# QUIMPER GEOLOGICAL SOCIETY

# GUIDE FOR A WALK TO TAMANOWAS AND PEREGRINE ROCKS, JEFFERSON COUNTY, WASHINGTON

## JULY 2022


**GUIDE COMPILERS**

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## INTRODUCTION

This tour of bedrock and surficial geologic features (Fig. 1) is described in the context of Chimacum Valley, one of the more fertile agricultural areas in Jefferson County. The focus is on Tamanowas Rock and Peregrine Rock, but other subjects include the glacial history of the Quimper Peninsula, specifically Chimacum Valley, glacial erratics on the peninsula, and the geology and tectonic history of the underlying Eocene volcanic rocks that form Tamanowas Rock.

The Tamanowas Rock Sanctuary is protected from development and owned by the Jamestown S'Kallam Tribe, who hold it sacred. The sanctuary is the result of a successful collaboration among tribal, non-profit, and governmental organizations to protect Tamanowas Rock. Many other sacred sites across North America and around the world are threatened by development or use incompatible with their sacred status, and the hope is that the process that created this site can serve as a model for other groups.

Tamanowas Rock is a remnant of an explosive volcano that erupted about 43 million years ago, well before the adjacent Olympia Mountains existed. The rock is a tuff composed of adakite, an unusual type of lava that forms under anomalously high temperatures where a subducted oceanic plate starts to melt, Tamanowas Rock forms a large conical spire that can be seen from several view-points around Chimacum Valley.

Peregrine Rock is a glacial erratic. It currently is the largest erratic documented on the Quimper Peninsula.

In the late Pleistocene (Ice Age), the Puget Sound at this latitude (48° North) was covered with 900 to 1200 meters (m) (3000-4000 feet [ft]) of ice of the Puget lobe, which advanced south from Canada and the northern Cascades. This advance occurred during the Vashon Glaciation, which climaxed about 17,500 years ago. By 15,000 years ago, the lobe's advance had stalled, the ice was melting away, and glacial runoff in this area concentrated in Chimacum Valley, the prominent meltwater channel that leads north-northwest to Discovery Bay. To the south, channels in Center and Beaver valleys fed the Chimacum Valley.

Note: Timing estimates for glacial events are based on numerous types of age control and are continually being revised. Do not be concerned with the actual numbers; focus on the rapid advance and retreat of ice at the climax of our most recent glacial episode.

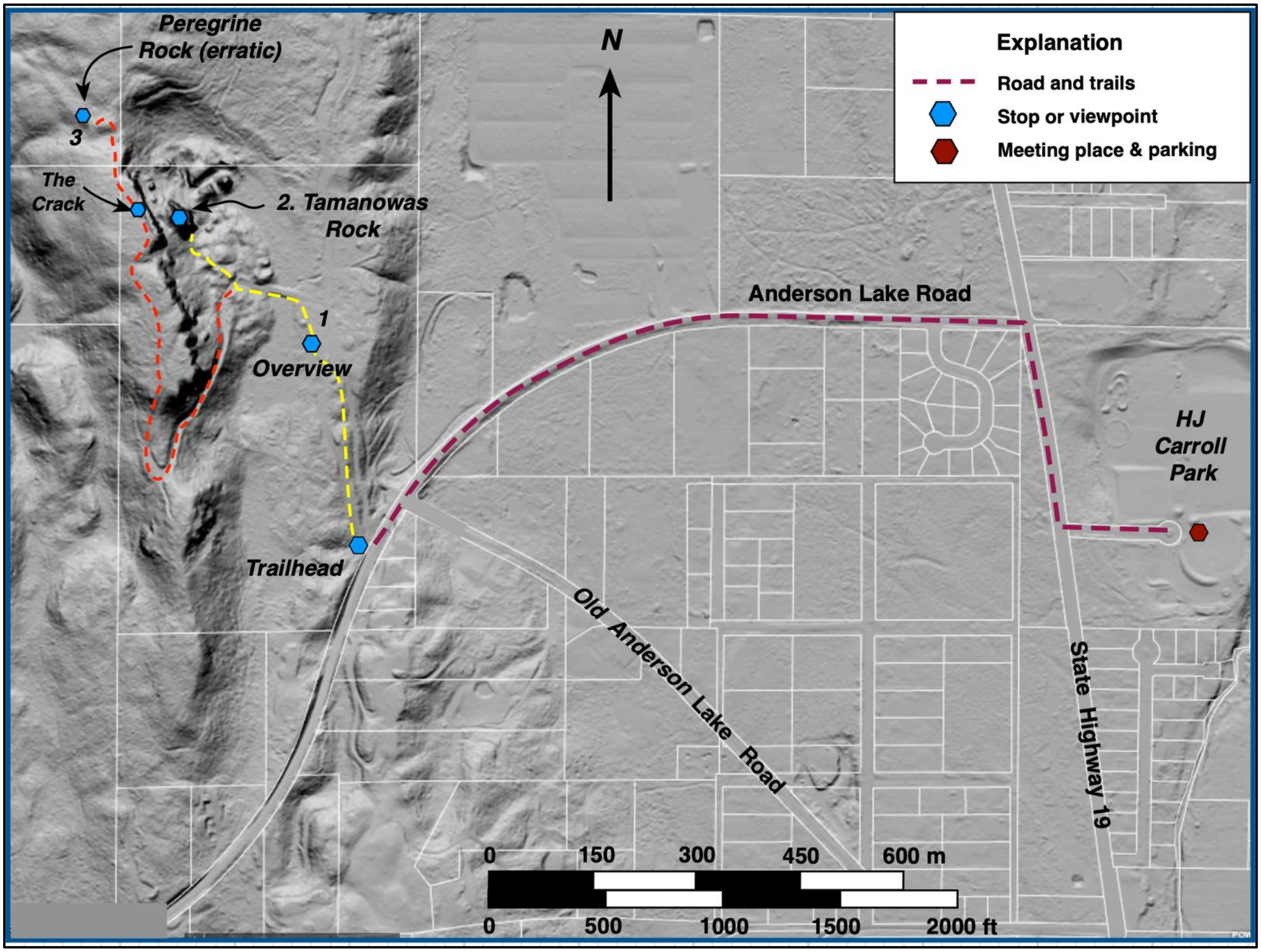


***Figure 1.*** *Route map for the walk to the rocks. The first stop is at the Overview (1), followed by Tamanowas Rock (2), then The Crack and Peregrine Rock (3). The hike is about three miles (4.8 kilometers) round trip from the starting point at HJ Carroll Park, with steeper, rougher ground beyond the trailhead. The Tamanowas Rock Sanctuary is marked by the large white rectangle that includes Stops 1 and 2. The base for this map is clipped from lidar imagery available at https://gisweb.jeffcowa.us/LandRecords/. Lidar is an imaging technique that allows one to "see through" vegetation and creates an image of the land surface.*

## TRIP GUIDE

**START**: HJ Carroll County Park, outdoor enclosure.

GPS: 48° 1′ 5.9″ N
122° 46′ 32.6″ W

Folks traveling on foot should to be careful when crossing Highway 19. Traffic moves fast at this location. Safety vests are recommended.

