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Suspended sediment dynamics in the forefield of the rapidly deglaciating Castle Creek Glacier, British Columbia

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Purpose: In British Columbia (BC), Canada, glaciers cover about 3% of the landmass influencing 20% of the watersheds, and most of these glaciers are presently retreating. We examine sediment dynamics within the proglacial zone of Castle Creek Glacier, BC, which has retreated 1.2 km in the past 50 years. The suspended sediment load of rivers draining basins with more than 1% glacial cover is higher than the global average. Glaciers are sensitive climate change indicators that respond to temperature and precipitation. Sediment loads during deglaciation can be higher due to elevated meltwater runoff interacting with recently exposed unconsolidated glacial till by the retreating snout.

Methods: Suspended sediment concentration and stream flow were monitored at six stations within the alluvial controlled proglacial zone for 60 days from 14 July – 11 September, 2011 to determine suspended sediment flux. Automatic water samplers, pressure transducers and turbidity probes were deployed, and 776 synchronous water samples were analysed for their suspended sediment concentration (SSC). Field calibration curves were established for each turbidity probe, and rating curves were developed to estimate discharge (Q) for each stream gauging station. Suspended sediment loads (SSL) were computed for each site from independent 5 minute SSC and Q data. Principal Component Analysis and Cluster Analysis was used to categorize meteorological conditions, hydrometric conditions and the shape and magnitude of suspended sediment load for each hydrologic day of the study period.

Results and conclusions: During Hot and Dry conditions, 64 % of the total SSL came from the proximal stations, and 13 % of the SSL was stored within the proglacial channel upstream of the distal station. During Cold and Wet and Warm and Damp conditions, ca. 60 % of the SSL was from the proximal stations and there was a net storage of sediment within the proglacial zone. There were two storm days that accounted for 7 % of the stream flow and 20 % of the SSL for the study period. The sediment load increased at all sites during storm events, however, the contribution from the three proximal sites dropped to 43 %, and 35 % of the total load was derived from exposed proglacial sediments and transported into the channel by ephemeral channels between the middle station and the distal station. For 80 % of the study period, the proximal stations contributed the majority of the SSL (ca. 58%) to the stream, and there was net storage (2 – 13 %) within the active proglacial channel network. Exposed sediment within the proglacial zone is a significant source of sediment during intense storm events, but is generally transport limited and disconnected from the stream network. These results show that meltwater from the glacier and area immediately proximal to the retreating ice are the dominant source of sediment in proglacial channels, while the diffuse sediment that is available in proglacial zone is only entrained by episodic events. We can expect elevated SSL to continue until deglaciation is complete, and for episodic fluvial events to continue to entrain proglacial sediments into the stream network over the paraglacial period.

KEYWORDS: suspended sediment; proglacial; British Columbia; turbidity; sediment sources