The Role of Subduction Zone Processes in the Cultural History of the Cascade Region

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INTRODUCTION

Geological processes and events dictate the internal structure and composition of the Earth and sculpt its surface. As such, geological forces also shape and impact human lives and cultures in many ways. Nowhere is this more evident than in the dynamic geological provinces of subduction zones, where geological forces provide important resources, such as water, rock, and mineral deposits, and where dramatic geological events, such as earthquakes and volcanic eruptions, cause subduction zone processes to loom large in many cultural representations.

The Cascade Range and Cascadia subduction zone provide many excellent examples of the impact and importance of subduction zone processes in human cultures (Fig. 1). This article highlights some examples of this importance and impact on Indigenous peoples and European settlers, as well as today’s culture. Indigenous peoples have many oral histories directly attributable to geological processes, such as earthquakes, landslides, and volcanic eruptions, and the subduction zone also provides critical technological and economic resources, including obsidian, important metals such as gold and mercury, and road gravels. Post-colonial cultures likewise create oral histories of volcanic eruptions and earthquakes. Events such as the 1980 eruption of Mount St. Helens heavily impact the present-day economy and emotional well-being of Pacific Northwest residents, and our society relies on Cascadia for water, mineral, and recreational resources. Future events such as an impending Cascadia megathrust earthquake also figure prominently in the collective consciousness, and find outlets in media and the arts.

The Cascadia subduction zone continuously shapes the landscape of the Pacific Northwest of North America and the cultures of its inhabitants. The impacts of subduction processes on Pacific Northwest societies and cultures are varied, but Native Americans and European settler cultures alike have described geological processes through oral histories and have relied on resources provided by the subduction zone. Indigenous peoples focus on many aspects of their religious practices and art around the geohazards of the Cascadia region, and our melded modern cultures continue to take part in storytelling related to subduction zone hazards through movies and other forms of narration.

KEYWORDS: Cascadia subduction zone; Indigenous oral history; Cascadia history; geohazards; geologic cultural impacts

CASCADE ARC INFLUENCE ON INDIGENOUS CULTURES

Cascadia subduction zone processes and geohazards played a central role in the cultures of the earliest known inhabitants, the Indigenous Peoples of the Cascadian Region (IPOCR). The very fabric of the lives of the IPOCR were intertwined with the Earth, in a reciprocal and respectful relationship, and thus Indigenous people weaved narratives of subduction zone processes into their oral histories. This includes using narratives of the creation of local geologic landforms and geohazard events as part of their spiritual and religious practices, to teach lessons of morality and safety, and for social interactions with and among other peoples (e.g., Ludwin et al. 2005; Fox-Hodgson 2007; Vitaliano 2007). These oral histories are a record of the geologic observations of the IPOCR and their resulting hypotheses for the responsible geologic processes. The impact of subduction zone processes on Indigenous cultures is also apparent in archeological evidence that demonstrates how these people went about their daily lives, where and how they lived, the subduction zone materials they used as resources, and the observations they made to explain and interpret the geologic processes they witnessed (e.g., Connolly et al. 2015; McClure 2015; Andrews et al. 2016; O’Shea et al. 2021).

Impact on Indigenous Oral Histories

There are countless examples of oral histories from each of the IPOCR that explain the subduction zone landforms and processes witnessed by these peoples, or that record observations of specific hazard events. A notable accounting of the eruption of Mount Mazama that created Crater Lake about 7700 years ago (Bacon 1983) is part of the oral tradition of the Klamath people. In this narrative, the Chief of the Below World, who would often ascend to the surface of the Earth through an opening in Mount Mazama, fell in love with the daughter of a Klamath chief. She refused his advances, so the Chief of the Below World rose through the opening and stood on Mount Mazama, bent on revenge. The Chief of the Above World then descended from his home in the sky to land on Mount Shasta. A fierce battle ensued between the two, during which “red hot rocks fell from the sky” and “burning ashes fell like rain” (Clark 1953). Eventually, the Chief of the Above World struck a fateful blow, collapsing Mount Mazama onto the Chief of the Below World, sending him back to the underworld forever (Clark 1953). The hole that was left behind by the...
collapse slowly filled with rain to become Crater Lake. The imagery in this narrative is reflective of the type of explosive caldera eruption that led to the formation of Crater Lake, and records firsthand accounts of the eruption passed down through generations (Vitaliano 2007). Several Indigenous artifacts were found beneath the Mazama ash, including Fort Rock–style sandals (named for the locale, see Fig. 2) that have radiocarbon ages predating the eruption (8500 years before present; Connolly and Barker 2004). There is a didactic quality to this story as well, in that it ends with a warning to steer clear of Crater Lake, an allusion to the fact that the Klamath people recognized this area as volcanically active.