The route to Stop 1 goes north 0.3 kilometer (km) (0.2 mile [mi]) on Highway 19, then turns west on Anderson Lake Road.

Follow Anderson Lake Road about 1 km (0.6 mi) and watch for the turnout and entrance to the Jefferson Land Trust's Tamanowas Rock Sanctuary (Fig. 1). There is space for several cars here if you are making this tour on your own. The walk off road is approximately 4 km (2.4 mi) roundtrip from this point. Proceed uphill 0.3 km (0.2 mi) on the dirt track.

## STOP 1. OVERVIEW

GPS: 48° 1′ 14.2″ N
122° 47′ 27.0″ W

This walk is mostly in the Tamanowas Rock Sanctuary, but the adjacent ridge is in Anderson Lake State Park, which maintains hiking, biking, and horse trails. The 200-hectare (ha) (496-acre [ac]) state park was established in 1969.

The fairly flat bench at this first stop is a terrace (see Fig. 1), the remnant of a once-broader outwash plain composed of sand and gravel deposited by meltwater flowing south from the advancing ice. Logging took place on this and adjacent parcels before 1993. Later, concerned individuals began the process of purchasing and protecting this unique site, which had long been held sacred by members of the Jamestown S'Kallam Tribe.

### *A SACRED PLACE FOR THE S'KALLAM TRIBE*

(Modified from Blumhagen, 2013)

Covered in caves, crevices, and cliffs, Tamanowas Rock has been a sacred place for the native inhabitants of this area going back at least 10,000 years and is still sacred to many Pacific Northwest tribes today.

Across the globe there are places set apart, designated as places of worship, reflection, or other sacred use. Many such sites are integral to the preservation of traditional cultures and religions, as well as the preservation of land and biota. In the United States, many of these sites are on land lost during colonization and are threatened by encroaching development or desecrated by use incompatible with their sacred status.

The S'Klallam and Klallam peoples in their oral traditions recall Tamanowas Rock as a vantage point from which their ancestors hunted mastodons and as a place of refuge during tsunamis and other flooding events.

The Tribe purchased the property and some additional platted land beginning in 2008. They then engaged the Jefferson Land Trust to protect the 60-ha (150-ac) site from development by placing an easement on the deed to the property. Such easements are conservation tools commonly used to protect properties for a specific purpose forever. The easement here was finalized in 2012, the property was designated as the Tamanowas Rock Sanctuary, and the Jefferson Land Trust continues to monitor the use and maintenance of the sanctuary.

The creation of this sanctuary shows how cross-sector collaboration among a tribe, a non-profit organization, and a state government agency can be an effective tool for the preservation and continued management of a sacred site. By this sort of collaboration, those working to protect sacred sites can leverage additional resources, increase community awareness of their efforts, and ensure that their efforts address spiritual, cultural, and ecological values of the site. Tamanowas Rock is now protected from development and is under the ownership of the people who consider it sacred. This process serves as a model for other groups working to protect other sacred places.

### *A BRIEF GLACIAL HISTORY OF THE REGION*

At about 17,000 years ago, during the Vashon glacial stade, the region we are walking through was covered by thousands of feet of ice of the Puget lobe that advanced south from Canada and the northern Cascades. At Tamanowas Rock, the ice was about 1200 m (3900 ft) thick, on the basis of geophysical modeling (see Fig. 2; VGA, 2016).

The following summary is modified from Porter and Swanson (1998), a compilation on Wikipedia (2022), and a video simulation (VGA, 2016).

The Puget lobe remained at its maximum extent from around 16,950 years BP (Before Present, *i.e.*, 1950) to around 16,850 years BP, only about 100 years. The ice depths were slightly more than 1500 m (5000 ft) at the Canada–United States border, 1000 m (3300 ft) in Seattle, and 200 m (660 ft) at the glacier's terminus in the Tenino area, south of Olympia.

Around 16,850 years BP, the Puget lobe began melting back northward at a rate of about 340 m (1120 ft) per year. By about 16,650 years BP, the glacier terminus had melted back to present-day Olympia. The Puget lobe's retreat began to create Glacial Lake Russell. By 16,150 years BP, the lobe extended south only to Seattle. And by about 16,000 years BP, the ice had retreated far enough north that Glacial Lake Russell and the Strait of Juan de Fuca became connected, replacing Glacial Lake Russell with the salt water of Puget Sound again.

(Prior to the Pleistocene, the Puget Sound area was a lowland where rivers likely came together and drained to the north, then out the Strait of Juan de Fuca. During the late Pleistocene the drainage pattern was altered when ice blocked the drainage to the north, thereby creating Glacial Lake Russell to the south during the melting of the Puget lobe and adjacent mountain glaciers.)

The isopach map (lines of equal ice thickness) (Fig. 2) shows the maximum southern extent of the Puget lobe, which terminated near Tenino, about 19 km (12 mi) south of Olympia. The end of the glacier built a low terminal moraine that is partially preserved today as a series of east-trending hills south of Olympia. Most of the southern Puget lobe drained southwest into the Pacific Ocean near Aberdeen (west of Olympia).

Farther north, about 11 km (~6 mi) south of Chimacum, as the lobe's advance stalled, blocks of ice that were stranded in the area melted away,

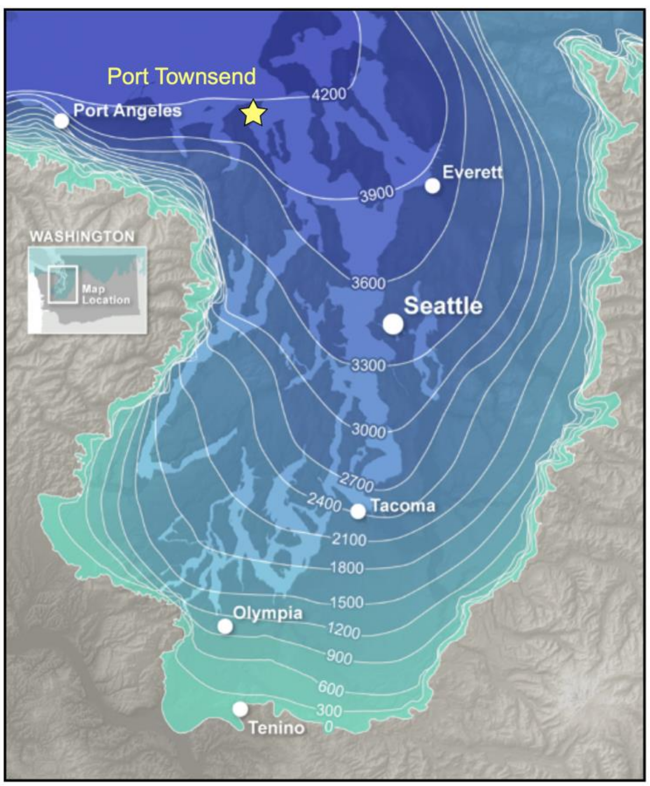


*Figure 2. Schematic map of ice thickness in feet for the Puget lobe at its maximum extent about 17,000 years ago. (WADNR, 2022)*

