

Lesson Title: A Slice in Time (the IslandWood Fault)

Overview: This lesson teaches students the events of the IslandWood fault (known locally as the Mac's Pond Scarp), and what kinds of things to look for to recognize earth movements.

Key goals and objectives: SWBAT explain the events of the IslandWood fault, and relate the events to the mega-thrust earthquake 1100 ybp (an estimated 7.4 shallow earthquake). SWBAT recognize simple geologic principles, such as crosscutting, original horizontality, and superposition.

Introduction and Activity: 1100 years ago, there was a large, shallow earthquake in the Seattle region that uplifted the south end of Bainbridge Island, and we have evidence of that quake here at IslandWood.

In the last lesson we saw how glaciers dramatically modified the landscape of the Puget Sound Lowland, so, by extension, if an earthquake breaks the surface in this area, we know that it is younger than the retreat of the glaciers (i.e. it happened after the glaciers left the area).

[Show BI LIDAR; note several things: the north-south trending hills (evidence of glacial retreat), the Toe Jam Hill Fault (east-west trending scarp south of Blakely Harbor), and small scarps south of Mac's Pond (see figure below and IW LIDAR for more detail).]

The core lesson: We already know that before the glaciers came into the Puget Lowlands that rivers from the Cascades and the Olympics flowed into our region. Those deposits comprise the *bedrock* of the region. The glacier left its own deposits, mostly *till*, the stuff that gets bulldozed in front and continually ground, and the erratics we have already seen, on top of this bedrock.

Which one is older the bedrock of the glacial deposits? In geology this the law of superposition — the younger rock is always on top of the older rock. In our case, the glacial deposit are younger than the bedrock, so in an undisturbed location the glacial deposits should always be on top.

Here at the trench we have something interesting going on, can you see what is going on? In this wall, you can see that the older bedrock [point to the rock] has been lifted over the younger

Theme: Events of IslandWood trench, earthquakes

Concepts: quantification, order, scale, relative time, earthquake, faulting

Skills: observation, analysis, infer

Age group: 12- 97

Venue/s: IslandWood trench (alt. Indoor with digital profile on learn.IslandWood.org)

Materials:

IW_LIDAR_Faults.pdf,
IW_Trench_Profile.pdf,
IW_Trench_Photo.pdf ,
Inquiry_in_Geology.pdf,
PNW_Faults.pdf, and
PNW_NS_Shortening.pdf,
IWAerial1977.jpg,
IW2001aerialphoto.pdf,
pencils, paper

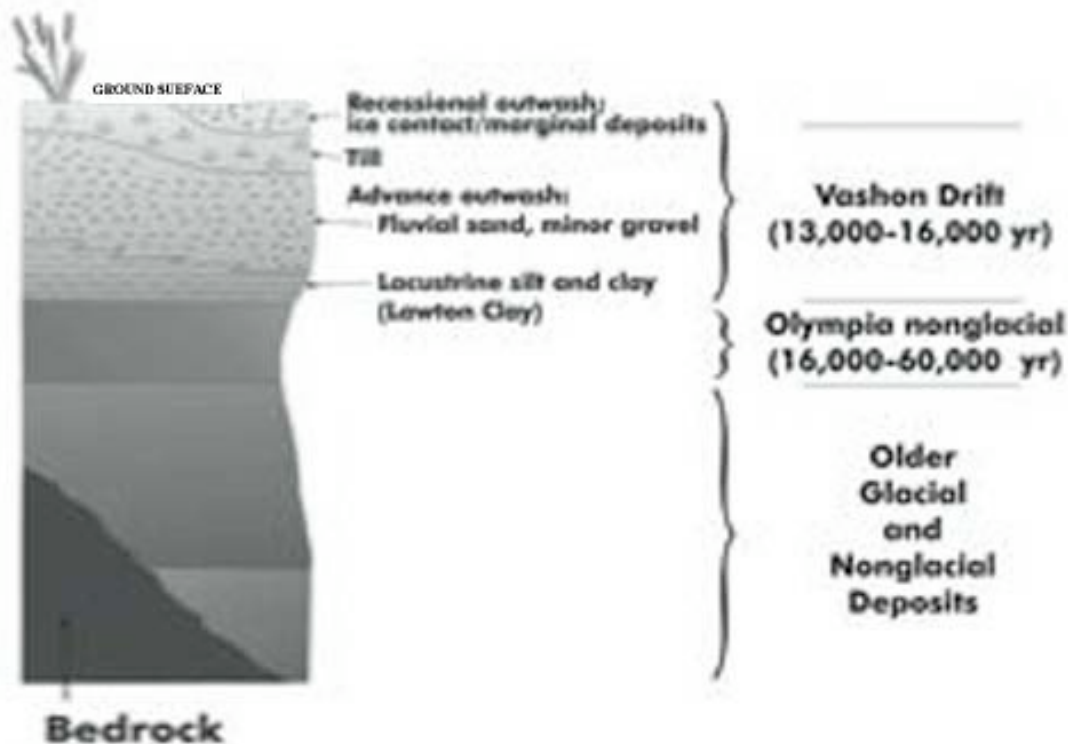
Locations with 11x17 laminated copies (5):
Learning Studio (PR, WC),
Fault
Shell Midden
MWC

Time: 45 minutes

Set up: none

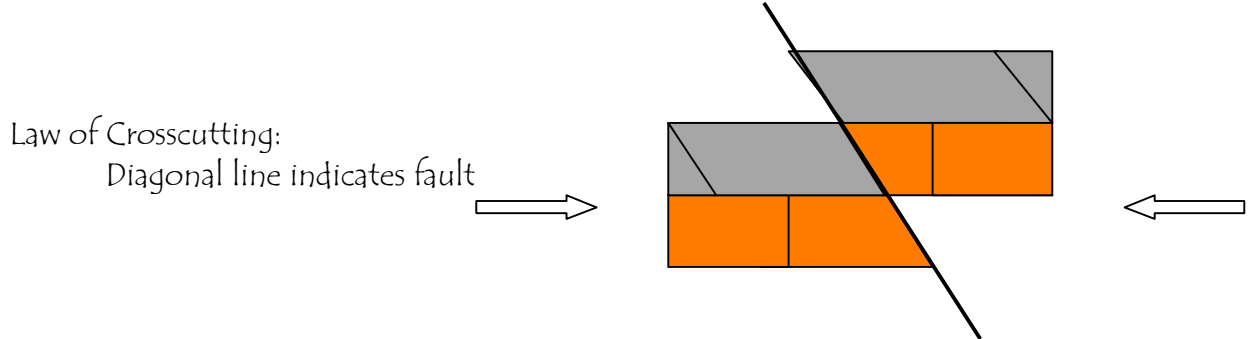
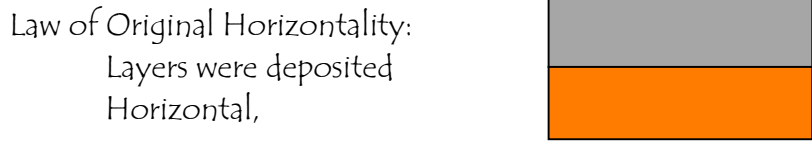
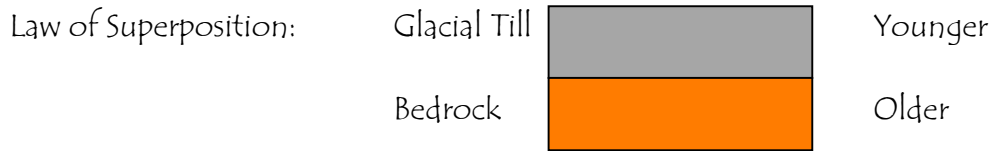
glacial till [point to the rock(s)]. Draw what you see. [Have students sketch what they see, and do not worry about accuracy, you will explain the events later.] What did you think happened here? Do you see anything that seems out of place in this wall? How would you know there was an earthquake? What would you look for? In geology the term crosscutting is used to describe this wall, and indicates that a disturbance (or (fault) is present.

