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ARTICLE

Líl̓wat Climbers Could See the Ocean from the Peak of Qw̓elqw̓elústen: Evaluating Oral Traditions with Viewshed Analyses from the Mount Meager Volcanic Complex Prior to Its 2360 BP Eruption

Bill Angelbeck[1], Chris Springer[2], Johnny Jones / Yaqalatqa7[3], Glyn Williams-Jones[4], and Michael C. Wilson[5]

[1]Department of Anthropology and Sociology, Douglas College, New Westminster, BC, Canada; [2]Independent Researcher, Maple Ridge, BC, Canada; [3]Land & Resources Department (retired), Líl̓wat Nation, Mount Currie, BC, Canada; [4]Centre for Natural Hazards Research, Department of Earth Sciences, Simon Fraser University, Burnaby, BC, Canada; and [5]Department of Earth and Environmental Sciences (emeritus), Douglas College, New Westminster, BC, Canada
Corresponding author: Bill Angelbeck; Email: angelbeckw@douglascollege.ca

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Abstract
Among Líl̓wat people of the Interior Plateau of British Columbia, an oral tradition relays how early ancestors used to ascend Qw̓elqw̓elústen, or Mount Meager. The account maintains that those climbers could see the ocean, which is not the case today, because the mountain is surrounded by many other high peaks, and the Strait of Georgia is several mountain ridges to the west. However, the mountain is an active and volatile volcano, which last erupted circa 2360 cal BP. It is also the site of the largest landslide in Canadian history, which occurred in 2010. Given that it had been a high, glacier-capped mountain throughout the Holocene, much like other volcanoes along the coastal range, we surmise that a climber may have reasonably been afforded a view of the ocean from its prior heights. We conducted viewshed analyses of the potential mountain height prior to its eruption and determined that one could indeed view the ocean if the mountain were at least 950 m higher than it is today. This aligns with the oral tradition, indicating that it may be over 2,400 years old, and plausibly in the range of 4,000 to 9,000 years old when the mountain may have been at such a height.

Resumen
Entre el pueblo Lil'wat de la meseta interior de la provincia de British Columbia, una tradición oral relata cómo los primeros ancestros solían ascender al Qw̓elqw̓elústen / Monte Meager. La narración sostiene que los escaladores podían ver el océano, evento que no sucede más actualmente, ya que la montaña está rodeada de muchos picos altos y el estrecho de Georgia está formado por varias crestas montañosas al Oeste. Sin embargo, el Monte Meager es un volcán activo que erupcionó por última vez hace aproximadamente 2360 años antes del presente y también es el sitio donde sucedió el deslizamiento de tierra más grande en la historia de Canadá en 2010. Considerando que durante todo el Holoceno este volcán fue más alto y cubierto de glaciar, parecido a otros volcanes localizados a lo largo de la cordillera costera, suponemos que un escalador podía razonablemente acceder a la vista del océano debido a la altitud del volcán en aquel tiempo. Conducimos un análisis de visibilidad de la altura potencial de la montaña antes de su erupción, y determinamos que efectivamente se podía ver el océano si el monte era al menos 950 metros más alto de lo que es hoy. Esto coincide con la tradición oral, lo que indica que el volcán podría haber tenido esa altura hace más de 2,400 años, y posiblemente entre 4.000 y 9.000 años antes del presente.

Keywords: oral traditions; volcanology; Líl̓wat; Interior Salish; GIS viewshed analyses

Palabras clave: tradiciones orales; vulcanología; Líl̓wat; Salish del Interior; análisis de cuencas visuales GIS

> That's where they stood on top of the mountain and they could see the ocean. That was before it blew its top. . . . That was the highest mountain at one time.
>
> — Harry Dick (2011)

An oral history among the Líl̓wat people of the Interior Plateau of British Columbia recounts how ancient climbers used to ascend Qwelqwélústen, once regarded as the highest mountain in their traditional territory. It was so high, their legends recounted, that one could see the ocean. This is not the case today, because the peak is surrounded by other high prominences of similar heights, and the Strait of Georgia is beyond several montane ridges to the west. However, Qwelqwélústen, also known as the Mount Meager Volcanic Complex, is characterized by long-lived volcanic activity having developed over a period of about 2 mya, with its last explosive eruption circa 2,360 years ago (e.g., Harris et al. 2022; Read 1990). The glacier-clad massif is currently made up of numerous individually named volcanic peaks and notable for its long record of landslides due to the combination of extensive hydrothermal alteration and glacial erosion (e.g., Friele et al. 2008; Roberti et al. 2018; Figures 1 and 2).

Given that the mountain may plausibly have been much higher prior to the 2360 cal BP eruption, we surmise that its previous height may have allowed one to see the ocean. Consequently, it is possible that the Líl̓wat oral tradition is based on such geological knowledge of its history and encodes it within its oral narratives. Here, we present the results of viewshed analyses of the potential mountain height prior to its eruption collapse. The results indicate that one could indeed see the ocean if the mountain was at least 950 m higher. These results provide support for observations recorded in the oral tradition and suggest that the oral tradition may be well over 2,400 years old.

In the following article, we present Líl̓wat oral traditional knowledge about Qwelqwélústen, its surroundings, and associated sites as recounted through various narratives and cultural knowledge, including place-names. In addition, we discuss how Indigenous traditions more generally provide intimate knowledge of volcanoes and high montane landscapes extending back millennia in the Pacific Northwest, and how they often form a core part of their territorial identity. We also present the

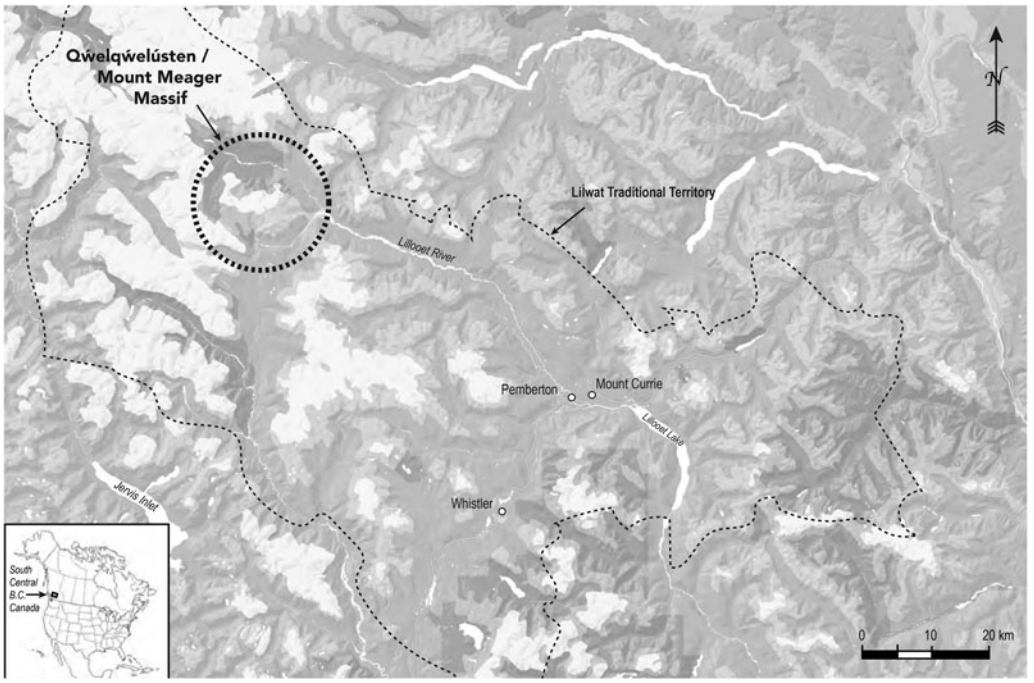

Figure 1. Location of Qwelqwélústen / Mount Meager massif in south-central British Columbia.