and the glacial runoff flowed northward in meltwater channels. This caused deepening of Chimacum Valley and its two southern feeders, Beaver and Center valleys south of Chimacum. The Chimacum Valley conduit was directed west-northwest, then west past the Jefferson County Airport to Discovery Bay (Fig. 3). In the past 11,500 years, the waters of Chimacum Creek have been captured by headward cutting of a small but steep channel at Irondale, thereby diverting Chimacum Creek to Port Townsend Bay. The present creek channel has now been incised upstream to Chimacum High School.

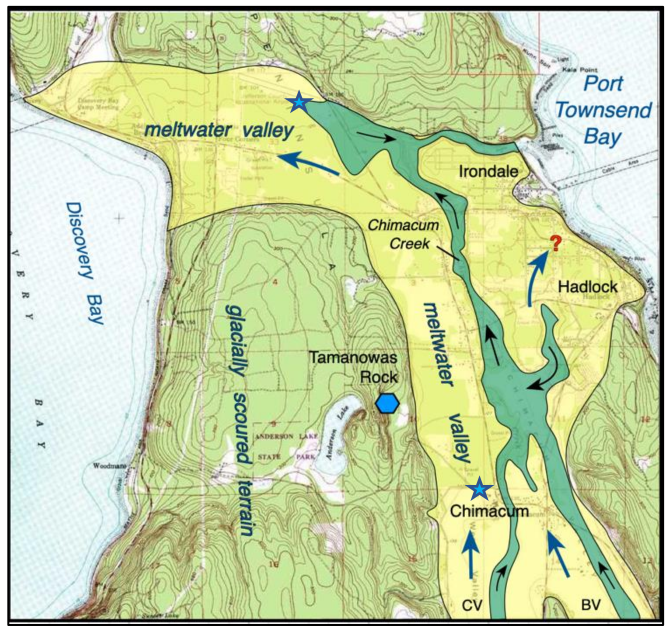


***Figure 3.** Sketch map of Chimacum Valley shows meltwater channels (blue arrows) during deglaciation and the current pathway of Chimacum Creek (black arrows). The feeders to Chimacum Valley are Beaver Valley (BV) and Center Valley (CV). Northern blue star is the location of the Jefferson County Airport, the southern blue star is the location of Chimacum High School.*

**To get to Stop 2,** leave the flat paved area and walk north; the trail turns left (west) and heads into the woods. After another 90 m (~300 ft), take the trail's right fork and follow it to the base of Tamanowas Rock. (See route map, Fig. 1, and geologic map, Fig. 5.)

**STOP 2. TAMANOWAS ROCK**

GPS: 48° 1′ 19.5″ N
122° 47′ 35.5″ W

Tamanowas Rock is a S'Kallam tribe sacred site. Please do not disturb anything here, and do not collect rocks or any artifacts that you may find.

### *A VIEW OF TAMANOWAS ROCK*

Tamanowas Rock is visible from various locations, including Chimacum, the east margin of Chimacum Valley, and Port Hadlock. However, the view as you approach it today (Fig. 4) is obscured by forest, most of which has not been cut for decades. Mature (>50-year-old) Douglas fir is the predominant tree type locally, followed by Western red cedar, hemlock, and madrone.

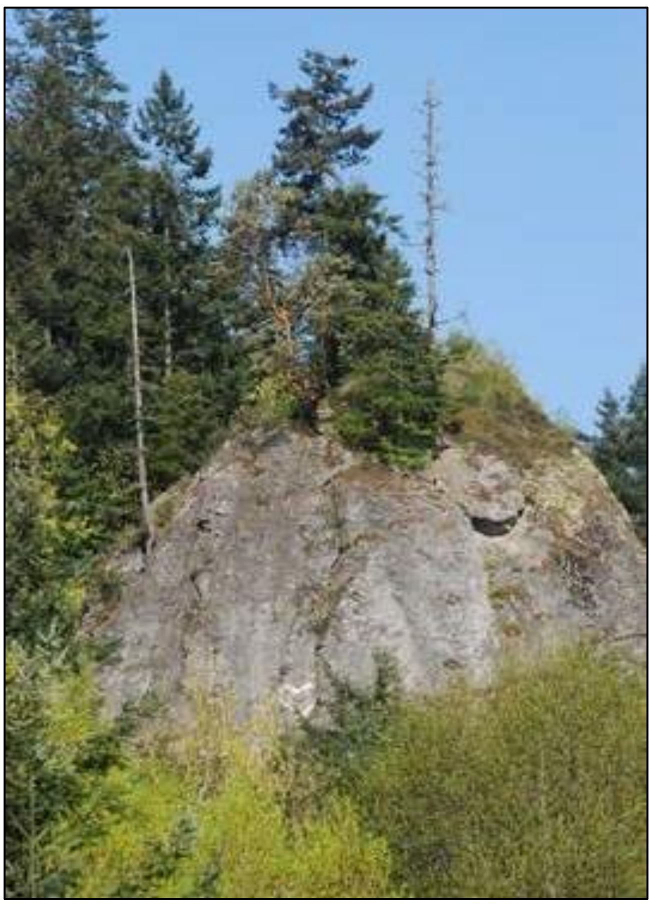

***Figure 4.*** *The top portion of Tamanowas Rock, as viewed from the southeast.*

### *GEOLOGY OF TAMANOWAS ROCK*

In addition to being culturally significant, Tamanowas Rock is also important scientifically. Rising ~45 m (150 ft) above the surrounding forest floor, it is an imposing monolith of ancient volcanic rock (Fig. 4).

This rock provides a unique window into a time when the local geology and landscape were very different from what you see today, and in a larger context, it documents tectonic events that led to the birth of the Cascade Range. This section of the guide briefly summarizes the story of Tamanowas Rock in five parts: (1) the type of volcano and style of eruption, (2) why and when volcanic activity occurred at this location, (3) erosion of the volcano and formation of the ridge above Anderson Lake, (4) creation of the isolated spire called Tamanowas Rock, and (5) geologically 'recent' weathering features.

