St. Anthony Falls Laboratory

UNIVERSITY OF MINNESOTA

Undergraduate Summer Research Symposium

Utilizing lithologic identification and repeat photos to understand the potential bedload contribution of a prominent cut bank cliff

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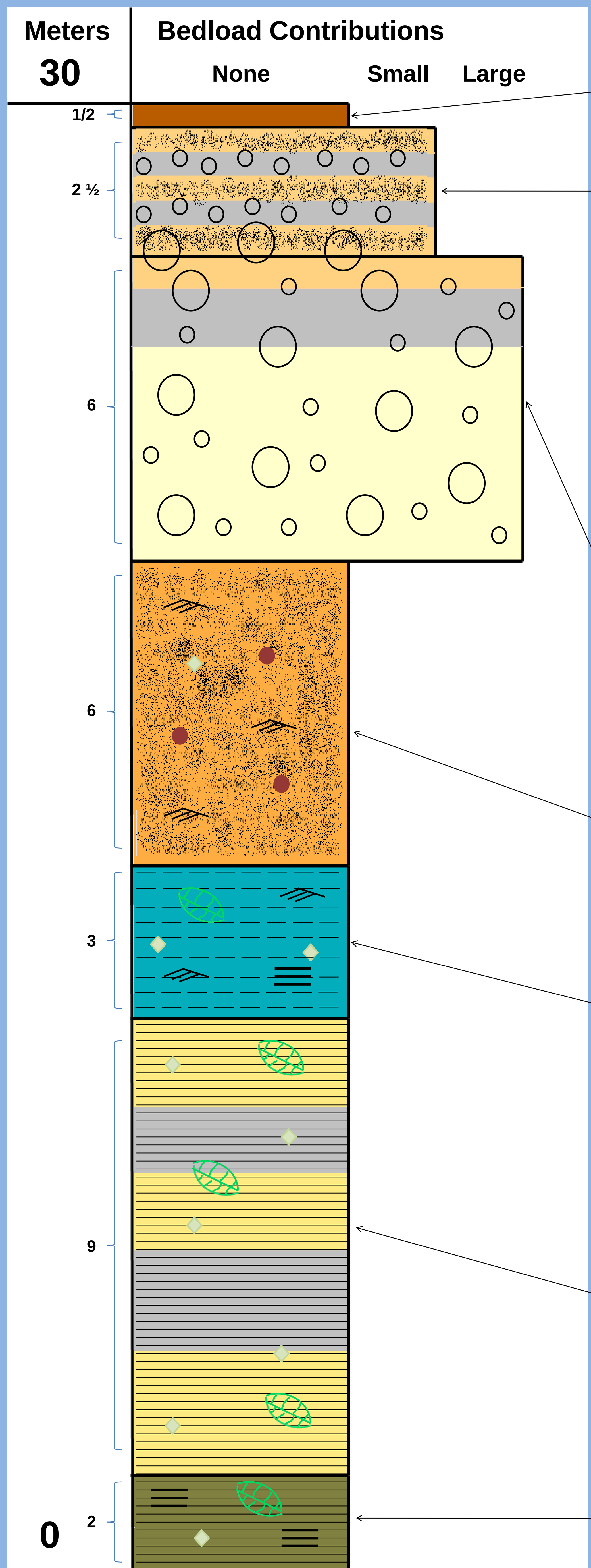


Organic soil horizon, agricultural field, thick vegetation

(A1) Tan fine silty sandstone: tuff fragments suggest a local felsic protolith and fluvial deposition

(A2) Gray glaciofluvial gravel conglomerate: formed from brief melting episodes of local glaciers, partially cemented, poorly sorted

(A3) Basal tan cobble conglomerate: not consistent throughout exposed layer suggesting a fluvial bar deposit

(B) White-gray-tan boulder-cobble conglomerate, poorly sorted: no apparent grain orientation or imbricated direction; consistent strata presence and size throughout local region suggests one large or multiple small debris flow events from extrusive igneous activity, melting snow and glaciers, and mobilization of Mount Hood sediment

