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The complex behavior of the Cordilleran Ice Sheet and mountain glaciers to abrupt climate change during the latest Pleistocene

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Surficial mapping and more than 70 radiometric ages ^{10}Be, ^{14}C] constrain the evolution of the Cordilleran Ice Sheet (CIS) and associated mountain glaciers in western Canada during the latest Pleistocene. Our data suggest that: i) there is widespread evidence for the Younger Dryas (YD) throughout the mountains of western Canada; ii) late Pleistocene climate reconstructions based solely on alpine moraines may be misleading in regions with decaying ice sheets; iii) extensive interfluves in some mountain regions were ice-free between 16 ka and 13 ka (kilo calibrated yrs BP). Initial decay of the CIS from its maximum extent around 16 ka was likely due to a combination of climatic (surface melting) and dynamical factors. Climate amelioration during the Bølling-Allerød Warm Period [14.7-12.9 ka], likely the cause for the major phase of CIS decay, resulted in ice sheet equilibrium line altitudes (ELAs) ranging from 2500 m asl in southern BC to around 2000 m asl along the BC-Yukon border. Hence, before the onset of the Younger Dryas (YD) Cold Period [12.9-11.7 ka], the ice sheet shrank and became a labyrinth of individual and coalescing valley glaciers fed by major accumulation zones centered on the Coast Mountains and other high ranges of NW Canada. The response of remnant ice and cirque glaciers to the YD climate deterioration was highly variable. In some cases, small glaciers (0.5-2 km^2) built YD moraines that were only hundreds of meters beyond those constructed during the Little Ice Age (LIA) [0.30-0.15 ka]. Our dating also reveals that much larger glaciers persisted in nearby valleys that lie hundreds of meters below the cirques. Hence, we infer that many cirques were completely deglaciated prior the YD, in contrast to low-lying valleys where ice sheet remnants persisted. Glaciers also advanced in north-central British Columbia during the YD, but here glaciers constructed large terminal and lateral moraines. In the Cassiar and northern Coast mountains, for example, 25 ^{10}Be [13.10-12.00 ka] and four minimum-limiting ^{14}C ages from lakes impounded by moraines show that glaciers existed up to 10 km beyond LIA glacier limits during the YD. These glaciers thus had ELAs that were 300-500 m lower than contemporary glaciers. We are currently performing high-resolution ($<$1 km) experiments using ice sheet models (PISM and UBC regional glaciation model) to test our field-based hypotheses of how the CIS decayed. Preliminary results confirm a complex pattern of ice sheet decay; initial decay is followed by advance of individual lobes of the CIS, expansion of detached and isolated trunk glaciers (north-central British Columbia) and regrowth of high-elevation cirque glaciers (Coast, Rocky, northern Cassiar, and St. Elias mountains).