***Tamanowas Volcano and its Eruption*.**

Upon arriving at Tamanowas Rock you will quickly see that the volcanic rocks here are quite different from the somewhat older basaltic lavas of the Crescent Formation that constitute most of the bedrock (under younger glacial deposits) of the Quimper Peninsula. Outcrops of Crescent basalt are visible along Highways 19 and 20.

Three differences of Tamanowas rock in particular are instructive here:

(1) This rock is <u>fragmental</u>: it consists of angular to sub-rounded clasts (fragments) as much as ~1 m (3 ft) across embedded in a matrix of similar, but much finer grained, material. Here the clasts appear to rest upon one another; these deposits are "clast supported". The fragmental character is indicative of an explosive eruption, very different from the relatively peaceful events that produced the Crescent lavas.

(2) The rock is <u>light gray</u> to tan, not dark gray to black like a basalt. A lighter color indicates a higher silica content, and magmas with higher silica tend to be more viscous and produce more explosive eruptions.

(3) Upon close inspection (a hand lens will help), you will see in the rock scattered crystals of plagioclase feldspar (white to gray) and <u>hornblende</u> (black and elongate but commonly

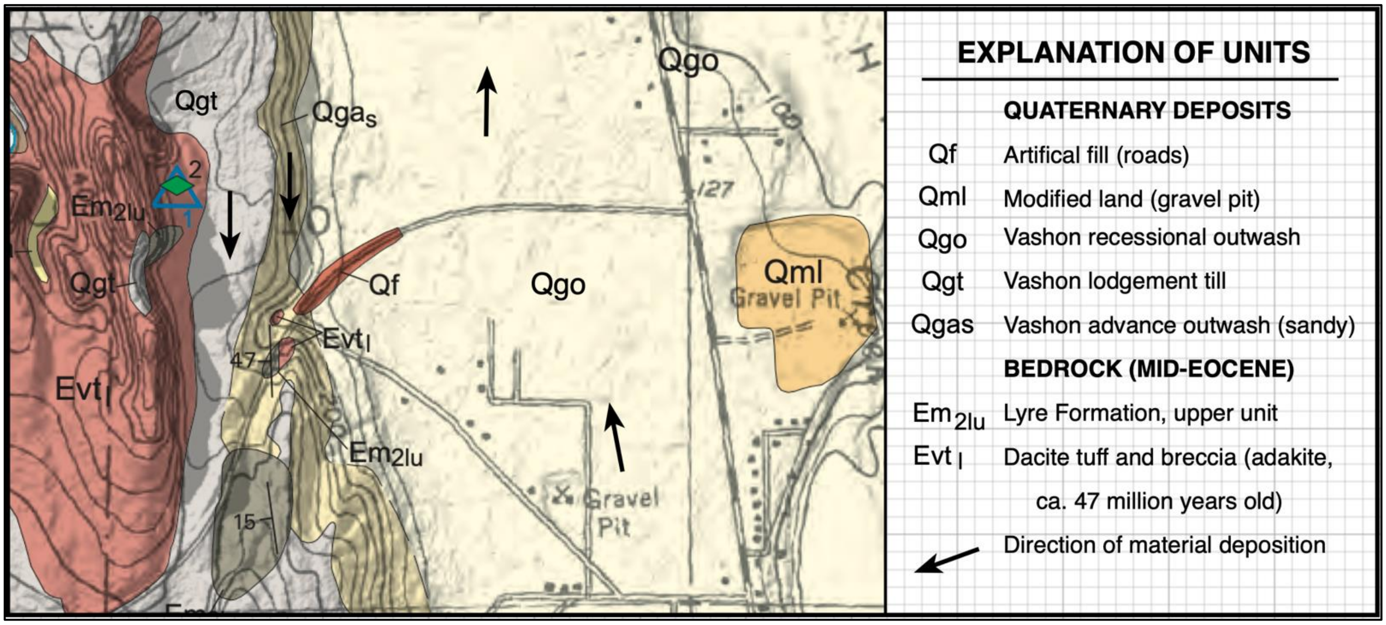


*__Figure 5.__ Geologic map of the area around Tamanowas Rock (study area in Fig. 1). The gravel pit (unit* Qml*) is the location of HJ Carroll County Park (starting point for this trip). Mapping and explanation of units are from Schasse and Slaughter (2005). Blue triangle and green diamond are sampling locations for dating the rock.*

appearing rusty). The hornblende is significant because it forms only in magmas that contain water. Water is more abundant in subduction zone magmas because melting in this setting is caused by the release of water from seafloor sediment and altered basalt that make up the subducted slab.

Hornblende is not present in Crescent Formation lavas (which formed in a hotspot/divergent boundary setting where subduction was not occurring), so its presence tells us there was a change in tectonic setting before Tamanowas Rock formed.

The chaotic, poorly sorted, fragmental nature of this deposit is characteristic of a block-and-ash flow, a type of pyroclastic eruption typically associated with the collapse of a dome volcano. To see a dramatic recent example of a block-and-ash flow, search YouTube for "Unzen pyroclastic flow". Such domes are fairly small, steep sided volcanoes, most less than a few thousand feet tall. (One is currently growing inside Mount St. Helens.) Dome collapse will unleash a violent avalanche of exploding rock fragments, ash, and hot gas that travels downslope at up to 100 km (60 mi) per hour and is usually confined to a stream channel or other topographic low. They rarely travel more than 10 km (6 mi) from the source, so

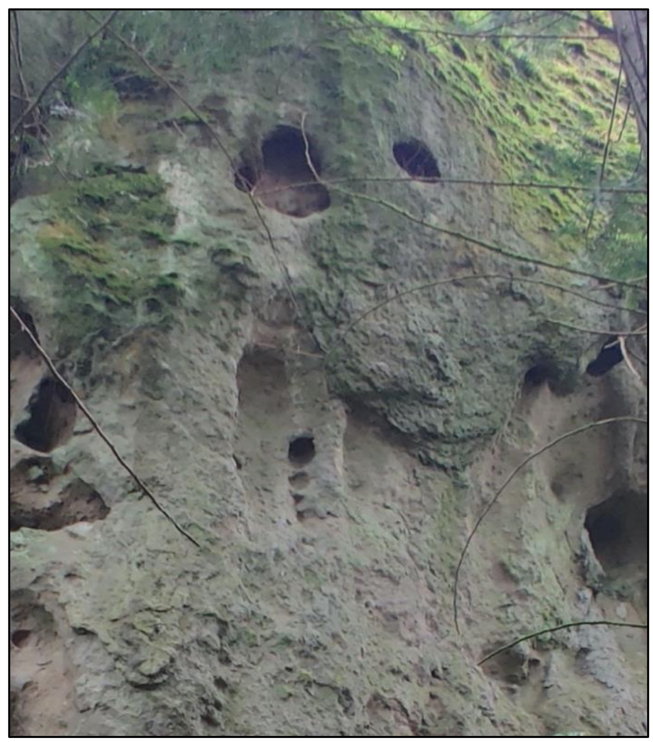

*__Figure 6.__ Vertical chimney-like features at photo center may be gas-escape structures. Escaping vapors, hot and acidic, would have hydrothermally altered the rock, which may explain why cavities are commonly associated with these features. The dark, round cavity in the center of the photo is approximately the size of a basketball.*

the fairly large size of the blocks at Tamanowas Rock (as much as ~1 m [3 ft] across) suggests the volcano was nearby.

