POTENTIAL SEISMIC HAZARDS OF THE SUMAS AND VEDDER MT. FAULTS

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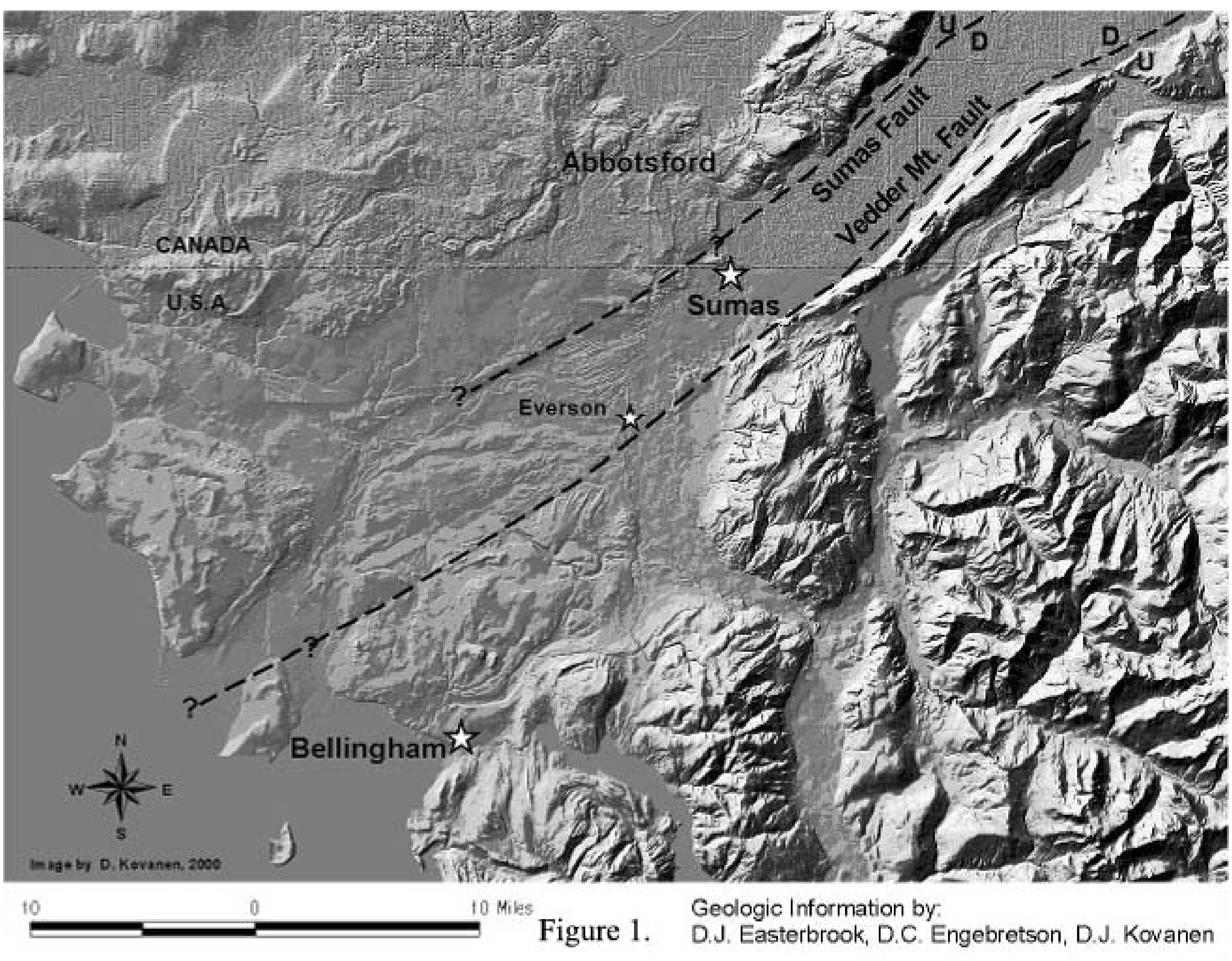
Two faults, the Vedder Mt. fault and a previously unnamed fault that we now call the Sumas fault, have long been known along the sides of the Sumas Valley. However, new data now indicates that the faults are both larger and more active than previously known. The Vedder Mt. fault extends from British Columbia into Washington along the margin of Vedder Mt., continues southwesterly across Whatcom County (Figure 1) and appears to continue westward to Sucia Island in the San Juan Islands and beyond. The fault is at least 65 miles long and may be considerably longer. The Sumas fault parallels the Vedder Mt. fault and extends southwesterly from British Columbia through Sumas and across Whatcom County.

