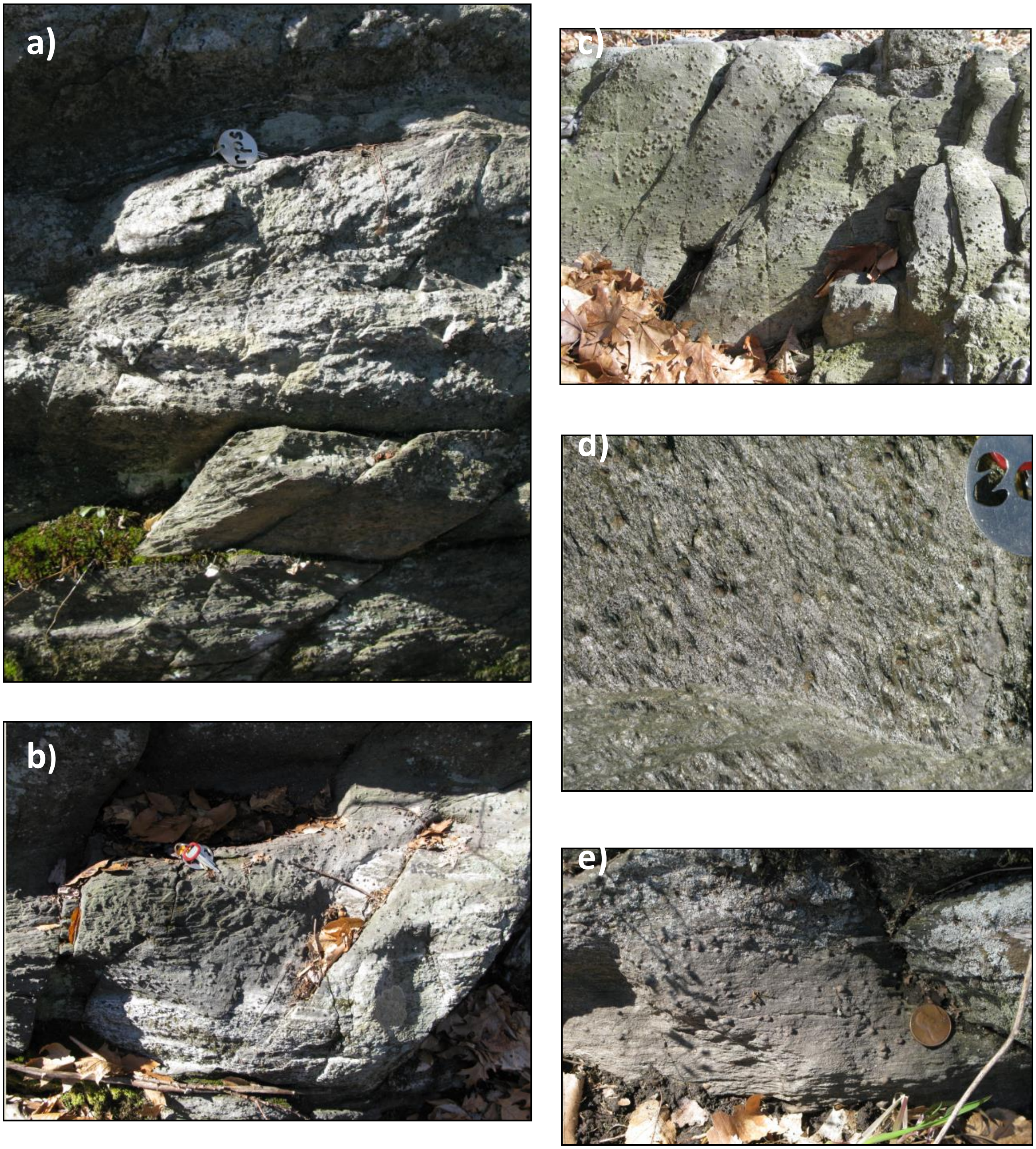

Figure 2. Wepawaug Schist. Upper left (a) shows general concordance of bedding and schistosity seen at most (but not all) exposures (key chain in upper center is 2" in diameter). Lighter layers contain more quartz and feldspar and less muscovite mica. Lower left (b) shows similar stratigraphy. Here garnets are a significant part of the mineral composition. Length of keys just to left and a little above center is about 2.5". Right top (c) shows garnetiferous (garnet-bearing) schist. Garnets up to one-half inch in diameter (scale inadvertently omitted: maple leaves are about 4" in diameter). Center right (d) shows detail of schistosity (upper left to lower right), garnets and bedding (along bottom of picture) that is cut by schistosity. The "2" on key chain disk is about ¾". Lower right (e) shows bedding (manifest by garnet abundance) and schistosity (penny for scale).

