Self-Guided Geologic Tour of the Skyline Trail in the Middlesex Fells Reservation (Part 5)

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Some general information before starting a tour in the Middlesex Fells:

1. The Skyline Trail has been broken into seven parts. You should not try to do the whole tour in one day (~7 miles or 11 km). It is a lot of hiking and a lot to comprehend in one dose. It's recommended that you do parts of the tour in order, moving counterclockwise around the park. Each tour and its stops are marked on the geologic maps with each part. PLEASE FOLLOW the maps as you go. ***It will be handy to have a sense of direction from the sun, remembering that at noon the sun is due South, in the morning it is to the southeast, and by late afternoon it is to the southwest.***

2. At many times of the year and on weekends, parking areas fill, so start early.

3. The tours require hiking over some steep and rocky trails, so plan ahead. It is recommended that you have sturdy hiking or trail shoes. I don't recommend sandals or heeled shoes.

4. Make sure you have enough food and water with you. In the Fells, there is nowhere to get water and the spring water is NOT drinkable.

5. In compliance with DCR rules, please stay on official marked trails as indicated on DCR maps. This is also a way of avoiding poison ivy and ticks. In making the geologic map, special permission was obtained from the DCR to go off the trails. See the DCR's official Middlesex Fells Reservation Trail Map (last updated in March 2020). This map accurately shows trails, except where they have been refurbished, and it has the numbered intersection designations indicated in the guide. The DCR map is online at: https://www.mass.gov/doc/middlesex-fells-reservation-trail-map/download and it is sometimes available at kiosks at Fells parking areas.

6. In wet or winter weather, some rock surfaces are slippery. DO NOT venture out onto frozen ponds and reservoirs. The ice may be too thin to support your weight and it is unpredictable!

7. Do not collect rocks on the tour or deface outcrops by writing on them. It is against DCR regulations. Please remove your own trash and follow other DCR rules. Leave no trace!

Some Fundamental Geology to Get Started:

1. The self-guided tours of the Fells focus primarily on **bedrock geology**. This is a characterization of the solid rock that occurs beneath our feet as viewed from above. Exposures of the **bedrock** surface are called **outcrops**. Loose rock debris (or **float**), sediment, and soils on top of the bedrock comprise the **surficial geology**.

2. **Rocks** are naturally occurring solids made of minerals and non-mineral materials. **Minerals** are naturally-occurring, inorganic, crystalline solids that have a specific chemical formula and unique properties that allow us to tell them apart. A **crystalline material** is one in which atoms have a repeated regular pattern (i.e., crystals or crystal structure). Minerals have names in addition to their chemical formulas. For example, sodium chloride ($NaCl$), which is the main ingredient of table salt, is known as the mineral **halite**, while silicon dioxide (SiO_2) is **quartz**. The most common mineral at Earth's surface is **feldspar**, an aluminosilicate containing sodium, potassium, and calcium. Non-mineral materials in rocks include organically-produced materials and **natural glass**, which is non-crystalline.

3. Rocks are divided into three main types:

   Igneous rocks – rocks formed by the solidification of molten rock, or **magma**. Magmas can invade older rock units in the subsurface and then crystallize to form **intrusions** or **intrusive igneous rocks**, which may later be exposed by erosion at Earth's surface. Magma can also escape to Earth's surface before hardening to form **extrusive** or **volcanic igneous rocks**. Examples of these are **lava flows** or magma explosively ejected into the air that later settles to produce **pyroclastic rocks**.

   Sedimentary rocks – rocks formed by the accumulation or deposition of particles produced by the breakdown and erosion of older rocks. This often happens in oceans and lakes or on river flood plains. Sedimentary rocks also include the accumulation of organically-produced sediment, such as clam shells and coral reefs (limestone) and plant material (coal), or chemical precipitates such as salt beds. **Fossils** occur in sedimentary rocks.

Metamorphic rocks – rocks resulting from exposure of existing rocks to increased temperatures or pressures that change the mineral composition and arrangement of mineral grains. We say these rocks are **metamorphosed**.

4. Solid materials (rocks and minerals) have been in existence on Earth for at least 4 billion years. This time in Earth's history defines the expanse of **geologic time**. Geologic time (**geologic time scale**) is subdivided based on past events represented by changes preserved in the rock record. Radiometric dating techniques are then used to place precise numerical ages on rock units and time unit boundaries. A geologic time scale can be found at: https://www.geosociety.org/documents/gsa/timescale/timescl.pdf.

5. On a geologic map, bedrock is classified into units known as **formations**, characterized by rock types and age. Formations have proper names from a place where they are well exposed or first defined. Sometimes, single formations are split into a sequence of mappable units called **members**. The boundaries between geologic units are known as **contacts**. On geologic maps, formations and members are given their own colors and patterns so they can be distinguished from each other. They also have abbreviations that consist of a capital letter for the unit's geologic time period (when it was formed) and lower-case letters that abbreviate for the unit's name. For example, "Zsg" = the Late Proterozoic (Z) Spot Pond Granodiorite (sg). Time period abbreviations in the Fells are Z (Late Proterozoic), P (Pennsylvanian), and Q (Quaternary). If a rock unit does not have a known age or formal name, only lower-case letters are used as an abbreviation. (For example: "d" stands for dolerite). Also shown on maps of the Fells are areas where the geology is concealed by human-made deposits, defined as **artificial fill** (af).

6. On the geologic maps in this guide, geographic north is shown with an arrow. **Compass directions** are given in the guide as degrees W or E of either N or S. For example, N50°E is 50 degrees east of north.

7. **Geologic symbols** on the maps are used to convey information; for example, on the maps here, the blue lines are faults. Symbols at stops on the tour are explained, but a complete description of all rock units and a listing of symbols on the map are given in map explanations at: https://sites.tufts.edu/fellsgeology/

8. The maps in the guide present detailed mapping of the Fells and introduce new formation names. It is an ongoing research project. Things will likely change with more field work and age determinations. Updates of the bedrock map, its explanation, and associated surficial geologic map and tours will be posted as they occur. We welcome feedback at: https://sites.tufts.edu/fellsgeology/.

