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The sedimentological impact of three extreme floods on the Assiniboine River, southwestern Manitoba

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Summary

Extreme floods – high magnitude, low frequency events - have the potential to cause significant geomorphic change on meandering rivers. However, the extent to which geomorphic change and the deposits associated with extreme floods differs from that of low-to-moderate magnitude, annual floods in the sedimentary record is unclear (Sambrook Smith et al., 2010; Gomez et al., 1995; Heitmuller et al., 2017). Therefore, high-magnitude flood events may be difficult to identify in the sedimentary record. The objective of this research is to identify sedimentary products of high-magnitude flooding on meandering rivers to improve recognition criteria for similar events in the stratigraphic record. Our research characterizes the impact of three >250-year-reccurrence-interval floods that have occurred on the Assiniboine River in the past decade, which have resulted in substantial geomorphic change and significant sedimentation along several meander bends of the river (Fig. 1).

The Assiniboine River is a meandering river that is 1070 km long, on average 95 m wide, with a depth that ranges from 4.75 m to 6.3 m. The average baseflow is between 45 m^3/s and 56 m^3/s. During the summer of 2020 and 2021, excavations on two point bars (Fallen Tree and Winter Rec; Fig. 1) characterized the sediments deposited over the last decade. In addition to trenches, surface grain-size measurements were collected to map the grain-size distribution around the meander bends. These field measurements are combined with satellite imagery that allowed for direct mapping of geomorphic change along the river channel through time, from pre-2011 flood to 2020 (Fig. 1). The Fallen Tree point bar has migrated approximately 350 m at its bend apex since 2011, a migration rate of approximately 40 m per year (Fig. 1). The Winter Rec point bar has migrated approximately 290 m at its bend apex over the same time period, resulting in a migration rate of approximately 30 m per year (Fig. 1). Meander-bend migration is episodic, with little to no migration occurring during low magnitude annual flows and significant migration, in excess of 5 m, resulting during each of the three extreme floods. occurring following the extreme flood events. Recent deposits of both point bars are characterized by cross-stratified sand and gravel deposited as subaqueous dunes associated with unit bars (Smith, 1974; Bridge, 1995), capped by up to 20 cm thick mud drapes associated with waning flood conditions. The deposits attributed to the 2011 and 2014 extreme floods have a unique coarsening-upwards trend that differs from the typical vertical facies profile for point bars (Allen,1970). Generally, beds increase in thickness with depth. Dune foresets indicate flow was directed downstream and across the bar, with little to no evidence of helical flow directed up the bar. The surface grain size measurements demonstrate fining downstream and coarsening with distance from the active channel trends (Fig. 2). In the case of the Assiniboine River, we see little to no preserved evidence of lower magnitude annual floods over the last decade, which is consistent with satellite image observations and a lack of channel migration.

The results of this study contribute to our understanding of the sedimentological impact of extreme floods, particularly when multiple extreme floods occur in a short time span, which may help identify these events in the sedimentary record. The results suggest that extreme flood deposits may have a unique coarsening-upward trend, and that silt and mud deposits can be preserved in coarse-grained fluvial environments even following extreme floods. Further, this research along with future work may help to limit the impact of future floods events on property and infrastructure by quantifying morphological change over time in response to extreme floods.

