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Assessing the Role of Outburst Floods in the Formation of the Lower St. Croix River Valley, MN/WI, USA

Hunter Delikowski[1,2], Grace Uchytil[1,2], Jayda Rowen[1,2], Abigail Fischer[1,2], Phillip Larson[1,2], Mark Johnson[3], Douglas Faulkner[4], Garry Running[4], Tammy Rittenour[5], Andrew Wickert[6], Andy Brown[1,2], Zachary Hilgendorf[4], and Ronald Schirmer[1,2]

[1]Earth Science Programs, Department of Anthropology and Geography, Minnesota State University, Mankato, Mankato, MN, USA

[2]EARTH Systems Laboratory, Minnesota State University, Mankato, Mankato, MN, USA

[3]University of Gothenburg, Department of Earth Sciences, Gothenburg, Sweden

[4]Department of Geography and Anthropology, University of Wisconsin-Eau Claire, Eau Claire, WI, USA

[5]Department of Geosciences, Utah State University, Logan, UT, USA

[6]Department of Earth & Environmental Sciences and Saint Anthony Falls Laboratory, University of Minnesota, Minneapolis, MN, USA

A burgeoning theme of research has focused on overflow and outburst flood events in reorganizing drainage basins, creating new fluvial landscapes and transverse drainages. Generalized conceptual ideas may not fully grasp the complexity of real proglacial and deglacial landscapes, making these landscapes important to examine. The St. Croix River valley (SCRV), MN/WI, USA, and its drainage basin contain well understood glacial geology, and the complex evolution of SCRV is largely the result of dyssynchronous advance and retreat of the Superior Lobe and Grantsburg Sublobe through the SCRV basin. Several proglacial lakes formed in and surrounding the SCRV, including Glacial Lake Duluth (GLD) in the Superior basin and Glacial Lake Grantsburg (GLG) at the margin of the Grantsburg Sublobe. Prior research identified multiple high-magnitude meltwater flood spillways that drain into the SCRV that formed between ~22–10.6 ka. However, these floods are not well constrained in terms of process, magnitude, and timing. Thus, the landscape evolution of the SCRV fluvial system remains poorly understood.

We focus on a specific reach of SCRV through which all high-magnitude meltwater discharge was routed. This reach contains numerous terraces, abandoned paleovalleys, a transverse reach and bedrock canyon, and an anomalously high and extensive terrace-like surface called the Osceola Bench (OB). We compile pre-existing data and add ground penetrating radar (GPR) data, describe sediments extracted with hand augers and a Geoprobe, date sediments with optically stimulated luminescence (OSL), and interpret sediment geochemistry using X-ray fluorescence (XRF). In addition, we map landforms using LiDAR DEMs and aerial imagery. We identify alluvial terraces and paleovalleys that step down from the OB towards the modern river. GPR results from OB and adjacent terraces reveal a horizontally continuous and shallow (<2.5 m) reflection. We interpret this to be a strath beneath alluvial sediments. Hyperbolic and inclined reflections within the alluvial sediments capping these landforms are interpreted as large clasts embedded within cross-

bedded sands and gravels – supported by augering/coring that encountered large boulders within deposits of sand and gravel. These landforms were capped by a silt to sandy loam that commonly fines upward. We interpret these sediments as being deposited during waning stages of high-magnitude flows.

We hypothesize OB was formed by catastrophic outflows from GLG (sometime between 16.3-13.6 ka), released as the Grantsburg Sublobe retreated westward. Sculpted bars on OB indicate a northeastern source and likely outlet of GLG. Strath terraces and incised paleovalleys inset into the western margin of OB step down towards the river, providing evidence for a progressive westward shift in meltwater flow and valley incision that mirrored retreat of the Grantsburg Sublobe. Incision does not appear to have reached the modern river level, suggesting later flows from GLD punctuated GLG incision. GLD flows are likely the primary cause of bedrock incision across the transverse reach at St. Croix Dells (between 13.6-10.6 ka). This superimposed sequence of top-down drainage events demonstrates the complexity of drainage-basin evolution in deglacial settings and emphasizes the need for field-based investigations to develop more comprehensive models of drainage basin evolution and integration.