Note: To Staff –
2 page letter –
w/18 Attachments
Referenced.
Andrea T.

From: Andrea Xaver, 19814 State Route 9, Mount Vernon, WA 98274 (360-422-8922)

To: GT/Custer Spur EIS
c/o CH2M Hill
1100 1112th Ave. NE, Suite 400
Bellevue, WA 98004

January 16, 2013

Subject: Scoping Process – Gateway Pacific Terminal re Coal/Trains

My Concerns:

Volcanic and other geologic activity in the Pacific Northwest - Have possible adverse impacts been considered relevant to the proposed terminal/coal trains?

Excessive rainwater and unstable soils - Have these adverse impacts been considered regarding the terminal site and/or along or under the railroad tracks running through western Washington?

Questions/Comments/Relevant Attachments:

Mount Baker - attachments 1 & 2 - a March 16,1997 Bellingham Herald publication had a large graphic and text about a United States Geological Survey (USGS) of what could happen when Mount Baker erupts, is impacted by a sizable earthquake, or falls down due to old age, all unpredictable possibilities, with lahars heading to the salt water. **Skagit County Vulnerability** - Residents of Skagit county and Whatcom county, indeed Western Washington, live in a geologically volatile area. Of the four places of concern regarding Mount Baker's devastation, Skagit county appeared most significant. Worst case here would bring **lahars** (rocks, water, and mud the consistency of fresh concrete) racing south; then west on the lowlands, roads, and waterways **at 65 miles per hour.** Baker to Edison and/or La Conner is less than 65 miles. Research for this USGS study and other Mount Baker facts can be found on-line. **Whatcom County** - melting snow and ice would interact with hot matter from an explosion and would reach all the way to Marietta and **Ferndale.**

U .S. Dept of the Interior's U.S. Geological Survey – attachment 3 - a small publication also points out what effects western volcanoes could have.

Skagit Valley Herald – attachment 4 - a 1-13-13 article mentions not if, but when Mt. Baker will erupt - and lahars could happen without warning.

The region near Deming...among the most active earthquake zones in the "state...." attachments 5 & 6 are excerpts from *Potential Seismic Hazards of the Sumas and Vedder Mountain Faults, circa 2000,* by Drs.: D.J. Easterbrook (Western Wa. U.), D.C. Engebretson (WWU) and D.J. Kovanen (University of British Columbia). A map shows the fault lines; a picture shows a gas pipeline explosion.

Faultlines, local, 1994 – attachment 7 - from *Regional Geology of Washington State – Department of Natural Resources [DNR], Geology Division Bulletin 80.*

Geologic Map of Washington, DNR, Div. of Geology, 2002 – Attachments 8 & 9 - depicts various fault lines in the northwest quadrant of Washington.

New earthquake faults near Bellingham, 2012 – significant findings near Blaine. Attachments 10-13 - new fault lines have been identified in recent years.

(continued on page 2)

The Natural History of Puget Sound Country, by Arthur Kruckeberg, published in 1991 – attachment 14 - shows the effects of a massive earth slide in 1965 as a result of a 6.5 earthquake in the Seattle/Tacoma area. The picture shows a **railroad track near Olympia hanging in midair** for quite a distance. The text mentions the likelihood of quakes of 6.0 and larger coming along about every 10 years, according to the State Department of Natural Resources' Geology Division. It is further stated that quakes of "lesser intensity occur in the Puget lowland with greater frequency."

Partial list of earthquakes – attachment 15 - earthquakes starting 1700, ending with a 7.5 magnitude west of Craig, Alaska, on 1-4-2013.

1700 Cascadia earthquake – attachment 16 & 17 - describes a quake of 8.7 to 9.2 in the subduction zone along the coast, which ranges 620 miles from mid Vancouver Island to northern California. A string of volcanoes parallels to the east; we are in the middle.

Unfinished nuclear power plant at Satsop in Grays Harbor County – attachment 18 - "Recent advances in our understanding of the tectonics and earthquake hazards of the Cascadia Subduction Zone were due at least partially to investigations prompted by...safety concerns at this facility." *Regional Geology of Washington State – Washington State Department of Natural Resources Geology Division Bulletin 80* – 1994.

Proposed Nuclear Power Plant in Skagit County – not built in the late 1970s due, in part, to a fault line by the project.

Do officials have adequate safety and escape plans if...? Assuming one has about an hour for you and your loved ones to reach safety - if you're notified, that is. I-5 is a huge north-south dam behind which lahars, people, houses, vehicles, logs, and deep water can collect for awhile and then burst further west. Or, if you're stuck somewhere during rush hour, and/or on school buses - waiting for a train to pass - or if you're working in, say, Mount Vernon, and have kids in daycare or school across the river, what then?

70 landslides between Everett and Seattle along the track(s) - since Thanksgiving, 2012 – not due to earthquakes, "just" too much water, and apparently unstable soils. How exactly will anyone prevent these problems?

Air quality - Bejing, China – **"Airpocalypse"** - a news report of 1-14-13 on Seattle's KOMO TV, Channel 4; earlier, the New York Times, and others – Bejing's air quality, on a scale of 1-500, is 755, and it was touted that this has effects on people as if they were instant smokers, causing heart attacks and strokes. (The worst record so far in the U.S. was 159.) The U.S. also has worsening air quality. To this, add local, idling engines waiting for trains; and winds bringing more pollution back from China.

Earthquake faults, tsunamis, fires, pipeline explosions, liquefaction, volcanic eruption, lahars, landslides, worsening air quality – a lot to think about and "prevent." How?

The Mission Statement for Washington State's Department of Ecology reads: "Our mission is to protect, preserve and enhance Washington's environment, and to promote the wise management of our air, land and water for the benefit of current and future generations." I hope so.

Attachments - 18 pages

Andrea Xaver

LIFESTYLE

CLASSIFIED Inside C

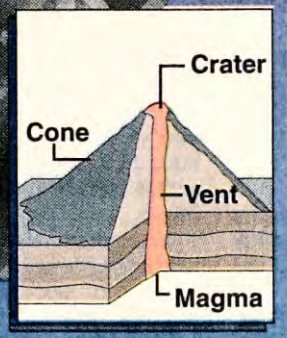
Xavier Attachment 1

Baker:

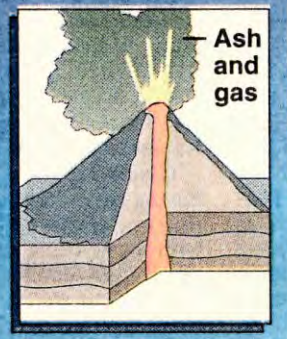
A matter of time

An eruption of Mount Baker is one of many hazards. Part of the mountain collapsing from an earthquake or old age – triggering a mudflow – is a more likely event.

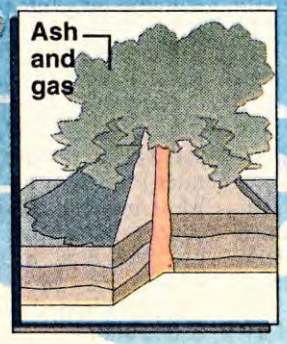
How a volcano erupts



FORCES BUILD
Magma permeated with hot gases under tremendous pressure creates a dome inside the crater.

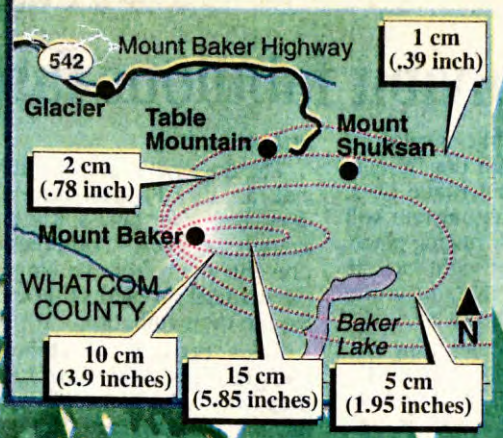


VOLCANO BLOWS
Dome explodes like a champagne cork, releasing tons of ash, molten rock and gases into the atmosphere.



