Proglacial meltwater features in North Central Washington

Introduction

During the final phase of the Pleistocene epoch, the terminus of the Cordilleran ice sheet was located along the margin of the Okanogan lobe in North Central Washington. This is a brief geographic study of the meltwater channels from this ice sheet.

Melting ice sheets produce flows of water that can create *fluvioglacial* landforms wherever the meltwater comes into contact with sediments or bedrock. *Proglacial meltwater channels* can be created by streams that drain along the margin or away from the terminus of a glacier. When surface water flows laterally along the margin of a glacier, these are termed *lateral meltwater channels*.

J Harlan Bretz (1959) brought attention to meltwater channels of epic proportions that resulted from the sudden collapse of ice-dammed Glacial Lake Missoula. Since then, evidence for similar large glacial outflows have been documented in many other areas of the post-glacial environment. Richard Waitt documented the occurrence of localized glacial outflows in the Methow Valley, Washington. Like the Missoula floods, some of these outflows were immense, carving channels hundreds of feet deep through bedrock and moving rocks the size of houses. Yet awareness of fluvioglacial landforms that lie outside the pale of the Missoula floods is incomplete. As with the channeled scablands studied by Bretz, many of the details of fluvioglacial features remain inaccessible or undocumented. Waitt's study was a classic endeavor, but even so he still missed some of the largest fluvioglacial channels in his study area, such as the immense spillway carved across the top of Tripod Mountain northeast of Twisp. It was this spillway that inspired the writing of this document.

The action of melting water may be combined with that of glacial ice. Whether from ice or water, the lay term for such proglacial features is familiar to everyone in North-central Washington: *coulee*. Features of meltwater flows include large, transported boulders located downstream from the release, steep valley walls, sometimes with one side of the channel lacking, alluvial materials such as outwash sands upstream of the release, and features and geographic position that correlate with meltwater.

An example of an extensive coulee system that carried large volumes of glacial meltwater occurs along the west edge of the Okanogan River Valley from Canada south to Lake Chelan, Washington (Figure 1). Along the length of this system, several areas show evidence of catastrophic release of water, such as the debris flow in the center of Figure 1.

Topographic position is one of the factors that help identify proglacial meltwater channels. Figure 2 shows a bedrock channel cut across the west ridge of Watson Draw, near Pateros Washington, where the ice filling the Columbia River Valley blocked water flowing along its edge. There are large outlet channels on most of the north-flowing rivers in the Pasayten Wilderness that formed when advancing ice forced proglacial lake water to seek an outlet. Both Holman Pass and Hidden Lakes served as outlets for the Pasayten River system. However these outlets were modified during later glaciation phases, depositing drift and widening the channels.

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Figure 1. The Sinlahekin Valley coulee, about 10 miles south of Loomis.

Figure 2. Bedrock channels cut through the ridge west of Watson Draw near Pateros.

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Most of the larger coulee systems have features of both ice and water underlying their origins. Numerous clues can be used to help determine whether the final phase of a coulee was dominated by hydrologic flows or by ice erosion. One clue indicating late-phase fluvial processes is a V-shaped channel cross-section, rather than a U-shaped one.

Channels formed during the final phase of meltwater flow are typically scoured of glacial drift that is a hallmark of glacial ice from the Okanogan lobe. Where soils do occur within a fluvioglacial channel they are more likely to be fine-grained outwash sands or post-glacial lake sediments or fallen cliff talus. In contrast, the presence of unsorted glacial cobbles in the bottom of a canyon is evidence that the final phase of formation was primarily due to ice. Fluvioglacial channels are frequently curved, however this is not a positive indicator of origin, since many complex factors can lead to straight or curved coulees.

The unique geomorphic features of these coulees contribute to the biological diversity of Okanogan County, which is otherwise dominated by deep glacial sediments. Rocky soils and deep canyons provide habitats for rare plants and animals, such as the Umatilla gooseberry that grows in deep fractures of McLaughlin Canyon, half a state away from the main population. Uncommon bats and snakes have been found in some of the canyons. Aquatic habitats and cold, upwelling springs were the basis for the creation of the Chewuch River RNA, that was formed by pulses of glacial meltwater and post-glacial and late-phase debris torrents.