This is what happened here, as we mentioned already, 1100 years ago there was a large earthquake that deformed the ground surface along an existing fault. When this happened the rocks were deformed and moved, and are now facing in different directions. In geology this is called original horizontality because they were deposited in horizontal planes. In this event the ground has been uplifted 23 feet (7 meters) above the mean sea level [Show IW_LIDAR_Faults.pdf, IW_Trench_Profile.pdf, IW_Trench_Photo.pdf (Sherrod 2003)]



Puget Sound stratigraphy, showing both before and after the Vashon glaciation (Booth, Haugerud, and Troost 2003:22).

Conclusion: How big was this earthquake? How would it have affected people living the area? How would we know that it did affect the people in area, and how would we look for that? What geologic principles are present, and how do we know? Make sure that you draw or record those relationships. What geologic principles are present, and how do we know? Make sure that you draw those relationships.

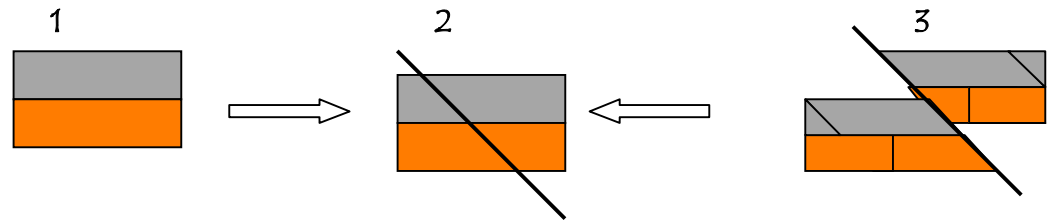


I already said that this earthquake uplifted the entire south end of Bainbridge Island, and now we are going to continue looking for evidence of this massive earthquake.

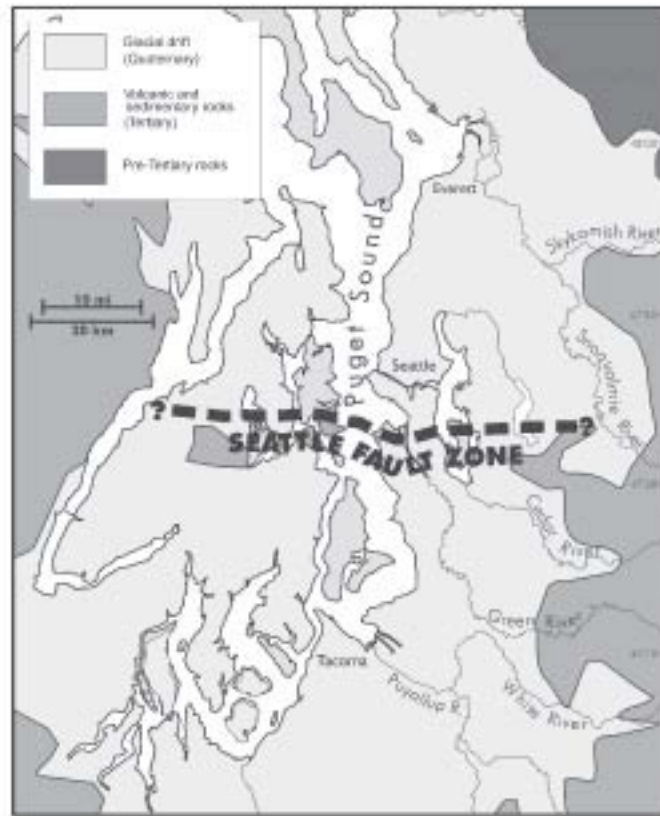
Assessment: Built-in to the experience or based on a follow-up in the next lesson. You may also ask them to share their drawings to see if they accurately depicted the older sediments overriding the younger sediments. There are many concepts imbedded into this lesson, and the most important is to recognize the principles of superposition, crosscutting, and original horizontality.

Extension: Technology Innovations with LIDAR and Aerial photo comparisons. With the former it is easy to see the North-South orientation of glacial landscaping, faults that were previously undocumented, and most strikingly virtual deforestation. Because LIDAR uses lasers to collect data, with computer modeling the trees can be removed for more topographic accuracy [compare the images on learn.IslandWood.org].

Science Notebooks or Journals: In addition to the images above to illustrate the geologic principles herein, students should draw the typical three-step sequence to illustrate faulting:



Background information: The IslandWood fault is a strand of the Seattle Fault, which extends from just south of Eagle Harbor to Waterman Point, south of Bremerton, and across the sound at Alki Point.



Location of the Seattle fault zone relative to the major rivers of the Puget Lowland. During the last great earthquake 1100 years ago on this fault, the south side rose as much as 7 m in the center of the Lowland; the north side subsided about 1 m.

(Booth, Haugerud, and Troost 2003:27).

Two recent advances in technology led to the identification of faults in the region, and especially the Mac's Pond Scarp (the official name of the IslandWood trench): *LIDAR* and *Aeromagnetics*.

