Channel Initiation Processes in Basalt and Sandstone Lithologies in Southwest Washington

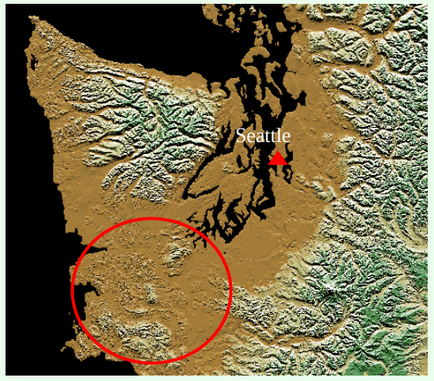
Abstract No. 3552

Kristin L. Jaeger and Susan M. Bolton
Center for Water and Watershed Studies, University of Washington
Seattle, Washington 98195
kljaeger@u.washington.edu

Introduction

A persistent problem for managers of headwater streams has been accurately identifying where these headwater channels begin on the hillslope and determining the physical extent of the channel network. Past research has found that local valley slope is inversely related to the contributing source area upslope of the channel head (inverse source area-slope relationship). Specifically, source areas decrease as the local gradient steepens.

This project compared channel head locations in streams underlain by two different lithologies, basalt and sedimentary. In addition, observations were made on seasonal changes in surface water expression in the streams occurring within the two bedrock types. Results from this study provide insight into channel initiation processes within steep, forested headwater systems.



Site Description

The study sites are located within the Willapa Hills region in southwestern Washington, which includes both basalt and sedimentary lithologies. The Capitol Forest site, Deadwood site, and a portion of the Trap site, are mapped as the Crescent Formation, a fine-grained, fractured, lower Eocene era basalt (~ 48 million years old). The Lonely Ridge site and the majority of the Trap site are mapped as the Astoria and McIntosh Formation, respectively. Both formations are poorly cemented, lower to middle Miocene era (25 million years old) and middle to upper Eocene era (37 million years old), sedimentary marine siltstone and sandstone.

The sites are located on active timber land, with a stand age of approximately 50 years. The topography is steep, with gradients of 30% to 40%. Average ridgeline elevations are 750 meters above sea level. Normal average annual precipitation ranges from about 200 cm to 230 cm at the Capitol Forest and Lonely Ridge sites, and 250 to 300 cm at the Trap and Deadwood sites.

Source Area-Slope Relationship

Hypotheses

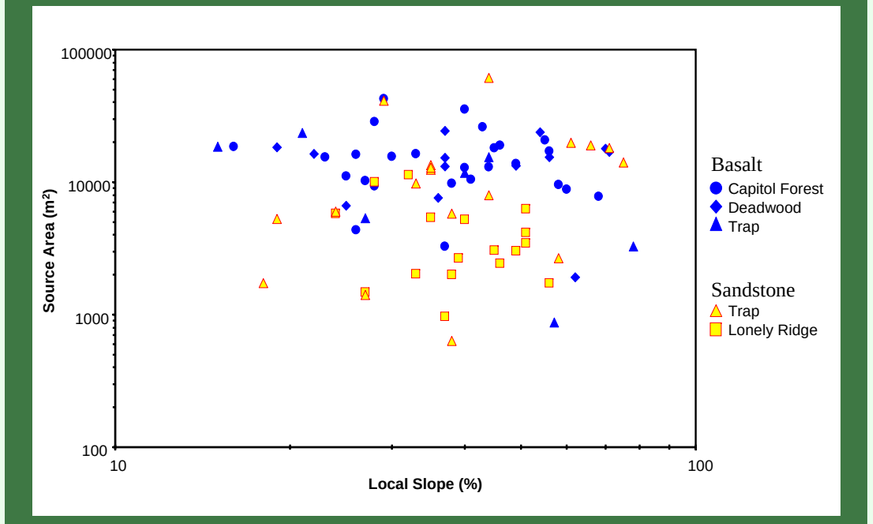
1. In sandstone, channel head locations are controlled by near surface hydrologic processes.
   - Subject to inverse source area-slope relationship
2. In basalt, channel head locations are controlled by underlying bedrock.
   - Not subject to inverse source area-slope relationship

Methods

- Field mapped channel heads using a high-resolution Global Positioning Systems (GPS) device.
- Field measured local slope at channel head.
- Delineated source areas in GIS using contour lines of 10 Meter DEM.

