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# Relative cooling rates derived from basalt column geometries

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Columnar joints form as a brittle relaxation response to tensile stresses that accumulate during cooling of lava flows, pyroclastic deposits, and intrusive magma bodies. Columnar jointing forms in different deposit types, in deposits of different compositions, and different outcrop geometries. Despite this diversity, columns follow a few “rules”: column diameter is inversely proportional to cooling rate (small/quick cooling times, small diameter columns), columns only ever coalesce (never bifurcate), and columnar joints always propagate parallel to but in the opposite direction of heat flow (towards the hottest part of the flow). Using these “rules,” cooling histories and emplacement environments can be reconstructed.

While column geometries and definitions of various columnar structures vary between authors (upper and lower colonnade and entablature vs. master cracks and pseudopillows), this study focuses on relatively simple outcrops of basalt lava within the Cheakamus River valley near Whistler, BC, Canada. The basalt lavas described here, thought to have erupted subglacially, contain columns comprising only well-defined upper and lower colonnades (i.e. no entablature). Comparing the relative thicknesses of upper and lower colonnades reveals the cooling history, relative cooling rates, and amounts of heat transferred from the upper and lower flow boundaries.

Forward numerical models using the finite element method are created with Matlab using the Partial Differential Equation Toolbox to model the outcrops in the Whistler field area, and determine the cooling rates and thermal gradients experienced by the lava flows during their formation. This study finds that noticeable differences in the thickness of upper and lower colonnades within an outcrop occur only when there are large differences in cooling rates between the upper and lower flow surfaces. Modeling shows that the cooling rates must differ by approximately an order of magnitude to produce the observed colonnade thicknesses. Possible explanations for the extremely asymmetrical cooling rates, including lava-ice interaction, are discussed.