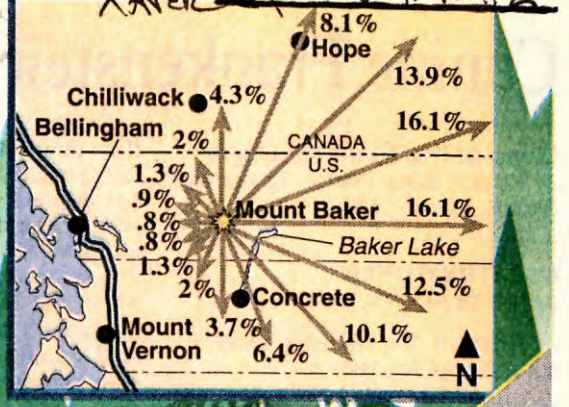
IMMINENT DANGER
An eruption can release deadly clouds of ash and gas, soon followed by avalanches of mud and lava.

there. Ash deposit will depend on prevailing winds and may not be to the east of the mountain.



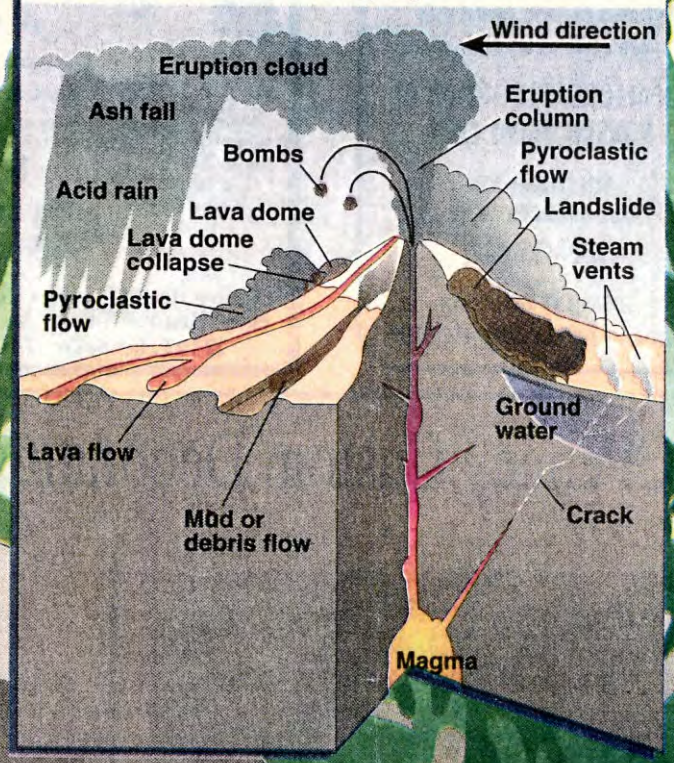
with the length of the arrow and percentage indicating the average that the wind blows in that direction.

XAVER Attachment 2



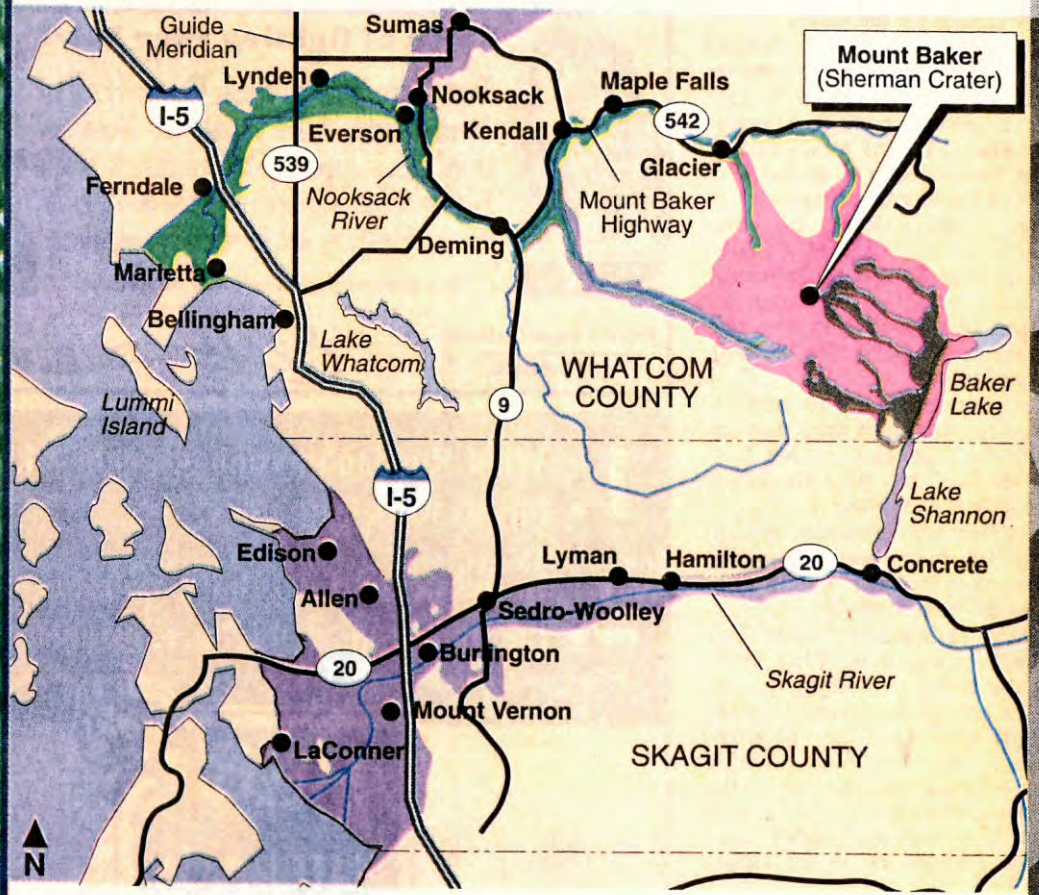
Volcanic hazards

Here are many of the natural hazards that can kill people and destroy property when a volcano erupts. Some hazards, such as mudflows and landslides, can occur even when a volcano is not erupting.



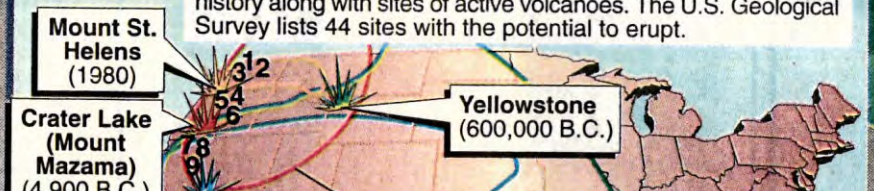
Where the mud flows

Here are four possible scenarios depicting the flow of mud and debris from an eruption of Mount Baker.



Blasts from the past

Historically, eruptions in the U.S. have often sent ash thousands of miles. Here are four of the major eruptions in recent geological history along with sites of active volcanoes. The U.S. Geological Survey lists 44 sites with the potential to erupt.



THE USGS PROVIDES INFORMATION, PRODUCTS, AND SERVICES ABOUT VOLCANO HAZARDS

The USGS at CVO offers a range of information about volcano hazards to scientists, planners, emergency-management officials, emergency-response teams, law-enforcement personnel, educators, and citizens.