Figure 1. Digital elevation model of Sumas and Vedder Mt. faults.



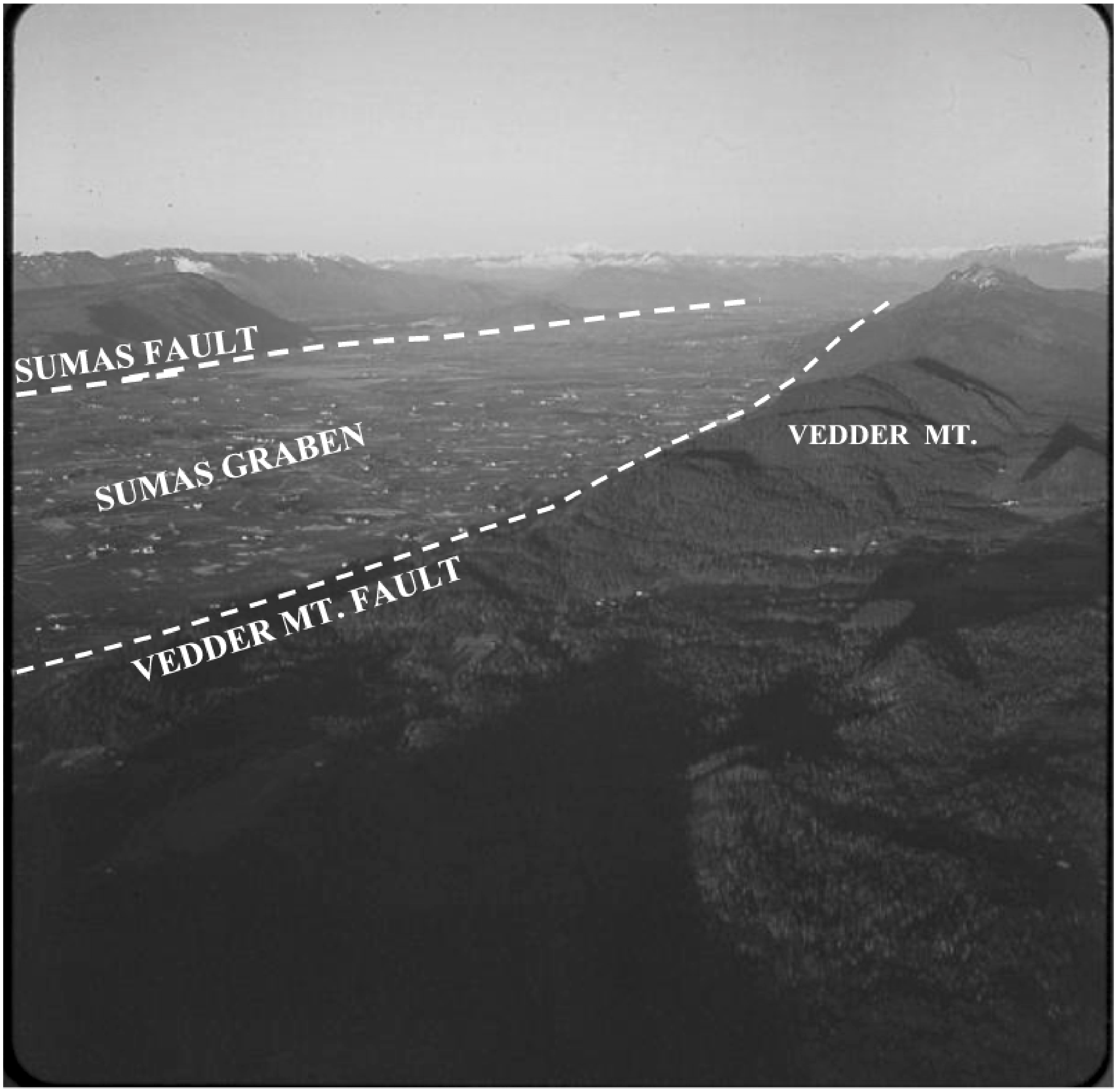


Figure 2. Down–dropped block (Sumas graben) between the Sumas and Vedder Mt. faults. The steep valley sides are made by the fault planes.