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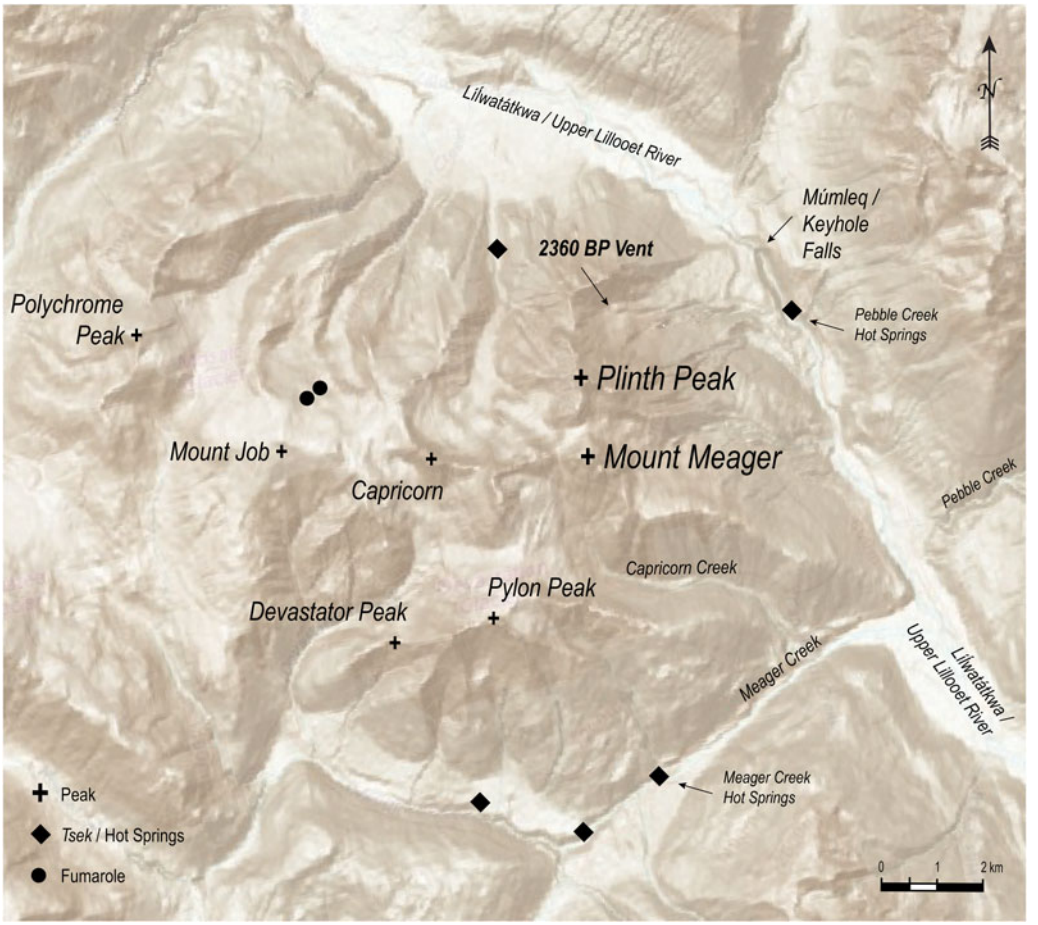

Figure 2. Topographic map indicating current peaks of the Mount Meager Complex.

volcanic geological history of the Mount Meager Volcanic Complex and discuss the possibility for its higher peaks in the millennia prior to the last eruption. Next, we detail the viewshed analyses conducted at various heights in the center of the complex to show that the ocean could be viewed from its previous heights. We discuss our results in light of other studies that have provided evidential support for oral traditions, providing another instance in which the great antiquity of Indigenous oral traditions can be maintained over millennia.

Oral Traditions about Líl̓wat Climbers

Harry Dick, an elder among the Líl̓wat Nation, has a story about early ancestors who climbed Qw̓elqw̓elústen (Mount Meager) long ago.[1] Two of the authors here, Bill Angelbeck and Johnny Jones / Yaqalatqa7, recorded an interview with him about the upper reaches of Líl̓wat traditional territory. Indeed, when asked about Qw̓elqw̓elústen, he recounted the following:

> One thing about Meager, I knew, is . . . when they first founded Lillooet territory is there's three . . . what did they call them [in English]? [Founders or transformers]—but anyhow, that's where they stood on top of the mountain and they could see the ocean. That was before it blew its top. . . . It was a dangerous place to be. . . . That was the highest mountain at one time—our grandmother told us. . . . The people that founded the Líl̓wat territory, that's where they met, then they came down [Dick 2011:261].

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In this account, we should first point out that Dick notes that this knowledge is associated with the earliest times of occupation and founding of the Líl̓wat territory.

Furthermore, it is associated with the Time of Transformation, when Transformer figures traversed Líl̓wat territory, altering the landscape into its general contemporary shape and converting many individuals or animals into distinctive geological features throughout the region. This was the general time of the Copper Canoe brothers, who were Líl̓wat shamans seeking spirit powers at the base of Qw̓elqw̓elústen. The narratives of their adventures detail how they shaped much of the Upper Lillooet River valley. Consequently, the story is viewed as ancient, one that is associated with the earliest Transformers and ancestors of Líl̓wat territory. Second, Dick (2011) acknowledges that it is impossible to see the ocean today but maintains that the narrative describes how the mountain had been much higher than it is now, that it was the "highest mountain at one time." Third, he also recounts some of the lineage of its telling. His grandmother provided the account, and he is a contemporary bearer of this story. He has also stated that he heard this story from grandparents on both sides of his family; his grandmother had recounted to him in their original language of Ucwalmícwts. In addition, other Líl̓wat members also had heard the story (Angelbeck and Yard 2022:51).

This, however, is not the only account about the mountain and how it figures prominently in Líl̓wat oral traditions. A recounting of some of these traditions provides context for this oral narrative.

Oral Traditions of the Qw̓elqw̓elústen Area

Charlie Mack, a renowned storyteller of the Líl̓wat, recounted that Qw̓elqw̓elústen was an important place for Líl̓wat people. Further, Qw̓elqw̓elústen was always regarded as a powerful and dangerous locale. As Kennedy and Bouchard (2010:18) relayed, Mack maintained there were tales of: "Líl̓wat adventurers, men far more spiritually powerful than himself, who also faced the mountain. Some call the mountain's power supernatural, mysterious, or even sacred."

Mack referred to it, in the Líl̓wat language of Ucwalmícwts, as *hi7*—a term that has "spiritually powerful" qualities, considered both sacred and dangerous. For him, this mountain was "kinda 'monster'" (as quoted in Kennedy and Bouchard 2010:19). In one story, an old man named 25-Mile Jim and a *scwená7em*, or shaman, attempted to climb the mountain, and the wind gusts around the top of the mountain were too strong:

> Well, they [were] blowed away. . . . They just walked off, they can't do nothing. They were hunting, they go up there to hunt goats and they couldn't make it. Then they start to make a noise; I guess they echo to the high mountain, and it start to blow. Well, 25-Mile Jim, he says: "I seen rocks go up in the air." It was blowing so hard, on the other end of the rock. It seems the echo started the *hi7* [Mack in Kennedy and Bouchard 2010:19].[2]

The name of the mountain, Qw̓elqw̓elústen, means "cooked face place" or "cooked fire place": *qw̓el* means "done, ripe, or cooked" and *qw̓elqw̓el* is a repetition, meaning that it is "very cooked"; the suffix *-us* is used for "face," "hill," or "fire," and the other suffix *-ten* indicates a location or place (also instrument or thing; Abraham 2000:1). Charlie Mack has described Qw̓elqw̓elústen as "the place where goat heads are cooked," which connects the traditional practice of hunting mountain goats with the associations of the heat of the place (quoted in Bouchard et al. 1975). Even today, the mountain emits clouds of volcanic gas from fumaroles within glaciovolcanic caves on Job Glacier (e.g., Warwick et al. 2022). Furthermore, evidence of the extensive volcanic hydrothermal system is provided by at least two hot springs, or *tsek,* at the mountain's base, near the confluences of two creeks that flow at its base: Pebble Creek, which flows to its southeast, and Nqempa stswaw'cw / Meager Creek, flowing to its southwest (Figure 2). Heat, cooking, and hot springs—all of these connotations are long held in Líl̓wat oral traditions about this mountain.

