Poorly Sorted Terrace Deposits of the Cispus Valley: Glacial Drift or Mount Adams Lahar?

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Abstract

Incising through folded Oligocene basaltic andesite bedrock, the Cispus River meanders along the western slopes of Mount Adams before flowing westward towards Mayfield Lake near Randle, Washington. A veneer of tephra dated 1.2 ka from Mount St. Helens covers the Cispus River terraces and adjoining hills, attesting to recent manifestation of volcanism in the region. Despite this valley being classified as high-risk for lahars from Mount Adams, little research has been done to identify any previous lahars along the drainage. Examination of the Cispus River terraces reveals imbricated, poorly sorted, reverse graded deposits typical of debris flows. These deposits are found along multiple terrace levels and are sedimentologically similar, while clast lithologies indicate a provenance to the east. The 30-meter elevation difference between the lowest terrace and the surface of the highest terrace denotes the minimum flow depth; it is here estimated that the lahar was 0.31 cubic kilometers. Clasts within the debris flow deposits are often andesites and volcaniclastics distinct from the local basaltic andesite bedrock. Coupled with the eastward dipping imbrication, the clast lithologies suggest a provenance to the east near Mount Adams. While the pumiceous tephra (1.2 ka) that blankets the region provides the minimum age, the poorly sorted terrace deposits have been previously dated as approximately 20 ka, which is based on the interpretation that the deposits are glacial drift. If these deposits are instead laharic in origin, however, the lack of overlying till or drift suggests a younger, late-glacial age of the lahar. This age correlates nicely to the latest series of Mount Adams eruptions from 40 ka to 10 ka during which time the present edifice of Mount Adams was produced. This lahar may be among the largest and oldest lahars yet identified from Mount Adams.

Figure 2. Flowing from the Goat Rocks Volcanic Field, the Cispus River winds through deformed bedrock of the primeval Cascade Range, receiving meltwater from Mount Adams via Adams Creek. Inset: above the terraces, a veneer of ash (1.2 ka) and paleosol (Evans Creek till?) mantles the Oligocene basaltic-andesite bedrock.

Figure 4. Boulders over two meters in diameter are found along or embedded in the depositional terraces of the Cispus River.

Introduction

Located in central Washington State, Mount Adams is one of the most prominent Quaternary stratocones in the Cascade Magmatic Arc. Rising over 3,700 m above sea level, Mount Adams has a long history of basaltic and andesitic eruptions, the most recent episode of volcanism being from 40 to 15 ka (Hildreth and Fierstein, 1997). Despite its current dormancy and relative seclusion from major populations, Mount Adams has been investigated for potential volcanic hazards, particularly due to its numerous glaciers. Five lahars have been identified from Mount Adams, each of which resulted from Holocene debris avalanches that inundated the southwestern drainages leading to the Columbia River via the White Salmon River (Vallance, 1999). Although smaller than historical lahars, the largest of these lahars, termed the Trout Lake lahar, crossed the Columbia River and deposited sediment on the opposite shore near Hood River, Oregon, approximately 6 ka, suggesting that future lahars may damage infrastructure along the Columbia River.

While mapping by Scott et al. (1995) has delineated the potential hazards along each major drainage leading from Mount Adams, little work has focused on identifying previous lahars along these valleys. One of these streams, the Cispus River flows south from the Goat Rocks Volcanic Field before turning westward where it is joined by Adams Creek from the northwest flanks of Mount Adams (fig. 2). The Cispus River continues west through the incised remnants of the primeval Oligocene Cascade Arc volcanoes north of Mount St. Helens until it reaches the broad Cowlitz River valley near Randle, Washington. Along the Cispus River drainage, a well-developed network of depositional terraces composed of poorly sorted terrace deposits fringe the stream. Contrary to previous interpretation proposing a glacial origin, recent investigation indicates that these terrace deposits resulted from a lahar from Mount Adams.

The Cispus River Terraces

Along its lower length, the Cispus River is bordered by depositional terraces mostly small and numerous that gradationally lead to the highest terrace level. Over thirty meters above the current river channel, this topmost terrace level is the broadest and can be correlated across the valley. The terraces first fringe the Cispus River near the junction of Adams Creek and continue until the Cispus River enters a narrow gorge bordered by higher strath terraces downstream the Cispus Learning Center (CLC) (fig. 1). Even after leaving the gorge, the Cispus River contains few terraces as it approaches the broad Cowlitz River channel, which has been mapped as prone to lahars from Mount Rainier (Hoblitt et al., 1995).

The depositional terraces are composed of poorly sorted matrix-supported deposits that transcend the terrace level, being sedimentologically similar at each level. As shown in cross-section along tributaries transecting the terraces (fig. 3), the clasts are imbricated with dips towards the east and are reverse graded into discrete strata. The clasts within the depositional terraces are primarily native Oligocene clasts mixed with andesite and volcaniclastic cobbles distinct from the bedrock. Early researchers interpreted the terrace deposits as glacial outwash during the Evans Creek Glaciation from 20 to 15 ka (Schuster, 1973), but the sedimentological nature of the terrace deposits is typical of debris flows. Native angular boulders over two meters in diameter are often found along or imbedded in terraces at several levels (fig. 4), refuting a glacial outwash interpretation. This is compounded by the terraces extending only to the Adams Creek junction and the lack of moraines in the area. Combined with the eastward-dipping imbrication, the clast lithologies and extent of the terraces suggest a lahar from Mount Adams inundated Adams Creek and entered the Cispus River.

