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A model for trace element distribution during the dynamic growth of lower oceanic crust at Wadi Gideah (Oman Ophiolite)

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The formation of the lower oceanic crust is one of the most significant means of crustal differentiation and heat loss from the Earth. In spite of a lot of geochemical and geophysical work, a comprehensive model for the genesis remains elusive. As a step toward achieving this goal, Koepke et al.[1] carried out a study of a specific section of the lower oceanic crust that is exposed as part of the ophiolite sequence at Wadi Gideah, Oman. Making use of the closely spaced and comprehensive petrological data set, they developed a model whereby the crust grows layer by layer from bottom up (as exposed today). Each layer is produced by fractional crystallization of a sill-like melt reservoir and the residual melt migrates upward, is mixed with more primitive melt, to generate the subsequent layers by different extents of fractional crystallization. Observed major element mineral chemistries and modal abundances in the lower three-quarters of the sequence are consistent with this. We have developed a model to simulate the evolution of trace element chemistry that emerges as a result of this process. The model allows growth and dissolution of mineral grains as found in [1]. Diffusion-controlled time-dependent distribution of multiple trace elements are tracked simultaneously in all coexisting mineral and melt phases. The final calculated concentrations and profiles may then be compared with observations. Our preliminary results indicate that (a) trace element concentrations in the melt remains similar for different rates of melt migration, but the compositional profiles in individual mineral grains may vary, (b) even when homogeneous mineral grains are observed, the melt they grew from was not a single batch with constant composition. Further studies of the details of the concentration distributions are in progress to make use of them as indicators of rates of melt migration and hence, crustal growth.

Ref:

[1] Koepke, J., Garbe-Schönberg, D., Müller, T., Mock, D., Müller, S., Nasir, S. (2022): A reference section through fast-spread lower oceanic crust, Wadi Gideah, Samail ophiolite (Sultanate of Oman): Petrography and petrology. Journal of Geophysical Research: Solid Earth, 127, e2021JB022735. https://doi.org/10.1029/2021JB022735.