Results: Source Area vs. Local Slope

Channel Head Locations



No source area-slope relationship apparent at channel heads underlain by either sandstone or basalt. However, the geometric mean source areas in the two basalt sites Capitol Forest and Deadwood are approximately four times larger than the geometric mean source area at the Lonely Ridge sandstone site ($p<0.001$).

Geometric Mean Source Area

Basalt		Sandstone	
Capitol Forest	13700 m²	Lonely Ridge (Astoria)	3300 m²
Deadwood	12600 m²	Trap (McIntosh)	8200 m²
Trap Basalt	7400 m²		

Surface Water Expression

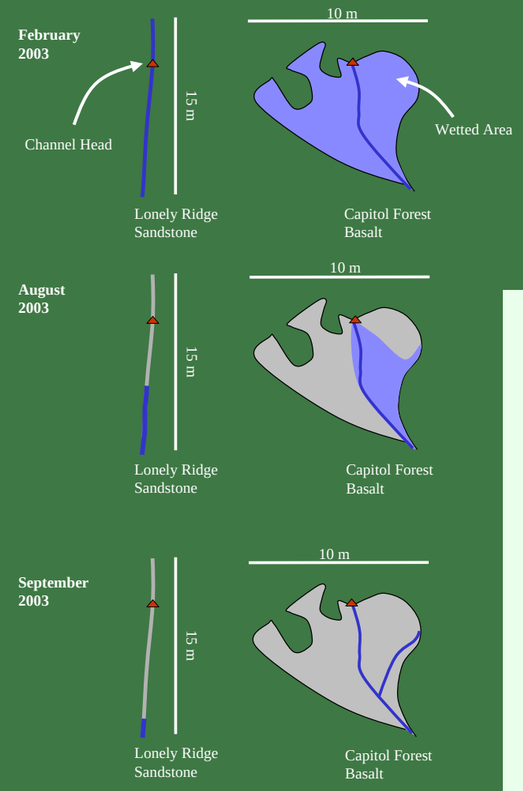
Hypotheses

1. In sandstone, channel head locations are controlled by near surface hydrologic processes.
   - Surface water expression will migrate downslope through the dry season.
2. In basalt, channel head locations are controlled by underlying bedrock.
   - Surface water expression will not migrate downslope through the dry season.

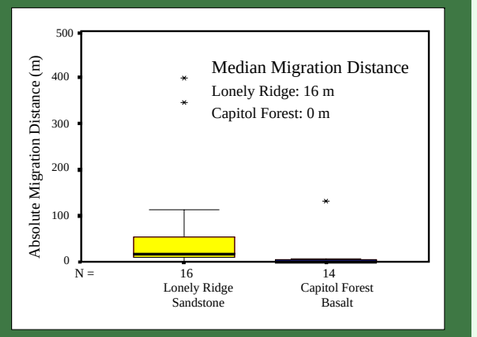
Methods

- Monitored the location of farthest upslope point of surface water expression in 16 sandstone streams (Lonely Ridge) and 14 basalt streams (Capitol Forest).
- Monitored from February through September 2003.
- Identified the Stream Head as the farthest upslope location of surface water presence during the driest time of year.

Results: Monitoring Observations



Seasonal Migration Distances of Surface Water



Mann-Whitney U test for equivalency shows two sets are not equivalent ($p<0.001$).

Monitoring observations revealed distinct differences in surface water expression between the sandstone and basalt sites. Surface flow in streams underlain by sandstone was confined to a 1-2 meter wide area extending within the channel or upslope of the channel head, and migrated downslope below the channel head during the summer baseflow period. In streams underlain by basalt, surface water generally expanded and contracted in a lateral direction around the channel head, rather than migrating downslope during baseflow conditions.

Conclusions

- Source Area-Slope Relation NOT evident for channel heads underlain by either sandstone or basalt.
- Downslope migration of surface water expression in streams underlain by sandstone suggests a near surface hydrologic control.
- Stationary location of surface water expression in streams underlain by basalt suggests a bedrock control.

Acknowledgments

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