Both the Sumas and Vedder Mt. faults have prominent, linear, northeast-trending scarps that can be traced for at least 50 km (Figures 1, 2, 3) and truncate bedrock structures at the western margin of the Cascade foothills. Well logs have penetrated 1000 feet of unconsolidated sediment on the down-dropped block between the two faults (the Sumas graben) (Figure 4), suggesting that significant offsetting of the bedrock is geologically very young. The total amount of offset along the Vedder Mt. fault is at least 2500 feet (the depth of the sediment fill, 1000 ft. plus the height of the fault plane along the side of Vedder Mt., 1500 ft.). Movement on the Sumas fault must be similar to accommodate the development of the graben. The faults disappear beneath unconsolidated glacial deposits that cover the much of western Whatcom County, but their extent can be traced below the surface by the depth of water wells to bedrock.

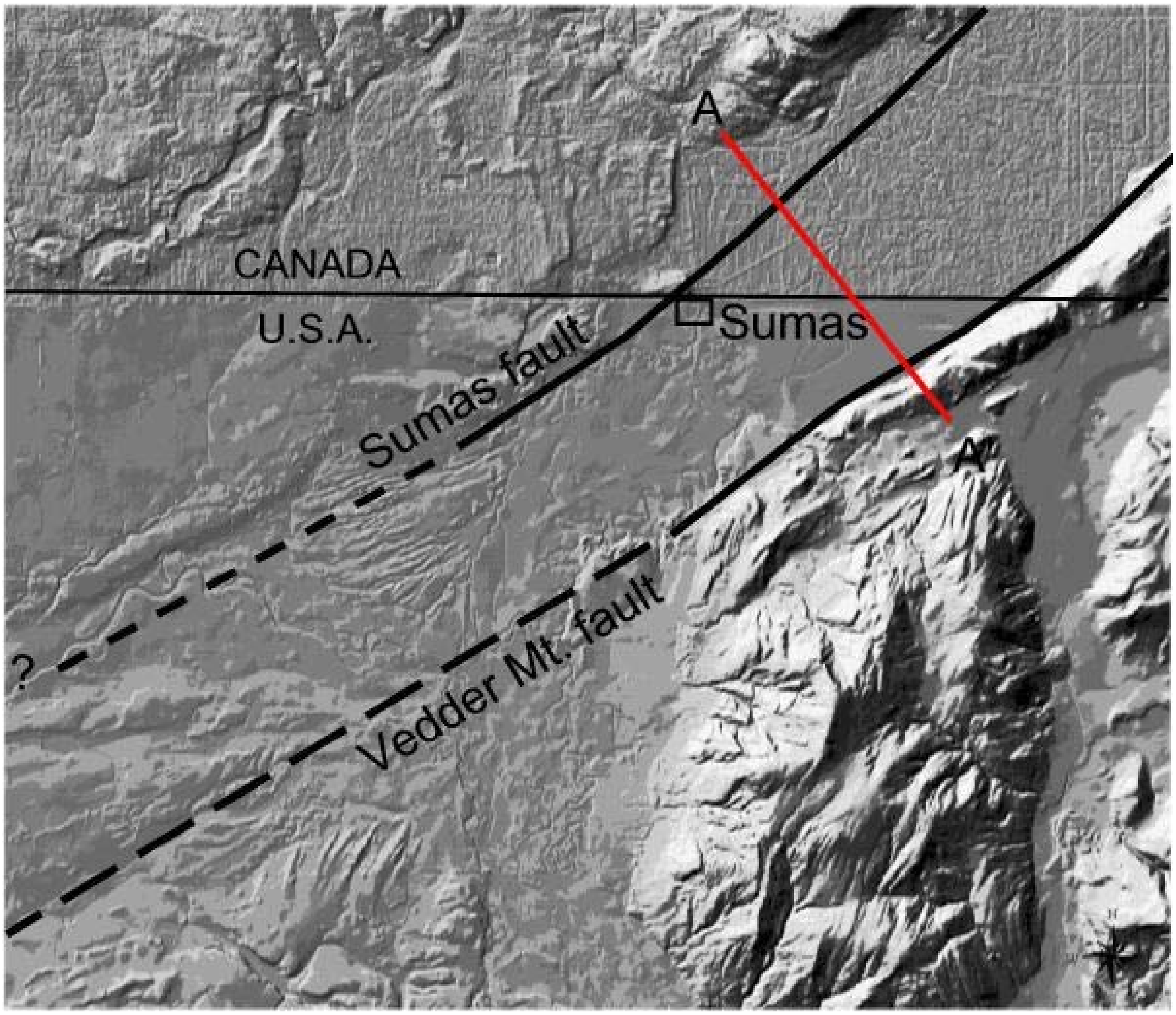
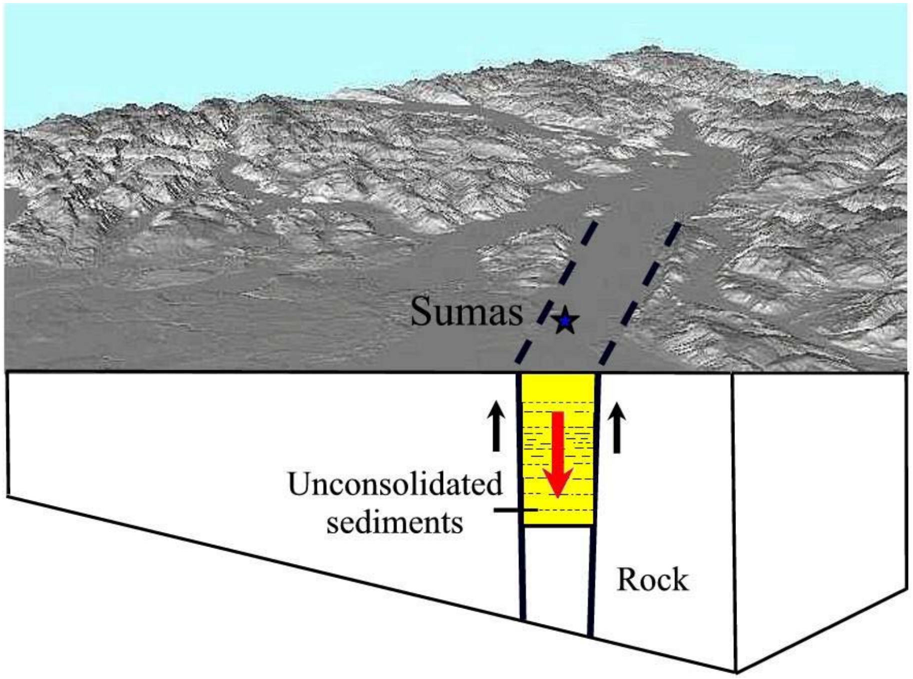