Other important narratives are connected with Qw̓elqw̓elústen, including a story from the Time of Transformation. Two shaman brothers, or *scwená7em*, sought to train for spiritual powers at the base of the mountain, because it was *hi7*. It is also remote—a location that is well north of Líl̓wat villages, close to the headwaters of the main river, Líl̓watátkwa/Lillooet River, from which they share their own

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name as Líl̓wat. This sharing of name indicates how tied the Líl̓wat are to this important river throughout their history. In Charlie Mack's telling, the brothers camped near the confluence of Salal Creek, at the base of the east slope of Qw̓elqw̓elústen (Kennedy and Bouchard 2010:20–21). James Teit (1912:303–304) is less specific, but he does note that it is at the headwaters of Líl̓watátkwa: "Two brothers lived at the very head waters of the Upper Lillooet River, and spent most of their time training themselves in the neighbouring mountains for they wished to become great."

The headwaters of the river encompass Mount Meager, the Lillooet Glacier, and Salal Creek, among other tributaries of the Upper Lillooet River within its viewshed. One of the brothers has a vision of a copper canoe:

> And they were bathing in there, singing at night, dreaming. They said they were scared sometimes when they dream something bad. If they are big enough, they grab a hold of it, what they dream. That is how they got this canoe. . . . They went to sleep and dream[t] about a canoe. A canoe, a Copper Canoe, and he grab a hold of it. When he got it, well, he own it; the canoe didn't disappear. . . . It started above the canyon, above the waterfall [Charlie Mack, quoted in Kennedy and Bouchard 2010:20–21].

Therefore, one of the *scwená7em* grabbed hold of this copper canoe from the dreamworld of his vision and pulled it into reality, and the two brothers hopped in it and floated down Líl̓watátkwa/Upper Lillooet River, facing numerous obstructions along the way, routing its new course altering the landscape in the process. The first obstacle to the brothers in the canoe was a wall of stone at the base of Qw̓elqw̓elústen, which Teit (1912:303) named Ilamüx: "They came to a place called Ilamüx. Here there was a rock which dammed the river. They made a hole through it to allow their canoe to pass. Even at the present day it appears like a stone bridge across the river."

With their copper canoe, they sliced through the rock wall—"cut right through there," says Mack—forming a slit from which the water descended into whirling pools at the base. The waterfall is named Múmleq. The shape of the narrow cut has resulted in it being called Keyhole Falls today. The brothers continued their journey south of Qw̓elqw̓elústen, encountering other obstacles, such as shifting mountains blocking their path, high gravel beds, and knots of bulrushes. With the copper canoe, they were able to overcome them as they continued their journey all the way down the course of the Lillooet River to its confluence with the Fraser River, and ultimately, to its mouth at the Salish Sea. At that point, they reached the "land of the salmon."

However, the salmon were blocked by a massive fish weir.[3] They ingratiated themselves with those that maintained the weir, however, and eventually pulled up some weir stakes, creating a gap that allowed the salmon to proceed upriver. One of the brothers "hollered up the river, 'Fix up the smokehouse, the fish [are] coming up now'" (Kennedy and Bouchard 2010:27). In so doing, the two *scwená7em* brothers, who gained their powers at the base of Qw̓elqw̓elústen, introduced salmon into Líl̓wat territory—one of their staple resources.

The two brothers followed the salmon up the river all the way back to Qw̓elqw̓elústen, where they took the salmon and cooked it in the waters of one of the hot springs. In a way, they complete the cycle and return to the starting point, symbolically emphasizing the connection of the powers of Qw̓elqw̓elústen to salmon. Elder Louie Joe (2011) also recounted memories of how such practices continue among Líl̓wat—given that his father used to travel up to Meager Hot Springs, always staying for several days, using the heated mineral waters to help train himself spiritually—and that Charlie Mack had cooked fish in the hot springs.

The whole region surrounding Qw̓elqw̓elústen contains places that are important to the Líl̓wat. The mountain is a place of spiritual reverence for them, owing to its spiritual, or *áx7a*, powers related to the Copper Canoe brothers long ago. The presence of two hot springs at the lower flanks of the mountain attest to locales sought for spiritual bathing, like the ones the original Copper Canoe brothers had sought. The mountain is more than a spiritual place, however, because it is a primary hunting locale, in particular for mountain goat. The southwestern flank of the mountain is called Ts'áq'alts, which translates as "peace-pipe rocks," possibly indicating its shape or indicating a lithic resource area (Abraham 2000:2). It is associated with numerous other resource-gathering activities, such as

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Indian paint fungus, cedar bark, and various mushrooms particular to the volcanic environments (Angelbeck and Yard 2022).

Throughout his life, Charlie Mack would camp at the mountain with family and friends for two weeks each year, going by canoe upriver as far as they could and then hiking the rest of the way. The men hunted, and women gathered yellow avalanche lily and dogtooth violet roots, or "wild sweet potatoes" (Kennedy and Bouchard 2010:112). At their base camp, they dried the meats and other roots before canoeing back home.

In a drawing, Johnny Jones / Yaqalatqa7 (Jones 2011) depicts Líl̓wat oral traditions related to the Qwelqwélústen area (Figure 3). His depiction is in the style of pictographic art; the original is even drawn in the color of red ochre, which pervades Líl̓wat territory at important locales. Jones has created several drawings for numerous parts of their territory, which have been featured in roadside kiosks throughout the region and published in an archaeological publication (Jones 2011). In the drawing for Qwelqwélústen, Jones depicts the mountain as an active and dangerous spirit in the landscape, with a spiral vortex at its center and forked tongues leading paths down its slopes. The recent debris avalanche and landslide of 2010, the largest in Canadian history (Roberti et al. 2018) along the southern Capricorn Creek is shown as reaching downriver along Meager Creek and the Upper Lillooet River (see Figures 2 and 3). Two other whorls indicate the location of the main *tsek*, or hot springs, on the eastern and southeastern flanks.

He depicts mountain goats just southwest of the mountain, with hunters actively shooting them with bows and arrows. People seeking power would also leap across the river's narrow and deep chasm that is just upriver from Múmleq, or above Keyhole Falls, as part of a rite of passage. The slit is quite narrow (about 3–4 m at the shortest point), yet some Líl̓wat seeking power would jump across the gorge; Dick (2011) referred to these as *scwená7em*, or shamans—individuals undergoing spiritual training. To fail the jump across meant falling into the crevasse and into the river unseen below, which loudly courses through the narrow walls to its outlet at Múmleq (Keyhole Falls),

Figure 3. Drawing of the storied landscape of the Upper Lillooet River Valley by Johnny Jones (2011).

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dropping about 50 m to shallow pools below. In other words, it meant falling to one's death. Charlie Mack also indicated that mountain goat hunters would jump across the narrows to ascend Mount Meager. In the drawing, Jones depicts the jumping-across point (Bouchard and Kennedy 2003:10).

Near the edge of the falls overlook is a rockshelter that likely was associated with *scwená7em*, given that one was near views of the Upper Lillooet River valley from above the falls and near views of the peaks of Qwelqwélusten (Sheppard et al. 2015). Indeed, one member of the community, Tony James (2011), relayed how he had stayed at the rockshelter above the falls during one of his "trainings"; this training relates to physical strengthening and endurance as well as the quest for spirit powers.

For Líl̓wat, the Qwelqwélusten area was a home for not only mountain goat but also grizzly bears, moose, and elk, which had migration corridors throughout, as recounted by Edwin "Buckshot" Bikadi (2011). Indeed, several rockshelter camps are located along the river at Qwelqwélusten's base, enough for a large party of hunters or other seasonal camping (Sheppard et al. 2015). The area is also historically known for where the Líl̓wat battled Chilcotin invaders. In one account by Harry Dick (2011), Líl̓wat warriors killed all of the members of the raiding party with the exception of one so that he could return home to tell of their failure; that is, it is a historic account involving the Qwelqwélusten area that is about defending Líl̓wat traditional territory.

Together, these Líl̓wat narratives weave Qwelqwélusten / Mount Meager and Múmleq / Keyhole Falls into multiple aspects of their heritage: into their oral histories (battles), into the settings about their traditional subsistence use (mountain goat hunting), and into particular places regarded as *áx7a*, or having spiritual power (sacred). Indeed, it is the first significant geographic marker noted in the telling of the Copper Canoe myth, the journey that transformed Líl̓wat traditional territory into the landscape known today and that is connected with the drawing up of salmon into their territory, one of the core components of their traditional subsistence livelihood.