Skyline Trail in the Middlesex Fells Reservation   version: January 11, 2024

Part 5: Grinding Rock Hill to Molly's Spring Road via Nanepashemet Hill

Total distance: 1.3 miles (2.16 km) to last stop of tour + 1.2 miles (1.83 km) return hike = 2.5 miles (~4 km)

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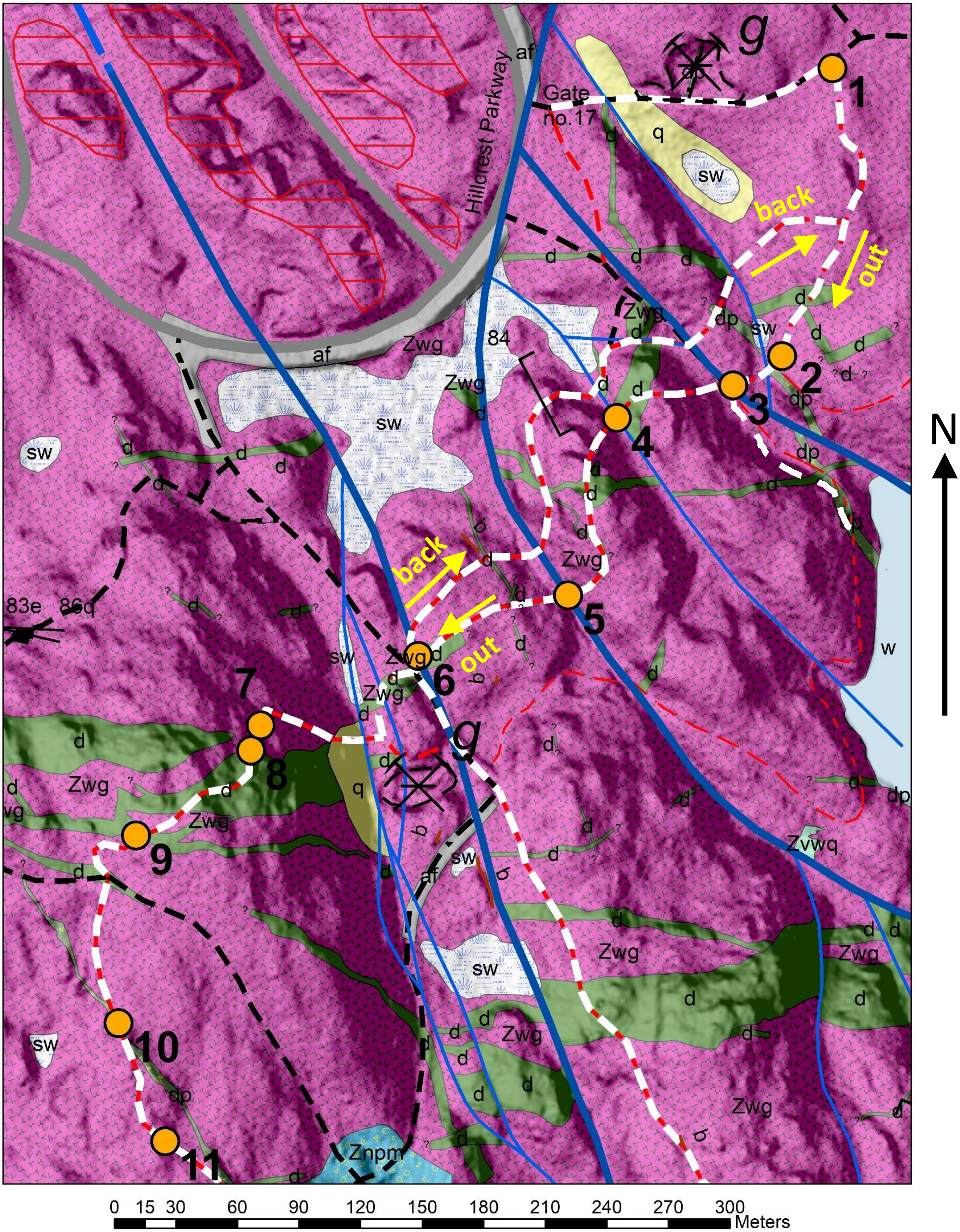
Starting point: Hillcrest Parkway (DCR Gate no. 17) in Winchester. Follow the trail on the geologic maps as you go. Stops on the tour are shown with orange circles and black numbers. Follow the white trail markers in the field and the dashed white path on the map. In the guide, trail junction numbers are given that appear on the official DCR trail map and are marked with signs in the field. Stop 1 of Part 5 is also Stop 17 of Part 4 of the Skyline tour.

To get to the first stop on the tour: From Hillcrest Parkway, head into the Fells (east) on the entrance road at DCR Gate no. 17 (see Map SKY-5A). The tour passes an old quarry (small excavation pit) on the north (left) side of the road and starts in the Winchester Granite (Zwg). The quarry (see crossed pickaxes on map) was dug into glacial sediment to obtain fill during road construction. Having a hand lens or magnifying glass can be helpful. Have fun!! Hope you enjoy the geology!

Part 5 focuses on the Neoproterozoic Westboro Formation, Nanepashemet Formation, and Winchester Granite. The Neoproterozoic Era was 1000 – 541 million years ago. You will also see younger dolerite dikes, faults, and some glacial features.

Map SKY-5A


Gate
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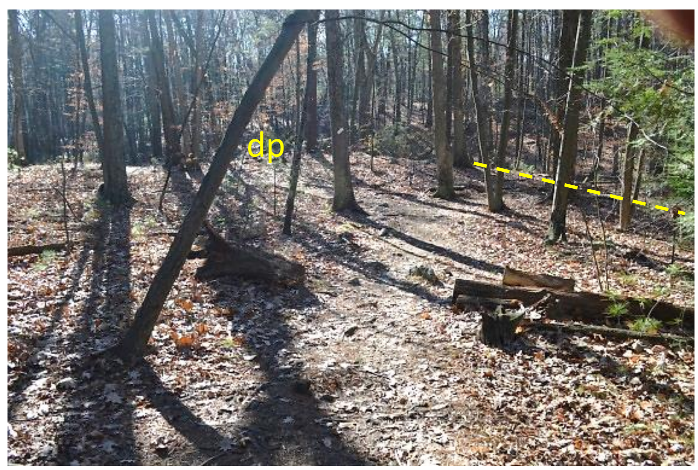
Meters

NOTE: Polished rock images are cut rock slabs photographed under water. Scale bars are in centimeters. In pictures of rock surfaces, there is often a camera lens cap, pencil, or rock hammer for scale.

STOP 1: At trail junction B2-3 (**Map SKY-5A,** image on right), the Skyline Trail continues south (right) from the road. The trail starts on knobby outcrops of the Winchester Granite (Zwg). The granite here is glacially eroded and has lots of veins. Granite is a coarse-grained (crystals visible with the naked eye) igneous rock in which 20-60% of the light-colored mineral grains are quartz and the remaining light minerals are about half plagioclase and half alkali feldspar. On the image (below to the right), quartz is gray, plagioclase is white, and alkali feldspar is pinkish-orange. The mafic (dark) minerals are biotite mica and amphibole (hornblende) that are almost entirely altered to chlorite. The Winchester Granite varies from place to place in its ratio of plagioclase to alkali feldspar, the color of the alkali feldspar (creamy pink to brownish-red), and the abundance of mafic minerals, which can comprise up to half of the rock. The granite is an intrusion, which is rock formed by the crystallization of magma (molten rock) that invaded existing rocks in the subsurface. The intrusion here has a large irregular shape and is called a pluton. For more on how plutons form see: Plutons. The granite has an age of about 609 Ma (mega-annum, or millions of years ago). This places the rock in the Neoproterozoic Era. This age was determined through measurements of naturally-occurring, trace amounts of radioactive isotopes of uranium and the lead isotopes to which they decay within tiny zircon crystals. Zircon (zirconium silicate) is a mineral used for determining radiometric ages of rocks because it is impervious to all except the most extreme heating and deformation and provides accurate results on a rock's age. For more on how ages are determined for rocks see: RockAges. **Continue south on the trail and split away to the south (left) from the Reservoir Trail (orange markers) at junction B2-4. Stay on the Skyline Trail (white markers).**