There are numerous vertical pipe-like structures in and around Tamanowas Rock that may be gas escape structures (Fig. 6). They imply the material was hot when deposited and are another characteristic feature of block-and-ash flow deposits.

The largest exposure of these rocks is also here, near Anderson Lake, and that further supports the inference that the volcano was nearby.

### *When and Why was There a Volcano Here?*

Two ash-flow samples from this site have been dated, yielding ages of 46.6 million years (Ma) (by Ar-Ar method) and 43.2 Ma (by zircon U-Pb method). Volcanism at Tamanowas Rock thus occurred after the accretion of Siletzia (~50 Ma) and about the same time as (or slightly before) the beginnings of Cascade Range magmatism (~46 Ma). Siletzia is a massive accumulation of early to middle Eocene marine basalts and interbedded sediments in the forearc of the Cascadia Subduction Zone. Siletzia is the basement rock under western Oregon and Washington and the southern tip of Vancouver Island.

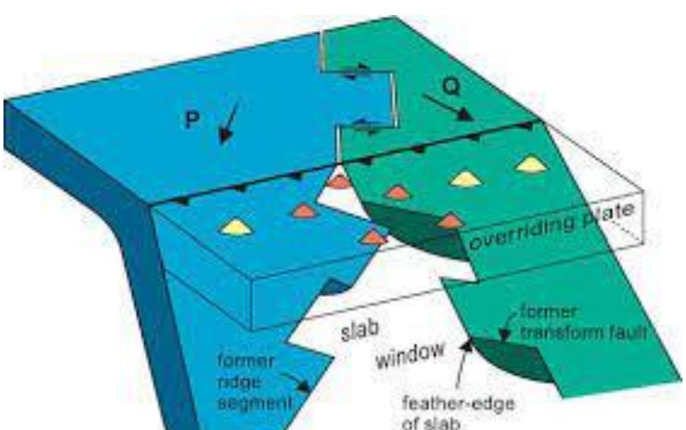


***Figure 7.*** *Diagram of a slab window forming where an oceanic spreading ridge between two diverging plates (P, Q) is being subducted. Hot mantle rising through the slab window (gap in the slab) drives the subducting slab to melt at its edges, producing adakite magmas (the orange volcano symbols) that differ from normal arc volcanoes (yellow symbols). From Thorkelson and Breitsprecher (2005).*

Chemically, the rocks that make up this ash flow are <u>adakites</u>, a rock type first described by Defant and Drummond (1990) and named for Adak Island in the Aleutians. In hand sample, adakites look like ordinary andesites or dacites (intermediate-composition lavas), but they have unusual trace element traits (*e.g.*, high Sr/Y), indicating they formed by melting of the subducting oceanic plate. Under normal subduction-zone conditions, the oceanic (overriding) plate does not melt, so creation of adakites requires unusually hot conditions. Two examples of situations in which adakites can form are: (1) at the edges of a slab window (Fig. 7), and (2) at the leading edge of the slab in a new subduction zone. In both situations the edge of the slab is a place where hot, up-welling mantle can drive melting and produce adakite magmas.

Because the age of the adakite at Tamanowas Rock overlaps the initiation of Cascade Range volcanism, the most likely explanation here is that the products of melting at the leading edge of the Juan de Fuca plate are the result of subduction re-starting after the collision of Siletzia and North America.

### *Erosion of the Volcano and Formation of the Ridge above Anderson Lake*

Ash flows travel down valleys, but at Tamanowas Rock these rocks currently form a ridge. This is an example of *topographic inversion*: the ash flow was originally deposited in a valley, but after it cooled and solidified (lithified), the ash flow was more resistant to erosion than the rocks that formed the valley walls. During the 40+ million years following ash deposition, those walls have eroded away, leaving the ash flow as a ridge (Fig. 8). The thickness of the ash-flow deposit (>100 m [325 ft]) implies that the original valley was at least this deep, but nothing remains of the older rock that composed its walls. The ash flow is part of the Lyre Formation, and small exposures of this unit are mapped nearby (Fig. 5), but we do not know whether similar conglomerates, sandstones, and siltstones formed the valley walls for the ash flow.

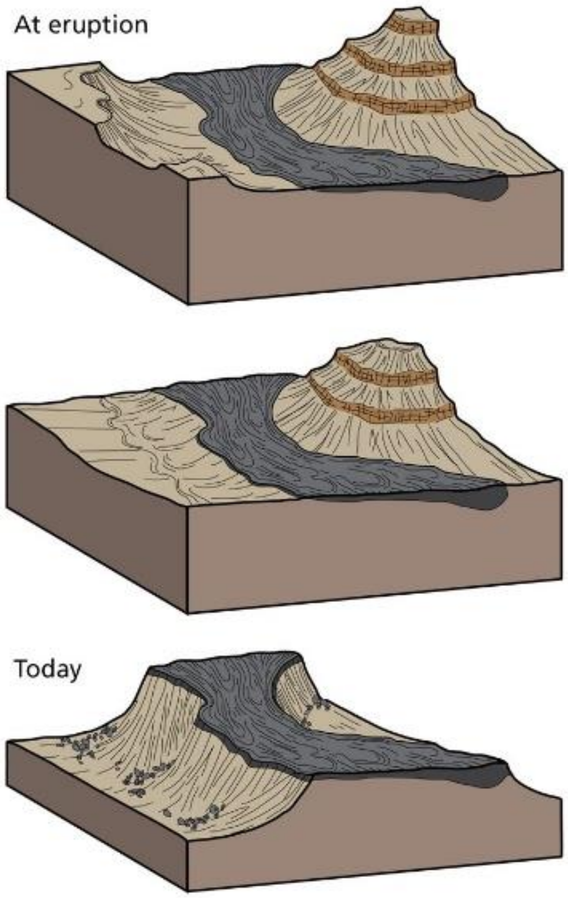


***Figure 8.*** *Diagram showing how a resistant rock (lava flow) can lead to inverted topography. (National Park Service)*

### *Glacial Processes and Creation of the Isolated Tamanowas Rock Monolith*

Today Tamanowas Rock stands alone, ~50 m (150 ft) separating it from the bluff behind, and this raises questions: Why is it separated from the rest of the ash-flow deposit? Is Tamanowas Rock in its original position, or has it moved?