Initial maps of rocky coulees were made to locate and inventory unique wildlife habitats during biological surveys. In addition to providing habitat for cliff-dwelling species such as bald eagles, rocky cliffs are habitat for rare species such as the night snake, *Hypsiglena torquata*, recently discovered in this part of the state, as well as anomalous occurrences of disjunct species such as the freshwater pearl mussel, *Margaritifera margaritifera*. It then became apparent that the locations and topographic position of fluvioglacial channels formed landscape patterns that were informative about the origin and other features of deglaciation, in its own right. Therefore, a map was created showing bedrock-carved fluvioglacial channels related to the Okanogan lobe of the Pleistocene ice sheet.

Geomorphic features of fluvioglacial channels can be remotely mapped using shaded relief maps and aerial photo-interpretation. Easily identified features of channels include V-shaped outlines, spillways, slopes greater than the angle of repose, position across ridgelines, and outwash deposits. The channels were mapped by manually digitizing areas with the above features on a set of shaded relief images created from 1:24,000 USGS digital elevation models (DEMs). Shaded relief images significantly enhance features of fluvioglacial channels over that of 1:24,000 contour maps (aerial photo-pair interpretation is another good evaluation method not used here). By limiting the selected set of channels to those with the above features visible on DEMs, the map shows patterns of proglacial meltwater channels formed in bedrock that were created primarily by fluvial processes, rather than by ice or by antecedent erosion of pre-existing channels.

Results

Glaciofluvial channels tend to occur in parallel clusters, such as the group of ice-marginal channels along the east side of the Chewuch River, east of Winthrop. A shaded relief map showing the location of these channels is shown in Figure 3. It can be seen that most of these channels are aligned north-south, in parallel with the larger Chewuch glacial valley along the east side of the figure. These channels must have been cut when successively lower glacial ice margins forced the draining ice-sheet to carve sets of valleys through bedrock ridges that lie perpendicular to Chewuch Valley. Although several streams appear to have been steepened along their lower reaches, these were not included in the map because they could have originated prior to glaciation.