STOP 2: The trail drops into a small valley with a minor fault (line on image to right) cutting through the Winchester Granite (Zwg). A fault is simply a fracture where rocks on opposite sides have moved relative to each other. The fault displaces a porphyritic dolerite dike (dp), which forms a high spot on the northeast side of the fault (image above right). A porphyritic rock (porphyry) is an igneous rock that has two crystal sizes: one set is coarser crystals, or phenocrysts, surrounded by finer material called the ground mass. In this case, the phenocrysts are plagioclase and appear on the surface as white crystals with parallel sides (image on right). The ground mass is dolerite, which is a mafic (dark-colored) igneous rock made of sand-sized crystals. The dolerite, like the granite, is also an intrusion, but it intruded along a fracture. As the sides of the fracture separated and the magma crystallized, it produced a slab-like body called a dike. Porphyritic and non-porphyritic dolerite dikes like this are common throughout the Fells.



Continue on the Skyline Trail into a valley at junction B3-7.

STOP 3: A major fault (image on right, view northwest across valley) follows this valley from Middle Reservoir and cuts through the Winchester Granite (Zwg). The minor fault at the last stop appears to be an offshoot of this major fault. Note on the map that the dolerite dikes (d) cut by this fault are offset. If you follow this valley southeast (left) to the reservoir, you can see an offset section of the porphyritic dolerite dike (dp) we saw at Stop 2. The offset dike is on the south (far) side of the valley.

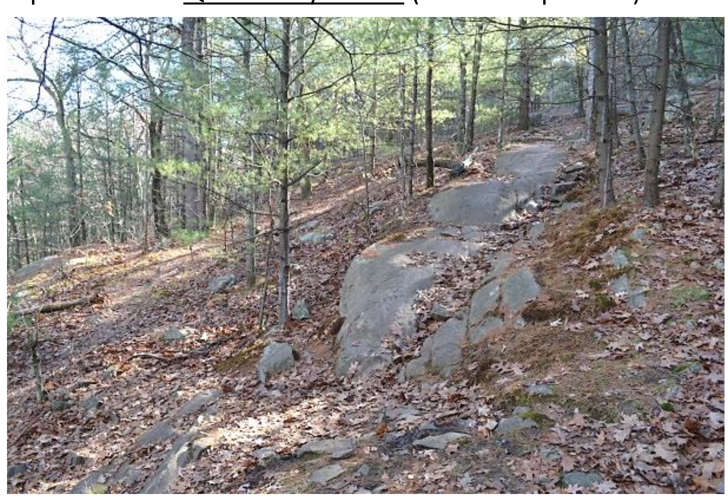
Return to the Skyline Trail and cross over the next ridge.

STOP 4: The trail crosses the ridge, which is made of Winchester Granite (Zwg), and a dolerite dike (d) before dropping into another valley with another minor fault (image to right, view looking back to east). The fault is very well defined by its valley and displaces several dolerite dikes (d). To the north, it cuts through a lowland with a swamp. To the south (view on image), the fault continues to Middle Reservoir. This area's parallel ridges and valleys may seem monotonous, but it is important to recognize how much both major and minor faults control the topography in the granite terrain. The rock is broken and more easily eroded along the faults.

STOP 5: After crossing another ridge of Winchester Granite (Zwg), the trail descends into another valley with a major fault at a footbridge that crosses the valley. This valley is sharply delineated and does not have a wide zone of fractured rock on either side. The ridge of granite before the fault (refer to the map) also has a dolerite dike (d) north of Stop 5 that is worth mentioning because it is offset by all the faults seen on the trip so far, including the one here at the footbridge.

Continue on the trail to road junction B3-6, where the Reservoir Trail (orange markers) and Mountain Bike Loop (green markers) split away from the Skyline Trail.

STOP 6: On both sides of the road and south (left) of the Skyline Trail is a dolerite dike (d) that cuts through the Winchester Granite (Zwg). There is a major fault running down the course of the road that slightly offsets the dike. Before reaching the steep slope to the west, the trail crosses the dike and some minor faults that are offshoots of the major fault. From here, the trail heads up a steep slope to the west. At the base of this slope is a deposit of fallen rock debris known as colluvium (q). This deposit is postglacial, meaning it was formed in the last 17,000 yr, after the last glacier receded from the area. Colluvium is any deposit formed by gravity without being transported by a fluid. It is indicated on the map with a yellow area marked as 'q' for deposits of the Quaternary Period (2.6 Ma to present). These deposits are much(!!!) younger than the rock units.

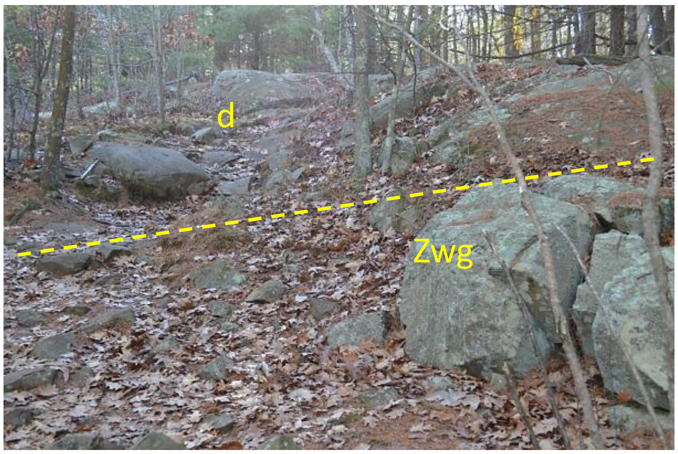


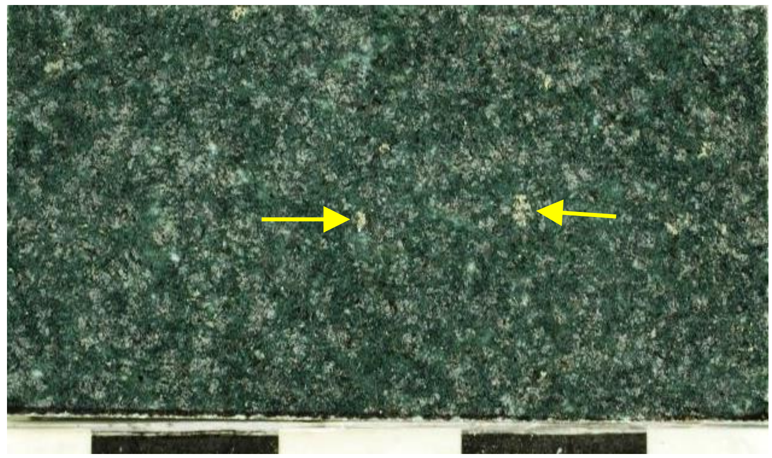
Continue up the steep slope to the first outcrops.