Glacial processes—both deposition and erosion—have profoundly influenced the present-day landscape of Tamanowas Rock and its surroundings.

The ice-rafted erratic on top of the ridge nearby is evidence that advancing ice flowed over Tamanowas ridge. Vashon lodgement till exposed in the area of Tamanowas Rock (Fig. 5) implies the face of the ridge was in contact with moving ice, which likely modified and steepened the slope face. Vast quantities of glacial meltwater that accompanied the multiple earlier advances and retreats of the Puget lobe (especially during the Vashon Stade) may have further facilitated undercutting/steepening of the slope and would have carried away material eroded from the cliffs. Both Beaver and Center valleys originated as meltwater channels (Fig. 3), and the horseshoe-shaped scarp near Tamanowas Rock (the northern "scour" in Fig. 9) may have been the site of an enormous meltwater eddy that raged north of where those two channels came together.

There has also been a long history of landsliding in the Tamanowas Rock area. The previously mentioned horseshoe-shaped feature (Fig. 9) strongly resembles a landslide scarp, but there is a lack of rubble directly below it, possibly because that debris was carried away by glacial meltwater. Lidar imagery (Fig. 9) clearly shows that additional slope failure(s) occurred after the deposition of the Vashon advance outwash/till terrace.

The face of the bluff behind (west of) Tamanowas Rock is nearly vertical. Below this face and notably around Tamanowas Rock is a massive, hummocky landslide deposit. This is depicted in Figure 10, where unit Qls overlies units $Qga_s$ and Qgt. Although the deposit itself is not dated, it must be no older than 17,500 years, the peak of the Vashon glacial advance. These slides may have occurred when northward-flowing glacial meltwater scoured material from the base of the slope, removing the buttress and allowing failure and deposition in the east direction. Tamanowas Rock itself may have dropped slightly and rotated valleyward.

The prominent crack along the pathway at the top of the ridge represents an initial stage of a future slope failure. It is not known whether there are planes of weakness in the ash-flow deposit (joints or possibly original depositional features) that control the orientation of slope failures, nor is it known whether the event that appears to have moved Tamanowas Rock was a topple or a deep-seated rotational landslide.

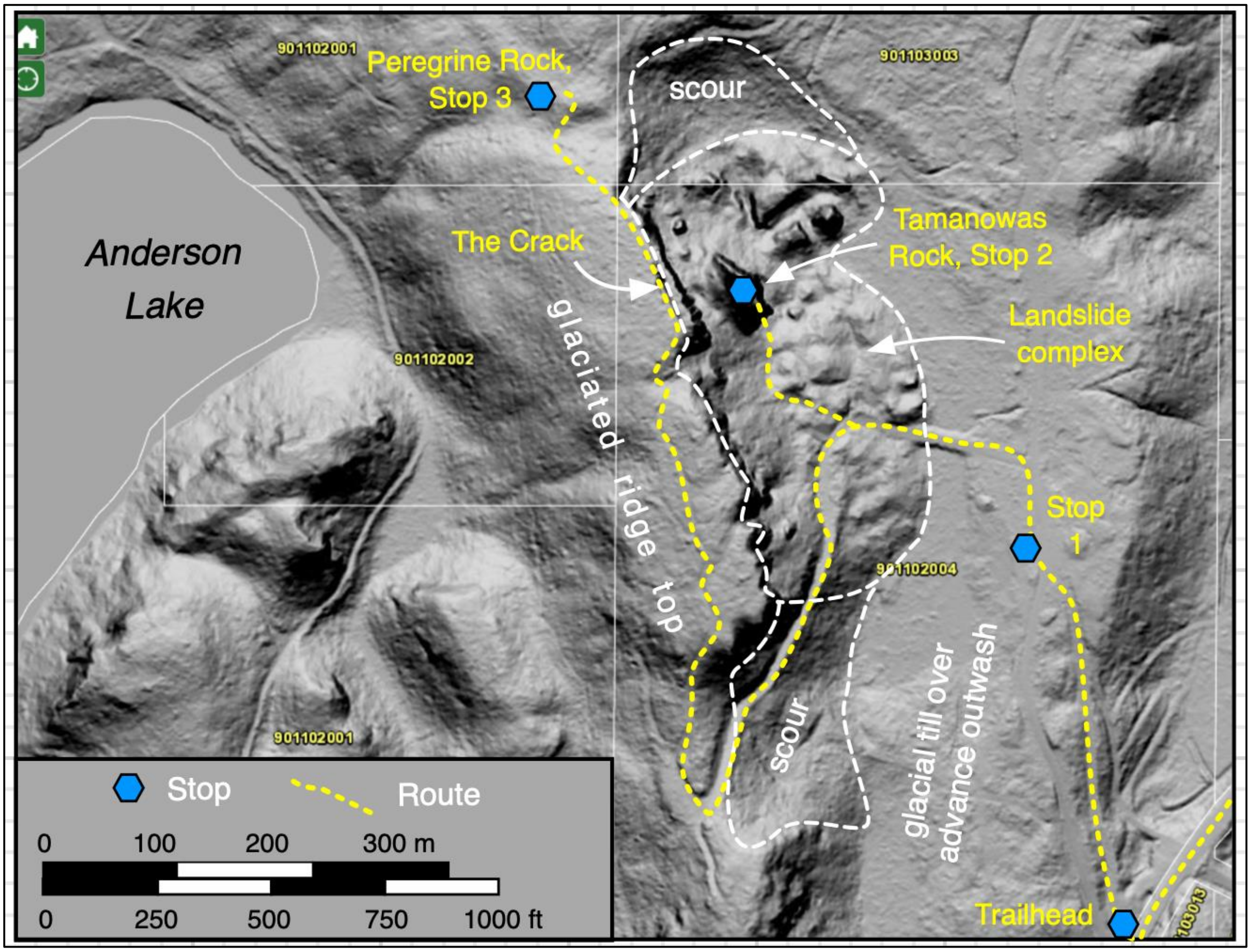


***Figure 9.*** *Landslide debris at and around Tamanowas Rock. The route is shown as yellow dotted line. Fine white lines and small yellow numbers are parcel boundaries and identifiers from* [*https://gisweb.jeffcowa.us/LandRecords/*](https://gisweb.jeffcowa.us/LandRecords/).