Other oral histories explain the presence of the Cascade mountains, coastal features, and local climate patterns. The Quinault and Cowitz/Taidnapam people tell of the time before rain came to Earth, wherein the people who lived east of where the Cascades now stand found themselves without water (William Thoms, personal communication, March 2022). A contingent of the people went to visit Ocean to ask for help, who sent his son and daughter, Clouds and Rain. Life improved, but the people became selfish and asked the Great Spirit to punish the evil deeds of the people. The Great Spirit scooped up a huge mound of Earth and formed a wall between the people and Ocean. The mound became the Cascades, and the hole the Puget Sound. The people east of the mountains are punished to this day because Ocean sends little water over the wall (Clark 1953). This story explains multiple Cascade landforms and demonstrates an understanding of the meteorological processes that lead to the rain shadow east of the Cascades (Vitaliano 1973).

The IPOCR all along the coast of the Pacific Northwest have oral histories that contain imagery of shaking and flooding, indicative that the people witnessed not only large subduction-related earthquakes but also tsunamis. The Yurok people of northern California tell the story of Earthquake, who ran up and down the coast, his heavy feet shaking the ground so much as he ran that the land sank and the ocean poured in (Finkbeiner 2015). According to the Nuu-chah-nulth peoples of British Columbia, a person who accidentally kicked a drum during a dance got earthquake-foot and afterward, every step he took caused an earthquake (Finkbeiner 2015). The Quileute and Hoh (Jay Powell, personal communication, March 2022), among other IPOCR from Vancouver Island through northern Oregon (Ludwin et al. 2005), tell the story of a great battle between Thunderbird and Whale, which made the mountains shake and uprooted trees; then, the ocean rose and covered the whole land (Clark 1953; Ludwin et al. 2005). These narratives can be traced back to the 1700 Cascadia earthquake and tsunami, or other subduction zone earthquakes and tsunamis, either of local origin or from across the Pacific (Ludwin et al. 2005). The many oral histories that include Thunderbird and Whale also include descriptions of the origin of some Olympic Peninsula landforms, such as the Forks and Tye prairies and the moraines of the Hoh Glacier, as remnant scars from the battles between these entities (Reagan 1934).
associated tsunamis caused subsidence and ultimately the abandonment of many coastal villages. This evidence comes from the dating of buried soils and overlying tsunami deposits that are interbedded with middens (human refuse deposits), marking the locations of former villages (Hutchinson and McMillian 1997). A depositional hiatus exists within the middens where tsunami deposits are present, indicating that the sites were abandoned and that the villages were relocated following these events. However, in many cases, these abandoned sites were reoccupied after a hiatus (Hutchinson and McMillian 1997), standing as a testament to the resilience and adaptability of Indigenous people to the ever-changing conditions in the subduction zone region.

Use of subduction zone volcanic materials in the daily lives of the Indigenous people was extensive. Obsidian is probably the most well-known volcanic material used by prehistoric people; obsidian as a tool material is unparalleled because of its luster, predictable flaking, and resultant sharp edges (Fig. 3). There are more than 100 obsidian sources within the region (mainly east of the Cascades) that were heavily used by the IPOCR, as evidenced by the density of subsurface obsidian artifacts from archaeological sites, which reaches up to 10,000 artifacts per cubic meter in some sites (McClure 2015). Many IPOCR, including the Yuki of northern California, placed spiritual and medical significance on obsidian: obsidian shamans performed both physical (surgical) and mental healing rites with obsidian. There are also many oral histories related to obsidian, demonstrating the importance to the IPOCR of using materials that are intimately connected with local volcanic activity (Fox-Hodgson 2007). Places where obsidian was quarried were considered sacred sites and neutral territory, even amongst warring parties. The task of obtaining obsidian was a spiritual quest and approached in a sustainable manner, undertaken by many IPOCR only once a year, whereby they extracted only what was needed at that time (Fox-Hodgson 2007). Obsidian was also an important item of trade among peoples, serving as the basis for regional trade networks (Connolly et al. 2015). Recent work unearthed submerged obsidian flakes dating to approximately 9000 years before present from the bottom of Lake Huron that can be traced back to their Wagonitie source in central Oregon (Fig. 1; O’Shea et al. 2021). This dispersal across most of the continent indicates that obsidian tool materials produced in Cascadia were highly valued, and that the prehistoric obsidian trade network reached considerable distances.