Figure 3. The Sumas graben bounded by the Sumas and Vedder Mt. faults.



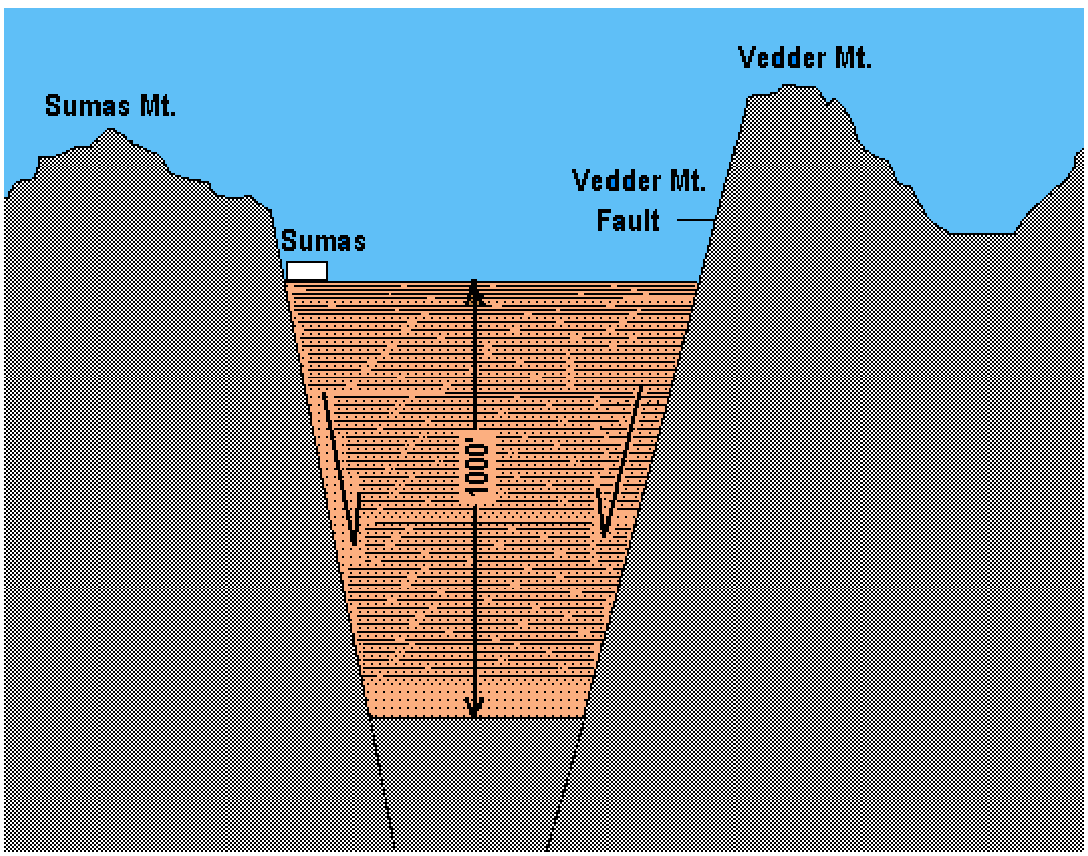


Figure 4. Geologic cross section of the Sumas graben dropped down along the Sumas and Vedder Mt. faults.

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.