PRODUCTS

- "Fact Sheets" about hazards and natural processes related to volcanoes
- Exhibits about individual volcanoes and volcanic hazards
- Resource materials for teachers about volcanoes and geology in general (booklets, videos, rock collections, etc.)
- Reports about scientific studies of hazardous processes and geological history of Cascades volcanoes
- Hazard assessment maps and reports for volcanoes in Washington, Oregon, and California (paper copies and digital files)

SERVICES

- World Wide Web Site: **http://vulcan.wr.usgs.gov**

  A wealth of information about Northwest volcanoes, real-time conditions at streams and rivers around Mount St. Helens, USGS volcano research activities, and some fact sheets, reports, and maps can be obtained through our Web Site.
- Educational presentations and workshops for schools, teachers, and community groups

Please contact the Public Information Officer at:

U.S. Geological Survey **Phone: 360-696-7693**

WHERE TO LEARN MORE ABOUT CASCADES REGION GEOLOGY, HYDROLOGY, AND HAZARDS

Maps and Reports

Geologic and topographic maps, and geologic and hydrologic reports for the Pacific Northwest can be purchased from:

U.S. Geological Survey
Earth Science Information Center
West 904 Riverside, Suite 135
Spokane, WA 99201
(509) 353-2524

U.S. Geological Survey
Branch of Distribution
P.O. Box 2528
Denver, CO 80225
(303) 202-4210
URL: http://www-nmd.usgs.gov

Books, maps, slides, and videos about Mount St. Helens

Items can be purchased from the Mount St. Helens National Volcanic Monument, either by visiting the Silver Lake Visitors Center, about 5 miles east of I-5 on Hwy 504, near Castle Rock, Washington (360) 274-2100, or by mail through the Northwest Interpretive Association (a nonprofit organization), (360) 274-2125.

Conditions and Hazards

Earthquake (**E**), Landslide (**L**), Flood (**F**), Coastal (**C**),
Ground water (**G**), Surface water (**S**)

National Earthquake Information Center (**E**)
U.S. Geological Survey, Denver, CO
(303) 273-8500
URL: http://wwwneic.cr.usgs.gov

National Landslide Information Center (**L**)
U.S. Geological Survey, Golden, CO
(303) 273-8588
URL: http://gldage.cr.usgs.gov

U.S. Geological Survey (**F,S,G**)
Washington District Office, Tacoma, WA
(253) 593-6510
URL: http://wwwdwatcm.wr.usgs.gov

U.S. Geological Survey (**F,S,G**)
Oregon District Office, Portland, OR
(503) 251-3200
URL: http://wwworegon.wr.usgs.gov

National Weather Service (**F**)
Columbia River Basin/Oregon
Flood Forecasting, Portland, OR
(503) 326-2340 or (360) 694-6136
URL: http://nimbo.wrh.noaa.gov/Portland

Washington Department of Natural Resources (**E,L,C**)
Geology & Earth Resources, Olympia, WA
(360) 902-1450
URL: http://www.wadnr.gov

Oregon Department of Geology and Mineral Industries (**E,L,C**)
Portland, OR
(503) 731-4100
URL: http://www.naturenw.org

U.S. Army Corps of Engineers (**F**)
Flood Plain Management, Portland, OR
(503) 326-6411

WHO'S KEEPING WATCH OVER

CASCADES VOLCANOES?

The U.S. Geological Survey (USGS)

U.S. Department of the Interior
U.S. Geological Survey
Cascades Volcano Observatory
Vancouver, Washington

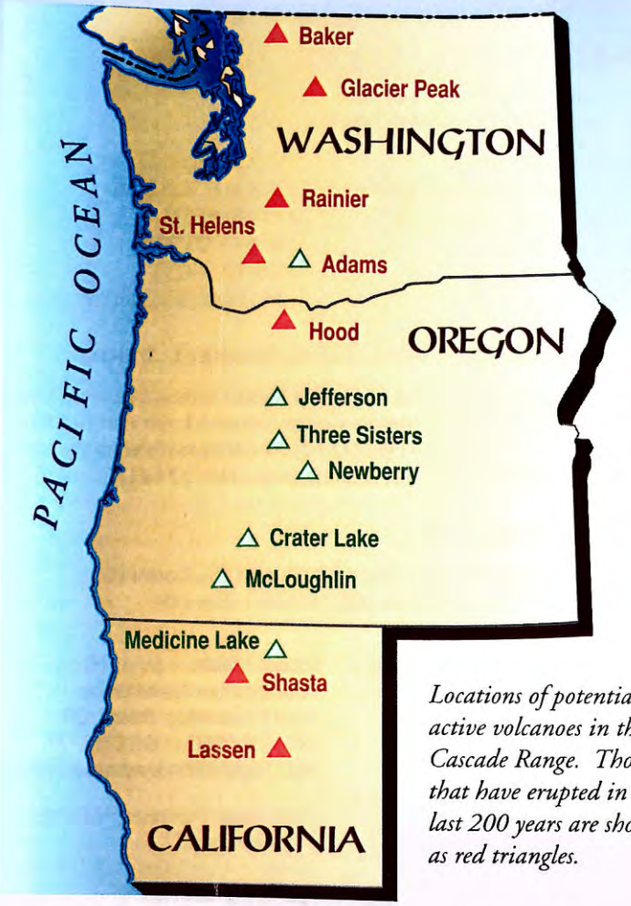
THE USGS OBSERVES, MEASURES, AND STUDIES VOLCANOES IN THE CASCADES

The USGS Cascades Volcano Observatory (CVO) in Vancouver, Washington, was founded in 1980 following the devastating eruption of Mount St. Helens. It is one of three such observatories in the country today (others are in Hawaii and Alaska). Observatory scientists, technicians, and support staff work in partnership with colleagues at other USGS centers, universities, and other agencies to:

- Monitor restless volcanoes and provide timely warning of eruptions
- Assess hazards from volcanoes, including water-related hazards in valleys draining volcanoes
- Share volcano information with emergency-management and planning officials
- Develop new techniques and methods to better monitor and predict behavior of volcanoes
- Study volcanic processes
- Educate public officials, citizens, and the news media about what volcanoes can do

Geologists measuring gas escaping from the lava dome in the

THE USGS WORKS TO PREVENT VOLCANIC DISASTERS



Locations of potentially active volcanoes in the Cascade Range. Those that have erupted in the last 200 years are shown as red triangles.

In the past 200 years, seven volcanoes in the Cascades have erupted, and Cascade eruptions can trigger a variety of hazardous processes. Areas within 10 to 20 miles of erupting volcanoes can be devastated by flows and blasts of hot rock and superheated air, and valleys may be exposed to high concentrations of lethal volcanic gases (also possible during noneruptive periods). Volcanic ash can rise high into the air to drift with the wind, threatening aircraft and disrupting life on the ground hundreds of miles downwind. Eruptions (and sometimes giant landslides not related to eruptions) can also send floods or torrents of mud and rock

Xavier Attachment 3

THE USGS SENDS RAPID RESPONSE TEAMS TO AREAS OF VOLCANIC CRISIS

The core of the USGS volcano rapid response team is located at CVO. Team members are capable of responding within 24 hours to threatening volcanic activity anywhere in the US or the rest of the world. USGS staff have the experience that is often needed and requested by the US Agency for International Development (Office of Foreign Disaster Assistance) for crisis situations in many countries. The additional experience gained from work at foreign volcanoes greatly strengthens the USGS program because it provides a training ground where skills are sharpened, experience is broadened, and equipment is tested. USGS scientists then are better prepared to respond to volcano crises at home.

Locations of volcanoes (dots) where USGS scientists have assisted in predicting eruptions and lessening their direct and indirect effects on populations.

Village buried by volcanic mud and rock following the eruption of Mount Pinatubo, Philippines, 1991.

In the shadow of an ACTIVE VOLCANO

Fumaroles (openings that permit steam and gases to escape) can be seen in this image taken at Mount Baker.