While obsidian is the best-known and farthest-traded volcanic material from the Cascadia subduction zone, pumice, basalt, and tuff were also used as tools, for shelter, and in artwork (e.g., Strong and Schenck 1925; Strong 1961; Burtchard 1998; Edwards 2000; Connolly and Barker 2004; Andrews et al. 2016). Pumice was used in the creation of abraders, cylindrical tools with a groove on at least one surface, used for sanding or filing other tools into sharp points or edges. Abraders and other lithic tools were discovered at Berkely Rockshelter in Mount Rainier National Park, a site containing two closely neighboring shallow caves that were likely used as a temporary camp and storage cache (Andrews et al. 2016). A similar type of rock shelter was occupied in a cave of tuff at Fort Rock, where many Indigenous artifacts have been excavated (including the Fort Rock–style sandals shown in Fig. 2; Connolly and Barker 2004). Basalt was also used for tool-making throughout the region, from Mount Rainier to the northern Sierra Nevada, as both flaked and groundstone tools and anchors for boats or nets (Burtchard 1998; Edwards 2000). In addition to everyday uses, basalt was an important medium for rock art throughout the region (Fig. 4). Basalt in and around the Columbia River Gorge served as a canvas for IPOCR who carved geometric, anthropomorphic, and animalistic figures as petroglyphs into the rock (Strong and Schenck 1925). Rock art is not the only way IPOCR transformed volcanic materials into the artistic realm; the people of the Columbia River Gorge region also converted utilitarian materials into artistry by carving forms resembling animals and people into their mortars, mauls, and bowls (Strong 1961).
Lassen Volcanic National Park in 1952. Sulfur is used in the century until it was acquired from the Supan family by the Lassen area at the Lassen volcanic center in northern California. This site was exploited for sulfur beginning in the mid-19th century until it was acquired from the Supan family by the Lassen area at the Lassen volcanic center in northern California. This site was exploited for sulfur beginning in the mid-19th

Despite the rich Indigenous oral record of hazard processes, Western scientists did not recognize the Cascadia subduction zone until the 1960s, and even then it was considered inactive (Ludwin et al. 2005). However, the European settlers made geologic observations of active processes in the region. There is no obvious indication that Lewis and Clark perceived that the Cascade mountains are volcanoes, but they recorded observations of active volcanic processes on their expedition through the Columbia River Gorge in 1805. Their description of the Sandy River delta and “quicksand” therein documented a recent eruption of Mount Hood that brought extensive lahars down the Sandy River, which had impinged upon and restricted the width of the Columbia River where the two joined (O’Connor 2004). European settlers also helped document the very active recent eruptive history of Mount St. Helens. What may in fact be the first written settler record of volcanic activity at Mount St. Helens was reported by Dr. Meredith Gairdner, a medical officer stationed at Fort Vancouver in 1835, describing a few days of ash fall in March of that year. Once the ash fall subsided and the edifice was once again visible, the snow cover had disappeared. He also described lava flows observed through a spyglass telescope though, based on other evidence, in all likelihood he witnessed lahars or small pyroclastic flows (Holmes 1955).

