The Meaning of Global Ocean Ridge Basalt Major Element Compositions

Yaoling Niu, University of Durham, Durham, United Kingdom

Abstract Text:

The correlated large MORB major element compositional variations are well understood as the result of cooling-dominated crustal level processes (e.g., fractional crystallization, magma mixing, melt-rock assimilation/reaction and other aspects of complex open-magma chamber processes), but it remains under debate what messages MORB major elements may carry on mantle sources and processes. To reveal mantle messages, it is logical to correct MORB melts for the effects of crustal level processes to $Mg^{\#} \geq 0.72$. Such corrected MORB major element (e.g., Si_{72}, Ti_{72}, Al_{72}, Fe_{72}, Mg_{72}, Ca_{72} and Na_{72}) compositional variations thus reflect fertile mantle compositional variation, composition-controlled mantle physical property variation (e.g., density and solidus), variation in the extent and pressure of melting. Because ridge axial depth variation and plate spreading rate variation are the only two largest known physical variables of the global ocean ridge system, correlations of MORB major element compositions with these two physical variables are expected to reveal intrinsic controls on global MORB petrogenesis and ocean ridge dynamics. The ridge axial depth variation and MORB chemistry variation are two different effects of a common cause by fertile mantle compositional variation. The latter determines (1) variation in both composition and mode of mantle mineralogy, (2) variation of mantle density, (3) variation of ridge axial depth, (4) source-inherited MORB compositional variation, (4) density-controlled variation in the amplitude of mantle upwelling, (5) apparent variation in the extent of melting, and (6) the correlated variation of MORB chemistry with ridge axial depth. Also, the extent of mantle melting increases with, and caused by, increasing plate spreading rate. Mantle temperature variation could play a part, but there is no convincing evidence for large mantle temperature variation beneath ridges away from mantle plumes.