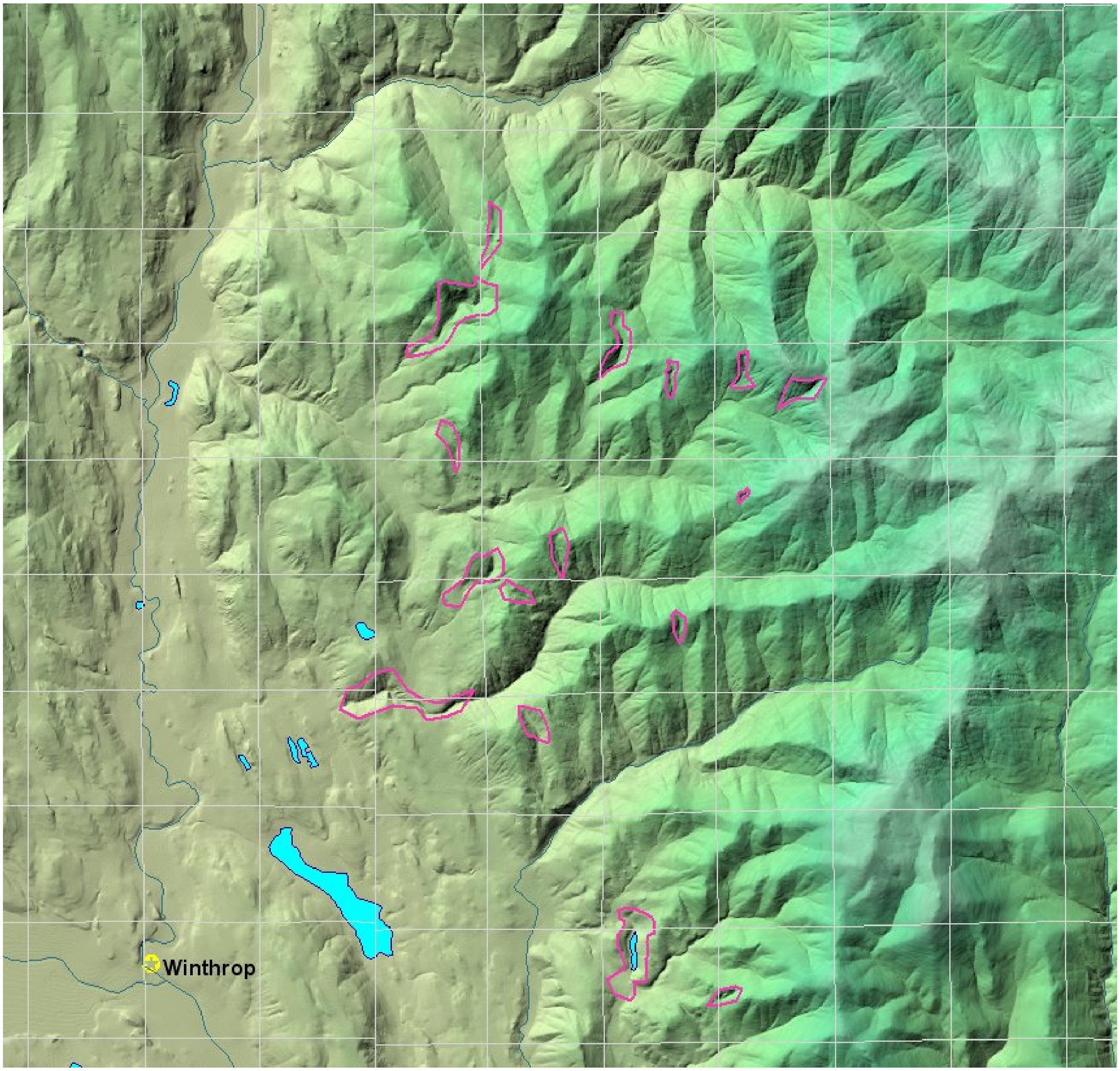

Figure 3. A group of fluvioglacial channels (pink outline) cut into bedrock along the east margin of the Chewuch valley glacier (section lines are approximately 1 mile on a side).

The Okanogan Valley has numerous examples of fluvioglacial meltwater channels. Figure 4 shows the DEM of this valley. The large coulee running between Loomis and Conconully is the Sinlahekin Valley, a well-known example of an extensive coulee system, with features derived both from ice as well as immense and sudden releases of water. A coulee this size could never have been carved by the tiny Sinlahekin and Similkameen streams that now lie in the valley bottom. In addition to this channel, there are readily visible channels cut parallel to the Okanogan River east of Conconully. There is less awareness of the extent of these "smaller" channels, although many exhibit features of concentrated release of energy, including channel steepening and deepening. For instance, the dark lines just south of Tonasket represent vertical bedrock cliffs that reach over 500 feet in height.

