**MORB chemistry and ridge axial depth: A new interpretation**

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The paper by Klein and Langmuir [JGR, 1987] is a milestone on MORB genesis. They showed that MORB chemistry correlates with ridge axial depth on a global scale: CaO/Al\(_2\)O\(_3\) and Fe\(_8\) (FeO corrected for fractionation to MgO = 8.0 wt%) increase whereas Na\(_8\) decreases as the ridge shallows. They interpreted such correlations as resulting from varying pressures and degrees of melting caused by mantle potential temperature (\(T_P\)) variation of up to 250°C from beneath cold deep ridges to hot shallow ridges. This interpretation is reasonable because a hotter rising mantle begins to melt deeper (high Fe\(_8\)), has a taller melting column, and melts more (high CaO/Al\(_2\)O\(_3\), low Na\(_8\)) than a cooler mantle. The validity of this interpretation depends heavily on Fe\(_8\). HIDDEN in this interpretation is the FACT that at MgO = 8 wt%, the inverse Fe\(_8\)-depth correlation equals a positive Mg\(^{#}\)-depth correlation. That is, Mg\(^{#}\) decreases from ~ 0.66 at deep ridges (e.g., Cayman Trough, or CT, > 5 km below sea level) to ~ 0.56 at shallow ridges (e.g., Reykjanes Ridge, RR, close to sea level). This means that by using Fe\(_8\) (total range: 7 - 11) one examines the progressively more evolved melt from deep ridges to shallow ridges, which does not tell pressures of melting, thus provide no \(T_P\) information.

By correcting for fractionation to Mg\(^{#}\) = 0.72, one examines largely the mantle signals of MORB melts. In this case, the range of Fe\(_{72}\) is reduced (7.5 - 8.5), and the Fe\(_{72}\)-depth correlation essentially disappears. IF one used Fe\(_{72}\) to estimate \(T_P\), then ~ 60°C variation may be reasonable beneath global ridges. That is, degrees of mantle melting may not vary significantly with varying ridge depth. However, significant Na\(_{72}\)-depth (+) and Ca\(_{72}\)/Al\(_{72}\)-depth (-) trends remain. Assuming spreading rate effect is small and melting region shape effect is averaged out, then Na\(_{72}\) and Ca\(_{72}\)/Al\(_{72}\) largely reflect fertile mantle composition. Deeper ridges are underlined by more fertile mantle with higher Al\(_2\)O\(_3\) and Na\(_2\)O that make denser garnet and jadeite-rich cpx, thus greater bulk density in the mantle than shallower ridges. In order to explain the > 5 km ridge depth variation, we use CT as a reference point to calculate isostatic compensation depth:

\[
D_C (\text{km}) = 339.82X^{(-0.79355)},
\]

where X is % mantle density reduction. This says that the 5 km elevation of RR (vs. CT) results from its sub-ridge mantle density reduction of 0.5% (equivalent to 150°C hotter) with \(D_C = 600 \text{ km, or 1\% (} ~300°C \text{ hotter) with } D_C = 334 \text{ km. Obviously, density reduction due to variation in composition more realistic than temperature beneath global ocean ridges.} \]