Debris flow modeling

USGS debris flow flume at H. J. Andrews Experimental Forest

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Flume technical details are from U.S. Geological Survey Open-File Report 92-483, http://vulcan.wr.usgs.gov/Projects/MassMovement/Publications/OFR92-483/framework.html

One type of landslide common in Oregon is the channelized debris flow. Typically, a debris flow originates as a small, shallow landslide above a drainage channel and is triggered by intense rainfall, rapid snow or glacial melting, or volcanic eruption (lahar); the debris mixes with water already in the channel to become a slurry of water, rock, soil, and other organic material that can attain speeds greater than 10 m/s.

Debris flows can also initiate within a channel through erosion of channel sediment during times of increased water flow due to heavy rain or rapid snow or glacial melting. During rapid descent down the channel (commonly termed transport), debris flows can grow in size and speed. By the time a debris flow reaches the mouth of the channel, what started as a small shallow landslide may have grown into a potentially devastating, rapidly moving landslide that can cause major damage to structures and roads, change drainage patterns, and sometimes cause loss of human life (Figure 1) (Iverson and others, 1992).

Observations and measurements of naturally occurring debris flows are problematic. In 1991 the U.S. Geological Survey (USGS), motivated by Richard Iverson, constructed a flume (Figure 2) to conduct controlled experiments on debris flows. The flume is located about 72 km east of Eugene, Oregon, in the Cascades Range foothills in the Andrews Experimental Forest. USGS Cascades Volcanic Observatory (CVO) personnel, led by Iverson, perform experiments at the flume.

The flume is a reinforced concrete channel 95 m long, 2 m wide, and 1.2 m deep that slopes 31 degrees (60 percent), an angle typical of terrain where natural debris flows originate. Removable glass windows built into the side of the flume allow flows to be observed and photographed as they sweep past. Eighteen data-collection ports in the floor of the flume permit measurements of forces due to particles sliding and colliding at the base of flows.

To create a debris flow, up to 20 cubic meters (about 40 tons) of sediment are placed behind a steel gate at the head of the flume, saturated with water from subsurface channels and surface sprinklers, and released. Alternatively, a sloping mass of sediment is behind a retaining wall at the flume head and watered until slope failure occurs. The ensuing debris flow descends the flume and forms a deposit on a nearly flat runout surface at the flume base. The flume design thus accommodates research on all stages of the debris-flow process, from initiation through deposition. Experiments can be conducted using a variety of materials, from mixtures of well-sorted gravel and water to heterogeneous natural slope debris. Experimental materials are recycled by excavating deposits with a front-end loader, placing them in a dump truck, and hauling them back to the staging area at the head of the flume.

Experiments at the flume have expanded our understanding of debris flows and have increased development of computer models for interpreting and forecasting future debris flows in susceptible areas (Iverson and others, 1992). Some of these models were used to create lahar hazard zones for volcanic hazard maps (http://vulcan.wr.usgs.gov/Publications/hazards_reports.html). Experiments in September 2006 conducted at the flume through col-

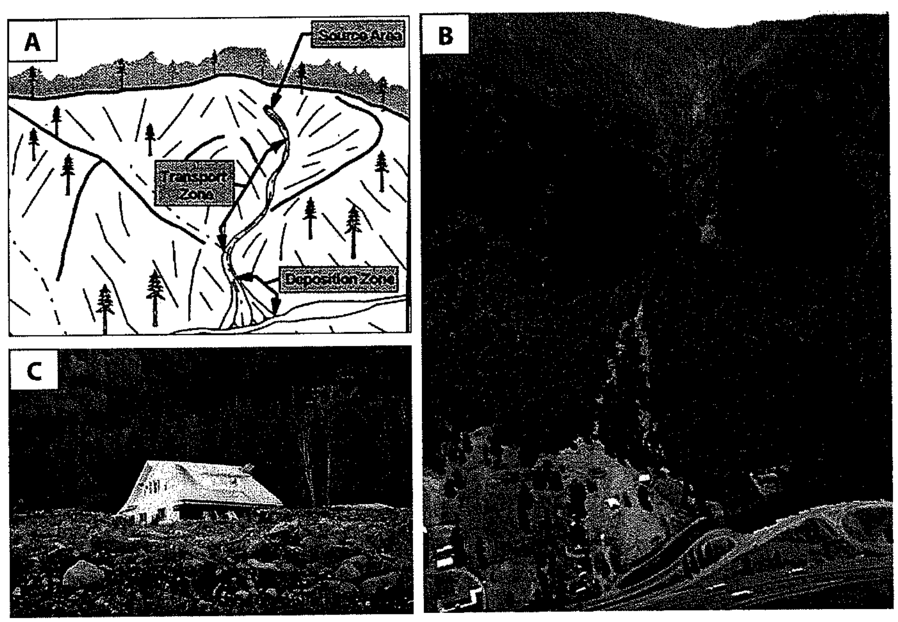

Figure 1. (A) Schematic diagram of debris flow zones including initiation (source area), transport zone, and deposition zone (Pyles and others, 1998). (B) Oblique aerial photograph of the Dodson, Oregon, debris flow of February 1996 in the Columbia River Gorge. (C) Photograph of a house buried by the Dodson debris flow (photograph courtesy of Kenneth Cruikshank, Portland State University).