Courtesy of Mount Baker Volcano Research Center

DAVE TUCKER GETS UP CLOSE AND PERSONAL WITH CASCADE MOUNTAINS VOLCANOES

Story by **KATE MARTIN** / Skagit Valley Herald

MOUNT VERNON — Climbing the steep slopes of legendary Cascade Mountains volcanoes has led Dave Tucker on a winding path through life.

"I started out in high school being a mountain climber, which in the Cascades requires you to go up and down things like Mount Baker and Mount St. Helens," said the Steilacoom native.

The ascents fueled Tucker's interest in volcanoes and their geology. In college he minored in geology, graduating with a degree in environmental studies. For a while, he worked as a mountaineering guide.

But in the mid-1990s he was encouraged to return to school by U.S. Geological Survey scientist Wes Hildreth, who had hired him to help with a Mount Baker ascent.

By the time he finished his master's degree, Tucker was in his late 50s.

"Any kind of career in geology was out of the question," he said.

See **TUCKER,** Page D2

At a glance

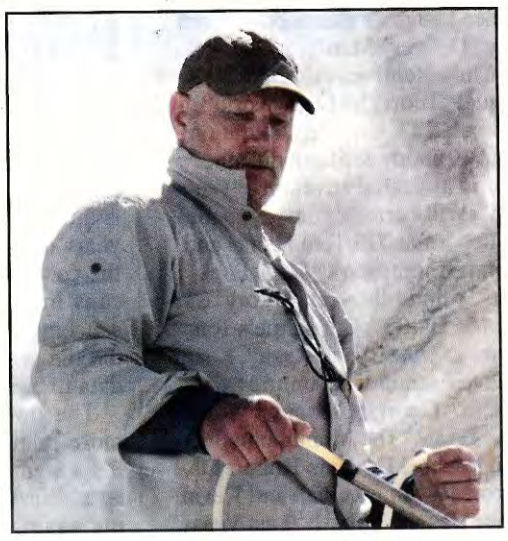
What: The Volcano in our Backyard — Mount Baker: Eruption History, Hazards and Monitoring

When: 7 p.m. Thursday, Jan. 31 (doors open at 6:30 p.m.)

Where: Phillip Tarro Theater, Skagit Valley College, 2405 E. College Way

Features: Dave Tucker, volcanologist and director of the Mount Baker Volcano Research Center

Information: www.mbvrc.wordpress.com



Surrounded by steam from fumaroles, geologist and volcano researcher David Tucker takes readings at Mount Baker.

Courtesy of John Scurlock

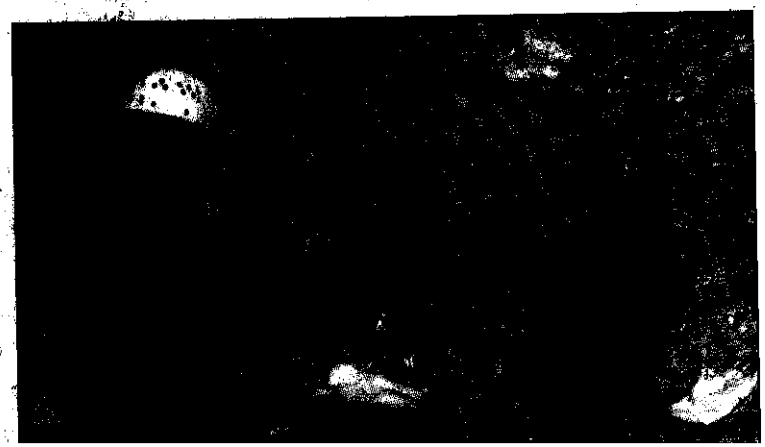
over →

Courtesy of John Scurlock

An aerial view of an active crater at Mount Baker shows fumaroles releasing steam and other gases.

Tucker

Continued from Page D1



These days, Tucker runs a roof and gutter cleaning business to pay the bills. He also writes grants to pay for his passion: studying Mount Baker. He founded the Mount Baker Volcanic Research Center and travels around the area to talk about the mountain's eruptive past.

On Thursday, Jan. 31, Tucker will present his talk for the first

from: "Potential Seismic Hazards of the Sumas & Vedder Mtn. Faults" by Drs: D.J. Easterbrook (WWU) D.C. Engebretson (WWU) D.J. Kovanen (U. of Brit. Col.) circa 2000

Xavier Attachment S

SEISMICITY

More than 500 earthquakes of magnitude 2 or greater occurred in Whatcom, Skagit and San Juan counties between 1969 and 1993. Ten historic quakes with magnitudes 4 to 7.4 occurred between 1872 and 1969. The region near Deming is among the most active earthquake zones in the state with hundreds of quakes since 1969, including the April 14, 1990 quake (Richter magnitude 5.2), which was one of the five largest quakes in the Pacific Northwest between 1965 and 1992.

A number of earthquakes have occurred along the traces of the Sumas and Vedder Mt. faults since 1964, indicating that the faults are presently active. A magnitude 5.0 earthquake occurred along the extension of the Sumas fault in 1964 (Figure 5) and a magnitude 6.0 earthquake occurred in 1909 in the San Juan Islands near the distal trace of the Vedder Mt. fault. A number of earthquakes have occurred along the trace of the Vedder Mt. fault since 1964 (Figure 5), indicating that the fault is also presently active.