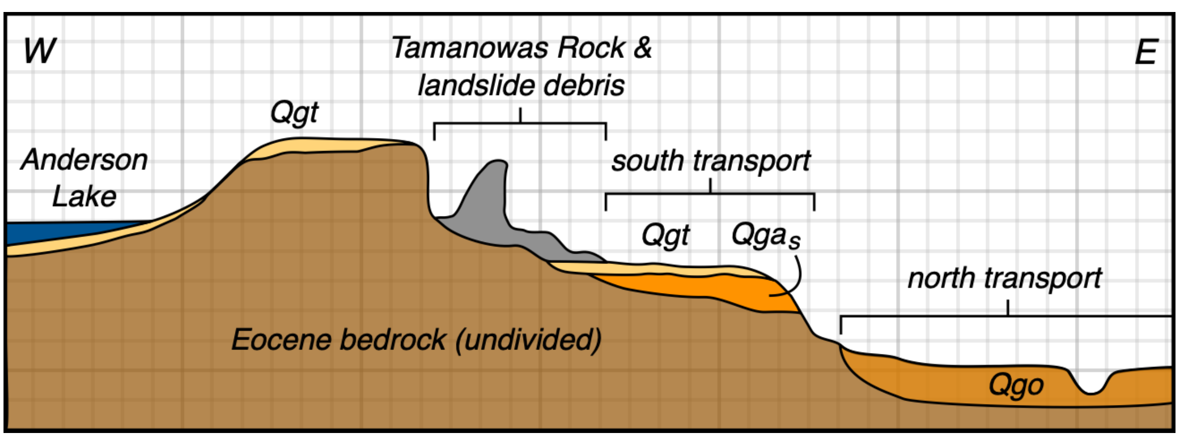


***Figure 10.*** *Diagrammatic cross-section of the Tamanowas Rock area. All subsurface contacts are our interpretations with no depth control; geology is based on the mapping of Schasse and Slaughter (2005); see Figure 5 for definitions of geologic unit symbols. Note the south-transported units are early glacial advance outwash and till, whereas the more deeply channelized meltwater flowed to the north, leaving recessional outwash deposits. Anderson Lake sits in a glacially excavated basin.*

***Figure 11.*** *Tafoni (honeycomb weathering) near the base of Tamanowas Rock. Note that this texture is missing in the center left area, where the surface of the rock has broken away. The pits are roughly the size of a racquetball.*

### *Recent Weathering Features of Tamanowas Rock*

Many surfaces of Tamanowas Rock and the ridge behind it are pockmarked by cavities and shallow depressions (Fig. 11). These are weathering features, sometimes referred to as <u>*tafoni*</u> or honeycomb weathering, here better developed on weathered surfaces and absent on fresh ones. This is strong evidence they did not originate as gas bubbles, which would be present throughout the rock. How tafoni form is unclear, but with large cavities, weathering processes probably took advantage of zones of 'weakness', such as hydrothermally altered areas.

**To get to Stop 3,** leave Tamanowas Rock and head back south to the fork in the trail and turn right. See route map, Fig. 9.

## STOP 3. PEREGRINE ROCK (ERRATIC) AND THE CRACK

From Tamanowas Rock, the trail to the ridge top climbs through poorly exposed Eocene sediment of the Lyre Formation, which is coeval with the adakite of Tamanowas Rock. The ridge itself has been planed off by glacial erosion, not once but possibly a dozen times during the Pleistocene (the past 2.6 Ma). Figure 5 shows both bedrock and glacial till (units $Em_{2lu}$ and Qgt) here, but lodgement till is more extensive to the west in the area of Anderson Lake. The term lodgement till, in geology, refers to unsorted material deposited directly by glacial ice and that lacks stratification. Here, most of the surface has at least a thin cap of such till and, more importantly, erratics.

### *The Crack*

At the ridge crest, the trail turns north (to the right) and parallels the bluff above Tamanowas Rock. At one point, the trail descends into a linear crack that is just wide enough to walk through. This crack is a tell-tale sign of incipient slope failure in the bedrock that forms the cliff behind Tamanowas Rock. With time, this crack will likely widen and eventually fail. Notice the sharp and fairly straight edge to the near-vertical bluff. This is not the result of stream erosion, but it instead likely marks the edge of a large landslide complex. This situation is not clear on conventional aerial photography, but it is clear on the lidar image (Fig. 9).

### *Glaciations*

During ice advances, alpine and more sheet-like continental glaciers grow through mass accumulation of snow/ice and, driven by gravity, extend down slope or in valleys. With time, typically thousands to tens of thousands of years, glaciers can become dominant landscapes, such as in the Puget Lowland. Although undocumented, our area may have been subject to a dozen glacial advances during the Pleistocene. So, one asks, where is the evidence?

One important thing to remember about glaciers is that they are indiscriminate bulldozers on a grand scale. They may be tens of kilometers/miles wide in large lowland valleys or many hundreds of kilometers/miles wide, such as the Laurentide Ice Sheet in the upper midwestern U.S.

During repeated glaciations, typically each subsequent ice advance removes most evidence of the previous one. Some older glacial deposits may remain, but they are rarely continuous enough for geologists to map out their true extent. For example, Pleistocene deposits in the Puget Sound area include some dating from 500,000 years ago or more, but they are preserved in isolated exposures, and many are dated only by their position relative to younger or older deposits. The point here is that the local topography is dominated by glacial processes, primarily from the most recent Vashon Glaciation, but some features are inherited from the distant past.

***Figure 12.*** *Glaciers in Wrangell-St. Elias National Park, Alaska. Note the bands of dark debris (rock); these supply much of the rock for glacial till and erratics where the glacier comes to rest. (National Park Service)*

### *Erratics*

Glacial erratics are defined as rocks that are out of place, having traveled tens or even hundreds of kilometers/miles in and on the backs of glaciers (Fig. 12). Erratics are typically composed of rock types that are exotic to the local geology. For example, many of the erratics found on the Quimper Peninsula are granitic in composition, but no granites are exposed in the Olympic Mountains as bedrock. Hence, these erratics are exotic.

### *Peregrine Rock*

GPS: 48° 1′ 23.6″ N
122° 47′ 42.7″ W

Peregrine Rock is an exceptionally large glacial erratic named by local resident Eric Nagle in 2020 (Fig. 13; see Table 1). The name comes from the archaic definition of peregrine: One who wanders, coming from another country (Canada?), foreign or strange.

Peregrine Rock has been resting in what is now Anderson Lake State Park for almost 16,000 years. It is a humongous rounded boulder shaped like a Russet potato (Fig.13). Having used a tape measure, we find it is 14 m (46 ft) long x 11 m (36 ft) wide. The second line for Peregrine Rock in Table 1 represents an earlier estimate of the dimensions.

The south end of the rock (Fig. 13) is broken off, with at least 1.3 m (4 ft) left as debris. So, the actual length must be about 15 m (50 ft). The base is not exposed, but the rock has an exposed height of 6 m (20 ft).