Even today, Qwelqwélusten remains an important part of Líl̓wat concern. It is a focal point for the northern part of their traditional territory of the Upper Lillooet River watershed. In the Líl̓wat Land Use Plan (Líl̓wat Nation 2006), they recognize the area as one of their *a7×7úlm'ecw,* translated as areas of "spirited ground." This means that any work proposed for the area requires studies to ensure the continuity of Líl̓wat practices, whether concerning hunting, gathering, or spirituality. Líl̓wat Nation is protective of its territory and the archaeological heritage contained within it, often to the point of activism, such as establishing blockades (Angelbeck and Jones 2018).

This overview of oral traditions, histories, and archaeologies indicates how prominent Qwelqwélusten has been and how it remains important for Líl̓wat people. The story of the climbing of the mountain by ancient Líl̓wat is one thread of many that are woven into the territory about the area. In this way, Qwelqwélusten is a chronotope in which narratives are tied materially to sites in the landscape; as Keith Basso (1996) described for Apache territory, these chronotopes are where "wisdom sits in places." Yet, because these are storied locations, this does not mean that only wisdom is contained within the stories. Rather, broader forms of traditional knowledge are also present in them. In a related work, we have published an account of how Líl̓wat oral histories provide insights and additional formation regarding the eruption of Mount Meager in 2360 cal BP (Wilson et al. 2024). The narrative of Líl̓wat climbers seeing the ocean prior to its eruption is one that contains an avenue to be tested for supporting evidence in its claims, as we proceed to do in the this article. First, we set the context of oral traditions concerning volcanoes throughout the Northwest.

Oral History Correlations with Western Scientific Approaches

In northwestern North America, there have been several studies that examine the correlations between Indigenous oral traditions and those of Western scientific approaches. This indicates that this is a growing field of investigation, given that Indigenous oral histories provide a broad set of potential avenues of investigation in relation to the past.

Rick Budhwa (2002, 2021) conducted studies of the relationships between the 6850 cal BP eruption of Mount Mazama (in Oregon; known as Giiwas by the Klamath and Modoc peoples), the Bonneville landslide circa 900–400 cal BP (Washington State), and the earthquake and tsunami of AD 1700 in relation to Indigenous oral histories of the Northwest. He found that oral histories record details

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from past events that can be used to aid scientific approaches. As he put it, "a combination of the two perspectives may yield a richer, more holistic view of the past" (Budhwa 2002:iii). McMillan and Hutchinson (2002) compiled numerous oral histories concerning earthquakes and tsunami and showed how they were described in numerous Indigenous oral narratives of the West Coast of North America throughout the Holocene. They showed how these were not only remembered through stories but also relayed through their arts and ritual ceremonies, indicating the importance of their impact on these communities. This is especially the case for instances of village abandonment due to such events (e.g., Hutchinson and McMillan 1997). Similarly, Moodie and Catchpole (1992) detail how Athapaskan oral traditions of a volcanic eruption correlate with the White River Basin eruption in AD 720, necessitating the widespread relocation of villages. Such approaches to integrating Western and Indigenous knowledges is becoming increasingly common (e.g., Mackenthun and Mucher 2021).

Wilson and Harris (2005) provide numerous symmetries between Haida oral histories and Western scientific paleoenvironmental histories. Some narratives describe a period prior to the growth of trees, suggesting human presence early in the Holocene, which correlates with archaeological evidence (Fedje and Mathewes 2005). De Laguna (1958) has reported on correlations of glaciological history with the Tlingit oral histories, whereas Le Moigne and colleagues (2022) established the chronology of Canada's second most recent volcanic eruption (Sii Aks / Tseax) by integrating geological data with observational information recorded in the Nisga'a *Adaawak* (Nisga'a histories). Cruikshank (2001) has described how oral traditions provide perspectives on the geological history of glaciers, arguing that Indigenous traditions can provide information for scientific research of paleoenvironments that are useful for understanding climate change, and that these traditions are necessarily important for being the only human histories available about such times. As she has emphasized, "It is no longer a question of *whether* oral tradition includes historical knowledge, but how much is present, how long a time span it covers, and how valid it is" (Cruikshank 1981:68).

Other scholars have documented how Indigenous oral traditions contain not only environmental information from the past but also details about social histories. In the Tsimshian area, oral traditions largely recorded by William Beynon—a Tsimshian scholar who worked with Boas and Barbeau—provided great historical details about battles waged with Tlingit groups to the north (Barbeau et al. 1987a, 1987b). The accounts contained evidence of village abandonment, the construction of forts, and the retaking of territories. The stories were so detailed—with village locations, names of warriors, and strategies deployed—that many scholars surmised that these might only be about battles waged just prior to Euro-American contact. Yet, Martindale and Marsden (2003) showed that archaeological evidence indicated that these battles occurred 1,500 to 2,000 years ago. Furthermore, Edinborough and colleagues (2017) assessed Tsimshian oral traditions regarding population reductions in the Prince Rupert Harbour, finding that these correlated with the radiocarbon dates from the area. Such case studies indicate that oral historical knowledge can be passed along for multiple generations and still be very useful for archaeological understandings. All of these studies add some weight to the Delgamuukw case, which allowed oral histories to be submitted as evidence in courts in Canada (e.g., see Thom 2001a, 2001b).

Despite some opposition to the use of oral tradition in archaeology (Mason 2000), Echo-Hawk (2000) and Whiteley (2002) have argued that there is much to be gained from archaeologists engaging in dialogue with Indigenous oral traditions for a better and more well-rounded understanding of the past. In the spirit of these works, we aim to highlight how this Líl̓wat oral history recounts evidence of past geological and volcanic knowledge of Mount Meager.

The Eruptive History of Qwelqwélústen

Qwelqwélústen, or the Mount Meager Volcanic Complex, is a large glaciated massif that developed over a period of about 2 mya and is characterized by long-lived volcanic activity, substantial uplift, and numerous large-scale landslides. It is located near the northern end of the Garibaldi Volcanic Belt, which itself represents the northern segment of the Cascade Volcanic Arc, formed by subduction of the Juan de Fuca Plate beneath the North American Plate (e.g., Russell et al. 2023). Prominent peaks include Devastator Peak, Pylon Peak, Mount Job, Capricorn Mountain, Mount Meager, and Plinth

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Peak; for comparison of heights, several of the volcanoes have prominent peaks throughout the Cascade Range (Table 1; see also Figure 2). Eruptive volcanic materials from Mount Meager are compositionally diverse, ranging from basalts to rhyodacites, and they include both lava flows and explosive fragmental deposits (e.g., Andrews et al. 2014; Harris et al. 2022; Read 1977, 1990; Simpson et al. 2006). Due to the extensive periods of glaciation and limited exposures and preservation of volcanic deposits, there is still only an incomplete eruptive history; a number of modern $^{40}Ar/^{39}Ar$ ages for basaltic to rhyodacite effusive and explosive products have been recently reported (~440, 200, 106, 24, and 17 ka; Harris et al. 2023; Russell et al. 2021).

The most recent dated eruption of Qwelqwélusten occurred circa 2360–2332 cal BP, originating from a vent on the slope of Plinth Peak, with an eruptive cloud column likely reaching up to 14–18 km, where it interacted with the jet stream (e.g., Andrews et al. 2014; Hickson et al. 1999). The resulting Bridge River tephra was deposited as a still-recognizable stratum as far east as central Alberta (Clague et al. 1995; Jensen et al. 2019; Mathewes and Westgate 1980; Westgate et al. 1970). The eruption may have been associated with one or more edifice (flank and/or summit) collapses, well documented for andesitic to dacitic stratovolcanoes (e.g., Begét and Kienle 1992; Lipman and Mullineaux 1981; Siebert 1984, 2002). Pyroclastic density currents from this eruption led to the formation of an impermeable roughly 110 m high dam that blocked the Upper Lillooet River, creating a temporary lake that swelled up to 780 m asl, with an estimated volume of approximately 0.55 km^3 of water that lasted for about two months. Continued rise of the lake eventually led to catastrophic failure of the dam, resulting in a flood outburst that carved through the dam (Andrews et al. 2014). Remnants of this event are seen in the narrow slit of Múmleq / Keyhole Falls, located at the southeast base of Qwelqwélusten. The assemblage comprises a series of lithologies representing different eruptive styles, from oldest to youngest: (1) pyroclastic airfall from five phases of eruption separated by short time intervals, each evolving from phreatomagmatic to magmatic activity; (2) pyroclastic block and ash

Table 1. Prominent Volcanic Peaks of the Cascade Volcanic Arc, Sorted by Height, in Comparison with Qwelqwélusten / Mount Meager Volcanic Complex Peaks.

