

When glaciers meet lakes: reassessing the behavior of glaciers that terminate in lakes based on multibeam bathymetric surveys

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Glaciers often terminate in lakes, where they may form prominent moraines, and are considered relatively stable. During the Little Ice Age (LIA: ca 1300-1900AD), strong regional cooling across the northern North Atlantic led to widespread glacier advances. At its peak, summer temperatures in Iceland are estimated to have been 3 to 4 °C lower than during the early Holocene optimum (Björnsson 1979), or about half the amplitude of the full glacial/ interglacial temperature change for most of the rest of the world. The dramatic impact of the LIA on Iceland is explicit in both historical accounts describing prominent advances of glaciers and sea ice formation (i.e. Ogilvie 1991, 1992), resulting in degradation of vegetation and famine. The LIA moraines in Iceland represent the most advanced ice margins since regional deglaciation. One of the sites reflecting this cooling is the glacial lake Hvítárvatn, which sits beneath Langjökull the second largest ice cap in Iceland. LIA moraines are prominent around two of Langjökull outlet glaciers that calved into the lake at the peak of the LIA and until the 1950's.

To evaluate the impact of LIA outlet glaciers on sedimentation in Hvítárvatn, and whether their terminal positions marked a stable equilibrium state, we collected high-resolution multibeam bathymetric data from the lake in 2005. Combined with seismic reflection profiles and sediment core data from the lake, the multibeam data enhance our understanding of sediment distribution and processes in the lake during the Holocene and glacier stability/instability and their link to climate change during the Little Ice Age. The bathymetric data indicate that the northern glacier remained at its terminal position for many decades, forming a large terminal moraine related to a hyaloclastite bedrock ridge. The southern glacier exhibits very different behavior. It did not form a terminal moraine, and bathymetric features clearly define a fundamentally unstable behavior, with large sections of the terminus breaking off at different times during the LIA.

We suggest that the stability of glaciers terminating in lakes is controlled by different factors than for glaciers that terminate in the ocean. Stability is strongly influenced by lake-floor characteristics; bedrock structures facilitate stabilization, whereas thick soft sediment facilitates sliding and instability. Because lakes are effectively closed systems, iceberg production can easily exceed iceberg melt, and as the lake is filled with icebergs, these act to stabilize outlet glaciers. Our results suggest that in some settings, glaciers terminating in lakes may be inherently unstable.

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