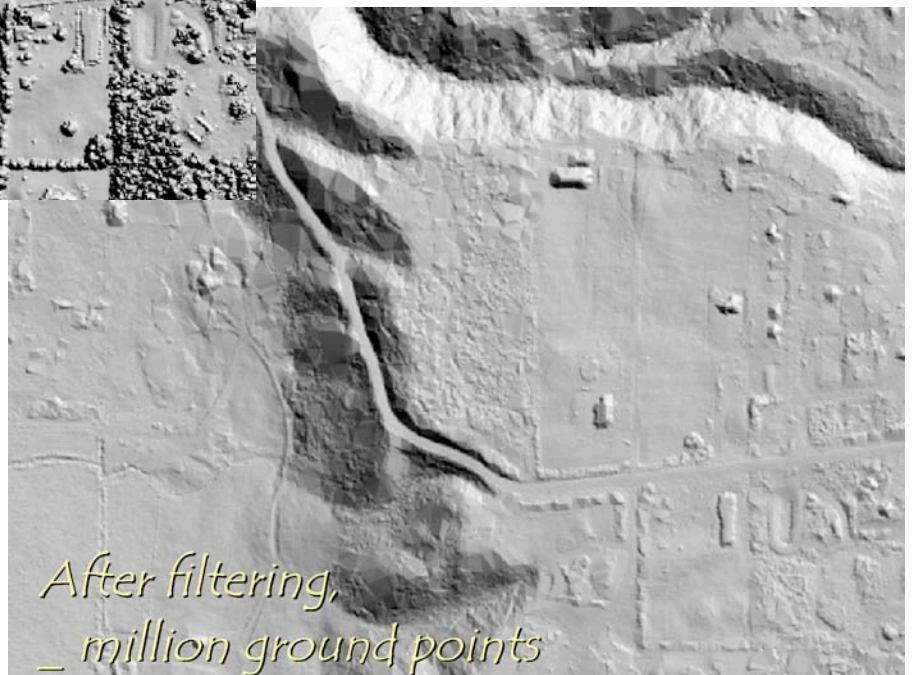
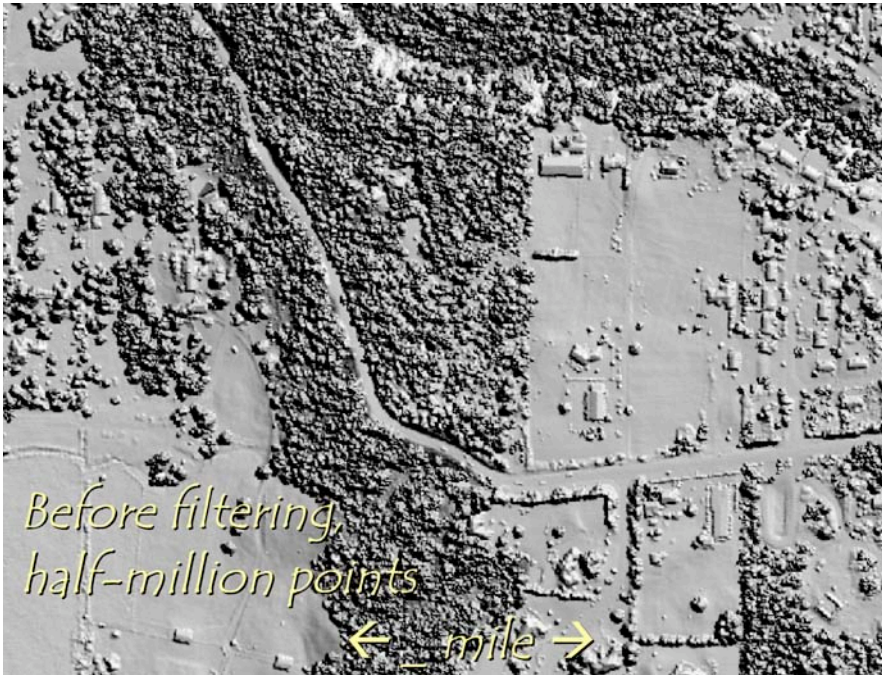
Aeromagnetics maps the region using the magnetic fields present in volcanic (igneous) rocks to identify faults. Where the bedrock has been uplifted, there is an increase in magnetic resonance, and this accurately depicts the boundaries of the Seattle Fault Zone.

The magnetic method exploits the fact that some rocks are more magnetic than others. A volcanic rock, for example, is typically more magnetic than sediments. Very small magnetic forces emanate from places where magnetic rocks are in contact

with less magnetic rocks. In this example, a fault has offset a thin volcanic layer, and the offset produces a very small magnetic field. We can detect that field with sensitive instruments. Typically we put these sensors in airplanes, fly them close to the ground, and call them aeromagnetic surveys. What we are actually measuring is the magnetic force above the earth.

LIDAR (LIght DIstance ANd Ranging, also known as Airborne Laser Swath Mapping or ALSM) is a relatively new technology that employs an airborne scanning laser rangefinder to produce accurate topographic surveys of unparalleled detail. ALSM technology uses an airborne laser rangefinder, a differential GPS, and an inertial navigation system to produce 30,000 points per second at about 15cm accuracy. The cost is about \$500/mi², and with 10⁶ points/mi² that equates to about 0.05

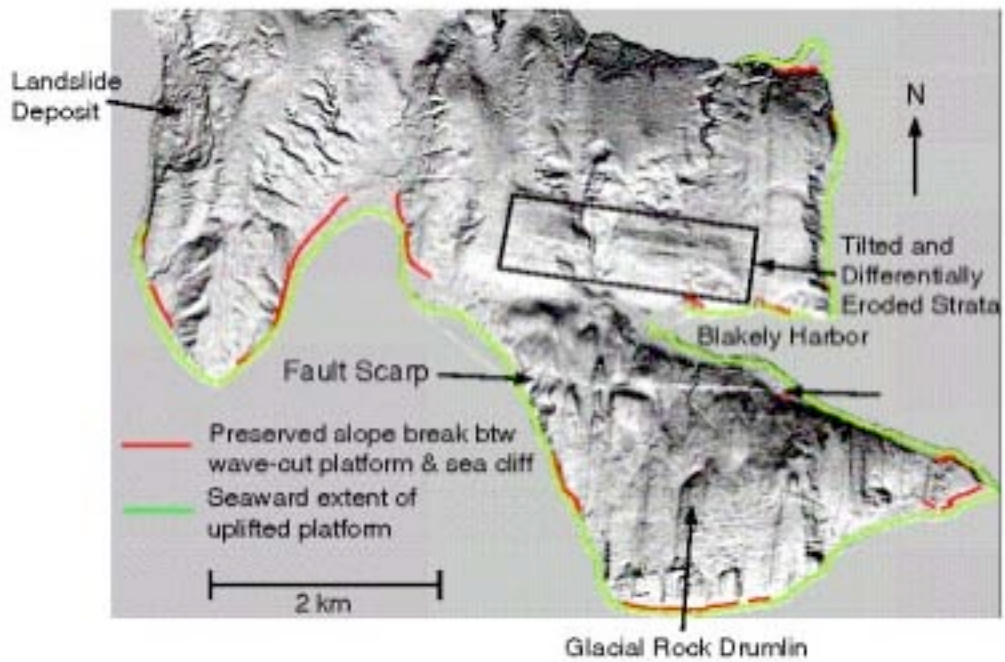
cents/point. Moreover, it is possible, with the aid of several algorithms and geometric filtering to remove the tree canopy (virtual deforestation) (Haugerud, and Harding, 2001, Harding and Berghoff 2000, PSLC 2002).