Contemporary Peak	Indigenous Name(s)	Height (m)	Height (ft.)
Mount Rainier	Tacoma (Puyallup)	4,392	14,411
Mount Shasta	Withassa (Shasta); Bohem Puyuik (Wintu)	4,322	14,179
Mount Adams	Pahto (Klickitat)	3,743	12,281
Mount Hood	Wy'east (Multnomah)	3,429	11,249
Mount Baker	Kwelshán/Kulshan (Nooksack); Qwú'mə Kwəlshén (Lummi); T'kuba (Upper Skagit)	3,286	10,781
Glacier Peak	Dakobed (Sauk-Suiattle)	3,207	10.525
Mount St. Helens (former/current)	Loowit (Sahaptin); Louwala-Clough (Klickitat)	2,950 / 2,549	9,677 / 8,363
Mount Garibaldi	Nch'kay (Squamish)	2,678	8,786
Mount Meager Complex Peak	Qwelqwélusten	Height (m)	Height (ft.)
Plinth Peak		2,680	8,790
Mount Meager		2,650	8,690
Pylon Peak		2,481	8,140
Devastator Peak		2,327	7,635
Mount Job		2,493	8,179
Mount Capricorn		2,551	8,369
Polychrome Peak		2,494	8,182

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flow with entrained charred logs and pumice blocks; and (3) dacite lavas. Atop these is a volcanic debris flow (Hickson et al. 1999; Stasiuk and Russell 1990).

Major flank collapses have occurred at the Mount Meager Volcanic Complex repeatedly through the Holocene and likely close in time to the most recent eruption, around 2360 cal BP. Although most of the collapses were probably not associated with eruptions, these processes continue today with both major landslides and debris flows.[4] Evidence indicates that the volcano experienced multiple episodes of flank collapse throughout the Holocene, with lahars flowing into the Lillooet drainage. According to a summary by Friele and colleagues (2008), about 25 landslides have been documented over the last 8,000 years. Of particular note is the 2010 Capricorn Creek landslide, which, at 53 million m^3, is the largest landslide in Canadian recorded history. Occurring along Qwelqwélústen's southern flank, the landslide caused the temporary damming of the Upper Lillooet River and Meager Creek and forced the evacuation of more than 1,500 residents downriver in Pemberton (e.g., Guthrie et al. 2012; Roberti et al. 2018). Currently, there are at least 27 slopes with volumes greater than 0.5 million m^3 and that show evidence of active motion (Roberti et al. 2018). Combining estimates from the Holocene, this amounts to a minimum estimated volume of 3.6 billion m^3 (or 3.6 km^3) in debris that has failed from the Mount Meager Volcanic Complex within the last 8,000 years (Friele et al. 2008; Table 2). For comparison, 5.5 km^3 of Socompa, a volcano in northern Chile, failed during a singular 6180 cal BP sector collapse event, lowering the summit height by approximately 400 m (Grosse et al. 2022). In Mount St. Helens's eruption in 1980, 0.51 km^3 of material was lost in landslides, which also reduced its height by 400 m (Brantley and Myers 2000).

This geological history of Qwelqwélústen is characterized by repeated explosive and effusive volcanism in conjunction with widespread glaciation and numerous large-volume flank failures. It is therefore plausible that Qwelqwélústen may have been much higher and in line with Dick's statement that it was the "highest mountain" in Líl̓wat territory. The history also reveals that the eruptive events continued to alter and shape the Upper Lillooet River valley. There are clear parallels to Líl̓wat descriptions of the mountain, suggesting its prominent role in shaping the upper parts of their territory. Next, we assess correlations of this geological history with Líl̓wat oral traditions through viewshed analyses.

Methodology for Viewshed Analyses

Viewshed analyses, or visibility analyses, have been increasingly used in archaeology to understand perspectives concerning the visibility of monuments or culturally important landscape features from certain vantage points (Llobera 2003; Wheatley and Gillings 2000; Whiteley 2002). Some have applied viewshed analyses to understand settlement placement—as among the Iroquois (Jones 2006) or Wari (Marsh and Schreiber 2015)—and the visibility of Chacoan tower kivas in the Southwest (Kantner and Hobgood 2016). As well, viewshed analyses have been used for evaluating the intervisibility of sites (Bernardini and Peeples 2015; Wheatley 1995) or sightlines for better defensive lookouts or fortifications (Conolly and Lake 2006:229; Keeley et al. 2007:70–72).

In the Northwest Interior, within the broader Lillooet territory—of which Líl̓wat are a part—Sakaguchi, Morin, and Dickie (2010) have applied such analyses to understand the defensibility of pithouse villages that were situated on high, steep terraces in the Fraser Canyon. To the northwest of the Líl̓wat region, Maschner (1996) has applied viewshed analyses to assess the placement of plankhouse villages among the Tlingit, whereas to the southeast, Supernant (2014) assessed intervisibility of rock-walled sites along the Fraser River. Furthermore, Le Moigne and colleagues (2022) used viewshed analyses to determine the minimum height estimates of volcanic eruption plumes visible from Nisga'a villages in the Nass Valley. These studies indicate the variety of applications and show how viewshed analyses can enhance our understandings of human perspectives in the past. For such reasons, Wheatley (2004) has made the following argument:

> Viewshed analyses begin from the human-scale experience of existing in the physical and social world. As such, they contribute to the formulation of substantive approaches to issues as diverse as cognitive perception, culture/nature dichotomy, visualism and sensory primacy, temporality and directionality [Wheatley 2004].

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Table 2. Major Volcanic Landslides Identified over the Last 8,000 Years in the Qwelqwélusten Area.

Years Ago (BP)	Source Area of Meager Massif	Volume of Debris (m^3)
7900	Pylon Peak	4.5×10^8
6250	Job Creek	10^8–10^9
5250	Capricorn Creek	10^6–10^7
4400	Pylon Peak	2×10^8
2600	Job Creek	10^8–10^9
2400	Syn-eruptive pyroclastic flow	2×10^8
2400	Syn- to post-eruptive avalanche	4.4×10^7
2240	Job Creek	10^6
2170	Devastation Creek	1.2×10^7
1920	Angel Creek	10^5–10^6
1860	Job Creek	10^6
870	Job Creek	8×10^6–10^7
800	No Good Creek	10^5
630	Job Creek	1×10^6
370	No Good Creek	10^6–10^7
210	Angel Creek	10^5
150	Capricorn Creek	10^5–10^6
Age (AD)	Source Area of Meager Massif	Volume of Debris (m^3)
1931	Devastation Creek	3×10^6
1947	Devastation Creek	10^5
1972	Capricorn Creek	2×10^5
1975	Devastation Creek	1.2×10^7
1984	Affliction Creek	2×10^5
1986	Mount Meager	10^5–10^6
1998	Capricorn Creek	1.2×10^6
2010	Capricorn Creek	1.6×10^9
	Estimated Total Debris Flow	**$\sim 3.6 \times 10^9$**

Note: Data compiled from Friele and colleagues (2008), with the addition of the 2010 Capricorn Creek volume details from Guthrie and colleagues (2012).

This study is therefore one of only a few using viewshed analyses to assess the viability of oral traditions. It is one that explicitly states that something in particular (the ocean) could be seen from a specific vantage point (Qwelqwélusten/Mount Meager), sometime prior to a singular event long ago (the ca. 2360 cal BP eruption).

To examine visibility from Qwelqwélusten as described in Líl̓wat oral tradition, we conducted viewshed analyses from various elevations, beginning at 2,680 m asl—the current highest point within the Mount Meager Volcanic Complex at Plinth Peak—to a height of 3780 m asl. The observer was symbolized as an arced polyline feature, rather than a single point, using the drawing tool in ArcMap. We chose a polyline feature for two reasons. First, the direction is generally westward. Second, we assumed that an observer or observers could have been standing anywhere on the peak or its upper west slope facing the Salish Sea. The polyline feature was placed at the general location of the last known eruption of Qwelqwélusten (ca. 2360 cal BP) at the current elevation of its highest point of Plinth Peak (2,680 m asl).

