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One View from the Experimental perspective: Some OIB are Hot, Some are Not

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The relationship between the mantle geotherm and the peridotite solidus defines the depth and degree of partial melting. This, in turn, is reflected, sometimes directly but usually indirectly, in the chemistry of the eruptives that are sampled at Earth's surface. Experimental data on the melting behavior of peridotite over a wide range of conditions appropriate for the upper mantle (e.g. P, T, X) have been collected over the last half-century. Armed with such data, it is possible to construct forward models, with a generally high degree of confidence, of the processes of melt extraction and subsequent low- to moderate-pressure crystallization differentiation. Conversely, inverse models, calibrated with experimental data, which are based on the chemistry of eruptives and their phenocrysts, can be used to make inferences about the conditions of primary melt segregation from the mantle. There is a considerable body of work on the most voluminous of all eruptives, MORB, which is based on the chemistry of basalts and their residues, abyssal peridotites. It seems fair to say that the consensus opinion is that the mantle beneath ridges erupting normal-MORB has a relatively low volatile content, and that the potential temperature is 1300 ± 100 ºC, which can be inferred as the baseline upper mantle temperature. As a rule, ocean island basalt (OIB) has a different chemical pedigree than normal-MORB. Differences can arise from factors that include variations in depth and degree of melting of a generally MORB-type mantle (e.g. different potential potential temperature, deep lithospheric base), and variations in major or minor element composition of the mantle, especially volatiles, that can substantially effect phase relations and melt composition. Currently, the two largest OIB provinces are Hawaii and Iceland. Based on both forward and inverse models, the mantle potential temperature beneath Hawaii is modeled to be of the order 1550 ± 50 ºC, a value that is most well constrained by direct evidence form MgO-rich glasses (~ 15 wt%), and by Mg/Fe systematics of olivine phenocrysts in lavas. High-MgO glasses have not been recovered from Iceland, but reconstruction of primitive melt compositions based on phenocryst olivines yield estimated mantle potential temperatures of the order 1450 ± 50 ºC. Although caveats exist regarding the composition of mantle source regions (e.g. Mg#, incompatible element content, volatile content), the preponderance of evidence indicates strongly that the mantle source regions beneath Hawaii, and to a lesser extent, Iceland, are 'hot' relative to normal MORB mantle. In contrast, other OIB lavas, most notably HiMu-type, apparently carry a signal of low-degree, deep melting in the presence of volatiles, in which cases the mantle potential temperature may be nearer that of ambient mantle.