Historic use of the products of the Cascadia subduction zone took the form of industrial mineral extraction during the European settlement and colonization of the Pacific Northwest. While the West is best known for its gold, copper, and mercury mines, these resources have been the subject of extensive geologic exploration and mining in the region. Copper mines were an important part of the Oregon and California economies in a boom-bust cycle from 1880 until shortly after World War I. The onset of that war made copper metal a key commodity given its use in wiring and motors, but this was the final copper boom in the Pacific Northwest. Following World War I, other countries took the lead in worldwide copper production, and the small resources available in Cascadia became economically insignificant (Burch 1942). Epithermal deposits at Black Butte Mine in Lane County, Oregon, were mined as a source of mercury (via native mercury and cinnabar) on and off from 1890 to 1969. At that time, mercury was an important resource for processing gold through amalgamation, preserving wood, and as a pigment in paints (California Department of Transportation 2008). The mercury mineralization present in volcanic and pyroclastic host rocks from the Oligocene Western Cascades is a result of subvolcanic hydrothermal mineralization (Derky 1973). The site of this former mine is now a U.S. Environmental Protection Agency Superfund Site as a result of mercury contamination of the local soil, sediments, surface, and groundwater from the prolonged mining operation and residual tailings. Sulfur mining, while not the economic driver that copper and gold were, still played a role throughout the region. One example is San’s Sulphur Works, located at an active hydrothermal area near the active volcanic center in northern California (Kushiro and others 2000). This site was exploited for sulfur beginning in the mid-19th century until it was acquired from the San family by Lassen Volcanic National Park in 1952. Sulfur is used in fertilizer production, paper manufacturing, and petroleum refinement (California Department of Transportation 2008).

**CASCADE ARC INFLUENCE ON OUR MODERN CULTURES**

The way in which oral histories about the Cascadia subduction zone are incorporated into present cultures may be somewhat different than that of Indigenous oral histories, but these modern narratives play a similar role in some ways. Today we, the modern descendants of IPOCR and post-colonial peoples, recount subduction zone processes as both a creative outlet and for entertainment. Movies such as Dante’s Peak (1997), St. Helens (1981), and many documentaries/nonfiction films (e.g., PBS’s Cascade Volcanoes: When Sleeping Giants Wake, 1997) demonstrate our fascination with Cascadia geologic processes. This fascination extends to the media, and has led to what have effectively become urban legends surrounding the “overdue” nature of a major earthquake along the subduction zone. An article from *The New Yorker*, entitled “The Really Big One” (Schultz 2013), that focused on the chances of a large magnitude subduction zone earthquake occurring in the near future and our society’s lack of readiness for such an event, went viral and prompted a media storm. It won the author a Pulitzer Prize, but also prompted panic and anxiety in many readers and those who heard the information second-hand. Following its publication, some people actually abandoned plans to move to the Pacific Northwest, while others took the opportunity to become more prepared by creating earthquake disaster kits. If nothing else, it was an eye-opening moment for many who were simply unaware of the real threat posed by the active arc on which they live.

Such a reaction by our modern culture is also likely because our society is so globally connected in real time that we have all either witnessed or indirectly experienced impacts of such hazard events from locations worldwide. For example, the firsthand experiences of the 2011 Tohoku earthquake and tsunami generated an extensive and visceral video record of events that documented the tragedy and spread around the globe. The lingering memory of hazard events in the Cascadia subduction zone still exists for many. An explosive eruption at Lassen Peak in 1915 generated a pyroclastic flow and lahars that devastated the surrounding forest (Eppler 1987). Though no deaths were reported from this event, it was the first eruption of a Cascade volcano to be photographed and filmed, and it served as an important indication that the arc is anything but dormant. In contrast, the more devastating eruption of Mount St. Helens in 1980 was 30 times larger, removed 1300 feet of the volcanic edifice, killed 57 people, and created the largest landslide in recorded history (Harris 2005). When this eruption comes up in conversation with Pacific Northwesterners who experienced the event, their experiences that day are inevitably shared—where they were, what the eruption looked like from their vantage point, and how they collected ash they still have to this day. Finally, the Mw 6.8 intraslab Nisqually earthquake in Washington in 2001 with a hypocentral depth of 54 km (Kao et al. 2008) was a preview of just how devastating a moderate subduction zone earthquake can be, causing 440 injuries and an estimated 1–3 billion dollars in damage to mainly older structures in the Seattle area (McDonough 2002).

Though devastating, the impacts of hazard events are rare, in contrast to many aspects of the subduction zone that affect contemporary daily life. Many communities in the Pacific Northwest use glacial or groundwater runoff from the Cascade volcanoes as part of their municipal water supplies (e.g., Jefferson et al. 2006), and the scenic and
CONCLUSIONS

The Cascadia subduction zone has dramatically impacted the culture of every civilization that has lived in its shadow, from oral history and storytelling to impacts on everyday life, art and religion, recreational activities, and where and when people live there. Though our present way of life is quite distinct from that of the IPOCR and European settlers, the subduction zone and its associated geological processes have equally affected all cultures of the region in vast and complementary ways.

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