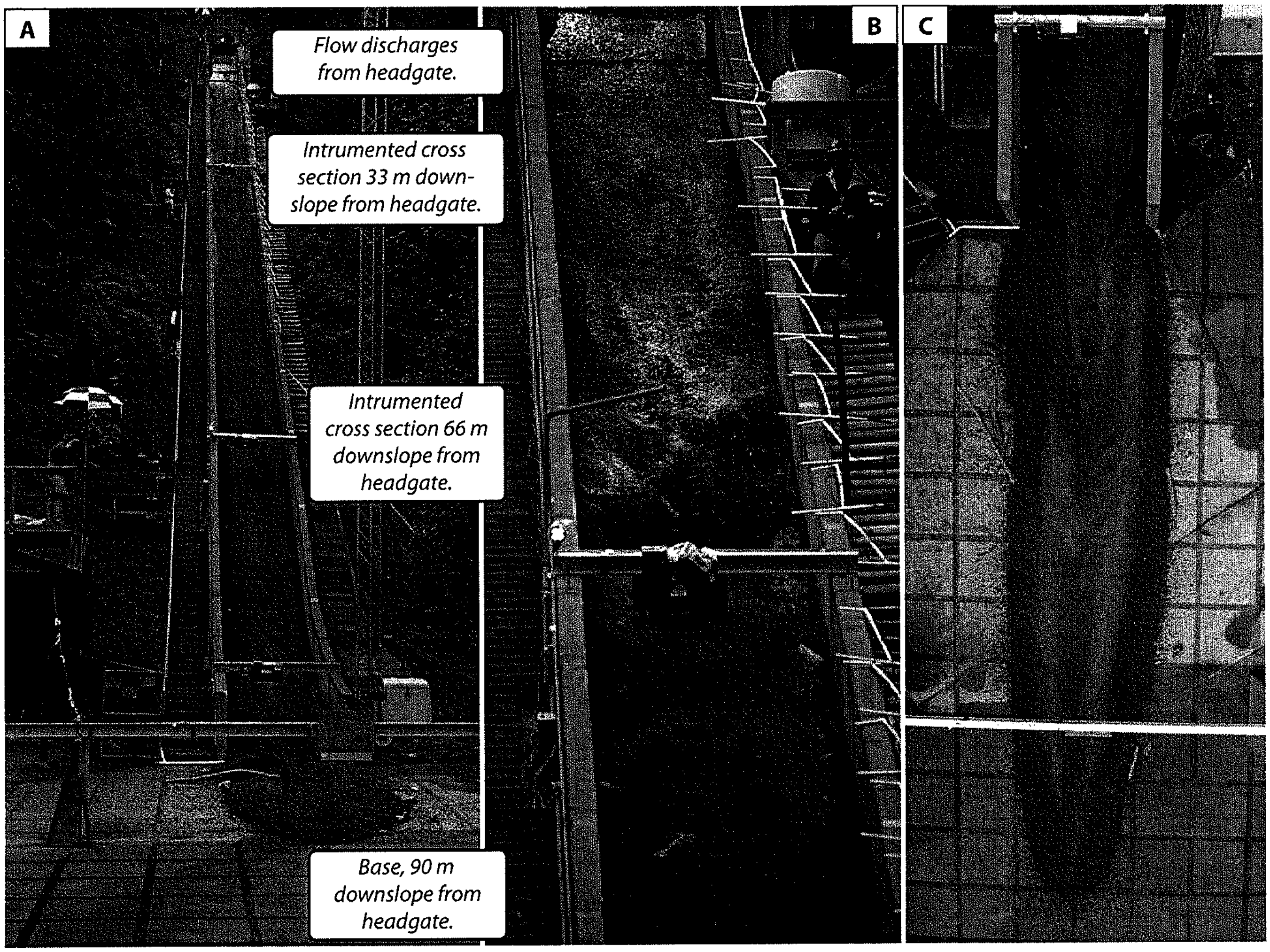

Figure 2. September 2006 debris flow flume experiment. (A) General flume setup and debris deposit, (B) flow front as it advances across the sediment-covered bed in the upper part of the flume, and (C) looking directly down at the deposit. (Photographs courtesy of Richard Iverson, USGS CVO.)

laborative research by the USGS Volcano Hazards Program and the USGS Landslide Hazard Program (LHP) were aimed at further understanding the entrainment phenomenon, or growth in size of debris flow, during transport. These experiments examined scour of wet sediment on the flume bed by an advancing debris flow. Sediment entrainment by debris flows, a common phenomenon in Oregon, creates larger flows. Entrainment processes are poorly understood but are critical to forecasting debris-flow impact velocities and inundation areas (Iverson and Reid, 2006).

The USGS LHP is working closely with Oregon state agencies in a 5-year program. The LHP is engaged in activities suggested in the National Landslide Hazard Mitigation Strategy and supports the Oregon Department of Geology and Mineral Industries (DOGAMI) to improve the level of landslide hazard mitigation in Oregon (USGS, 2006).

One of the goals of this partnership is to increase our understanding of debris flow hazards in Oregon and to reduce long-term losses from these hazards. One of the most successful regional ways communities in Oregon have begun to reduce future losses is through the creation of hazard maps tied to codes or ordinances requiring detailed site-specific studies and mitigation design prior to future development in hazard areas (Iverson and Reid, 2006).

References

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