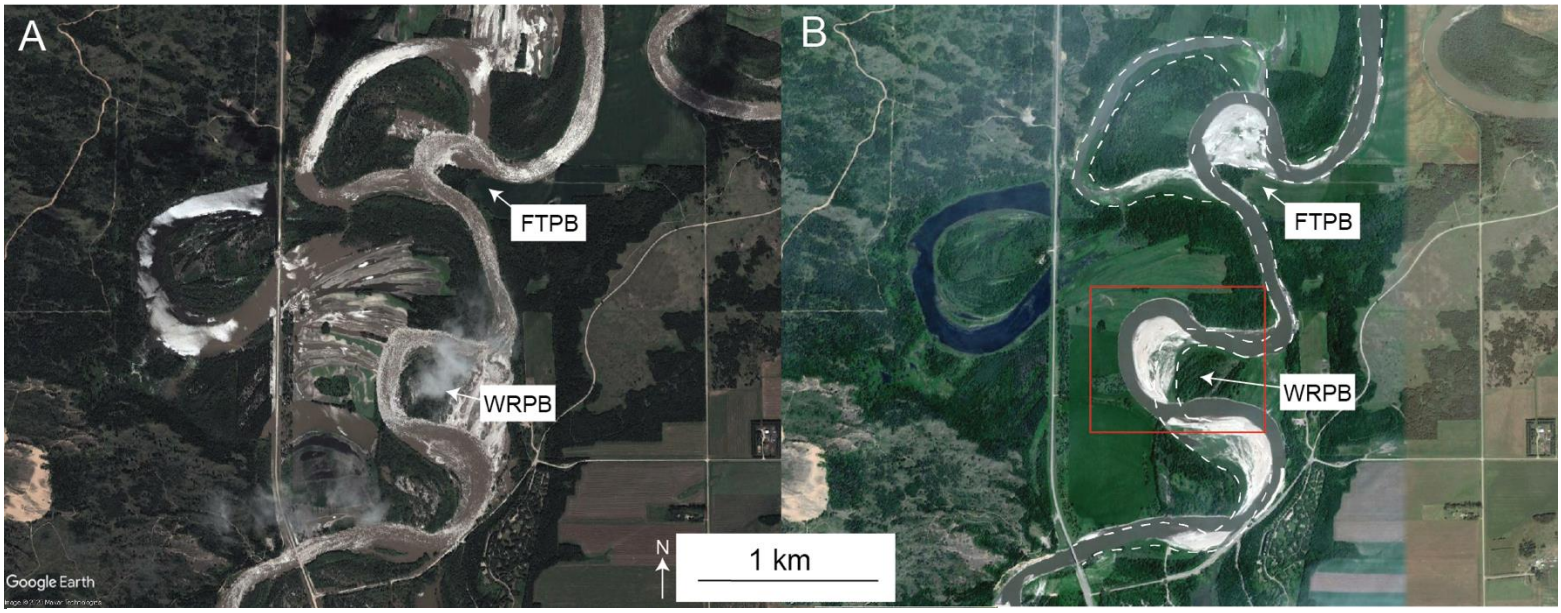

Figure 1. The geomorphic change of two point bars, Winter Rec Point Bar [WRPB] and Fallen Tree Point Bar [FTPB], on the Assiniboine River from (A) July 2011 to (B) September 2017. Red box indicates the location of Fig 2.

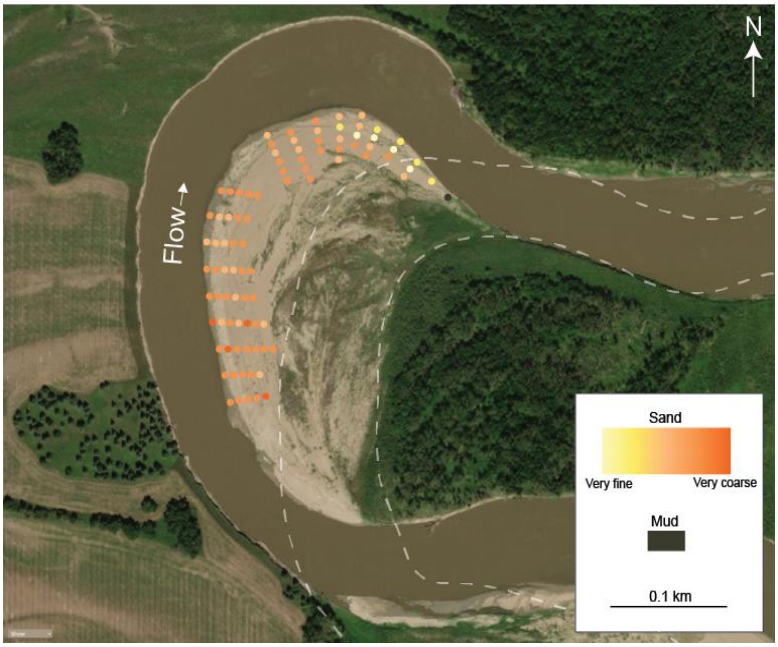

Figure 2. Surface grain size measurements of Winter Rec Point Bar (Location indicated by red box in Fig. 1). White dashed line indicates location of the channel in July 2011.

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