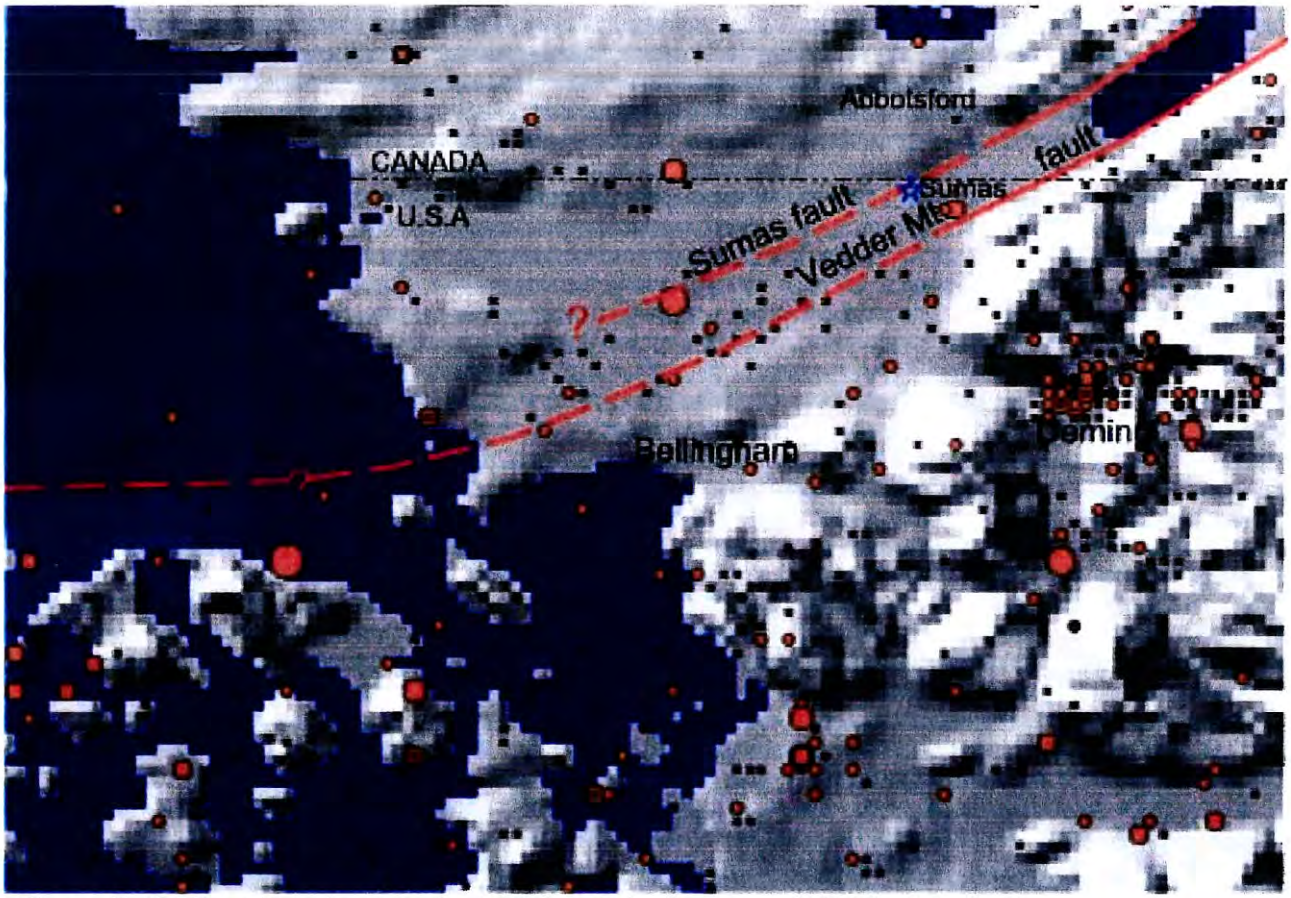


Figure 5. Earthquake epicenters (red dots) and the Sumas and Vedder Mt. faults.

Fr: "Potential Seismic Hazards of the Sumas & Vedder Mt. Faults by Drs: Easterbrook, Engleretson, & Kovanen

Attachment 6

The problem of ground failure due to liquefaction in Sumas is critical with respect to the proposed SE2 power plant because (1) it cannot be overcome by engineering design—no large structure can be designed to withstand sudden ground failure beneath its foundation, (2) the plant uses natural gas that is subject to explosion if the line is breached, and (3) toxic materials will apparently be stored on the site. The reason that these factors pose such a hazard to the population of Sumas is that the gas pipeline is likely to break and explode during a significant earthquake. Whatcom County has recently seen the results of two pipeline breakages, one a natural gas pipeline, the other a gasoline pipeline, with explosive results. Figure 8 shows the explosion and fire that resulted from breaking of the gas pipeline by small downslope movement on Sumas Mt. just south of Sumas on February 8, 1997.

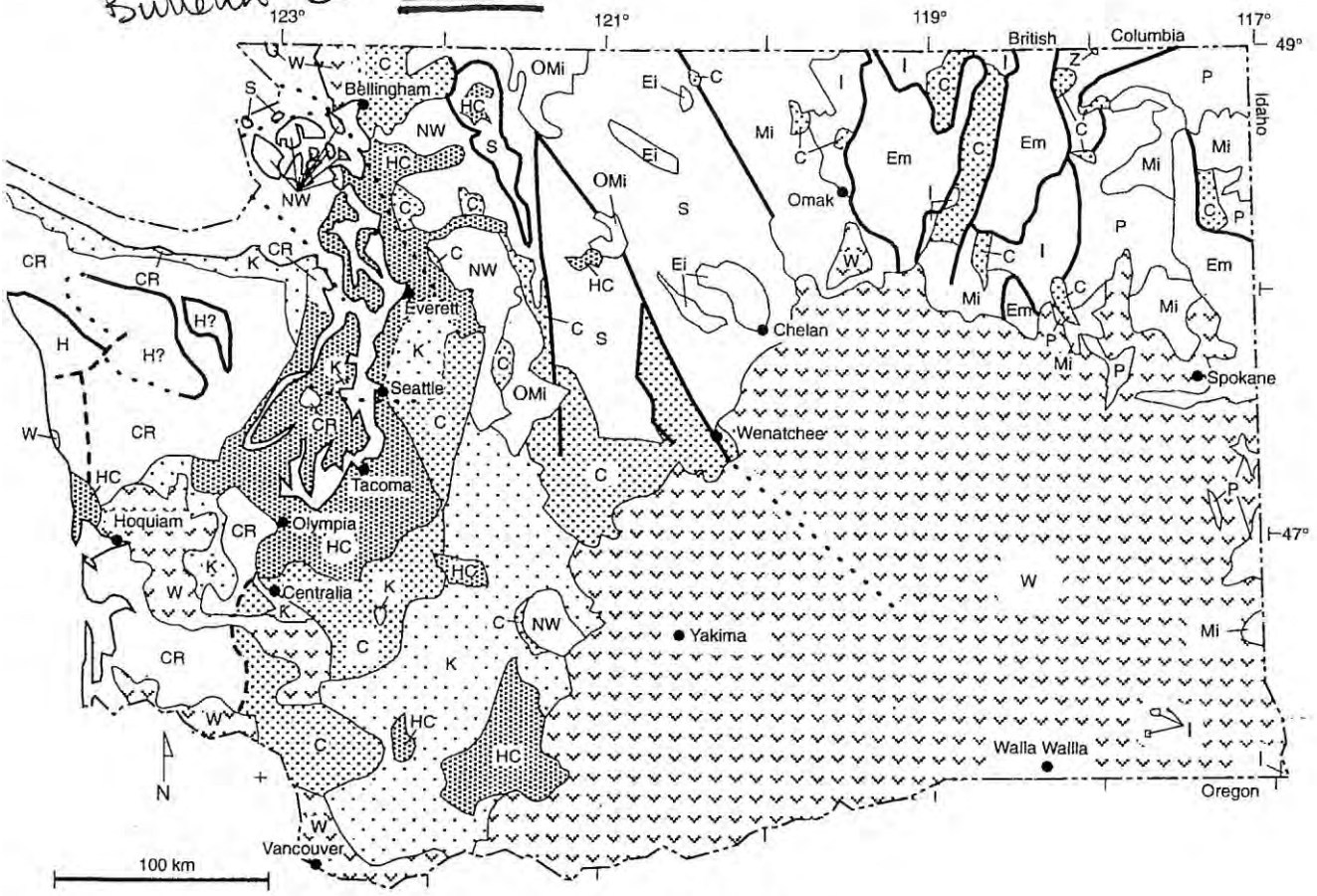
Figure 8. Illustration of the hazard associated with gas pipeline breakage—explosion and fire on Sumas Mt. Feb. 8, 1997

Offset of the land surface along a fault

Abrupt displacement along a fault can offset the land surface 15-20 feet in a single event. Such dislocations of the ground surface have occurred historically in Idaho, Montana, Wyoming, California, and other places. For example, Bainbridge Island jumped 21 feet out of Puget Sound

From Regional Geology of Washington State — DNR - Geology Division Bulletin 80 — 1994

Attachment 7



EXPLANATION

SYMBOLS	Age	Post-accretionary Units	Accreted Terranes (age of accretion)	North American Sequences
Faults (dotted where covered, dashed where inferred)	Oligocene to Pleistocene			HC - High Cascade
			H - Hoh	W - Walpapi
		OMi - batholiths		K - Kittitas
Contacts (dotted where covered, dashed where inferred)	Eocene		CR - Coast Range	
		Em - metamorphic core complexs		C - Challis
		Ei - batholiths		
	Creta-ceous		NW - Northwest Cascade	
			S - Insular	Z - Zuni
	Juras-sic	Mi - batholiths		
			I - Intermontane	
	Proterozoic and Paleozoic			P - Kaskaskia, Tippecanoe, Sauk, Proterozoic

XAVIER Attachment 8

XAVIER Attachment 8

Geologic Map of Washington - GM-50
Northwest Quadrant
WA D.N.R. Division of Geology 2002