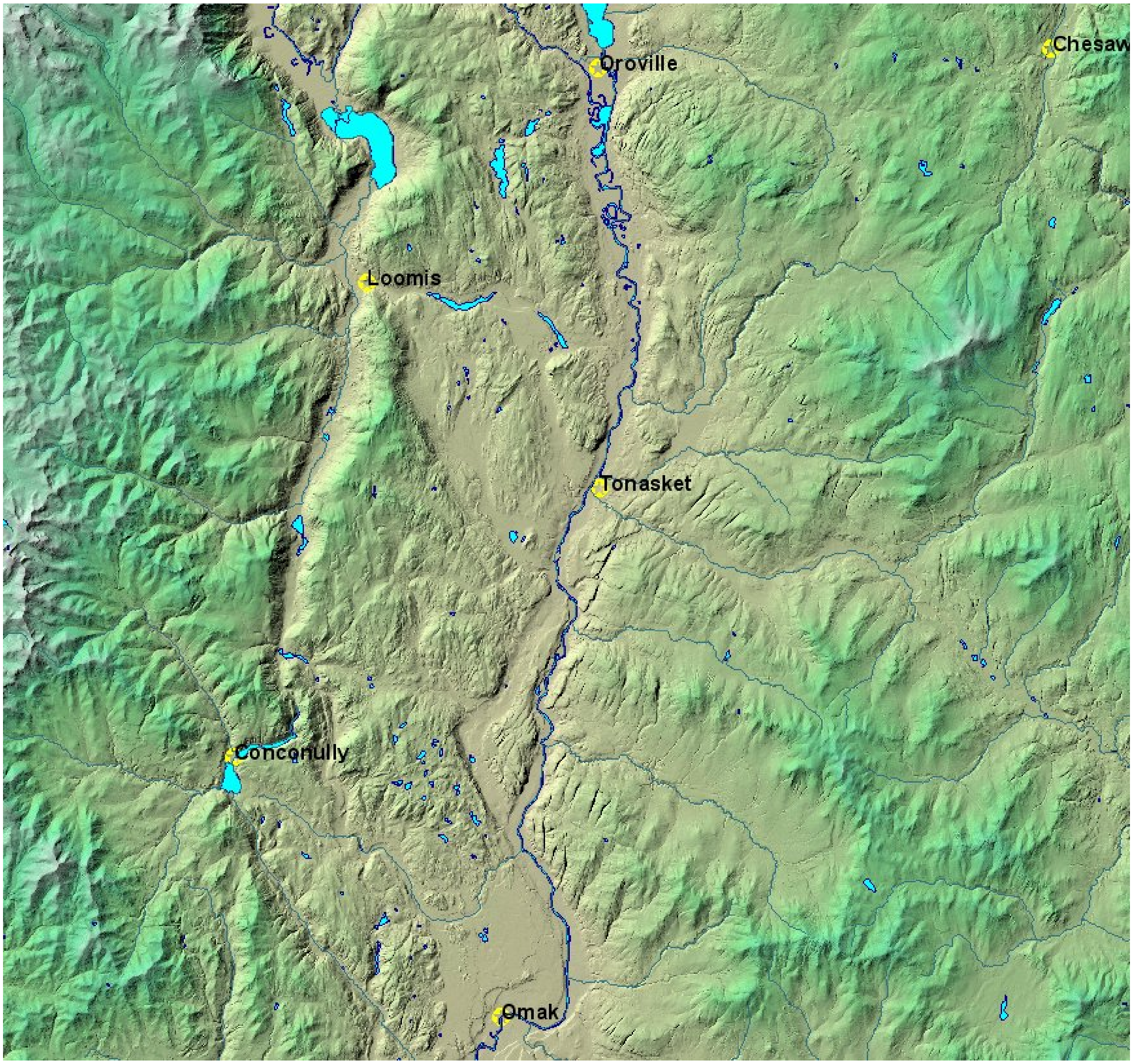

Figure 4. Fluvioglacial channels in the Okanogan Valley can be seen as dark lines in this DEM image.

In extending the map of fluvioglacial features beyond the Okanogan and Methow Valleys, the frequency of channels decreases (Figure 5). To the south and east, the landscape becomes dominated by the large outflow channels of Glacial Lake Missoula, while smaller channels are further apart. To the west, fluvioglacial features also become less frequent, perhaps because there was a smaller area of glacial margin to constrain flows. The Pleistocene ice sheet did not extend significantly into the Cascades west of the Methow River, south of Canada.

In conclusion, there is much yet to be learned about the final phases of the Pleistocene deglaciation. These studies can be informed by studying the topographic position of fluvioglacial channels and patterns of clusters of these channels in relationship to the former ice sheet. Further studies should concentrate on determining the relative influence of timing versus location, on the relationship of glacial meltwater to fluvioglacial channels.