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We used ArcMap on the ArcGIS 10.7 platform to calculate viewsheds from the point of view of observers standing at the height of the polyline. A total of nine viewshed analyses were conducted. To account for changes in the distance to the horizon as observer elevation increased, the Earth curvature option was engaged for each analysis. We constrained the viewshed analyses in two ways: (1) we limited the horizontal angle of the observer's scan, and (2) we applied a maximum viewing distance or radius. We limited the horizontal angle of the observer's scan to 150° between 150° and 300° in the polyline feature attribute table to focus toward the Salish Sea and its inlets, which is generally westward to southwestward. This was done to decrease calculation time and because there is no ocean to view beyond those parameters.

The viewing distance or radius was based on the maximum distance to the horizon from a given location, based on the elevation above sea level; the heights of the upper peaks of the Mount Meager massif range from to 2,627 m (Devastator Peak) to 2,680 m (Plinth Peak) above sea level (see Table 2). These constraints allowed for the determination of what was potentially visible from a given point and precluded issues with edge effects on the calculated viewsheds. In some cases, the calculated viewing distances resulted in viewsheds with significant coverage. Because context plays a significant role in identification (Bar 2004; Oliva and Torralba 2007; Palmer 1975), it is likely that even small patches of ocean would have been recognizable from an extreme distance and elevation, especially given sea color or the reflections of sunlight. Moreover, Líl̓wat were familiar with routes to the sea, given that oral traditions recount travels to Coast Salish villages along numerous inlets of the Salish Sea for visits and trade (Kennedy and Bouchard 2010:78–91); such travelers are depicted in the drawing by Jones (see Figure 3).

The digital elevation models (DEMs) for the viewshed analyses were downloaded from the Natural Resources of Canada GeoGratis website (GeoGratis 2020). The tiles were mosaicked into a single DEM with a Transverse Mercator projection, resulting in surface map portrayals (Figure 4).

Viewshed Analysis Results

Four of the nine viewshed analyses conducted were positive for visibility of the ocean (Table 3). First, we provide a viewshed from the current height from the highest point of the massif, Plinth Peak, at 2,680 m (Figure 5). A small patch of the Salish Sea first barely becomes visible at an elevation of 3,580 m asl, or 900 m above current maximum height. However, it is an extremely constrained area, revealing only a few hundred meters. This is likely to be unnoticed or confused with a small lake. It is more likely that the oral tradition refers to individuals at a slightly higher elevation, 950 m higher, from which a greater stretch of ocean is visible along the shoreline and reveals a sliver across the Strait of Georgia in the Salish Sea, from 3,630 m asl (Figure 6a). The area of the Salish Sea that becomes visible is off the east coast of Vancouver Island, south from the southeastern tip of Texada Island, near Nanoose Bay. In total, about a 1 km wide stretch of the sea is visible in two portions along the Vancouver Island shoreline, which extends into the Salish Sea for a length of 5 km.

With an additional 50 m in elevation, or 1,000 m above its current height, the view of the ocean expands much farther (Figure 6b). Viewable portions include two apertures, involving 2 km and 2.5 km wide corridors for a total of about 4.5 km wide stretches of the Salish Sea along the shoreline; the stretches extend for 10 km, nearly one-third of the distance across the Salish Sea in that section.

Although those stretches of 4.5 km may seem slim on the maps, note that these stretches of visibility encompass about 2° of the viewshed horizon overall. For comparison, the moon and sun each comprise only a half a degree of the skyline, so these 4.5 km stretches could be envisaged as four lengths of the moon on the horizon. Note also that the ocean would not be confused with other bodies of water, given that there are no large lakes between the volcano and the ocean. Such stretches of water would also be highlighted in reflecting the available sunlight, standing out among the other features of the viewscape. Furthermore, the stretches of visibility involve 5 km and 10 km long stretches—at 950 and 1,000 m higher elevations, respectively—extending up to one-third of the entire width of the Salish Sea in that section of the coast. Here, we have primarily considered the minimal heights for visibility; further heights in elevation would only increase the visibility of the Salish Sea even more. We should note that some fluctuations in the height needed for the visibility of oceans also may be affected by atmospheric

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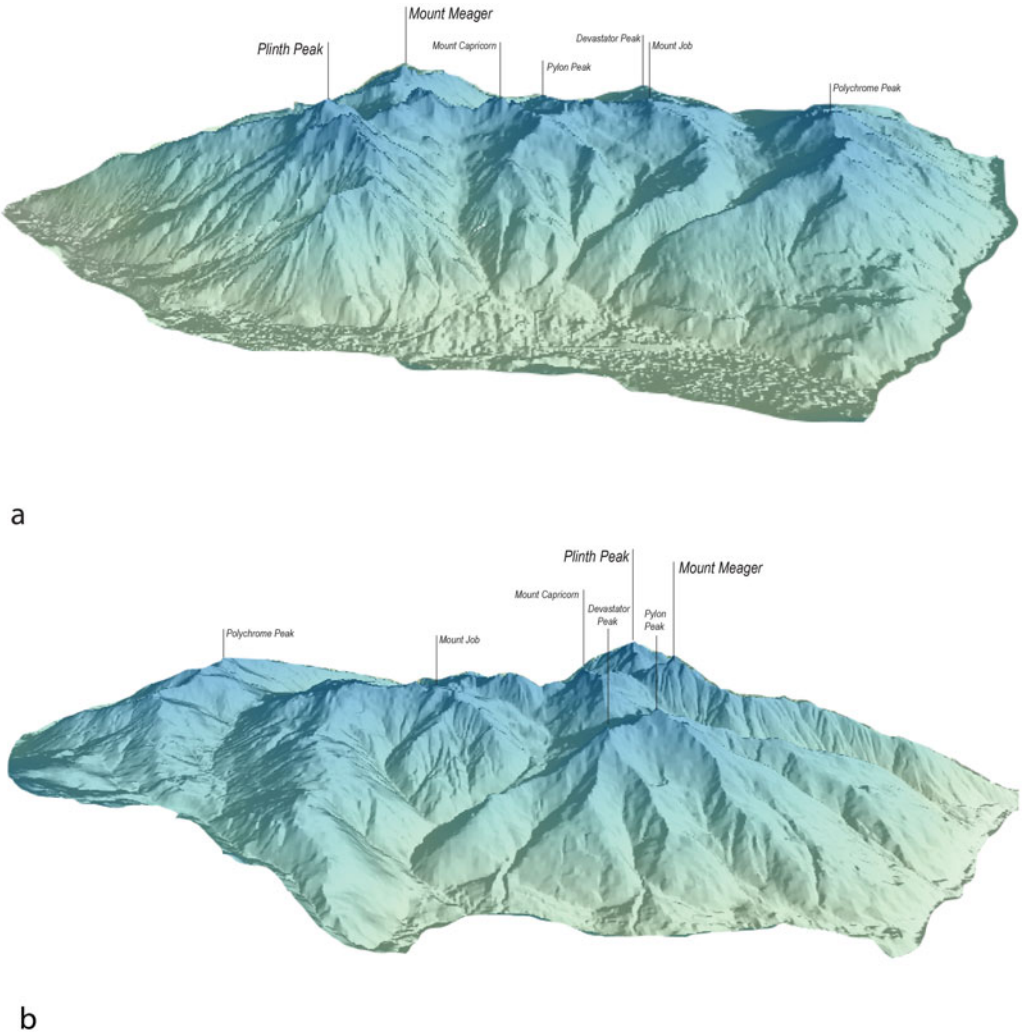

Figure 4. Surface map of post-eruption Mount Meager massif: (a) view of northern aspect and (b) view of southern aspect.

refraction of light, as with the optical dynamics of mirages, when hotter temperatures can elevate an image on the horizon. Moreover, if over 5,000 years ago, as is possible here, the sea levels may have been up to 200 m higher (Mackie et al. 2018), which also would reduce the height needed to some degree.