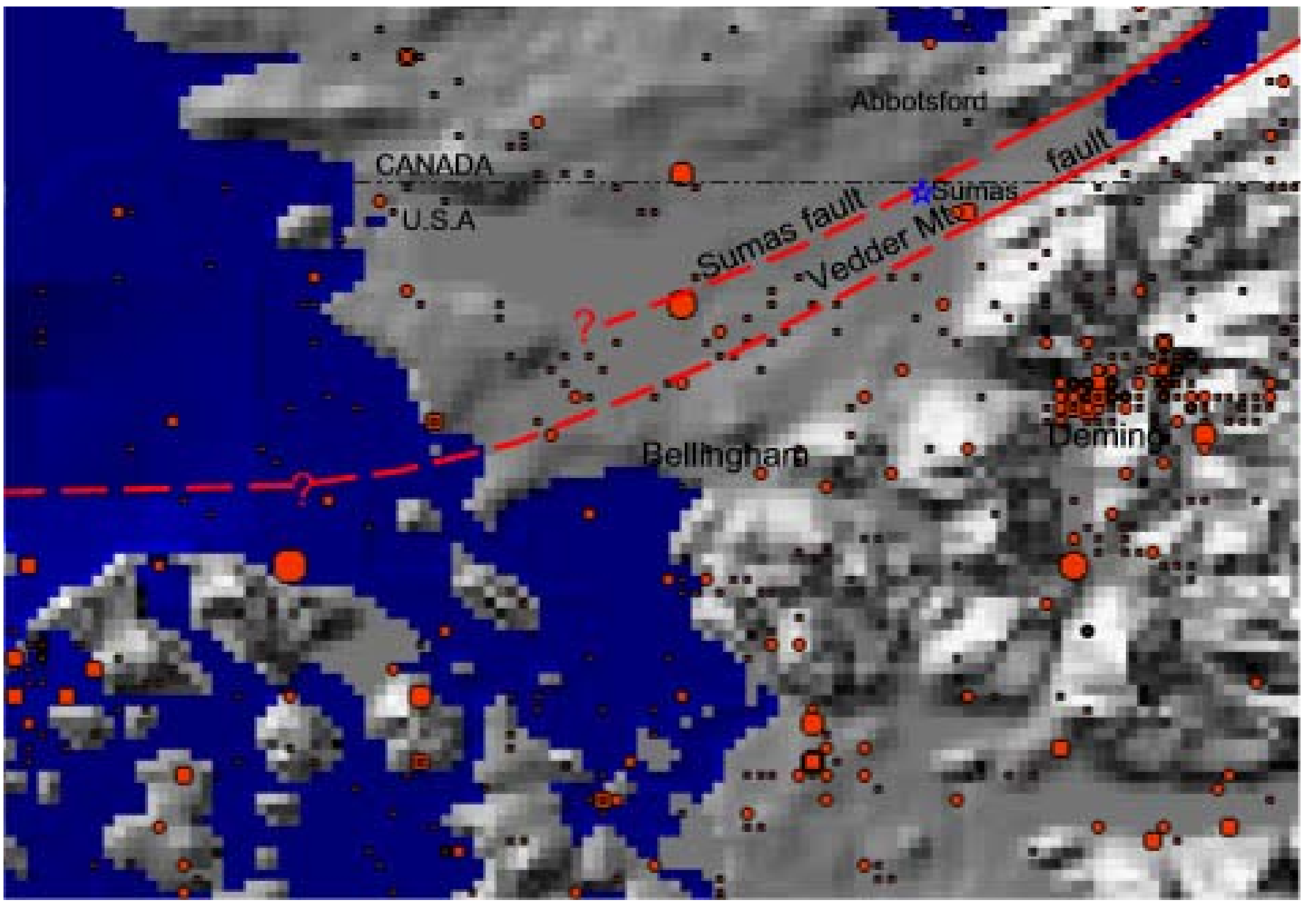


Figure 5. Earthquake epicenters (red dots) and the Sumas and Vedder Mt. faults.

The orientation of a fault that produces an earthquake can be determined by a process called focal plane mechanism analysis. Focal plane mechanisms of earthquake epicenters in Whatcom County have been determined by Roberts (Figure 6) and confirm that the earthquakes along the Sumas-Vedder Mt. fault system are coming from active, NE-SW-trending faults, upthrown on the south side, directly correlating with the conditions shown by the geology.

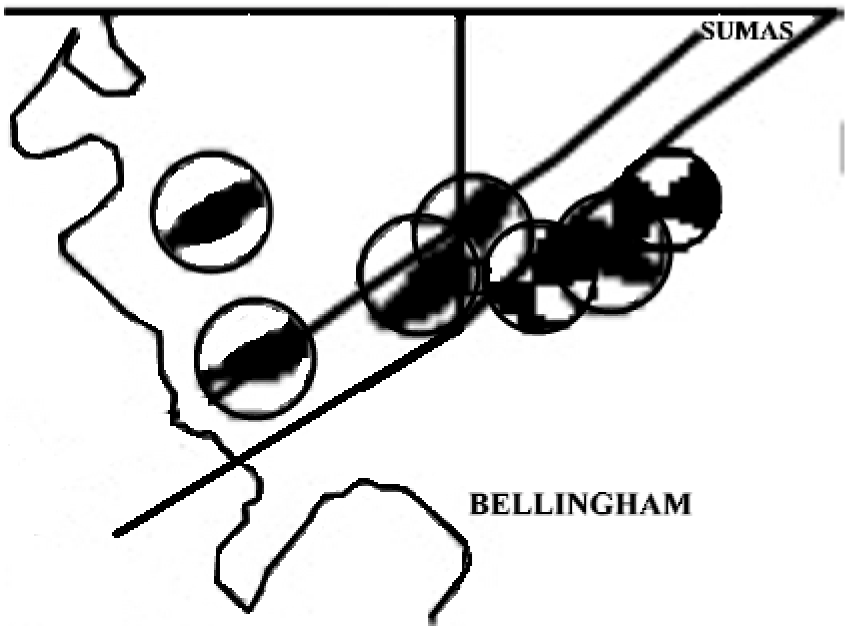


Figure 6. Focal plane mechanisms for the earthquakes along the Sumas and Vedder Mt. faults.

POTENTIAL SEISMIC HAZARDS

Until very recently, what few seismic hazard analyses have been undertaken have greatly underestimated seismic and geological hazards in Whatcom County. Our studies have found new geologic evidence of active faults that have generated earthquakes since the mid-19060s. . Two very large faults, the Sumas fault and the Vedder Mt. fault pose serious seismic hazards to the region. In light of the new geologic and seismic evidence, the proximity of the towns of Sumas, Everson, Lynden, and Abbotsford to these faults has great importance with respect to potential seismic hazards in this populated area. In addition, the proposal to build a large power plant in Sumas (SE2) poses very real threats to the population there. Some of the more significant ramifications of these hazards are outlined below.