STOP 7: On the steep slope, the first rock unit encountered on the trail is the Winchester Granite (Zwg), which was glacially eroded and has a smooth, streamlined surface (image on right). Sliding glacial ice dragged rock debris across this surface, which abraded it and produced the sculpted landforms seen today. Unfortunately, glacial striations are not well preserved here.

Continue to the top of the steep slope.

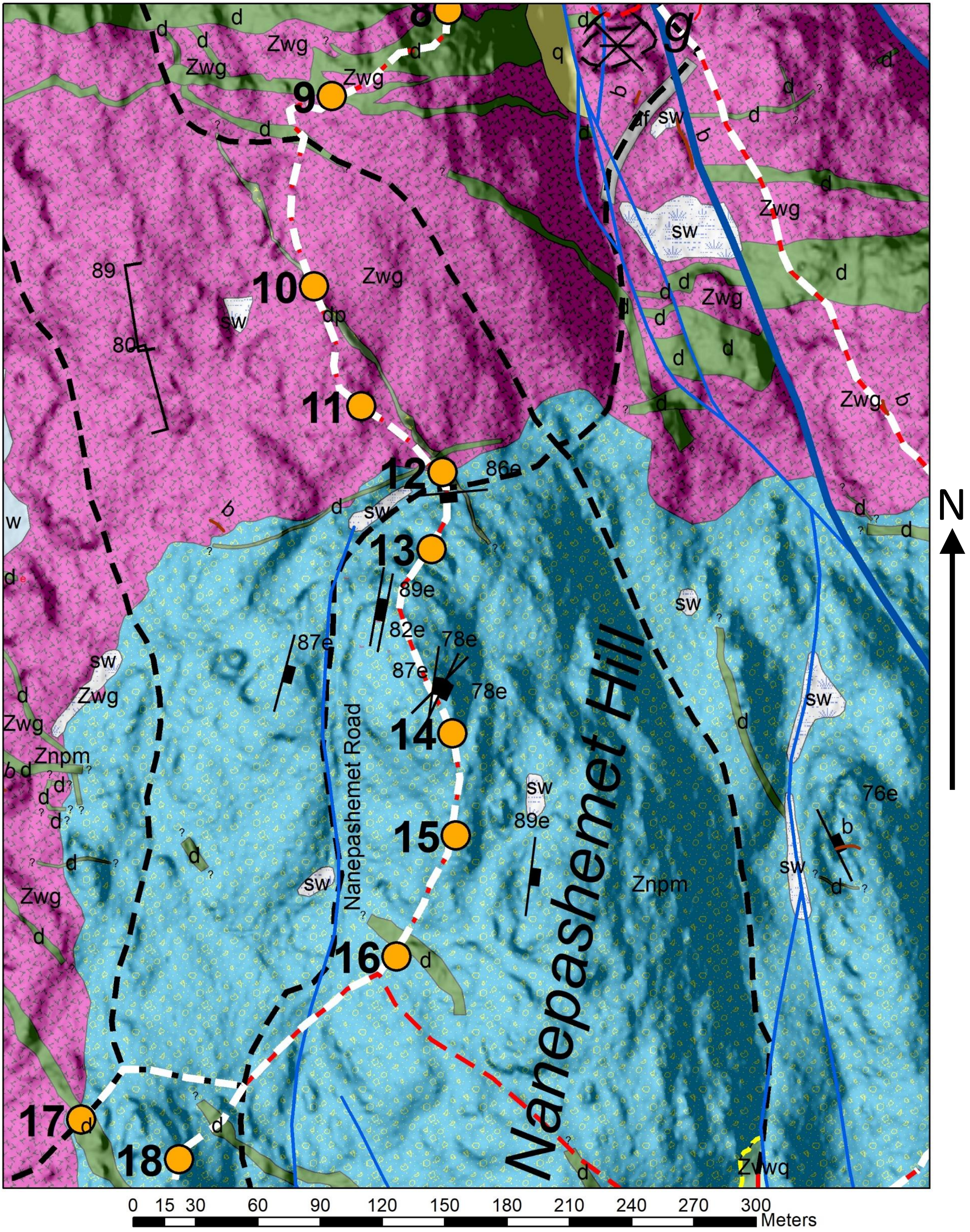
STOP 8: Near the top of the slope is the contact between the Winchester Granite (Zwg) to the north and a very wide dolerite dike (d) to the south (image below on left, view up slope). Looking at the map you can see not only the width of this dike (up to 35 m) but also the complex pattern it has, where it seems to be split into several segments separated by granite. Also note on the map that it appears to be offset in a complicated way along the faults to the east. After this, the hilltop levels to a broad surface, where the dolerite is well exposed on the trail. Below on the right is a piece of the dolerite cut to a flat surface on a rock saw. The faintly purplish-gray and green areas are the mineral pyroxene, which is partly altered to amphibole and chlorite. Small white to gray areas are plagioclase feldspar. The two brassy mineral grains in the center of the image are pyrite, which is a metallic iron sulfide mineral, commonly known as fool's gold (arrows on image). At the top of the hill, look for the glacial grooves left by glacial ice sliding across the top of the hill during the last ice age. The grooves are oriented S24°E.





STOP 9: After crossing the top of the hill, the trail gently descends across the dolerite dike (d). The dike has a complicated outcrop pattern (see the map) because, when it intruded the Winchester Granite (Zwg), the granite broke apart into the dolerite magma along irregular fractures, producing large inclusions (image to right, view back upslope). An inclusion is a piece of a pre-existing rock that broke off into a magma body and got trapped when the magma crystallized. ***Inclusions are always from a rock unit older than the surrounding igneous rock.*** After this stop, the Winchester Granite (Zwg) is exposed along the entire trail until just before junction B3-12, where the trail crosses a small NW-SE trending dolerite dike (d). West (to right) of here, this small dike is crosscut by the large dolerite dike (d) seen at Stops 8-9 upslope.

Continue the tour on Map SKY-5B. Continue on the Skyline Trail beyond junction B3-12.



Nanepashemet Hill
Nanepashemet Road
Zwg
Znpm
sw
d
q
g
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Zwq
N
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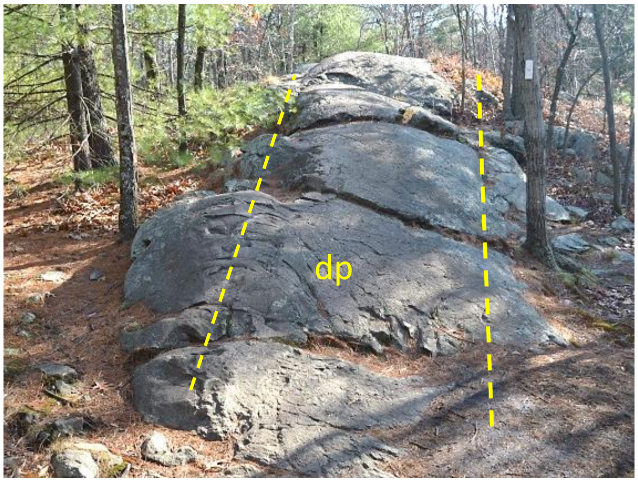
Meters

STOP 10: The first large knob on the trail (image below on left) is one of the most unusual rock units in the Fells. The flat-topped knob is a porphyritic dolerite dike (dp) that intruded the Winchester Granite (Zwg). What makes this dike unique is that it has enormous phenocrysts (mega-phenocrysts) of plagioclase (image below on right) that are as big as tongue depressors (up to 5 x 15 cm). The large phenocrysts seem to form a traffic jam in the middle of the dike extending out to narrow chill zones along the edges of the dike. A chill zone is a finer-grained area of an intrusion where the magma cooled more rapidly along its margins, producing a finer grain size. The trail follows the dike for at least 40 m before the dike veers off to the east (left) of the trail. It appears again along the east (left) side of the trail after the next stop. To the north, it pinches out prior to the large dolerite dike you saw at Stops 8 and 9.