We find that these results are significant both culturally and geologically. With respect to their cultural significance, they suggest that the Líl̓wat oral tradition regarding visibility from Qw̓elqw̓elústen is at least 2,400 years old, and likely much older, given the volatility of the mountain and its long history of debris landslides throughout the Holocene, as documented between 4,000 and 8,000 years ago (see Table 2). Furthermore, ancestral Líl̓wat understood the broader cultural landscape of which they were a part through travel and trade networks reaching the inlets (Teit 1906:232), so the small patches of ocean that were visible would be understood to be saltwater amid known features of the landscape. These results highlight the familiarity of high-elevation terrain for peoples of the Pacific Northwest (Mierendorf 1999; Reimer 2000, 2003).

Interestingly, the main saltwater areas with which they would have been familiar through trade and kinship relations are not visible from the Mount Meager Volcanic Complex. The inlets that cut into the western flank of the Coastal Range—Bute Inlet, Toba Inlet, Jervis Inlet—were important trade conduits for Coastal and Interior groups, and the Líl̓wat were familiar with these waterways (Kennedy and

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Table 3. Results of Viewshed Analyses from Increasing Heights above the Current Volcanic Massif.

Viewshed Iteration Height		Vantage Point
Height above Peak (m)	Viewshed Peak / Observer Height (m asl)	Visibility within Observer Viewshed from Qẃelqẃelústen to the West for Views of the Salish Sea
1,100	3,781.7	**Viewable**. Apertures of visibility widen; 3 to 4 km wide, 15 km long.
1,000	3,681.7	**Viewable**. Apertures of visibility widen; 2 to 3 km wide, 10 km long.
950	3,631.7	**Salish Sea is viewable** in waters along Vancouver Island, near Nanoose Bay (two apertures include corridors of about 10 km stretches of sea)
900	3,581.7	Sea is not viewable, but there are expanded views of island peaks. Near-coastal regions are viewable (a narrow portion of sea is viewable)
800	3,481.7	Sea is not viewable, but there are expanded views of island ranges.
700	3,381.7	Sea is not viewable, but there are expanded views of island peaks.
600	3,281.7	Sea is not viewable, but peaks of Vancouver Island and Texada Island are.
500	3,181.7	Sea is not viewable, but Vancouver Island Peaks are.
0	2,681.7	Sea is not viewable.

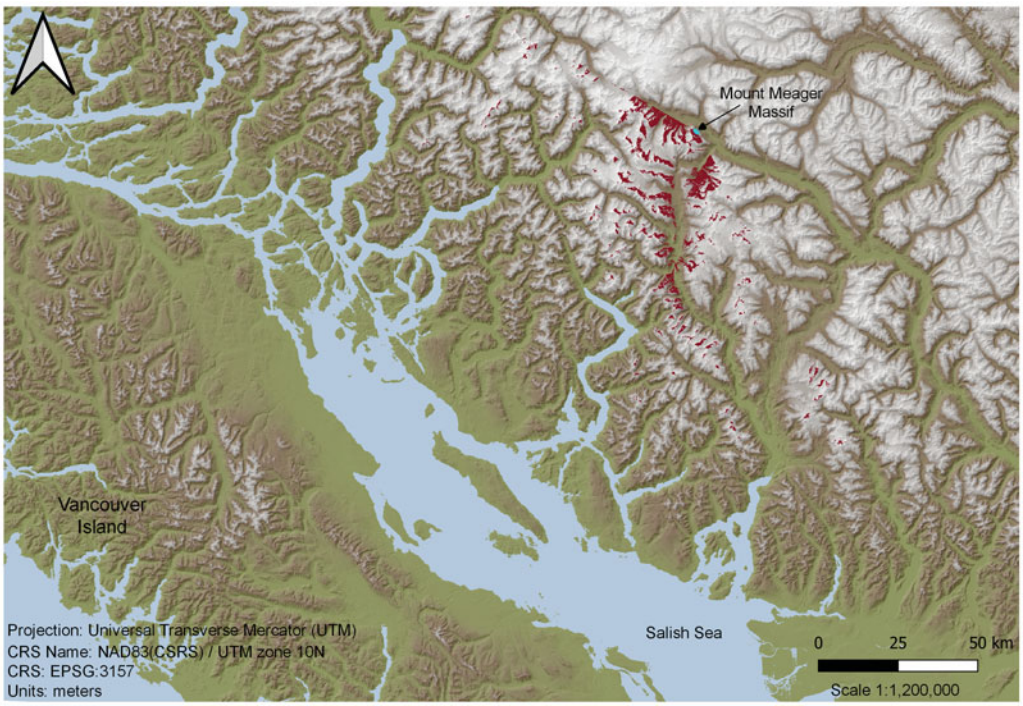

Figure 5. Viewshed analysis from current highest viewpoint at 2,680 MASL. Note: no visibility of the Salish Sea is possible.

Bouchard 2010:79–91; Teit 1906:232). Their invisibility from Qẃelqẃelústen is due to the height of the coastal ranges combined with the deeply incised nature of the fjord-like inlets that spur off of the Salish Sea.

From a geological perspective, the results are also significant. They suggest that Qẃelqẃelústen may have lost as much as 950 m of its original height through volcanic eruption, landslides, and massive

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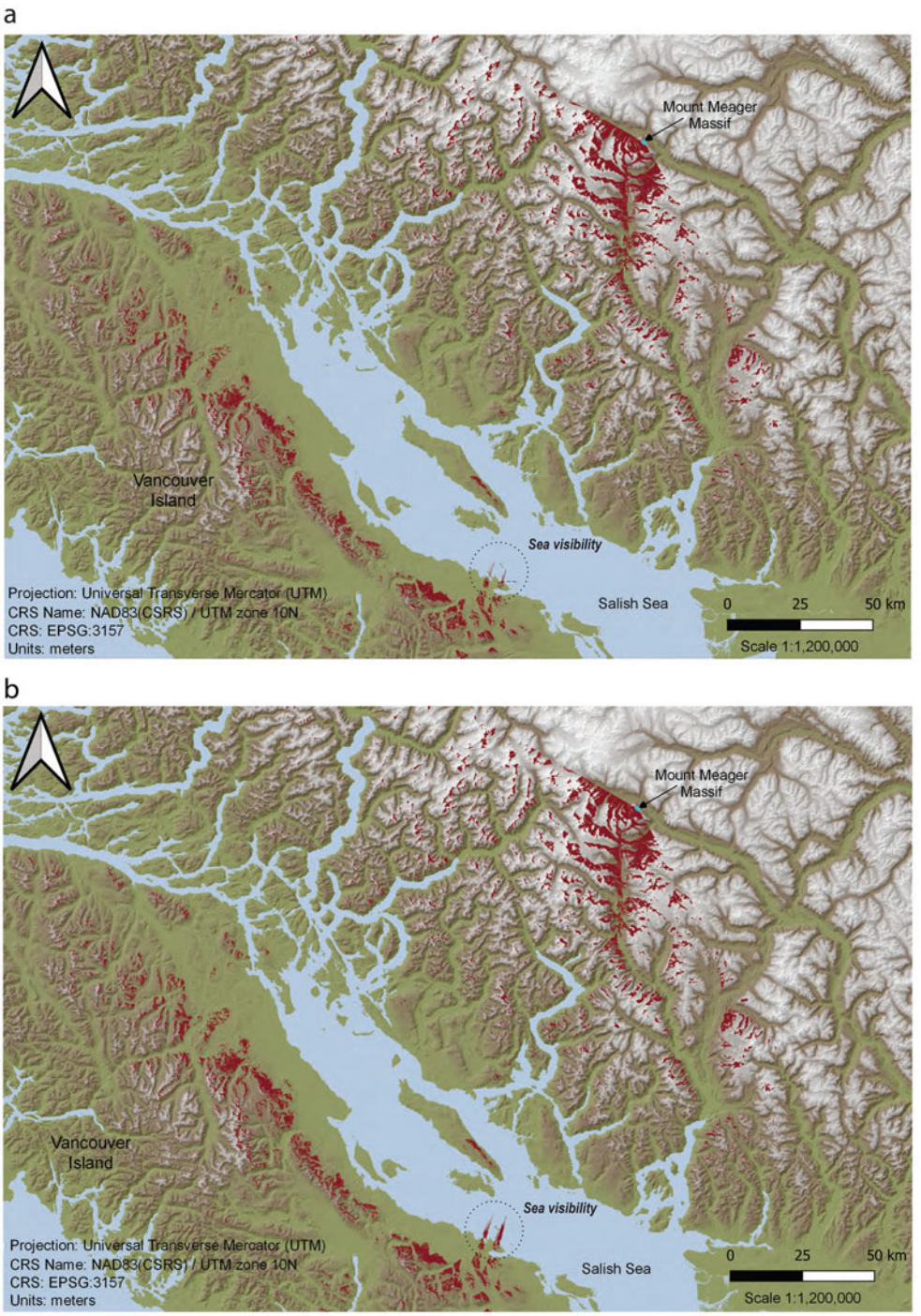