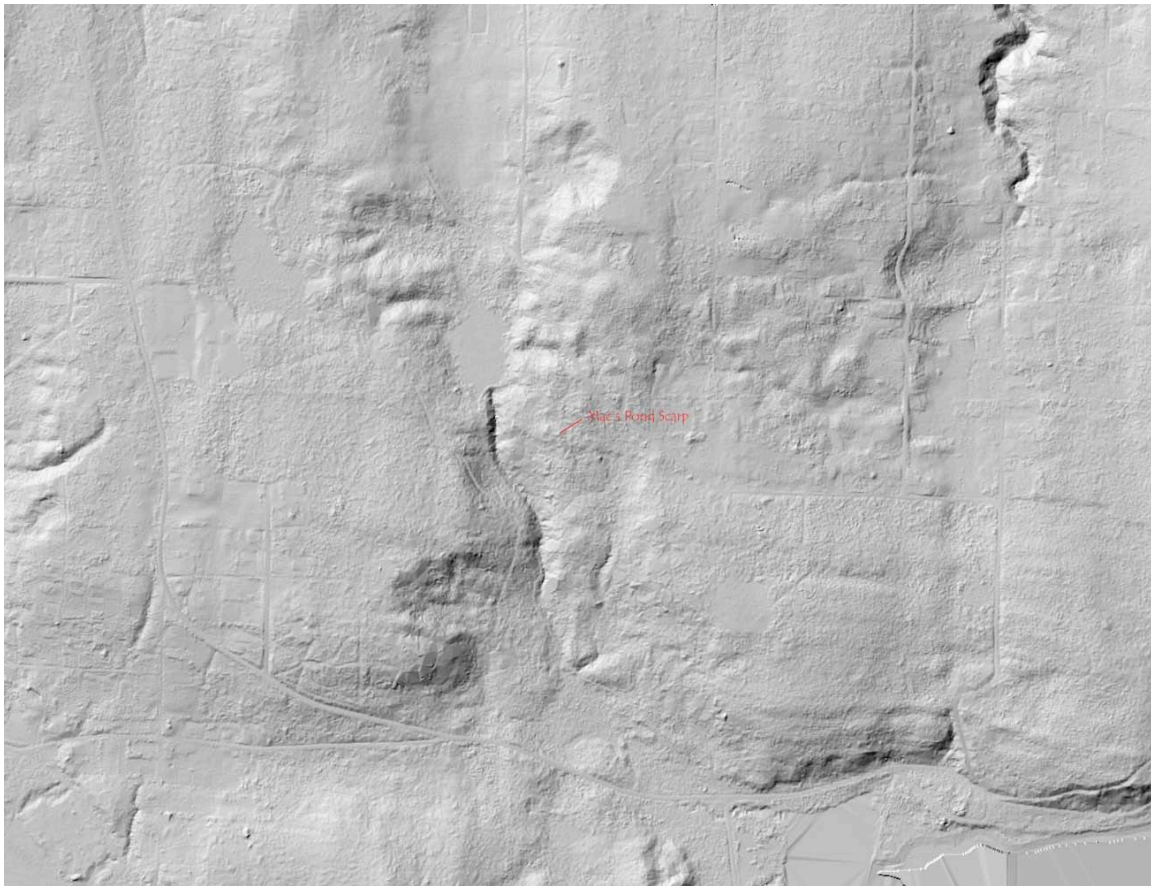
An example of virtual deforestation over a selected area both before (above) and after (below) (Haugerud, and Harding, 2001).



Bainbridge Island LIDAR and shaded relief map, note the North-South oriented hills (Harding and Berghoff 2000:3).



The Mac's Pond Scarp is noted in the rectangular box before being excavated (Harding and Berghoff 2000:4).



(Image created by Matthew John Brewer, adapted from [t24nr023_ne.jpg](#) and [t25nr02e_se.jpg](#) available on the web—PSLC 2002.)

Earthquake Hazards in Washington and Oregon

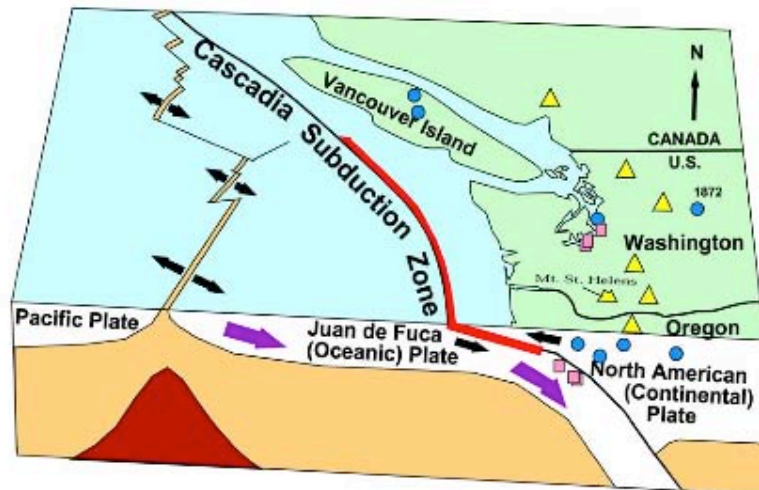
The seismology lab at the University of Washington records roughly 1,000 earthquakes per year in Washington and Oregon. Between one and two dozen of these, cause enough ground shaking to be felt by residents. Most are in the Puget Sound region, and few cause any damage. However, based on the history of past damaging earthquakes and our understanding of the geologic history of the Pacific Northwest, we are certain that damaging earthquakes (magnitude 6 or greater) will recur in our area, although we have no way to predict whether this is more likely to be today or years from now. A [map and list of selected historic earthquakes](#) (Pacific Northwest Seismograph Network 2003) shows that while the most damaging events were fairly deep, many moderate sized earthquakes are fairly shallow.



Earthquake Hazards in Washington and Oregon Three Source Zones

Damaging Pacific Northwest earthquakes can arise from three distinct source zones:

- Deep earthquakes beneath the Puget Sound have damaged Seattle and Olympia
- Shallow faults can cause intense local shaking – urban areas are especially vulnerable
- An offshore subduction zone fault can cause strong shaking across the entire region.



- Deep earthquakes (30 miles below the Earth's surface) are within the subducting oceanic plate as it bends beneath the continental plate. The largest deep Northwest earthquakes known were in 1949 (M 7.1), 1965 (M 6.5), and 2001 (M 6.8).
- Shallow earthquakes (less than 15 miles deep) are caused by faults in the North American Continent. The Seattle fault produced a shallow magnitude 7+ earthquake 1,100 years ago. Other magnitude 7+ earthquakes occurred in 1872, 1918, and 1946.
- Subduction earthquakes are huge quakes that result when the boundary between the oceanic and continental plates ruptures. In 1700, the most recent Cascadia Subduction Zone earthquake sent a tsunami as far as Japan.
- ▲▲ Mt. St. Helens/Other Cascade Volcanos

(Pacific Northwest Seismograph Network 2003)

Earthquakes are driven by geologic processes that produce stresses in the earth. In the Pacific Northwest, oceanic crust is being pushed beneath the North American continent along a major boundary parallel to the coast of Washington and Oregon.

This boundary called the "Cascadia Subduction Zone," lies about 50 miles offshore and extends from the middle of Vancouver Island in British Columbia past Washington and Oregon to northern California.

Deep Earthquakes: The three most recent damaging earthquakes in Washington, in 2001 (magnitude 6.8, near Olympia), 1965 (magnitude 6.5, located between Seattle and Tacoma), and in 1949 (magnitude 7.1, near Olympia), were roughly 40 miles deep and were in the oceanic plate where it lies beneath the continent. Each earthquake caused serious damage, and was felt as far away as Montana. No aftershocks were felt following the 1965 and 1949 earthquakes, and only two small aftershocks were felt after the 2001 quake. Other sizable events that were probably deep occurred in 1882, 1909, and 1939 (Pacific Northwest Seismograph Network 2002a).

Shallow crustal earthquakes: The largest historic earthquake in Washington or Oregon occurred in 1872 in the North Cascades. This earthquake had an estimated magnitude of 7.4 and was followed by many aftershocks. It was probably at a depth of 10 miles or less within the continental crust. In 1993, a magnitude 5.6 earthquake in the Willamette Valley caused \$28 million in damages (including damage to the Oregon State Capitol in Salem), and a pair of earthquakes near Klamath Falls, OR (magnitudes 5.9 and 6.0) caused two fatalities and \$7 million in damages. Many other crustal sources in Washington and Oregon could also produce damaging earthquakes. Recent studies have found geologic evidence for large shallow earthquakes 1,100 years ago within the central Puget Basin. Massive block landslides into Lake Washington, marsh subsidence and tsunami deposits at West Point in Seattle, tsunami deposits at Cultus Bay on Whidbey Island, and large rock avalanches on the southeastern Olympic Peninsula have all been dated to approximately 1,100 years ago (2002e).