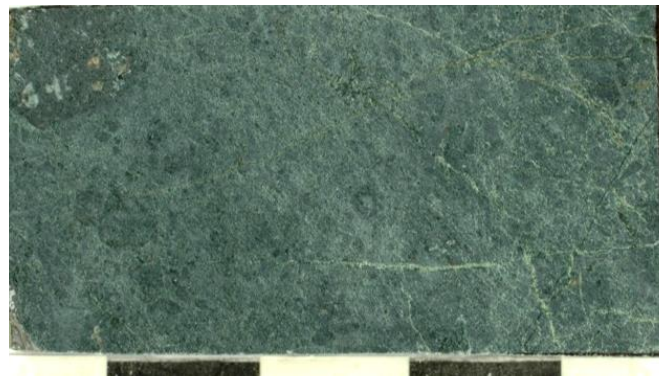
STOP 11: Just beyond the porphyritic dolerite dike (dp) with mega-phenocrysts at Stop 10 is the last outcrop of Winchester Granite (Zwg) for a while (see map SKY-4B). The outcrops at this ledge (image on right) are very nearly the last bit of the granite before its contact with the Nanepashemet Formation (Znpm). On Map 5B look at how the topography drops off when the trail crosses into the Nanepashemet; it is less resistant to weathering and erosion than the granite here, producing the lowland. Just east of here (ahead), the mega-phenocryst dike continues through the woods and across the Winchester/Nanepashemet contact.

Continue south to junction B3-17 at Nanepashemet Road.

STOP 12: Just before crossing Nanepashemet Road at junction B3-17, the last outcrop on the east (left) side of the Skyline Trail is the N-S trending porphyritic dolerite dike (dp) with mega-phenocrysts (no image). About 15-20 m north of the road, an E-W trending dolerite dike (d) crosscuts the porphyritic dike very close to the Winchester Granite (Zwg) contact with the Nanepashemet Formation (Znpm). The dolerite dike is well exposed on the east (left) side of the trail.

Cross Nanepashemet Road and head up the hillslope.

STOP 13: The trail ascends a slope on the Nanepashemet Formation (Znpm, image to right). The Nanepashemet Formation was originally basalt, a fine-grained mafic igneous rock that here was in the form of lava flows and basalt ash deposits, but it has been altered to hornfels. Hornfels is a hard, brittle rock formed by high temperature heating of fine mineral grains near an intrusion. In this case, it was the magma of the Winchester Granite (Zwg) that baked the basalt. The fine-grained basalt in the Nanepashemet recrystallized when it was baked, much like the firing of pottery in a kiln, but it still has the dark greenish-gray color of basalt. We call the changes produced by this heating of surrounding rocks contact metamorphism or baking. This unit also has many fragments of volcanic rock, mostly broken basalt fragments, and occasional conglomerate layers with mafic volcanic pebbles between basalt flows. Conglomerate is a sedimentary rock made of particles larger than 2 mm. On the image to the right, you can see a fragment of porphyritic basalt in the upper left corner, and other smaller fragments that blend into the fine-grained parts of the rock. There is much work that must be done to determine a more precise origin for this rock formation.

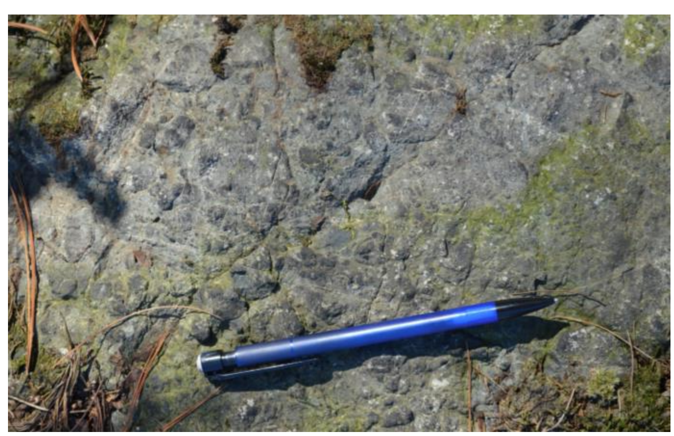


Continue to the top of Nanepashemet Hill.

STOP 14: The top of Nanepashemet Hill is bare, and the basaltic hornfels of the Nanepashemet Formation (Znpm) is well exposed (image to right). You will see a dark gray rock with many veins passing through it. Veins are fractures that are filled with mineral precipitates. The main minerals seen in the veins are pistachio green-colored epidote along with quartz. Veins on the hilltop have a consistent orientation, being nearly vertical and having an NNE-SSW trend. Symbols on the map, black bars with boxes on them, indicate the trend and dip of the veins. In addition to the veins, there are a few thin pods of the fine-grained, light-colored igneous rock called rhyolite that may be offshoots from the Winchester Granite (Zwg), which is not far down in the subsurface and is responsible for baking the Nanepashemet Formation.

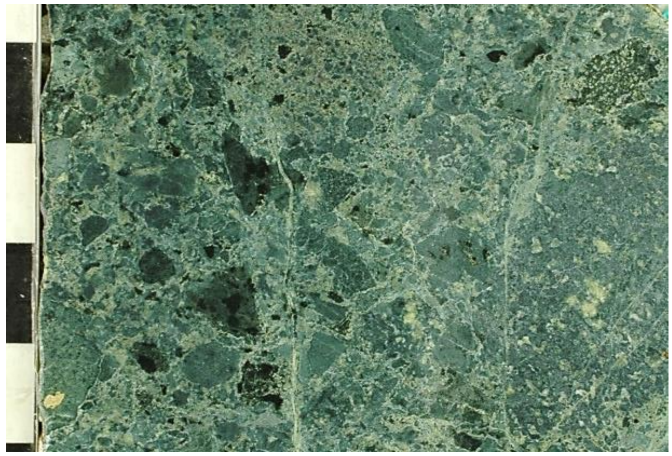
Continue across the flat hilltop and descend the relatively steep south slope of the hill.

STOP 15: At the last outcrop before the trail flattens again, the Nanepashemet Formation (Znpm) is composed of a volcanic breccia. Breccia is a type of conglomerate made of angular fragments, which in this case are basalt. Although the rock is partially baked to hornfels, you can still make out the outlines of angular basalt pebbles. The best place to see the unit is on the east (left) side of the ledge exposed on the trail (image to right), but it is hard to discern without direct sunlight as in the image. Sometimes important features are very subtle!



