How To Form Columnar Jointing: The Effect of Crystallization

Nakatake, Genki (School: Miyazaki Nishi High School)

Columnar jointing is a well-known feature of frozen magma flows. World-famous examples include the UNESCO world heritage site, the Giant's Causeway, UK. Columnar jointing can be divided into ‘colonnade’ and ‘entablature’ domains. Colonnade domains form by contraction as the magma cools from both the upper and lower surfaces. Contraction causes the rock to fracture in regular patterns called joints. Prominent joint sets of the colonnade commonly form hexagonal patterns and develop perpendicular to the cooling surfaces. The entablature domain occurs sandwiched between upper and lower colonnade domains and consists of irregular columns oriented at high angles to the colonnade columns. The entablature formation mechanism is not well understood. Previous explanations highlight the importance of changes in the geometry of isothermal surfaces. However, such explanations are expected to result in gradual changes, not the observed sharp boundaries. A suite of samples collected from a well-defined region of columnar jointing shows a rapid increase in density of approximately 6% from the colonnade to the entablature domains. X-ray diffraction measurements of the same samples suggest there is a corresponding increase in crystal size, confirmed by examination of thin sections under the polarizing microscope. A sudden increase in the proportion of crystals in the magma should cause an increase in density and shrinking. This phase change can account for the formation of the observed features of the entablature better than previous models. Testing of this new hypothesis requires a comparison with other similar outcrops around the world.

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