Subduction Zone earthquakes: Although no large earthquakes have happened along the offshore Cascadia Subduction Zone since our historic records began in 1790, similar subduction zones worldwide do produce "great" earthquakes - magnitude 8 or larger. These occur because the oceanic crust "sticks" as it is being pushed beneath the continent, rather than sliding smoothly. Over hundreds of years, large stresses build which are released suddenly in great earthquakes. Such earthquakes typically have a minute or more of strong ground shaking, and are quickly followed by damaging tsunamis and numerous large aftershocks. The Alaskan earthquake of 1964 was a great subduction zone earthquake. Geologic evidence shows that the Cascadia Subduction Zone has also generated great earthquakes, and that the most recent one was about 300 years ago. Large earthquakes also occur at the southern end of the Cascadia Subduction Zone (in northern California near the Oregon border) where it meets the San Andreas Fault system; including a magnitude 7.1

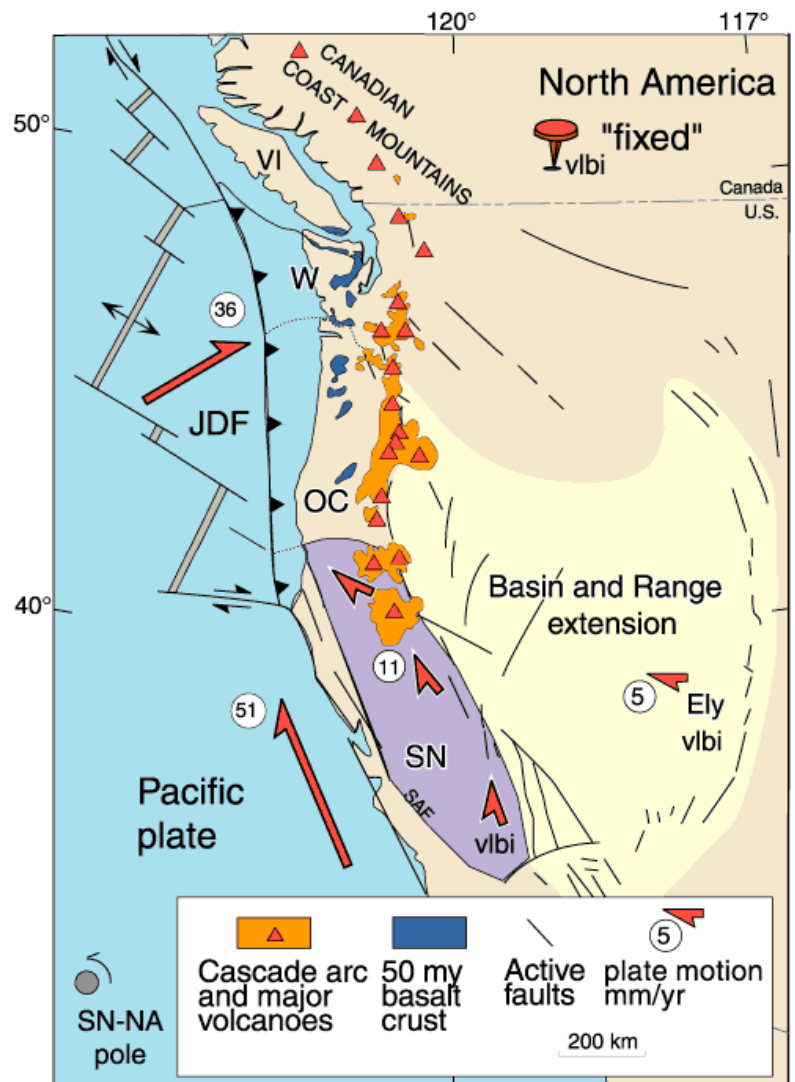
earthquake in 1992, and a magnitude 6.8 (estimated) earthquake in 1873 (2002f).

Although scientists have tried for decades to [predict earthquakes](#) (2002c), no one has discovered a method that can be applied with regular success. For some areas with well-understood patterns of seismicity, it may be possible to forecast decades-long time windows when large earthquakes are likely to occur. However, the Pacific Northwest has only been monitored for a couple of decades; not long enough to allow us to see what patterns, if any, exist here. Seismologists are still trying to understand what types of earthquakes are possible here, and what kind of shaking we will experience from future earthquakes (depending on the earthquake location and size, and the site geology and topography). Earthquake hazards can be reduced by advance preparation; such as coordinating emergency communications and activities across jurisdictional lines, preparing personal emergency plans, and considering seismic hazards in land use plans, building codes, and planning for medical, utility, and emergency facilities (Pacific Northwest Seismograph Network 2002b).

Shallow earthquakes are part of a larger picture. Cascadia and its small plates are caught between N. America and the much larger Pacific plate, which is moving NW at 51 mm/yr (about 2 in/yr)

Image at right (Wells, Blakely, Simpson, Weaver, Haugerud and Wheeler 2000b) explains:

- The western U.S., including Cascadia is deforming over a broad area.
- The continental margin and the Juan de Fuca plate are breaking up into smaller crustal blocks that are being dragged northward by the motion of the Pacific plate.
- Migrating continental margin terranes breaking up into: Washington (W), Oregon



Coastal (OC), and Sierra Nevada (SN) blocks.

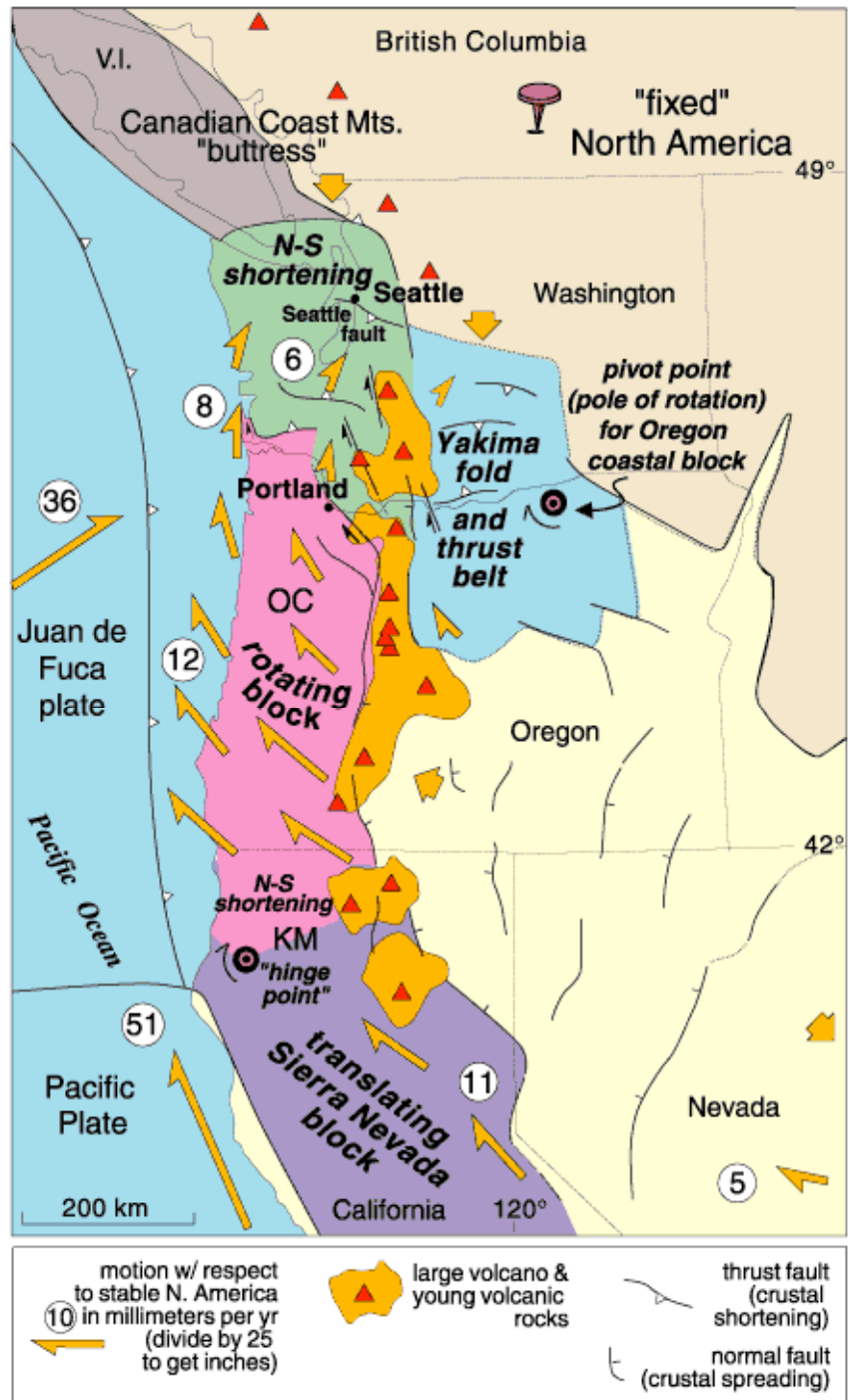
- Vancouver Island (VI) and Canadian Coast Mountains represent a relatively fixed buttress against which coastal terranes are deformed.