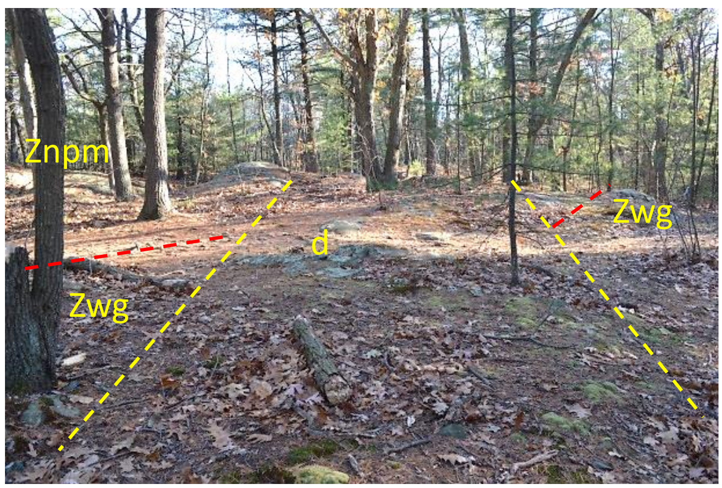
Continue downhill on the trail.

STOP 16: Just before a small trail joins the Skyline Trail from the east (left) at junction B3-22 and on the south side of a dolerite dike (d, see Map SKY-5B) is an outcrop of the Nanepashemet Formation (Znpm) with holes in it (image to right, view back up trail). The holes in the rock are a form of weathering called alveolar weathering, which occurs when a component of the rock weathers out to produce surface cavities. This appears to be common in places where large pyroxene crystals or breccia fragments were baked in hornfels of the Nanepashemet Formation, in this case next to a dolerite dike. The holes in the rock have the appearance of gas bubbles, or vesicles, which sometimes appear in lava flows, and they encourage a misidentification of the rock as vesicular basalt. However, closer examination of this rock in a slab cut on a rock saw (image below on right) shows that it is a volcanic breccia like at Stop 15. In this case, the angular fragments are fine-grained, mafic volcanic rock fragments (basalt) of various types, partly altered by contact metamorphism. Some of the fragments are porphyritic.

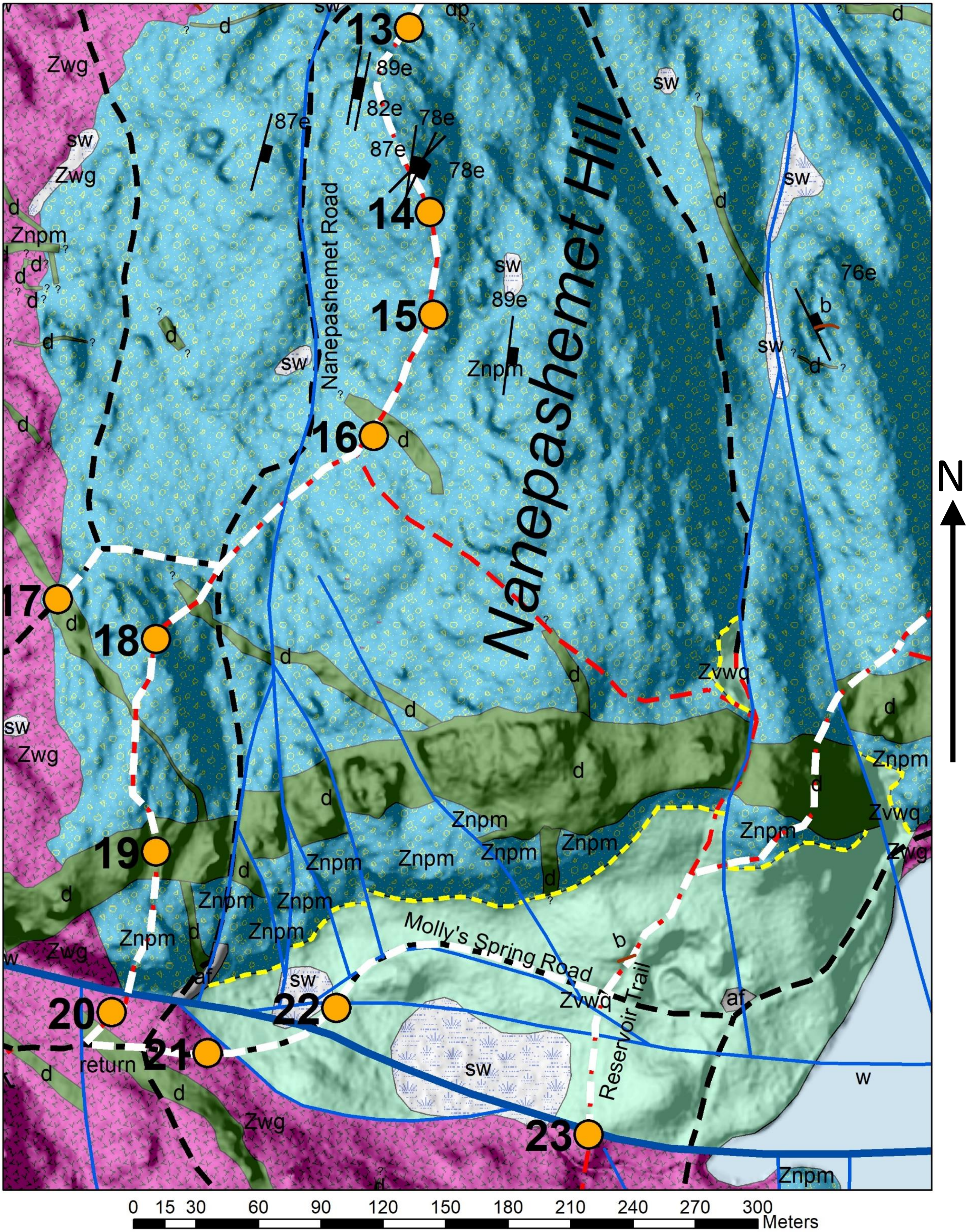


Continue the tour on Map SKY-5C. Follow the Skyline Trail to Nanepashemet Road (junction B3-21). The next stop is on a small side trip. After reaching the road, do not continue on the Skyline Trail, but instead take the trail to the west (right), heading due west from Nanepashemet Road for about 50 m to trail junction B3-20. Continue southwest (left) from junction B3-20 for about 25 m.

STOP 17: At a high spot in the trail is a dolerite dike (d) that crosses the contact of the Nanepashemet Formation (Znpm) and Winchester Granite (Zwg) (image to right, view from north (right side) of the trail, which crosses the center of image from left to right). The importance of the dike is that it crosses both the Nanepashemet Formation and the Winchester Granite. It is common to find dolerite or basaltic dikes associated with a basaltic rock formation like the Nanepashemet, but the difference here is that this dike also crosses through the granite. The Winchester Granite intruded the Nanepashemet Formation so therefore is younger than the Nanepashemet. The dike is younger than both units. This outcrop helps establish the relative ages of the rock units in the area. This outcrop also shows how difficult it is to separate the Nanepashemet Formation and dolerite dikes because of how similar they are in both color and grain size. See if you can find all the units mentioned above, and then find their contacts.



