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Coupled Geodynamical-Geochemical Perspectives on the Generation and Composition of Mid-Ocean Ridge Basalts

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Owing to their abundance and relative availability on Earth's seafloor, mid-ocean ridge basalts (MORBs) have a well-defined chemical element budget, reflected by the low standard deviation associated with typical normal MORB (N-MORB) composition [1]. However, the exact mechanisms leading to magma differentiation and MORB generation remain debated, which hinders our ability to evaluate MORB parental magma composition. In this study, we leverage the predictive power of the BDD21 numerical framework [2] to obtain a representative trace element budget of parental MORB magma and assess its ability to fractionate into the N-MORB composition. Utilising revised parameterisations for mineralogy, melting, and partitioning, we couple BDD21 with numerical simulations of a MOR system driven by seafloor spreading in which we track the evolution of partial melting, mineral modal abundances, and concentrations of incompatible elements. Parental magma compositions are determined once simulations reach a steady state, and magma chamber replenishment models are employed to predict the trace element budget of the erupted liquid. We explore a range of geophysical and geochemical parameters to evaluate their effect on computed trace element concentrations. Previous magma chamber replenishment models [3] are extended to account for multiple crystallisation events and melt-crystal interaction. Modelling outcomes suggest that petrologically constrained fractionation of parental magma compositions obtained through BDD21 yields glass compositions compatible with the N-MORB budget. Nevertheless, our results show a systematic underestimation of Sr concentration, indicating the presence of recycled oceanic crust in the MORB source region.

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