Cascadia's coastal blocks move northward

Tectonic model for long-term motion of Cascadia coastal blocks:

- If we link clockwise rotation of the Oregon coastal block (OC, pink) to NW motion of the Sierra Nevada block (purple) by a "hinge" in Klamath Mountains (KM), we can predict the long-term velocity of coastal blocks (yellow arrows) with respect to stable North America.
- Cascade volcanic arc (orange) erupts along trailing edge of Oregon block in region of crustal extension (compare the greater abundance of volcanism south of Mt. Rainier (MR) to lesser volume in the north, where block motion compresses the volcanic arc).
- Northward motion of Oregon block squeezes western Washington (green) against Canadian Coast Mountains restraining bend, causing N-S compression, uplift, thrust faulting, and earthquakes.

Image at right (Wells, Blakely, Simpson, Weaver, Haugerud and Wheeler 2000c)

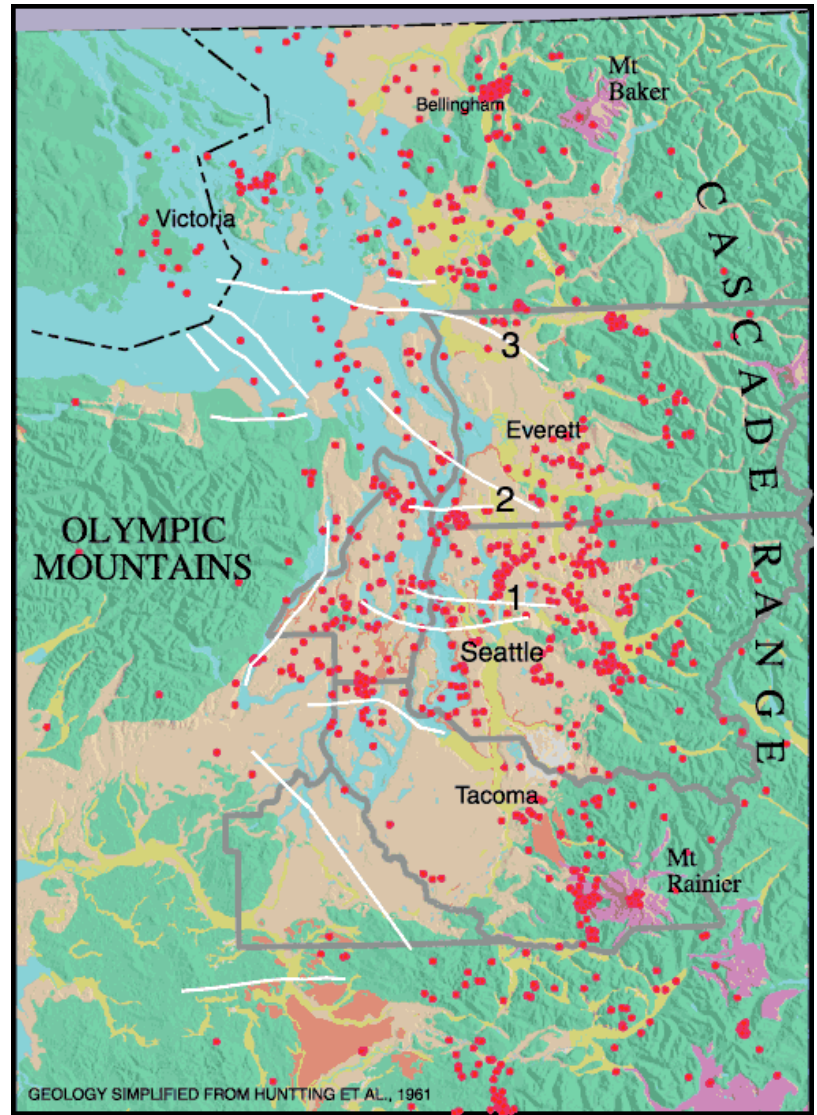


What happens in Puget Sound?

Some of the earthquakes and faults in Puget Sound are caused by the northward migration of coastal blocks

- East-west faults (white lines) are mostly thrust faults that absorb N-S compression and crustal shortening as the region is squeezed against the Canadian Coast Mountains buttress by northward-moving coastal blocks.
- The Seattle fault (1), the Kingston arch (2), and the Devils Mountain fault (3) are east-west fault zones that have a component of N-S thrust motion and related earthquakes (red dots) in Puget Sound.

Image at right (Wells, Blakely, Simpson, Weaver, Haugerud and Wheeler 2000d)

