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Computational fluid dynamics of paleoglacial lake: reconstruction of Glacial Lake Missoula

Petteri Alho (1), Victor Baker (2), and Larry Smith (3)

(1) University of Turku, Department of Geography, Turku, Finland (petteri.alho@utu.fi), (2) Department of Hydrology and Water Resources, University of Arizona, USA (baker@email.arizona.edu), (3) Department of Geological Engineering, Montana Tech University of Montana, USA (LSmith@mtech.edu)

Glacial Lake Missoula (GLM) was source of Earth's largest known peak flood discharges on Channeled Scabland, northwestern United States. Recent studies have emphasized the computational fluid dynamics of downstream megaflood routing and characteristics in the Channeled Scabland and adjacent areas. A one-dimensional numerical model has been utilised, combined with field evidence and radiocarbon age dating, to study the magnitude, frequency and chronology of late Pleistocene Missoula floods in Columbia River valley between the Pasco Basin, Washington, and Portland, Oregon. The one-dimensional numerical modeling approach is appropriate for a confined valley environment, such as Columbia River valley, where the majority of flood flow path is in one direction along the valley trend. However, flow branching, bifurcation, and reintegration of flood flow paths, as occurred during GLM drainings, are not adequately resolved by a one-dimensional approach. Therefore, multidimensional numerical assessments for cataclysmic megaflood reconstructions of the Channeled Scabland area were also employed. These studies consist of on a simple numerical code for a two-dimensional, pure water model based on the shallow-water equations and the semi-analytically and empirically derived friction coefficient. Their code enables shorter computation times and better exploration of parameter space than can be achieved with three-dimensional treatment of the flow. A similar approach has been used to analyze the central Asian paleolake drainages of the upper Yenisei River catchment in the Sayan Mountains.

The outburst flooding from the GLM is commonly taken to be the primary source for the megaflooding that is documented in the late Pleistocene landforms and sediments of the Channeled Scabland and along the Columbia River valley. The original studies of GLM were based on geomorphological mapping of lake sediments and shorelines. However, details of the lake-draining processes for GLM have received little scientific attention.

We will employ two-dimensional depth-averaged hydraulic modeling to understand the paleoflow conditions for different scenarios of draining Glacial Lake Missoula at its largest high stands. Our chosen scenarios employ lake outflow hydrographs (discharges of 2.6; 13; 17x106 m3 s-1) that were proposed by previous studies. These hydrographs were quantified from downstream geomorphologic evidence or from glaciohydrological principles. Our modeling predicts the water velocities and depths within the basin that could produce the postulated magnitude and duration of flows indicated by these hydrographs near the lake outlet. Modeled flow conditions within the complex bathymetry of the glacial lake are compared to the published stratigraphic and geomorphologic evidence for the Lake Missoula drainage event(s) in order to estimate the actual magnitude of the largest draining(s) of Glacial Lake Missoula and to understand the origin and genetic significance of various landforms and sediments associated with GLM and its drainings.

Consistent with previous regional mapping and with the original interpretation, the modeling shows that lake silt sequences in the basins and narrows areas of GLM must postdate the most highly energetic outburst events from the lake. This is because the flows generated in the lake by megaflood outflows are sufficiently energetic to erode any accumulated silt deposits. In contrast, the gravels underlying the silts include boulder-sized clasts, large-scale cross stratification, and 70-100 m-high bars forms, all of which indicate very high-energy flood-flow conditions. The model shows that flow conditions during the largest megaflood outflows would be capable of accounting for the observed bedrock scour, various eddy bars of flood gravel in narrows zones, and the subaqueous gravel dunes. The model also suggests that these inferred events must have been relatively low in energy relative to the earlier outburst(s) that emplaced the flood gravels, giant current ripples, and scabland-like erosion surfaces.