FIGURES

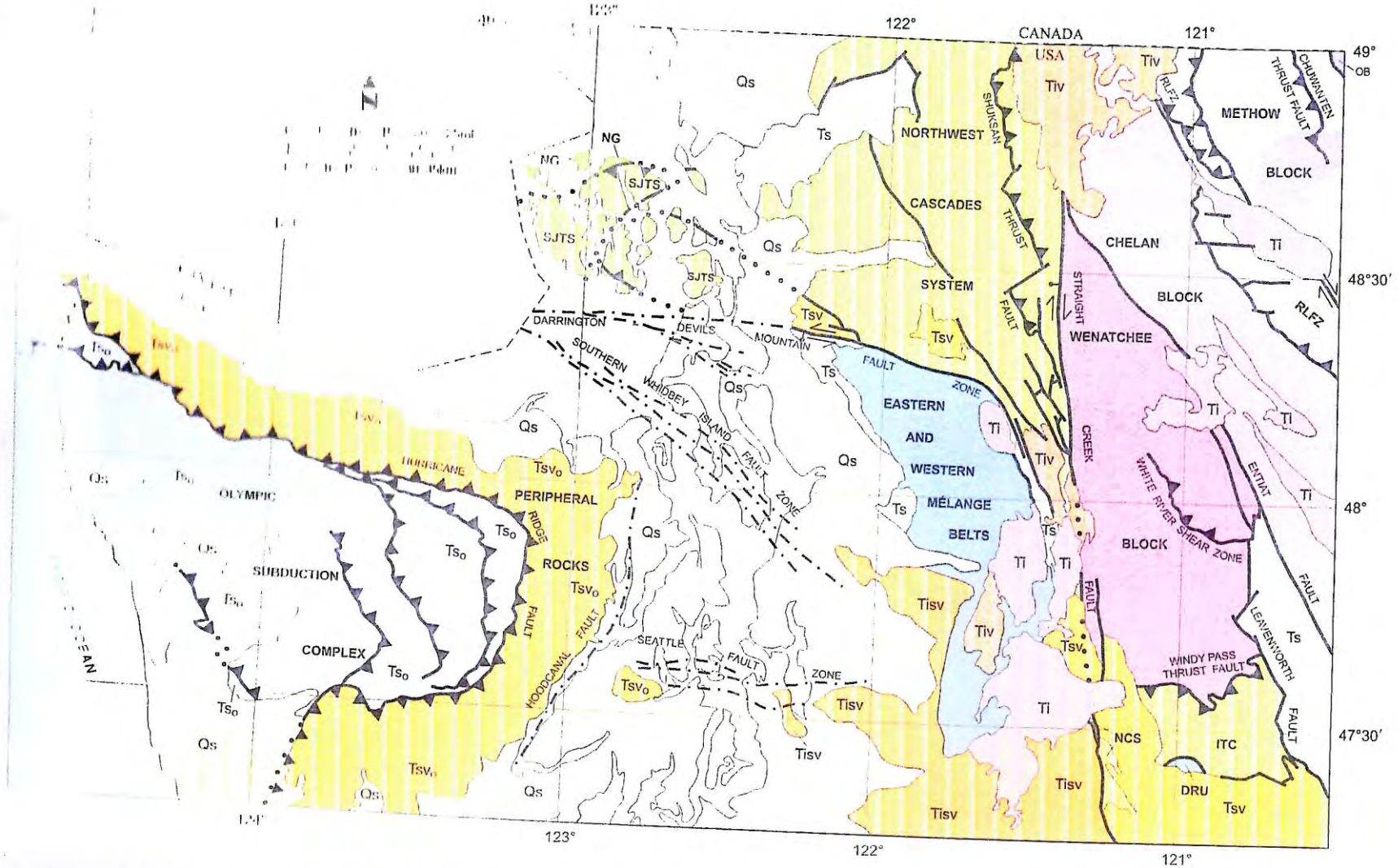
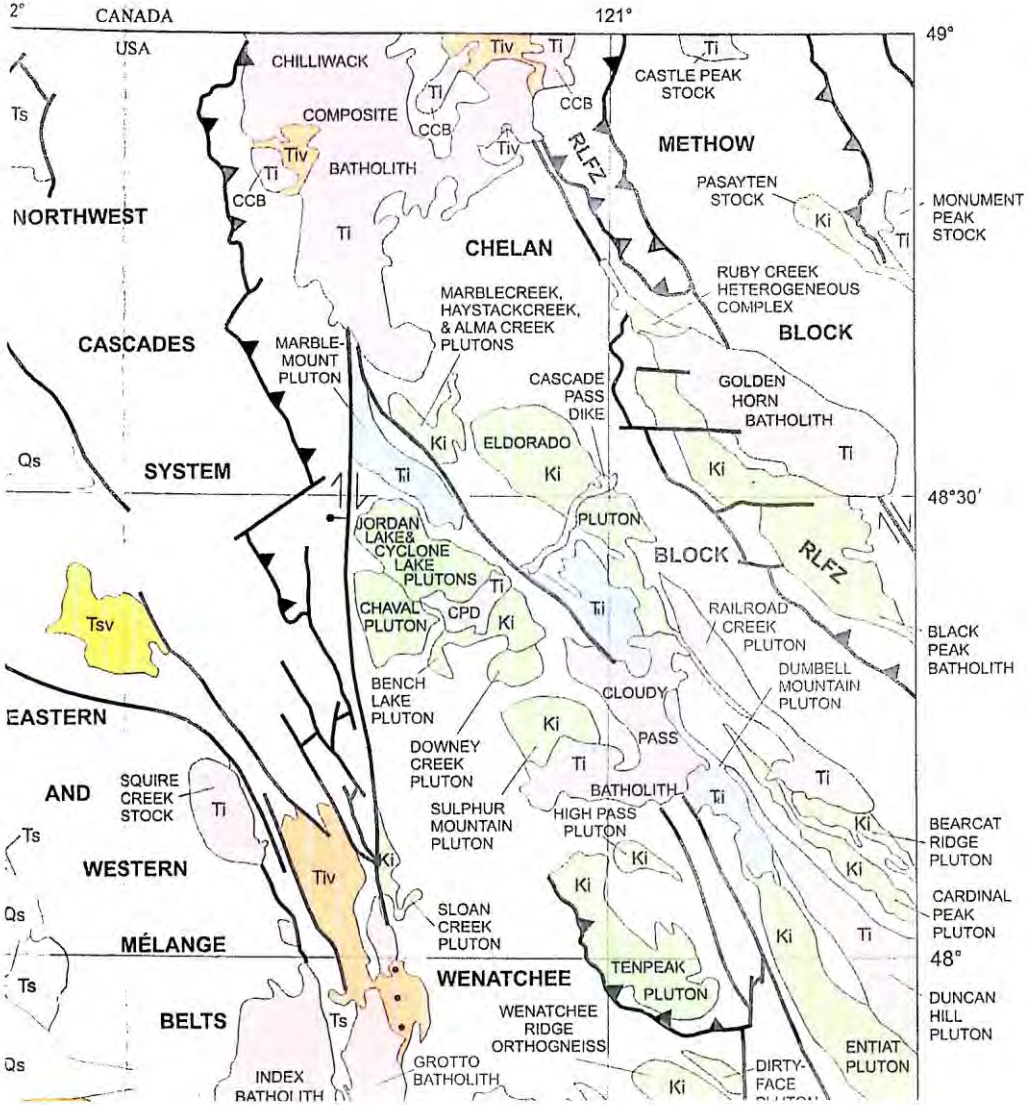


Figure 4. Simplified geologic map of northwestern Washington showing major lithotectonic domains. The Puget Lowland (Fig. 2) is transected by northwest-, northeast-, and west-trending faults bounding thick sequences of Paleocene to Miocene rocks. The Olympic subduction complex and peripheral rocks are separated by