From this stop, return to Nanepashemet Road (junction B3-21) and head southwest (sharp right) onto the Skyline Trail.



Nanepashemet Hill
Nanepashemet Road
Molly's Spring Road
Reservoir Trail
13
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19
20
21
22
23
return
Zwg
Znpm
Zvwq
sw
d
b
af
w
89e
82e
87e
78e
78e
87e
89e
76e
N
0 15 30 60 90 120 150 180 210 240 270 300
Meters

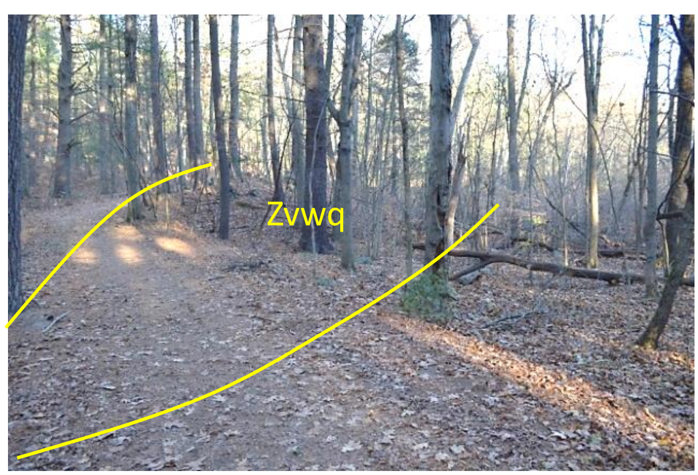
STOP 18: After climbing the steep slope from Nanepashemet Road, the trail levels off and heads south across the Nanepashemet Formation (Znpm), which again is hornfels (no image). Look for a small dolerite dike (same one as at Stop 17 but it is narrower) forming a linear ridge where the trail bends south (left).

STOP 19: As you begin to descend the flat-topped hill, the trail crosses through a very wide (up to 60 m east of here on Nanepashemet Hill) dolerite dike (d) that is traceable across much of the western Fells (image to right, see Map SKY-5C). This dike cuts through the Nanepashemet Formation (Znpm) and is displaced by many major and minor N-S trending faults. **Beyond the dike, descend a very steep slope to Molly's Spring Road**.

STOP 20: In the bottom of the valley is a major fault zone, known as the Molly's Spring Road Fault. Look at this on Map SKY-5C. Along this fault, most of the displacement was near vertical, with areas south of the fault moved upward relative to the north side. South of the fault is a block of the Winchester Granite (Zwg) and north of the fault in this area is the Nanepashemet Formation (Znpm). North of the fault and further east, the Westboro Formation (Zvwq) occurs beneath the Nanepashemet Formation along an unconformity (yellow dashed line on map). An unconformity is a boundary at the top of a unit that represents missing time in the rock record and is overlain by a sedimentary layer, ash deposit, or lava flow. The unconformity to the east is a surface eroded into the Westboro Formation and then overlain by the Nanepashemet Formation. For more on unconformities see: Unconformities. West of here, the Winchester Granite appears by itself on the north side of the Molly's Spring Road Fault. **Turn left onto Molly's Spring Road.**

STOP 21: Several slices of rock are separated by minor faults in the Molly's Spring Road Fault zone. It is not unusual for a large fault to be a series of branching displacement surfaces, rather than a single large fault plane. We refer to this as a fault zone. Slices of heavily fractured metasandstone of the Westboro Formation (Zvwq) were dragged upward from below along the faults. Metasandstone is simply metamorphosed sandstone, which here is almost entirely composed of quartz grains. A slice of metasandstone occurs at this stop (image on right) on the south side of the main fault. In the image, faults shown on the map are labeled along with rock formations they displace. Between the major and minor faults is a mound of shattered metasandstone (Zvwq) and to the south (right) is the Winchester Granite (Zwg).

STOP 22: Another 75 m east down Molly's Spring Road is a second slice of the Westboro Formation (Zvwq) along the Molly's Spring Road Fault, this time north of the main fault (image on right, view east). The traces of faults as shown on the map, are on the image, with a mound of shattered metasandstone (Zvwq) between them. The main fault is just off the image to the south (right), where it crosses beneath a wetland. Again, it is not unusual for a large fault to be a series of branching displacement surfaces like this, or a fault zone, rather than a single large fault plane.



From Stop 22, continue east on Molly's Spring Road to the Reservoir Trail (orange markers) and head south (right), crossing a wooden bridge after about 50 m on the south (far) side of the fault zone.

STOP 23: At the stream outlet from the swamp (at wooden bridge) is the approximate position of the major fault in the Molly's Spring Road Fault zone (image to right). The image is a view to the north (back towards Molly's Spring Road) from the hill south of the main fault (orange line on image), overlooking the footbridge. The hill is underlain by the Winchester Granite (Zwg). The Westboro Formation (Zvwq) near the fault is highly fractured. The position of the fault is shown on the north side of the granite knobs at the footbridge. The northern knob that is closest to the fault, may be an extremely large boulder instead of an outcrop. From this position, the Molly's Spring Road Fault heads eastward, where it goes beneath a small cove in South Reservoir.

Return to Start: The remainder of the tour heads north back to Hillcrest Parkway by way of the Reservoir Trail (orange markers). Initially, follow Map SKY-5C. From Stop 23, head north (backtrack) on the Reservoir Trail to Molly's Spring Road.

After crossing Molly's Spring Road and about 30-50 m beyond it on the Reservoir Trail you will see outcrops of the Westboro Formation (Zvwq). After crossing an unconformity, the trail climbs the edge of the upland which is underlain by basaltic hornfels of the Nanepashemet Formation (Znpm) and the same large dolerite dike (d) seen at Stop 19. For more on unconformities see: Unconformities.

Stay on the Reservoir Trail (orange markers in the field, white line with wide dashes on map), which branches east. The dashed yellow line on the map indicates the erosion surface separating the Westboro and overlying Nanepashemet Formation. Cross the hilltop and descend to the valley below.

Continue on Map SKY-5D: The trail crosses a small fault valley, and then again ascends the large dolerite dike (d) and a second upland in the Nanepashemet Formation.

The trail then crosses a major fault valley, and again winds across the dolerite dike (d). On this hill is also the contact of the Westboro Formation (Zvwq) and the Nanepashemet Formation (Znpm), indicated as an unconformity (yellow dashed line). For more on unconformities see: Unconformities.

About 150 m north of (beyond) the last place where the wide dolerite dike (d) is crossed, you will see a porphyritic rhyolite dike (fp) in the trail as you climb to the highest part of the hill. Look for a light-colored rock in the trail exposed by erosion and polished by foot traffic. The rhyolite dikes are fine-grained versions of granite and thought to be offshoots of the Winchester Granite in the subsurface. Note that they have about the same trend as veins in the area (indicated by black bars with boxes on the map). The trail levels off a short distance after the rhyolite dike.