Seismic Risk Considerations

Seismic shaking

The intensity of an earthquake and its potential for damage depend on several factors:

(1) The larger the size of an earthquake, the greater the intensity of shaking. For example, bigger quakes cause more damage (on the Richter scale, a magnitude 6 is 10 times larger than a magnitude 5). The proximity of Sumas to two major, active faults makes it unusually vulnerable to intense earthquakes.

(2) Nearness to the epicenter of the quake. The proposed SE2 plant lies directly above the Sumas fault. Earthquake intensity increases significantly with proximity to the epicenter, i.e., the closer to the epicenter, the greater the damage from earthquake. The recent earthquake that caused major damage in Seattle was from an epicenter about 35 miles away and about 35 miles deep. Because Sumas lies directly over the Sumas fault and within 2 miles of the Vedder Mt. fault, an earthquake of the same magnitude as the Seattle quake would be many times more intense because of the closeness to the epicenter.

(3) The nature of the material beneath the ground has two profound effects on earthquakes: (1) if the material is clay/silt the intensity of earthquake waves is greatly amplified—the size and intensity of seismic waves is much greater on clay/silt than on bedrock. (If you shake a brick and a bowl of jello, the jello produces much bigger waves, much like the difference between clay and rock in nature). and (2) the silt/clay may liquefy, losing all of its bearing capacity and causing it to flow as a liquid. The proposed SE2 site and the Sumas Valley are underlain by 1000 feet of unconsolidated deposits, including a thick section of fine-grained sediments subject to liquefaction.

(4) The type of construction—large structures are more vulnerable than smaller ones and structures that vibrate with the same wave frequencies as those of earthquake waves may undergo greatly amplified shaking.

All four of the seismic considerations listed above apply to the Sumas area, making it especially vulnerable to earthquake damage. Such damage can have dangerous effects in populated areas, such as the town of Sumas, where natural gas explosion and release of toxic chemicals pose hazards to the population.

Ground failure, liquefaction

During earthquakes, the ground may slide significantly. Failure of the ground beneath structures is highly destructive. Because of this, designing a large, earthquake-proof structure that could withstand ground failure is impossible.

Earthquake waves can cause clay, silt, and fine sand to act like liquids so that the ground literally flows, a process known as *liquefaction*. The floor of Sumas Valley is filled with thick, unconsolidated lake clay and silt that lie on more than 1000 feet of other fine-grained sediment. These sediments are vulnerable to shaking that could cause liquefaction. Figure 7 shows the area of the Sumas Valley underlain by sediment that has liquefaction potential.

