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Glaciovolcanism in the Canadian Cascade volcanic arc: a powerful proxy for ancient ice

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Volcanoes that interact with the cryosphere preserve indicators of their eruption environments. These glaciovolcanoes and their deposits are potential proxies for both local and global paleoclimates. The Garibaldi volcanic belt (GVB) is the northern (Canadian) segment of the Cascade volcanic arc of western North America. We present a comprehensive database of >100 Quaternary volcanic landforms and deposits in the GVB that incorporates new, high-resolution field mapping and 40Ar/39Ar geochronology. The GVB exhibits a high degree of volcanic diversity; a significant component of which is due to the abundance of glaciovolcanoes. These landforms include: tuyas, tindars, subglacial tephra cones, ice-impounded lavas, subglacial domes and breccias, subglacial lava flows and lava-dominated tuyas. The volcanoes are well distributed in space and time, and incorporate a wide range of magma compositions (alkaline basalt to rhyolite). As a group, they inform the spatial-temporal distribution of both continental-scale ice sheets (i.e. the Cordilleran ice sheet) and local glaciers, that have waxed and waned in thickness and extent across the region. We demonstrate how forensic volcanological studies can be used to constrain paleo-ice distributions by establishing: i) the presence or absence of ice during eruptions, ii) the age of corresponding ice (determined by isotopic dating of the lavas), and iii) ice thickness and ice surface elevation. In some instances, the volcanological data can even establish the hydrological conditions and basal thermal regime of the ice. We use our database to define a terrestrial-based reconstruction of the thickness and extent of the Cordilleran ice sheet and local glaciers in southwest British Columbia that spans the latter half of the Quaternary (i.e. <1 Ma). A key element to the reconstruction is a preliminary numerical strategy we use to model, extrapolate and visualise the extent and nature of the ice cover. Lastly, we compare our reconstruction to established proxies for global glacial extents (e.g. the Marine Isotope Stages record) and show both positive correlations and discordances. Our work shows glaciovolcanoes to be a significant, and vastly underutilized, tool for reconstructing the spatial-temporal distributions of ice sheets predating the last glaciation. On this basis, they offer an important additional proxy for Earth's paleoclimate.