XAVER Attachment 9

XAVER Attachment 9

Figure 4. Simplified geologic map of northwestern Washington showing major lithotectonic domains. The Puget Lowland (Fig. 2) is transected by northwest-, northeast-, and west-trending faults bounding thick sequences of Paleocene to Miocene rocks. The Olympic subduction complex and peripheral rocks are exposed as a westward-verging accretionary thrust belt in the core of an east-plunging antiform (Tabor, 1975). Metamorphic rocks in the Ross Lake fault zone (RLFZ) have protoliths characteristic of both the Methow block and the North Cascades Crystalline Core; metamorphism is intermediate between the high-grade metamorphic rocks of the crystalline core and non-metamorphosed rocks of the Methow block. The Chelan block has mostly Tertiary uplift or exhumation ages, while the Wenatchee block has mostly Late Cretaceous uplift or exhumation ages. In the Northwest Cascades System (NCS) and the San Juan thrust system (SJTS), the Helena–Haystack mélange and Fidalgo Complex (see Sheet 1) probably occur as the structurally highest portion (Whetten and others, 1980b; Tabor, 1994). The Nanaimo Group (NG) forms an external unit to the NCS and SJTS (Brandon and others, 1988). The Nooksack Formation (see Sheet 1), including the Wells Creek Volcanics of Misch (1966)(Nooksack terrane of Tabor and others, 1994), forms the autochthon upon which the Northwest Cascades System was tectonically emplaced during the Cretaceous. The De Roux unit (formerly part of the Ingalls Tectonic Complex) is probably a tectonic sliver of the Western mélange belt imbricated onto the Ingalls Tectonic Complex (Miller and others, 1993b). The Eastern and Western mélange belts of Frizzell and others (1984), including the Trafton sequence of Danner (1966), may have been thrust over Northwest Cascades System in the Cretaceous to earliest Tertiary (Tabor, 1994).



EXPLANATION (Figs. 4 and 5)

- high-angle fault – dotted where concealed
- thrust fault – sawteeth on upper plate; dotted where concealed
- oblique-slip fault – arrows show relative horizontal movement; bar and ball on downthrown side; dotted where concealed
- major suspected active faults

GEOLOGIC UNITS

Quaternary Deposits

- Qs — surficial deposits, undivided

Tertiary Rocks

- Tisv — intrusive, volcanic, and sedimentary rocks, undivided
- Ts — sedimentary rocks; locally divided into:
  - Ts_o — Olympic subduction complex
- Tsv — sedimentary and volcanic rocks; locally divided into:
  - Tsv_p — peripheral rocks of the Olympic Mountains
- Tiv — intrusive and volcanic rocks
- Ti — intrusive rocks

Pre-Tertiary Rocks

- OB — Okanogan block

Xaver Attachment 10

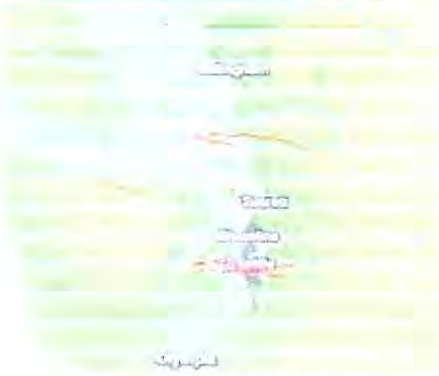
SCIENCE

Geologists Identify New Earthquake Faults Near Bellingham

Northwest News Network | April 18, 2012 9:39 a.m. | Updated: July 17, 2012 1:01 a.m.

CONTRIBUTED BY:

TOM BANSE



Geologists have discovered two previously unknown earthquake faults -- and possibly a third -- near Bellingham, Washington. The scientists working for the U.S. Geological Survey believe the shallow faults are capable of spawning damaging tremors.

The team of geologists from California and western Washington had a hunch there would be active earthquake faults near the U.S.-Canada border. Similar faults run right under Seattle and Tacoma. So they started looking in earnest five years ago.

USGS researcher Brian Sherrod says sediment cores and seismic surveys reveal two roughly parallel faults cutting across the Whatcom County coastline and Puget Sound lowlands north of Bellingham. Sherrod says the area has been quiet lately, but for how much longer he can't say.

"We don't know when these earthquakes are going to happen. We don't know how big they going to be," Sherrod says. "But you could be looking at earthquakes anywhere from magnitude six to maybe even a magnitude seven that are pretty shallow in depth."

Xavier Attachment 11

Sherrod says a release of seismic energy close to the surface puts buildings and people at greater risk. The evidence for the new faults is published in the Journal of Geophysical Research.

On the Web:

Bellingham fault study abstract:

http://www.agu.org/pubs/crossref/2012/2011JB008816.shtml

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The Bellingham Herald

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New seismic research reveals more quake hazards in Whatcom County

Published: April 22, 2012

By JOHN STARK — THE BELLINGHAM HERALD

About 1,200 years ago, a powerful earthquake lifted up Birch Bay tide flats and turned them into freshwater marshes beyond the reach of saltwater.

If the fault near the mouth of Terrell Creek experienced a similar event today, the damage could be significant as far south as Bellingham.

"It would be a pretty ugly event," said Brian Sherrod, U.S. Geological Survey research geologist and faculty member in the earth and space sciences department at the University of Washington.

In the Sandy Point area, the team found evidence of three past earthquakes, each powerful enough to raise the elevation of areas near the shoreline.

Sherrod is one of a team of four geologists who recently published their research on that fault and nearby faults near Sandy Point and Drayton Harbor. He added that the team's findings need not generate alarm.

"We don't know when or if these things are going to pop off another big one," Sherrod said. "We just know that they have. ... It reinforces the idea that we live in an area that has earthquakes."

While the highest magnitude of these quakes likely would be in the 6 to 6.5 range - much less than the 2010 Japan quake - they would be shallow enough to cause a lot of mayhem.

"You're going to feel it many, many, many times larger than Nisqually," Sherrod said, referring to the 2001 quake that vibrated Bellingham and damaged the state capitol dome in Olympia.

Similar-sized shallow quakes toppled buildings and killed 185 people in Christchurch, New Zealand, in 2011, Sherrod noted.

The researchers used airborne laser mapping and other techniques to pinpoint the locations of the faults and the evidence of the past earthquakes, Sherrod said.

Geologist Dan McShane, a former Whatcom County Council member, said this type of research is gradually incorporated into seismic hazard maps that are used to upgrade the seismic safety sections of building codes.

McShane said geologists have suspected the existence of the Sandy Point and Birch Bay area faults for years, based on signs of recent (in geological terms) uplift visible on the surface.

He said the most significant finding in the new research may be the faulting in the Drayton Harbor area near Blaine, which extends the known active fault zone farther north than previously demonstrated. The researchers also observe that this faulting probably extends north into the Vancouver, B.C., area, raising new levels of quake concern there.

Kaver Attachment 13

Asked if the new research meant a major or an incremental increase in the known quake risk here, McShane replied, "I would say it's probably incremental."

READ THE REPORT

Click here to read the report from the Journal of Geophysical Research.

Reach JOHN STARK at 715-2274 or john.stark@bellinghamherald.com . Read the Politics Blog at blogs.bellinghamherald.com/politics.