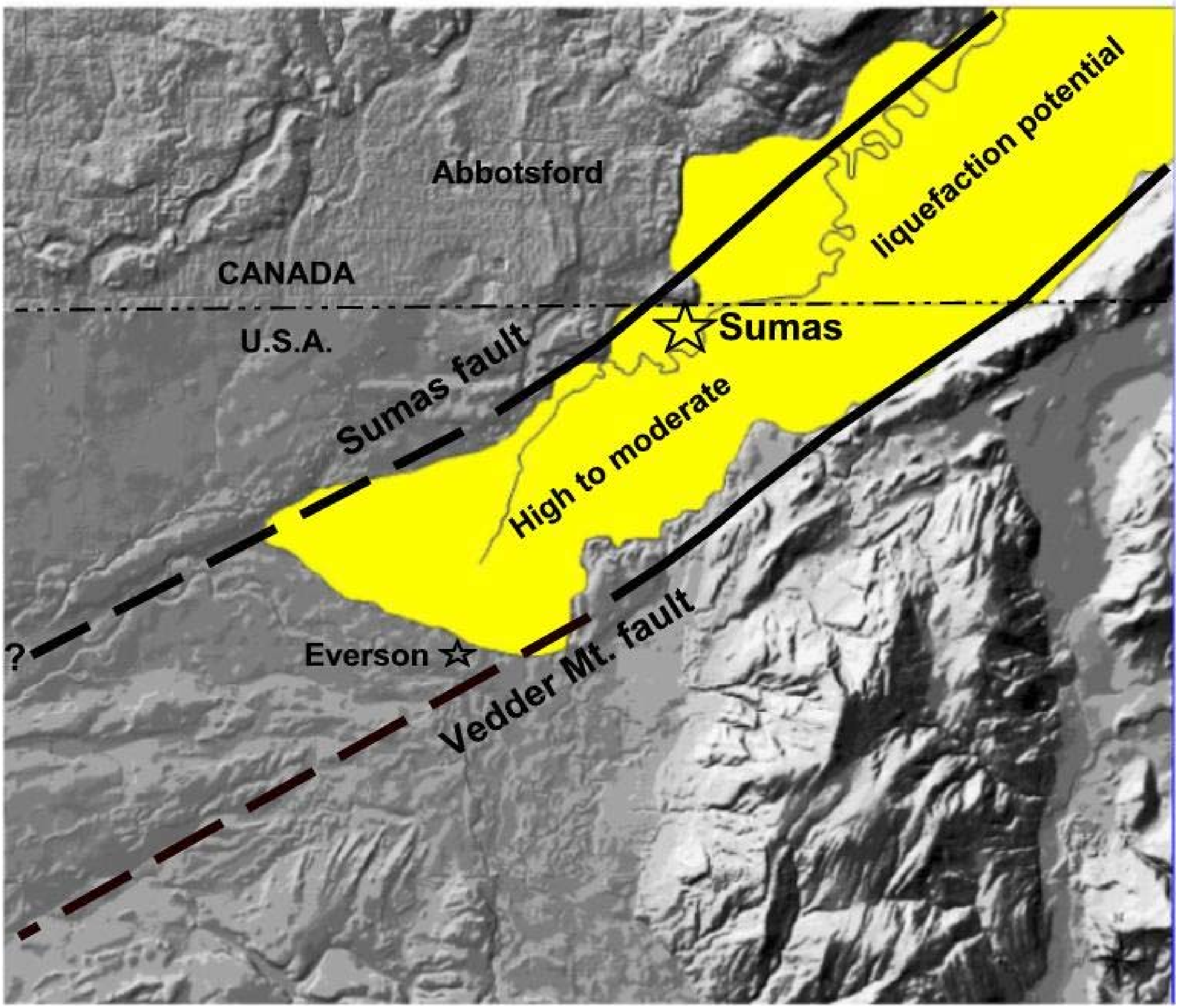


Figure 7. Area in the Sumas Valley subject to liquefaction during an earthquake.

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 along the Seattle fault about 1000 years ago. The Vedder Mt. and Sumas faults are similar in size, amount of offset, and sense of motion. Although most fault movements do not break the ground surface, when they do, they are devastating.

Two areas along the trace of the Sumas fault may possibly represent previous offsets of the land surface along the fault, but we have not yet positively confirmed them. One possible offset is just southwest of Sumas where an anomalously straight bluff appears to be unrelated to other surface processes. Another anomalous scarp between Lynden and Birch Bay also appears to be unrelated to surface processes. Although these scarps are anomalous and may represent offset along a fault, we cannot yet definitely prove that.

Landslides

Earthquakes are capable of triggering large landslides. In a study of landslides in bedrock in the Nooksack drainage just south of Sumas, we found five unusually large, deep-seated, seismically induced landslides. The largest was 6.2 miles long, 1.6 miles wide, and up to 312 feet thick. Three other deep-seated, bedrock landslide were about 2 miles long. Thus, we know that landslides from the valley sides, triggered by earthquakes, could reach Sumas and the SE2 plant. However, in this event, the town of Sumas would be in as much danger from the landslide as from landslide damage to the proposed SE2 plant.

ADEQUACY OF SE2 PROPOSAL.

The SE2 proposal contains no seismic risk analysis at all. It includes only a very vague discussion of earthquakes in the western U.S. and makes no mention at all of any faults or earthquakes in Whatcom County. None of the issues outlined in this report have been adequately addressed by SE2. Public statements by SE2 officials discount any seismic hazard as not being a safety issue because "Washington is known to have faults everywhere and they can't be avoided." Documents filed by SE2 suggest that they will address seismic safety issues ***after*** a permit has been issued. They propose to overcome the problem of seismic liquefaction by "placing piling to bedrock" or "removing the clay/silt by excavation". Neither of these proposals makes any sense at all because bedrock is 1000 feet down and no piling is capable of reaching that far. The same difficulty applies to their suggestion of removing the silt/clay—it's too thick to remove.