MORB chemistry and ridge axial depth: A new interpretation

Y. Niu[1] and M.J. O'Hara[2]

[1] Department of Earth Sciences, Durham University, Durham DH1 3LE, UK; yaoling.niu@durham.ac.uk

[2] Institute of Geography and Earth Sciences, University of Wales, Aberystwyth SY23 3DB, UK; mio@aber.ac.uk

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_2O_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_2O_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_2O_3 and Na_2O that make denser garnet and jadeiite-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 (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 km, or 1% (~ 300°C hotter) with D_C = 334 km. Obviously, density reduction due to variation in composition more realistic than temperature beneath global ocean ridges.