Anastomosing Channels

In the gorge west of CLC, the depositional terraces are replaced by broad strath terraces thirty-six meters above the river. As shown by LiDAR, the strath terraces are etched by anastomosing channels that generally parallel the valley but are truncated by the current river channel, producing "hanging valleys". These anastomosing channels are gentler than those bearing current streams but are similar to braided channels in the Channeled Scablands produced during Winsconsian-age Missoula floods. This suggests that the lahar recorded by Cispus River terraces upstream was funneled into this gorge wherein the lahar increased depth and potentially maintained a temporary hydraulic dam.

Volume and Age Constraints

From CLC to the gorge, the lahar potentially created a hydraulic dam, thereby allowing us to estimate the volume. Because the channel's structure is nearly pyramidal prismatic due to the various terrace levels above the river, we may insert the channel depth (>30 m) and inundated area in the pyramidal prism volume equation. While underestimating the volume, this calculation yields 0.31 cubic km, 4.4 times larger than Trout Lake lahar (0.07 cubic km).

The Cispus terraces have been presumed to be around 20 ka based on an outwash interpretation, but a laharic origin would necessitate a younger age due to the lack of overlying glacial drift. The pumiceous tephra mantling the site provides a minimum age of 1.2 ka (Schuster, 1973), but Swanson (1991) found clasts of the Springs Creek basalt incorporated into the "outwash" terraces with rinds suggestive of Evans Creek age (20 to 15 ka), indicating that the lahar was no greater than 21.55 ka but possibly not much younger. This implies that the lahar was during or just after the waning of the Evans Creek Glaciation.

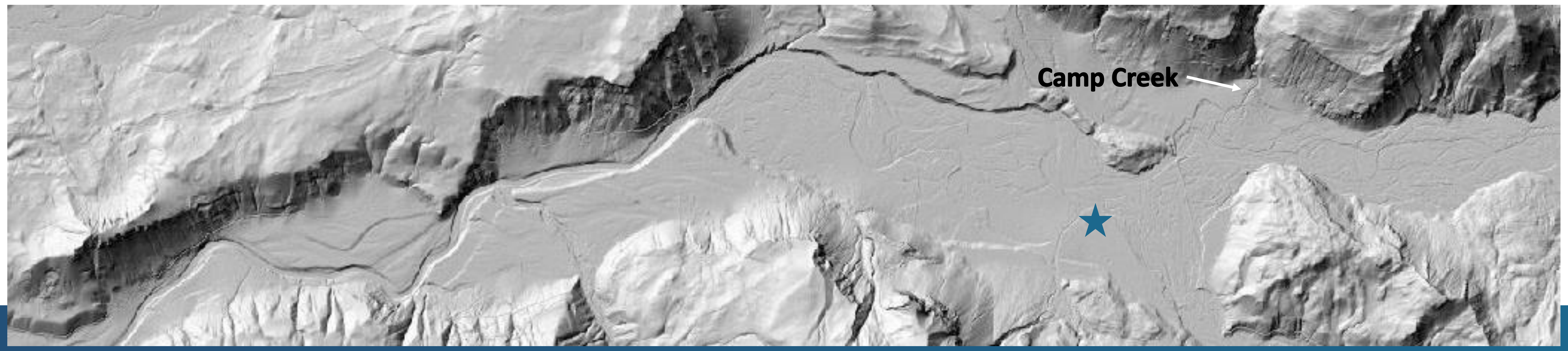

Figure 1. Near the Cispus Learning Center (CLC; denoted by star), the Cispus River flows through a broad valley flanked by depositional terraces up to 30 m above the Cispus River until it enters a gorge with a broad terrace on the southern edge and many smaller terraces as many as 36 m high.

Figure 3. Minor terracing along Camp Creek delineates two reverse graded, slightly imbricated deposits along a Cispus River terrace.

Conclusions and Further Work

This study has showcased mounting evidence that the poorly sorted terrace deposits along the Cispus River resulted not from glacial outwash but from a Mount Adams lahar. Reaching over thirty meters in depth, this lahar inundated the Cispus Valley where it deposited sediments to boulder size before entering a narrow gorge, carving anastomosing channels along strath terraces thirty-six meters above the present-day river. While the age of the lahar is not well constrained, the lack of overlying glacial drift suggests that the lahar did not precede glaciation. The pumiceous tephra that mantles the terraces indicates the lahar is over 1.2 ka, but Swanson (1991) noted that weathering rinds of Springs Creek basalt (21.55 ka) clasts suggest they were incorporated into the terraces during Evans Creek age (20 to 15 ka), implying that the lahar occurred during or just after the waning stages of the Evans Creek Glaciation.

Over 4.4 times more voluminous than the Trout Lake lahar, the Cispus lahar as the largest yet identified lahar in the region provides key insights into potential hazards from Mount Adams. Further study should ascertain the extent of the lahar once it entered the Cowlitz River valley and should better bracket the age of the lahar. Research may also investigate whether the lahar was initiated during an eruption, making it not only the largest and potentially oldest lahar from Mount Adams yet identified but also the only one initiated directly by an eruption and thus only one of several unknown concomitant lahars.

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