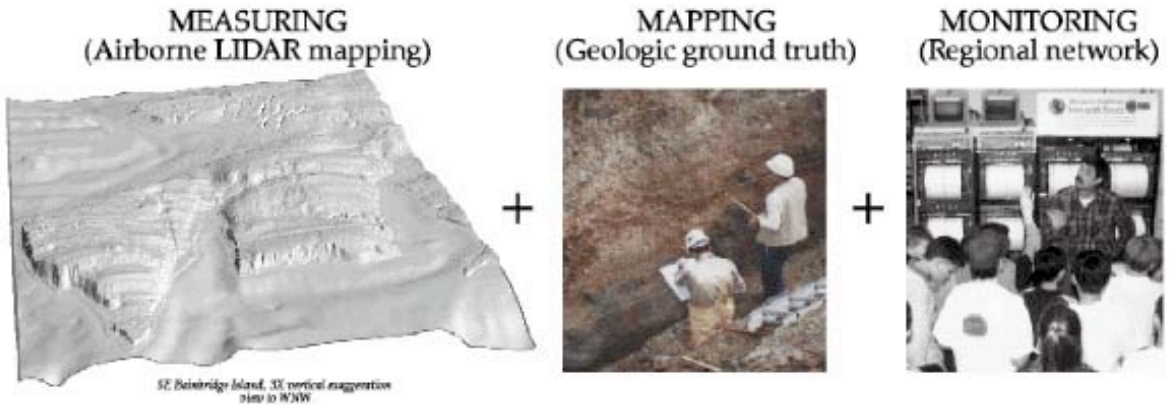


red dots = earthquakes; white lines = faults

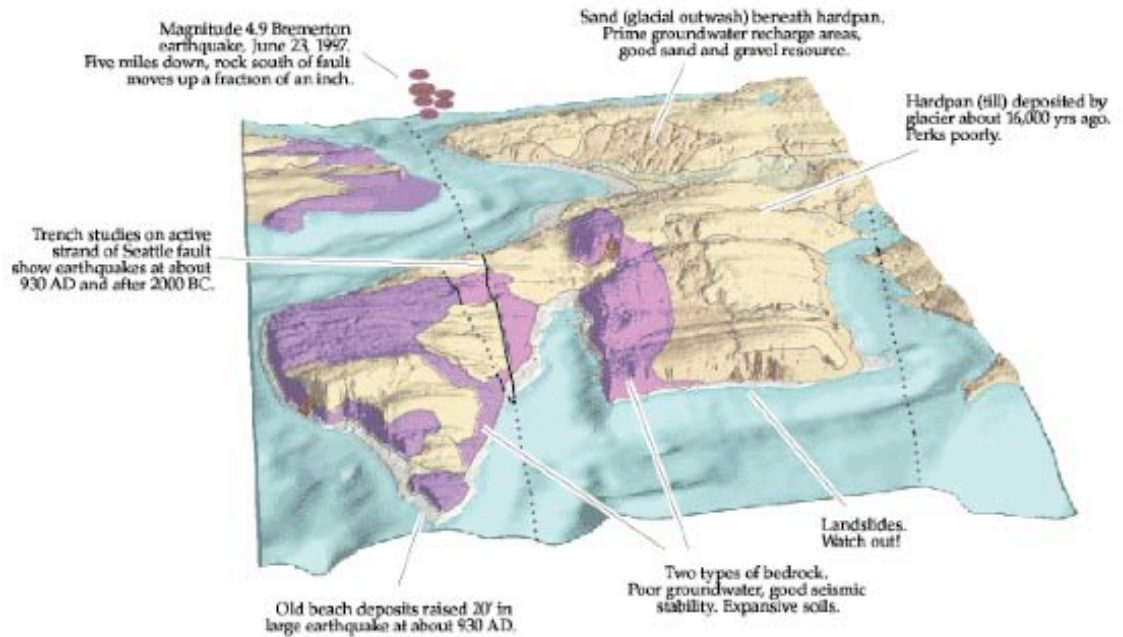
Intensive study of the Seattle fault and other crustal faults is underway to understand their contribution to the earthquake hazard

- On Bainbridge Island, a strand of the Seattle fault actually reaches the surface, where trenching confirms the strand is an active thrust fault, dipping to the north.
- Work is underway to determine the size and frequency of earthquakes on this and other faults in the Puget lowland (Wells, Blakely, Simpson, Weaver, Haugerud and

Wheeler 2000).



**INFORMATION FOR HAZARDS MITIGATION
AND RESOURCE MANAGEMENT**

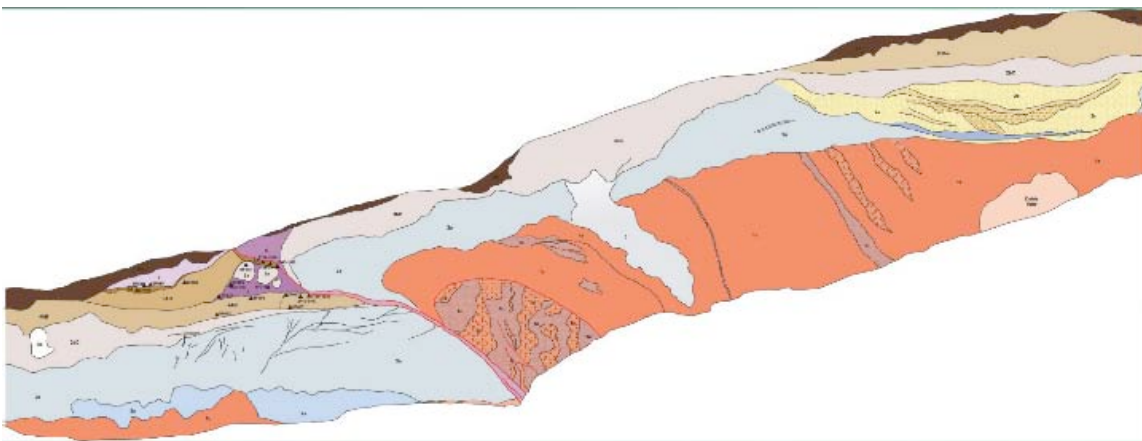


(Wells, Blakely, Simpson, Weaver, Haugerud, and Wheeler 2000e)

Brian Sherrod (2003a) began excavation at the IslandWood site on August 17, 2003 and finished September 9, 2003.



(Mac's Pond Scarp photo, courtesy of Brian Sherrod (2003b))



(Mac's Pond Scarp profile, courtesy of Brian Sherrod (2003b))

Safety Considerations: No immediate safety considerations, except to use extreme caution entering the trench area until a permanent structure is built.

Alternative Misconceptions:

Students need not understand plate tectonics, or the complexity of a subduction zone, but they must the basic mechanism of an earthquake. Every surface that rubs against another creates friction, and rocks, crustal plates, and faults are no different; an earthquake is movement caused by the release of this friction in the earth's crust. Although emphasis could be placed onto the types of earthquakes (i.e. deep, shallow, or subduction mentioned above), simple explanations of the three geologic principles are all that is needed.

The biggest difficulty in this lesson and the previous lesson (glaciers) is the abstraction of time. The concept of deep time (beyond a known life time) in relation to the glaciers or the mega-thrust earthquake 1100 ybp are best understood as a long long time ago, but more recent than the dinosaurs. Several mnemonics exist to correlate time [see learn.IslandWood.org].

Benchmarks have been established by American Association for the Advancement of Science (AAAS), the National Science Education Standards, and the Washington State EALRs. Please visit learn.IslandWood.org for a more thorough guide to the corresponding matrixes.

References:

American Association for the Advancement of Science (AAAS)
(1993). *Benchmarks for Science Literacy: Project 2061*. New York: Oxford University Press.
(2001). *Processes that Shape the Earth: Changes in the Earth's Surfaces (CS), Plate Tectonics (PT)*. In *Atlas of Scientific Literacy: Project 2061*. New York: Oxford University Press. Pp.50-53

Blakely, Richard J., Wells, Ray E., Weaver, Craig S., and Johnson, Samuel Y.
(2002). "Location, structure, and seismicity of the Seattle fault zone, Washington: Evidence from aeromagnetic anomalies, geologic mapping, and seismic-reflection data." *GSA Bulletin*, January 2002 v.114, no. 1, pp.169-177.

Booth, Derek B., Haugerud, Ralph A., and Troost Kathy Goetz
(2003). "The Geology of Puget Lowland Rivers." In *Restoration of Puget Sound Rivers* (Montgomery, Bolton, Booth and Wall, eds.) Seattle: University of Washington Press.