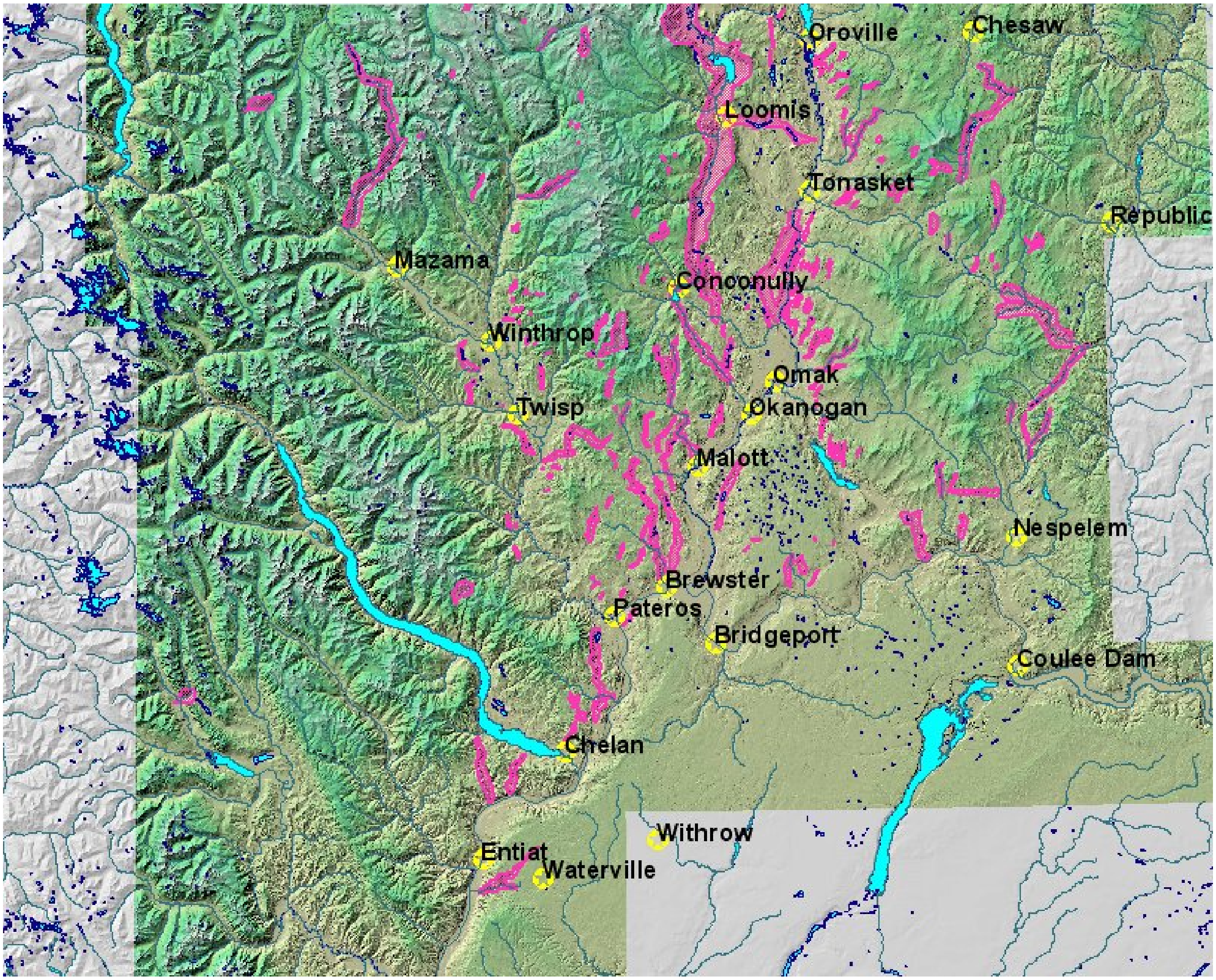

Figure 5. Map of fluvioglacial channels in North Central Washington. The colored DEM represents the extent of the mapped study area.

References

Waitt, R.B. 1972. Geomorphology and glacial geology of the Methow drainage basin, Eastern North Cascade Range, Washington. Ph.D. Thesis on file at University of Washington, Seattle, WA.
Bretz, J Harlan. 1959. Washington's channeled scabland. Washington Div. Mines and Geol. Bull. 45.