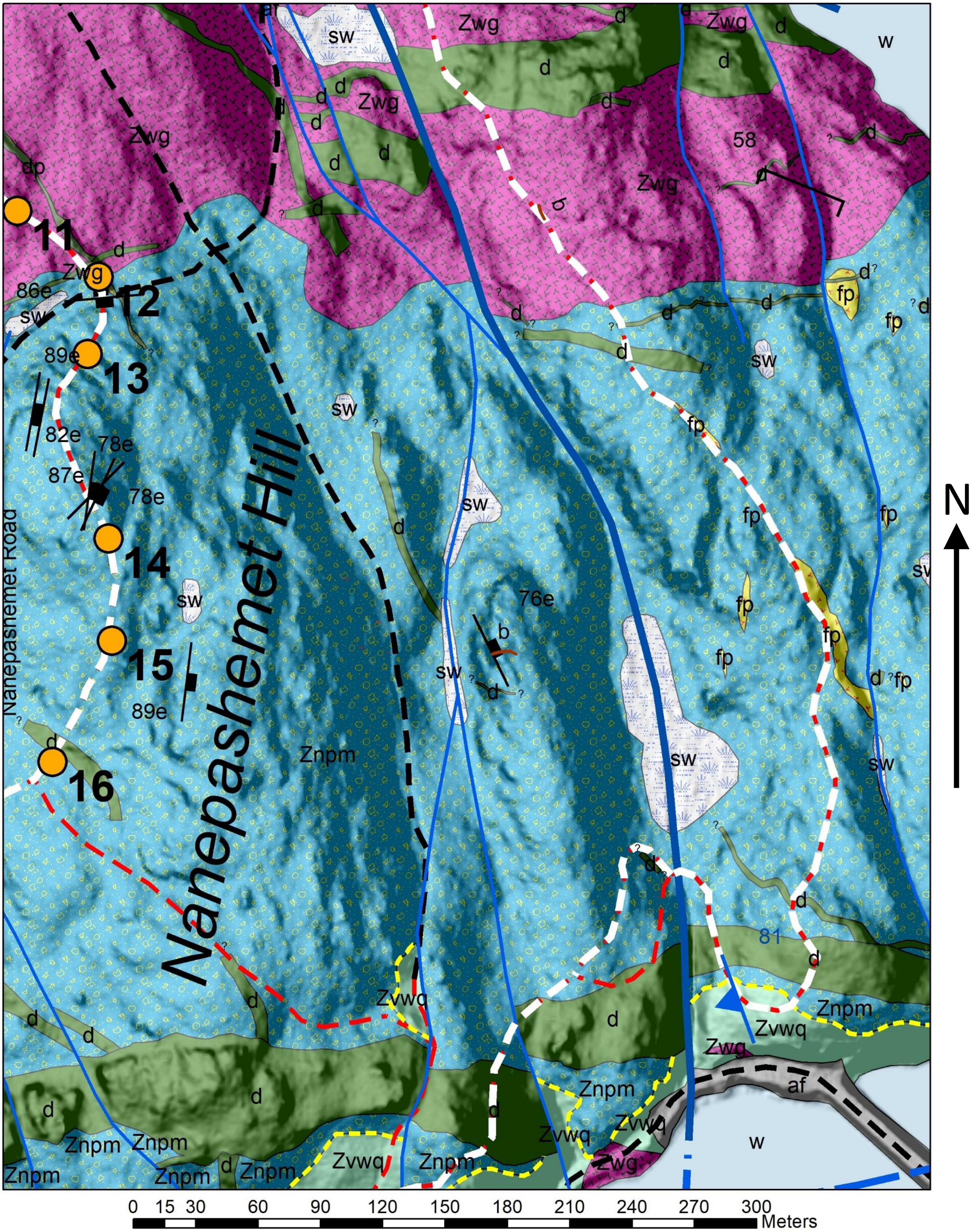
In another 150 m, the far end of the hill crosses the Nanepashemet Formation (Znpm) contact with the Winchester Granite (Zwg) where the granite intrudes the basalt.

In another 100 meters, the trail crosses another large dolerite dike (d) cutting through the Winchester Granite.

For the remainder of the tour refer to Map SKY-5A. Continue on the Reservoir Trail (orange markers) to Stop 6, where the Reservoir Trail (orange markers) crosses the Skyline Trail (white markers) from earlier in the tour. Stay on the Reservoir Trail after Stop 6.

The map will take you through the same granitic ridges and valleys you saw on Stops 2 through 6, but on the Reservoir Trail, which heads east from Stop 6 and parallels the Skyline Trail before rejoining it at junction B2-4. From B2-4 follow the Skyline Trail north (left) to Stop 1 (also Stop 17 of Part 4 of the Skyline tour) at the access road. Head west (left) on the access road to Hillcrest Parkway and Gate no. 17.

END OF PART 5


Nanepashemet Hill
Nanepashemet Road
Zwg
Znpm
Zvwq
sw
d
fp
af
w
b
11
12
13
14
15
16
86e
89e
82e
78e
87e
76e
58
81
N
0 15 30 60 90 120 150 180 210 240 270 300 Meters

Below is a listing of all the rock units you have seen on Part 5 of the Skyline Trail tour. Can you make a list of the relative order in which the rock units and major faults (E-W and N-S) formed? Use the relationships seen on the map as well as information gathered in the field.

dolerite (diabase) dikes (d)
porphyritic dolerite dike (dp)
rhyolite dikes (fp)
Nanepashemet Formation (Znpm)
Westboro Formation (Zvwq)
Winchester Granite (Zwg)

Here is a summary of the features and vocabulary for Part 5 of the Skyline Trail tour:

minerals:
- quartz
- plagioclase feldspar
- alkali feldspar
- mafic rocks and minerals
- pyroxene
- amphibole – hornblende
- chlorite
- biotite mica
- zircon
- pyrite

igneous rocks:
- coarse-grained vs. fine-grained
- dolerite
- granite
- rhyolite
- porphyry, porphyritic)
  - (phenocrysts + ground mass)
- magma – molten rock, magma chamber
- intrusion
- dike
- pluton - For more on how plutons form see: Plutons.
- inclusion (xenolith)
- chill zone or chilled margin
- volcanic breccia
- crosscutting
- veins

sedimentary rocks:
- conglomerate
- sandstone
- mudstone

metamorphic rocks:
- contact metamorphism
- hornfels
- basaltic hornfels
- metasandstone

time abbreviations:
- Ma = mega-ano = millions of years ago

radiometric dating - For more on how ages are determined for rocks see: RockAges.
Neoproterozoic Era
contacts
Unconformity - For more on unconformities see: Unconformities.

fracture planes or joints
fault, fault displacement
Fault zone

erosion surface - unconformity
weathering – mechanical and chemical break down of rocks
erosion – removal of weathered material
colluvium – mass movement debris
glaciation or ice age
glacial striations and grooves
glacial erratic