Figure 6. Viewshed analyses from the vantage point of Mount Meager massif: (a) viewshed analysis from 950 m above current mountain height (2,680 m asl), indicating visibility of the Salish Sea; (b) viewshed analysis from 1,000 m above current mountain height, indicating greater visibility of the Salish Sea.

debris flows (e.g., Hickson et al. 1999; Roberti et al. 2018). The proposed elevation of between approximately 3,500 and 3,700 m asl is not outside the realm of possibility given that other volcanoes within the Cascade Volcanic Arc are of similar or higher elevations (see Table 1). This could place the original

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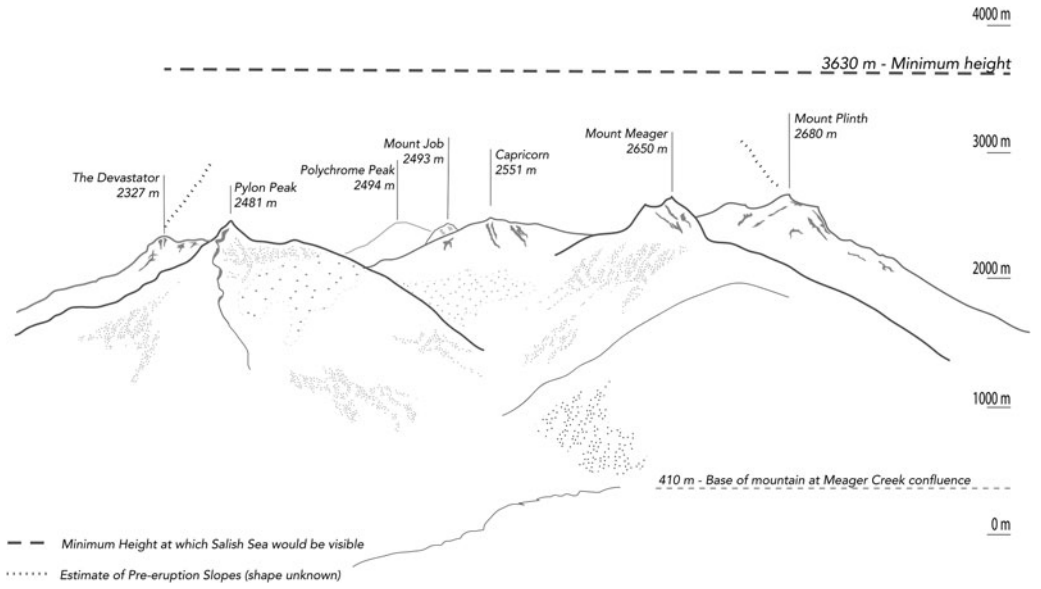

Figure 7. Profile view of Qwelqwélusten / Mount Meager prior to the approximately 2360 cal BP eruption, showing relative height of peaks in relation to the minimal height for visibility of the Salish Sea (3,630 m).

height of Qwelqwélusten on the order of that of Mount Adams (3,743 m) or Mount Hood (3,429 m). A profile of the current peaks of Qwelqwélusten is shown along with the minimal height in which the Salish Sea is visible (Figure 7).

Based on the slopes of the extant peaks of the massif, there are some indications of the shape of the original mountain peak. The iteration heights for the visibility of the Salish Sea do appear to be readily possible. A mountain of such prominence would indeed have been of central importance within the whole of Líl̓wat traditional territory, just as it features in its oral traditions. In this way, not only does the geological information align with the oral tradition, but the oral tradition provides information to better our understandings of the geological history of the massif.

Conclusion

Líl̓wat oral traditions told today recount that climbers of the mountain, known as Qwelqwélusten, could see the ocean. This is not possible now, because peaks of Mount Meager Volcanic Complex have heights that are similar to surrounding peaks, and several mountain ridges obscure the view of the Salish Sea to the west. Yet, as we have presented here, it is plausible that the mountain's height was significantly higher in the past, prior to its approximately 2360 cal BP eruption, when Líl̓wat narratives hold that it was the highest peak in their territory. The results of our viewshed analysis indicate that one would have been able to see the ocean if the original height of the massif had been at least about 950 m higher and well within the range of other white-capped volcanoes of the Cascade Volcanic Arc. We maintain that this indicates that this Líl̓wat oral tradition relays testimonies of the history prior to the volcano's eruption, and that this oral narrative is therefore well over 2,400 years old. Furthermore, because geological evidence suggests that the mountain's height was likely similar to that just prior to the 2360 cal BP eruption, the volume losses due to collapses and/or eruptions from 4,400 to 7,900 years ago more likely indicate the period for the greater height of the volcano (see Table 2).

The glaciers receded from the region over 11,000 years ago (Clague 2017), and soon after that time, peoples ancestral to Líl̓wat have occupied that territory. Their oral traditions, extending back to a Time of Transformation, recount how the landscape had been sculpted and shaped by major transformative events. For their Squamish neighbors adjacent to the west, Reimer (2012) has argued for the similarities between oral histories of a period of great transformation and the paleoenvironmental histories of major changes at the close of the Pleistocene and the settlement of sea levels. For Líl̓wat, a similar argument can

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be made about their histories of the Copper Canoe brothers, which tell of the shaping of their traditional territory during a time of geological transformation. Not only do Indigenous peoples of the Salishan area have oral histories of times long ago, but they also have a long familiarity with high montane landscapes, extending back many thousands of years. Reimer (2000, 2003) conveys this for the Squamish Coast Salish, whereas Mierendorf and Foit (2018; also Mierendorf 1999) recount the long familiarity with mountain passes of the Upper Skagit Coast Salish and Interior Salish at Cascade Pass dating back over 9,000 years of high-alpine travel. These are among other examples, as discussed above.

All of these avenues—oral history, geological history, and viewshed analyses—intersect and combine to indicate that these Líl̓wat oral traditions likely have substantial antiquity. Considering Occam's Razor, we maintain that the simplest explanation for the convergence of these lines of evidence is that the oral history is based on testimony of Líl̓wat climbers, likely mountain-goat hunters or shamans seeking power, who reached the peak earlier in the Holocene, prior to the large collapses and volcanic eruptions that formed the massif that stands today.

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Competing Interests. The authors declare none.

Notes

1. Given that Líl̓wat refer to this mountain as Qwelqwélusten, we will primarily use this name. In our view, it is the original name, and it has substantial antiquity, as indicated in Líl̓wat oral traditions. In contrast, the settler name was applied in 1923; they simply named it after J. B. Meager, who held timber licenses along its southern slopes. Because Líl̓wat never ceded their territory to Canada through treaty, despite colonial settlement of their territory, it is preferable to use their name for the mountain. See Reimer (2018), who advocates for the primary use of Indigenous names rather than settler ones.
2. He told this story after he, along with Kennedy and Bouchard (2010:13–15), was attempting to land on top of Qwelqwélusten in a helicopter. He had wanted to show them this important mountain. However, once they approached its peak, he had second thoughts because he saw the strong winds blowing across the summit of the massif, so he told the pilot, "No . . . don't land the helicopter." Mack realized that the power and danger of the mountain should be respected.
3. Numerous Northwest groups have oral traditions about massive fish weirs that blocked the upriver ascent of salmon during the Time of Transformation (Ritchie and Angelbeck 2020).
4. Numerous sources document such events (Bovis and Jakob 2000; Evans 1987, 1992; Friele and Clague 2004, 2009; Friele et al. 2008; Guthrie et al. 2012; Hetherington 2014; Patton 1976; Roberti et al. 2018; Simpson et al. 2006).

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