# Structures, textures, and cooling histories of Columbia River basalt flows

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Abstract

Flood basalt flows of the Columbia River Basalt Group commonly exhibit well-developed colonnade and entablature structures formed during cooling of individual flows. The colonnade refers to the well-defined columnar structure of many flows, which appears in the lowermost 10% to 30% and, in places, the uppermost 10% to 20%. Entablature refers to those parts of a flow that have smaller column diameters and more irregular pattern fractures than those of colonnade. Entablature commonly occupies the central 60% to 70% of a flow. In some cases, however, the entablature is interrupted by colonnade; in such cases, the entablature and colonnade may be repeated once or twice within a single flow. In other cases, flows may lack an entablature entirely.

Petrographic examination reveals a pronounced correlation between structural and textural features. Thin sections of colonnade basalt have relatively coarse cruciform or octahedral Fe-Ti oxide crystals and ~20% glassy mesostasis. The central entablature basalt, in contrast, has much more mesostasis (as much as 60%) and has textural features such as feathery Fe-Ti oxide crystals indicative of more rapid cooling. These features are the reverse of what might be expected for normal conductive

cooling because cooling rates at the flow margins should be greater than those in the flow interior. We reconciled the observed basalt textures with thermal models by taking into account rainfall and deranged drainage during crystallization of the flow. Downward migration of water through cracks would cause convective cooling of underlying, unsolidified lava. This effect and its consequences have been modeled numerically in order to clarify the physical constraints on the mechanism by which the central part of the lava can be quenched. We have found that a water infiltration front can explain the presence of a thick, quenched, flow interior, provided that the infiltration front moves downward just behind the lava solidification front. Despite heavy rainfall on Hawaii (for example, ~250 cm/yr at Kilauea Iki), exposed, prehistoric lava flows on that island exhibit only colonnades. We deduce from this that heavy rainfall alone is inadequate to quench flow interiors. Extensive flooding by deranged drainage, or perhaps extremely heavy rainfall (>>250 cm/yr), is apparently required to produce entablatures.

The model also can be used to explain the occurrence of repeated entablature and colonnade by considering the effects of intermittent inundation. The imposition of boundary conditions that mimic the removal and reoccurrence of flooding yields cooling histories that are consistent with the development of multiple colonnades and entablatures.