(C) Red moderately sorted sandstone: red coloring is from the iron oxidation of hematite nodules, bands, and visibly euhedral crystals; cross-bedding suggests a fluvial depositional environment of a point bar or stream channel

(D) Blue-gray fine sandy siltstone: thin laminations and fine cross bedding, along with the fine grain size, suggest a shallow lacustrine environment of possible glacial origin; density and size of the mica (muscovite, some biotite) crystals suggests a felsic protolith of close proximity; leaf litter and other vegetative detritus form distinct layers

(E) Tan-gray silty claystone: large vertical fractures, high muscovite content, some organic matter; absence of fine laminations in this clay-dominated layer suggests rapid deposition from an extrusive igneous event that clogged the local fluvial channels that fed this glaciolacustrine environment with volcanic ash

(F) Gray-brown claystone: thinly laminated, some muscovite, some organic matter; the lack of cross bedding suggests a stable glaciolacustrine environment

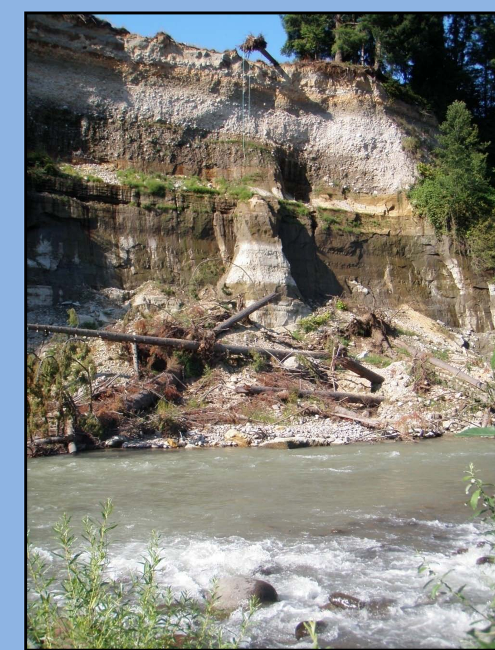
Legend:

- Mica
- Hematite
- Plant matter
- Lamination
- Cross-bedding

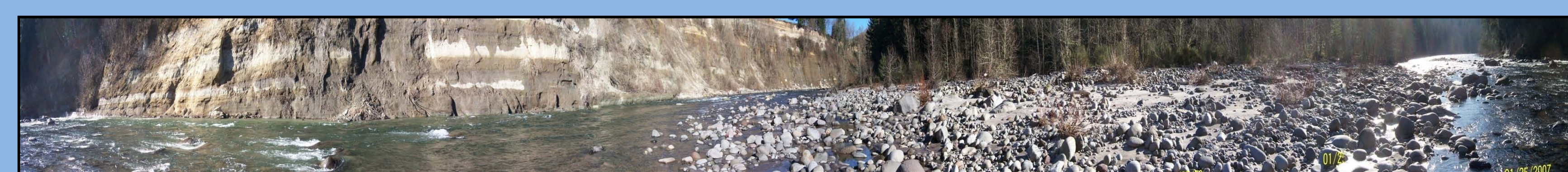
Siltstone | Claystone | Sandstone | Gravel conglomerate | Boulder-coble conglomerate

Introduction:

When the Marmot Dam was decommissioned in October of 2007, the release of the estimated 750,000 cubic meters of reservoir sediment provided a unique opportunity for geomorphologists to monitor the changes the massive sediment supply would inflict on the Sandy River, OR. Crucial to this venture is the "sediment budget." To track the reservoir sediment successfully, geormorphologists first must know what other sources are contributing significant amounts of sediment to the Sandy River. For this reason, the soil horizons and geologic formations adjacent to the river must be taken into consideration.



1660 m^3 landslide on cliff face



Panoramic: January 25th, 2008

Panoramic: May 14th, 2008

Panoramic: July 24th, 2008

Objective:

- Create a basic stratigraphic column of the lithology of a prominent cut bank cliff in a key reach.
- Make qualitative estimates concerning the bedload contributions of local geologic layers and advise the sediment budget accordingly.