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The Natural History of Puget Sound Country
1991 - UW Press

kes in the Puget Trough

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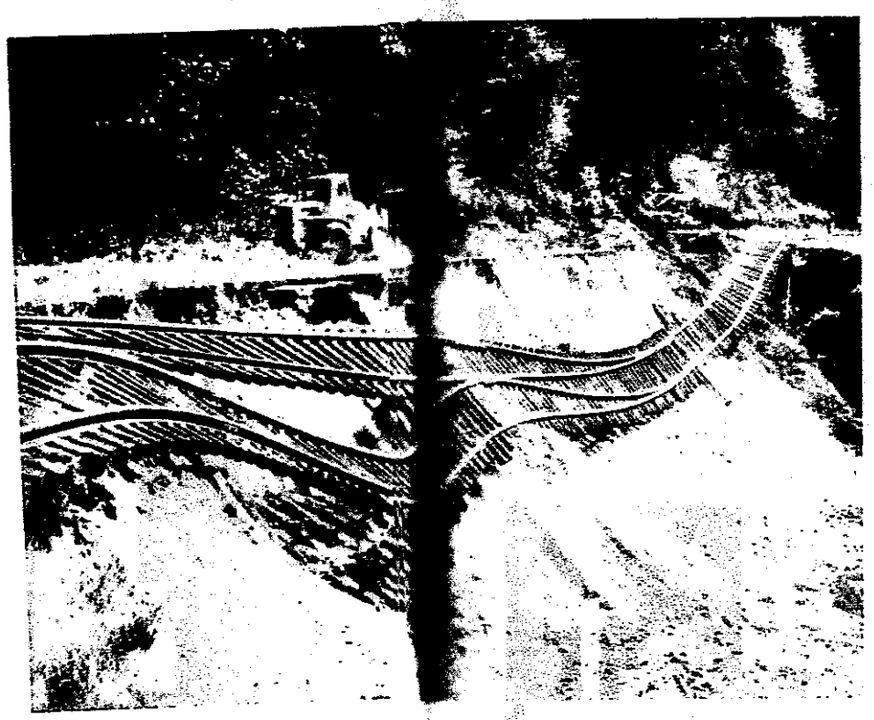
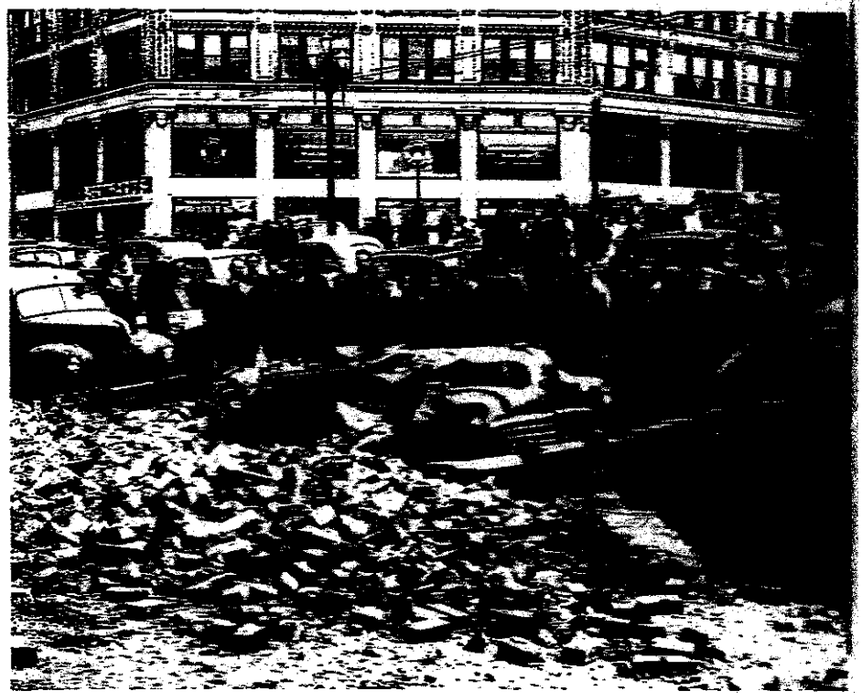
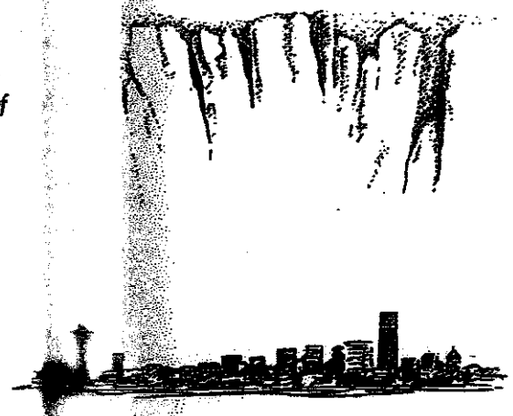
he Dominant Sculptor: Pleistocene Glaciers in Puget Sound

he end of the Tertiary, a lowland sedimentary trough, defined



A massive earth slide disrupted the rail line near Olympia during the Seattle-Tacoma earthquake. (Photo by G. W. Thorsen.)





The glacier that once covered Puget Sound was 3,000 feet thick. Some idea of its depth is shown in this drawing of the glacier as it might have looked towering over the Seattle skyline. (Drawing by Pamela Harlow.)

Puget Sound. It was the action of ice and its later meltwaters that gave shape to the landscapes of today.

Though often called the "Ice Age," the Pleistocene was not one period during which the land was continuously covered with ice. Many advances and retreats of continental glaciers are recorded by the repeated scourings and deposits of rock-laden glaciers.

The Fraser Glaciation was the latest of the major advances of northern ice into western Washington. Yet Washington and the Pacific Northwest were not alone in having endured repeated interludes of icy inundation. It was a time of repeated ice advances and retreats on the northern continents of our restless planet. The Pleistocene epoch, beginning about 2.2 million years ago, made a telling impression worldwide but especially on the northern parts of North America and Eurasia. Massive continental glaciers spread out over northern lands until a confluent mass of ice, two to seven thousand feet thick, covered vast landscapes.

Each glacial advance and retreat (a stade) was followed by a warmer interglacial period. During interglacials, montane glaciers,

From: The Natural History of Puget Sound Country
1991 - UW Press

Earthquakes in the Puget Trough

Geologists are fond of quoting historian Will Durant that "civilization exists by geological consent—subject to change without notice." Geologic events give their consent to human occupancy of the land mostly in slow, measured actions. But when earthquakes strike, the effects are sudden, dramatic, and often catastrophic. Puget Sound *is* earthquake country, even though the frequency and intensity of quakes is usually less than at other more turbulent places on the planet. Two major quakes in the Puget lowland stand out in recent history: the 1949 Olympia quake of 7.1 magnitude (cited as major) and the 1965 Tacoma-Seattle quake of 6.5 magnitude (large). Damage to buildings and other human fabrications was substantial and significant alterations of landforms occurred, mostly in the form of landslides. But earthquakes of lesser magnitude occur in the Puget lowland with greater frequency. Only quakes of large to major magnitude make the headlines.

Earthquakes in western Washington are intimately associated with the dynamics of plate tectonics. Just to the west of the Pacific Coast two massive plates of earth's mantle persistently converge. The oceanic Juan de Fuca plate dives under the continental North American plate to its east at the rate of three to four centimeters per year. The convergence of the two plates then becomes the stage on which seismic activity is displayed. Besides these deep earthquakes associated with subduction, other symptoms of plate convergence are present: the chain of Cascadian volcanoes from Mount Shasta in the south to Mount Garibaldi in British Columbia, and the highly deformed rocks of the Olympic peninsula.

Can we expect more major quakes like the ones of 1949 and 1965? A report on Washington earthquakes issued by the Division of Geology and Earth Resources, Washington State Department of Natural Resources, by Noson et al. (1988) estimates quakes of magnitude 6 (large) every 10 years, and return times of 35 to 110 years for quakes of greater magnitude. This report and a companion work (Thorson 1986) contain a wealth of detail on local seismicity and the geology of earth movements; they will remind us that our place on the planet is restless!

A massive earth slide disrupted the rail line near Olympia during the Seattle-Tacoma earthquake. (Photo by G. W. Thorsen.)

The glacier that once covered Puget Sound was 3,000 feet thick. Some idea of its depth is shown in this drawing of the glacier as it might have looked towering over the Seattle skyline. (Drawing by Pamela Harlow.)

Ice, the Dominant Sculptor: Pleistocene Glaciers in Puget Sound

By the end of the Tertiary, a lowland sedimentary trough, defined by two north-south mountain ranges, had been made ready for its next major shaping. Ice was to be the sculptor. Repeated advances and retreats of continental ice sheets from Canada descended into