Bucknam, R.C., Hemphill-Haley, E., and Leopold, E.B.
(1992). "Abrupt uplift within the past 1700 years at southern Puget Sound, Washington." *Science*, vol. 258, pp.1611-1614.

Bucknam, R.C., Sherrod, B.L., and Elendahl, G.
(1999). "A fault scarp of probable Holocene age in the Seattle fault zone, Bainbridge Island, Washington [abstract]." *Seismological Research Letters*, vol. 70, p. 233.

— —
(2003). *Earthquake Mechanisms*.
http://128.95.79.45/sgmp/services/education/resources/geology/eq_mech.htm.
Visited November 24, 2003.

Haugerud, Ralph A., and Harding, David J.
(2001). *Some Algorithms for Virtual Deforestation (VDF) of LIDAR Topographic Survey Data*. Presented at the International Society Photogrammetry and Remote Sensing Annual Conference Annapolis, MD October 2001.

Harding, David J., and Berghoff, Gregory S.
(2000). *Fault Scarp Detection beneath Dense Vegetation Cover: Airborne LIDAR Mapping of the Seattle Fault Zone, Bainbridge Island, Washington State*. Presented at the American Society of Photogrammetry and Remote Sensing Annual Conference, Washington D.C., May 2000.

Nelson, A.R., Johnson, S.Y., Wells, R.E., Pezzopane, S.K., Kelsey, H.M., Sherrod, B.L., Bradley, Lee-Ann, Koehler, Rick D. III, Bucknam, R.C., Haugerud, Ralph, and Laprade, W.T.

(2002). *Field and laboratory data from an earthquake history study of the Toe Jam Hill fault, Bainbridge Island, Washington*. [U.S. Geological Survey Open File Report OFR02-0060](http://pubs.usgs.gov/of/2002/ofr-02-0060/). <http://pubs.usgs.gov/of/2002/ofr-02-0060/>. Visited November 23, 2003.

The Pacific Northwest Seismograph Network
(2002a). *Deep Quakes in Washington and Oregon*. Updated July 25, 2002.
http://www.pnsn.org/INFO_GENERAL/platecontours.html. Visited February 9, 2004.

(2002b). *Earthquake Hazards in Washington and Oregon*. Updated July 1, 2002.
http://www.pnsn.org/INFO_GENERAL/eqhazards.html. Visited February 9, 2004.

(2002c). *Earthquake Prediction*. Updated November 13, 2002.
http://www.pnsn.org/INFO_GENERAL/eq_prediction.html. Visited February 9, 2004.

(2002d). *Pacific Northwest Earthquake-Related Hazards*. Updated June 14, 2002.
<http://www.pnsn.org/HAZARDS/welcome.html>. Visited February 9, 2004.

(2002e). *Shallow Crustal Quakes in Washington and Oregon*. Updated October 28, 2002. <http://www.pnsn.org/HAZARDS/SHALLOW/welcome.html>. Visited February 9, 2004.

(2002f). *The January 1700 Cascadia Subduction Zone earthquake and tsunami*. Updated July 1, 2002.
http://www.pnsn.org/HAZARDS/CASCADIA/cascadia_event.html. Visited February 9, 2004.

(2003). *Map and List of selected significant quakes in WA and OR*. Updated March 27, 2003. http://www.pnsn.org/INFO_GENERAL/hist.html. Visited February 9, 2004.

Puget Sound LIDAR Consortium

(2002). PSLC—About LIDAR. Updated March 3, 2002.
http://duff.geology.washington.edu/data/raster/lidar/About_LIDAR.htm. Visited November 23, 2003.

Sherrod, Brian.

(2003a). USGS Paleoseismologist, excavator of the IslandWood trench August 12, 2003 to September 7, 2003. Personal Communication with author August 22, 2003.

(2003b). Paleoseismology, Presentation at GSA Conference 2003, Seattle WA on Nov. 7, 2003. Available on power point.

Sherrod, Brian L. Vance, Joseph A., and Estella Leopold

(2002). Fission track ages of Tertiary bedrock in the hanging wall of the Seattle Fault Zone. *Geological Society of America* 34 (5) p. 108.

Stein, R. S.

(2002). Parkfield's unfulfilled promise (News & Views), *Nature*, 419, pp. 257-258, 19 September issue, doi:10.1038/419257, 2002.

http://quake.wr.usgs.gov/research/deformation/modeling/papers/2002/Stein_News&Views_2002.pdf

Washington State Essential Academic Learning Requirements (2002). *Science Benchmarks (5th) 1.1—1.1.1, 1.1.2 and 1.1.3*, pp.45–49. <http://www.k12.wa.us/CurriculumInstruct/EALR/pubdocs/EALRs-Technical-Manual.pdf>. Updated November 2002.

Weaver, C.S., Meagher, K., Blakely, R.A., and Wells, R.E., (1999). "The June 23 1997 Bainbridge Island, Washington, earthquake: Evidence that the Seattle fault is seismically active." *Seismological Research Letters*, v. 70, p. 219–220.

Wells, R.E., Blakely R.J., Simpson, R.W., Weaver, C.S, Haugerud, R. and K. Wheeler (2000a). Poster at the Great Cascadia Earthquake Tricentennial Open House, January 26, 2000, Burke Museum, University of Washington, Seattle WA. Updated June 21, 2002. <http://geology.wr.usgs.gov/wgmt/pacnw/rescasp1.html>. Visited March 8, 2004.

(2000b). "What causes earthquakes in the Pacific Northwest? – Shallow Earthquakes." Image b.gif *In* Poster at the Great Cascadia Earthquake Tricentennial Open House, January 26, 2000, Burke Museum, University of Washington, Seattle WA. Updated June 21, 2002. <http://geology.wr.usgs.gov/wgmt/pacnw/rescasp1.html>. Visited March 8, 2004.

(2000c). "Cascadia's coastal blocks move northward." Image e.gif. *In* Poster at the Great Cascadia Earthquake Tricentennial Open House, January 26, 2000, Burke Museum, University of Washington, Seattle WA. Updated June 21, 2002. <http://geology.wr.usgs.gov/wgmt/pacnw/rescasp1.html>. Visited March 8, 2004. Image modified by Matthew John Brewer as PNW_NS_Shortening.pdf March 8, 2004.

(2000d). "What Happens in Puget Sound?" Image g.gif *In* Poster at the Great Cascadia Earthquake Tricentennial Open House, January 26, 2000, Burke Museum, University of Washington, Seattle WA. Updated June 21, 2002. <http://geology.wr.usgs.gov/wgmt/pacnw/rescasp1.html>. Visited March 8, 2004. Image modified by Matthew John Brewer as PNW_Faults.pdf March 8, 2004.

(2000e). "Intensive study of the Seattle fault and other crustal faults is underway to understand their contribution to the earthquake hazard." Image h.gif. *In* Poster at the

Great Cascadia Earthquake Tricentennial Open House, January 26, 2000, Burke Museum, University of Washington, Seattle WA. Updated June 21, 2002.
<http://geology.wr.usgs.gov/wgmt/pacnw/rescasp1.html>. Visited March 8, 2004.
Image modified by Matthew John Brewer as Inquiry_in_Geology.pdf March 8, 2004.

Created by Matthew John Brewer on November 23, 2003, modified March 8, 2004.