Methodology:

- To make the **stratigraphic column,** the lithology of each strata had to be identified. This required observation with binoculars, swimming across the Sandy River to collect samples of landslides, taking detailed field notes, taking pictures of distinguishing features, and avoiding falling rocks. The top 12 meters were too high to obtain samples in situ. However the sediment stuck to the root systems of many fallen trees provided a way to sample the 3 meters underlying the "O" soil horizon; and by noting the color and location of fallen debris on higher parts of the landslides, it was possible to sample every layer.

- To **make an estimate** for bedload contribution being released, fixed annual panoramic photos near the cut bank cliff showing landslide creation, progression, and winter flow transport, were taken and analyzed with simple geometry. Next, using the height and grain size data that the stratigraphic column provided, a basic understanding of the **percentage of eroding sediment** contributing to bedload was ascertained.

- To **estimate the significance and magnitude** of sediment contribution, satellite/aerial photos of the specific reach were compared in ArcGIS to show the extent of movement and change in the cut bank cliff.

Analysis and **Conclusions**:

Landslides of lower cliff strata do not contribute to bedload. They do however weaken the cliff by undercutting. Every landslide is not a consistent mixture of every geologic layer. In fact, the larger landslides tended to be *mostly* sand, gravel, cobble, and boulders, overlying an undisclosed and *smaller* percentage of claystone and siltstone fragments. **Therefore, in the case of this cut bank cliff, landslides that provide large quantities of sediment to the river contribute much more to bedload sediment than to suspended sediment.**

In 2008, the cut bank cliff contributed 840 cubic meters of sediment to the Sandy. Only 49% of this can be considered for bedload calculations, leaving roughly 400 cubic meters. Four hundred cubic meters is only 0.053% of the mobilized Marmot Dam reservoir sediment. In May of 2009, a landslide with a volume of 1660 cubic meters, nearly doubled the 2008 contributions, leaving 800 cubic meters of bedload sediment amounting to 0.106% of the Marmot Dam reservoir sediment.

Comparing a georeferenced US Geological Survey aerial photo from 1995 with the most current photos of the cut bank cliff reveals that the Sandy River may have eroded through 30 meters of low river bank and close to 20 meters of an upstream portion of the cut bank cliff. The total volume of bedload sediment from this erosion would be:

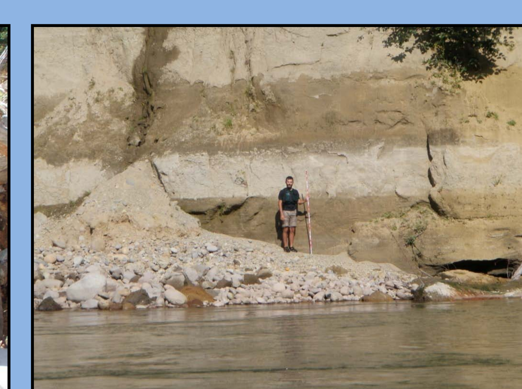
$$(3{,}000\ m^2)(29.5\ m)(0.49) = 43{,}365\ m^3$$

Spread out evenly over thirteen years this supposed sediment release of 3335 m^3 per year is a meager 0.44% of the entire Marmot Dam reservoir sediment budget.

To fully assess erosion's potential for affecting the Marmot Dam sediment budget a thorough analysis of other cut banks and cliffs adjacent to the river in every reach of the study could be conducted. However, because the other reaches do not have as prominent cliff faces as this project's reach, in all likelihood their bedload contributions would be lower.

Due to the large size of the Marmot Dam sediment budget and the short time span of the ongoing study on the Sandy River, it's not advisable to consider cut bank cliff erosion as raising the Marmot Dam study's uncertainty by any significant amount.

Fallen tree root system filled with sediment; hammer for scale



Gabriel using a pocket-rod for scaling the panoramic photos

Glaciofluvial gravel-pebble conglomerate; hammer for scale

Boulders and cobles from a large landslide; hammer for scale

Special thanks to the National Science Foundation for supporting summer research experiences for undergraduate and graduate students at the St. Anthony Falls Laboratory