### *Composition of the Rock*

At first, geologists thought Peregrine Rock was an outcrop of Tamanowas adakite, but it is actually a low-grade metamorphosed rock called a "greenstone". Its parent material (initial rock type) would have been a basalt or mafic igneous rock that was later subjected to low-temperature metamorphism.

Greenstones are common along convergent plate boundaries, such as the Cascadia Subduction Zone or, in Eocene time, the Siletzia collision margin. The greenish hue of these rocks generally derives from the presence of minerals such as chlorite, hornblende, or epidote; in some other localities, the metamorphism results in gemstone-quality jade.

Greenstone has a density of about 3.3 grams/cubic centimeter (g/cm$^3$)(210 pounds/cubic feet [lb/ft$^3$)]), considerably denser than granite (2.65 g/cm$^3$; 170 lb/ft$^3$). So, this erratic probably weighs a minimum of 5.25 million pounds or nearly 2400 tons (2200 metric tonnes)!! That is as much as 925 Ford F-150s. Peregrine Rock likely was larger when deposited. Fragments of the same rock type are scattered around it. These were likely shell-like layers developed as a result of exfoliation and freeze/thaw weathering.

***Table 1.*** *The 22 largest glacial erratics reported from the Quimper Geologic Society's Great Erratic Challenge, updated in 2022. These rocks are but a small fraction of those in the area. Most have been exposed in urban areas or by recent logging. Peregrine Rock is the largest known erratic on the Quimper Peninsula.*

| No. | Name | Dimensions (ft) | General location | GPS (N, W) | Submitted by |
|---|---|---|---|---|---|
| 1 | *Peregrine Rock | L 50, W 36, H 20 | Above Tamanowas Rock, on trail to Anderson Lake | 48° 01' 23.7" 122° 47' 42.7" | Eric Nagle |
| 2 | Pokorny's Rock | L 38, W 26, H 14 | Tarboo Valley, SW corner of the Valley Rock Farm | 47° 54' 14.5" 122° 49' 18.5" | Mark & Tami Pokorny, owners |
| 3 | Juanita's Rock | L 36, W 20, H 12 | Off Cottonwood Place, Woodland Hills | 48° 08' 38.4" 122° 46' 38.5" | Calmar McCune |
| 4 | Johnson's Rock #1 | L 27, W 25, H 24 | On DNR property, Tarboo Valley; 200 ft SW of No. 5 | 47° 54' 03" 122° 48' 55" | Diane & Charlie Johnson |
| 5 | Johnson's Rock #2 | L 26, W 24, H 15 | On DNR property,Tarboo Valley; 200 ft NE of No. 4 | 47° 54' 04" 122° 48' 53" | Diane & Charlie Johnson |
| 6 | Libby's Rock | L 23, W 17, H 5 | 53 Sulgrave Pl., Kala Point | 48° 03' 28.4" 122° 46' 53" | Previously reported (M. Machette) |
| 7 | Marrowstone Rock #16 | L 20, H 5 | Garden Club Rd.; No. 16 of Stahler | 48° 01' 38.2" 122° 41' 34.4" | Barbara Stahler |
| 8 | Sailor Vineyard | L 17.5, W 9, H 7.5 | 1452 Woodland Dr.; E. of Sailor Vineyard | 48° 03' 42.6" 122° 47' 39.7" | Kris Kiesel |
| 9 | Shy Acre Rock #3 | L 16.0, W 4.7, H 4.5 | SW corner, Discovery Rd. and San Juan Ave.; third of four submittals | 48° 07' 10.5" 122* 46' 42.4" | Keith and Dee Norlin |
| 10 | Cleveland | L 15.5, W 9, H 5 | Cleveland St. and 25th St. | 48° 03' 28.4" 122° 46' 53" | Pat and Dave Granger |
| 11 | Browning's Rock | L 15, W 12, H 8 | 230 Ridgeview Ct., Woodland Hills | 48° 03' 19.2" 122° 47' 51.2" | Scott Browning, owner |
| 12 | Egg & I Rock | L 14.5, W 7, H 8 | Egg and I Farm (Phil & Katie Vogelzang, owners) | 47° 57' 22.8" 122° 45' 39.4" | Barbara Stahler & Phil Vogelzang |
| 13 | Kelly's Rock | L 13, W 7, H 6 | 231 Ridgeview Ct., Woodland Hills | 48° 03' 19.4" 122° 47' 44.5" | Scott Minor and Mark Walter |
| 14 | Cappys Trail | L 12.5, W 9.2, H 8.25 | Cappy's Trail, Quimper Wildlife Corridor | 48° 01' 23" 123° 25' 37" | Tomi Evans Ziel |
| 15 | Marrowstone Rock #5 | L 12, H 3 | Flagler Rd. and Norton Rd.; No. 5 of Stahler | 48° 04' 03.3" 122° 42' 07.9" | Barbara Stahler |
| 16 | Ft. Flagler #9 | L 11.7, H 6 | Ft. Flagler State Park; No. 9 of Stahler | 48° 05' 52.6" 122° 42' 59.3" | Barbara Stahler |
| 17 | Jackman Rock | L 11, W 3, H 4 | 5374 Jackman St., North Beach | 48° 08' 19.2" 122° 47' 06.6" | Annie Karl |
| 18 | Yourish's Rock | L 11 | Meadow Rd. near Middle Point | 48° 06' 22.2" 122° 52' 15.8" | Robert Yourish |
| 19 | Darrow's Rock | L 10.8, W 9.6, H 6.5 | Near Rosencrans St. & Umatilla Ave. | 48° 07' 34" 122° 47' 50" | Dan Darrow |
| 20 | Pat's Rock | L 10.5, W 7, H 5 | Off Sheridan St. near PUD substation | 48° 06' 50" 122° 47' 58" | Pat and Dave Granger |
| 21 | Bill's Rock | L 10.3, H 6.8 | 7413 Hwy 20 (Colin Swindell owner); No. 41 of Stahler | 48° 03' 56.9" 122° 49' 12.0" | Barbara Stahler |
| 22 | Shy Acre Rock #2 | L 10.3, W 5.2, H 8.0 | SW corner, Discovery Rd. and San Juan Ave.; second of four submittals | 48° 07' 10.5" 122° 46' 42.4" | Keith & Dee Norlin |

***** Note: Peregrine Rock was remeasured on July 21, 2022. Length includes 4 ft of rock broken off of south end.

***Figure 13.*** *Peregrine Rock—the Wanderer, Eric Nagle (2 m or 6 ft tall) for scale. Its height is at least 6 meters (20 ft.). This is the more exposed, south side of the rock.*

## Review

Walk back to Stop 1. This is a great location to review what was seen and learned during the hike. This is also an ideal place to collect all participants before walking back to HJ Carroll Park.


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