The till (rocks and unsorted materials left by the glaciers) in the western part of the park is very thin and, indeed, bedrock crops out in many areas where till has been eroded or was not deposited (Figure 3). Natural bedrock exposures have been weathered and have a rough surface texture. Along a recently (last 100+ years) excavated road, the bedrock is smooth and even polished, (i.e. it has not been weathered). These surfaces contain glacial striations, or grooves in the rock created by the gouging of rocks that were frozen into the base of the glacier as it slowly scrapped over the ledge. It is likely that similar markings were present on most of the bedrock surfaces prior to their being exposed to the ravages of weathering.

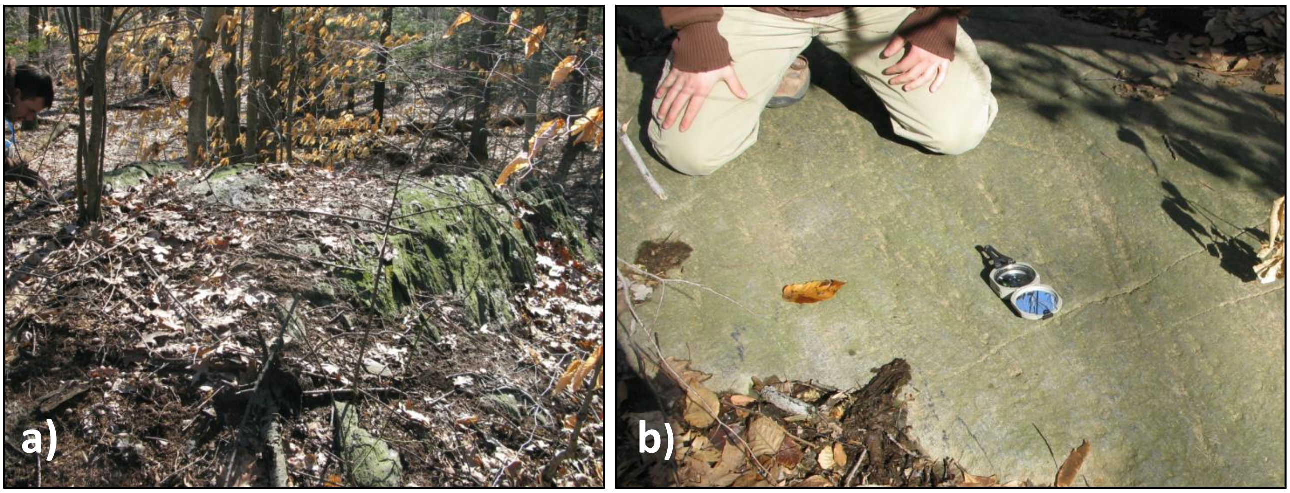

Figure 3. Image at left (a) shows typical bedrock surface that has weathered since deglaciation. The surface, although somewhat smooth, is rough in detail and no surface marks caused by passage of the glacier remain. Image on right (b) shows ledge recently uncovered by road construction (N. 41.24852º, -073.06404º). The surface is very smooth and has glacial striations that cut diagonally across the outcrop. Notice the line of garnets (foliation of rock) parallel to the side of the compass and at an angle to the striations. Striations indicate ice movement toward the southwest, parallel to the elongation of the drumlin on the other side of the river (see Stone and others, 2005). [**Note**: this outcrop was partially covered by a fallen tree the last time we visited the site. It may be difficult to locate without a GPS unit.]

Directions:

If you are using a GPS unit, find the following location on River Street in Milford: **N. 41.24731º, -073.06328º.** These will place you at an abandoned drive going up a steep hill on the west side of River Street. If you do not have a GPS unit, find the intersection of US-Rte. 1 and River Street. From the intersection of River Street and US-Rte. 1 (Boston Post Road) go north about a mile until you pass under the electricity transmission lines and immediately look for a space on the side of the road wide enough to park. You will find an abandoned drive on the left past the power lines. Large cement blocks have been placed across the drive to prevent vehicular access (these may be seen on “street-view” images of GoogleEarth). Walk up the drive and look for garnet-bearing outcrops of schist on west side. Glacial features may be seen by continuing up the hill. From I-95 N: Take exit 37 and turn right onto High Street at end of ramp and then left onto US-Rte 1 (Boston Post Road. Take a left onto River Street after passing under the highway overpass (Merritt Parkway connector). From I-95 S: Take exit 39A onto US-Rte 1 South (Boston Post Road). Follow Rte 1 about a mile and turn right onto River Street at first turn past CT-Rte 121. From Merritt Parkway (CT-Rte 15): Take exit 54 (I-95 connector). Follow connector past I-95 ramps and onto US-Rte. 1 north (Boston Post Road). Immediately take a left onto River Street. Another potential parking area is at Solomon Woods on West River Street in Milford. This parking area will also grant access to the garnets in Eisenhower Park.

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