Temperatures of mantle derived magmas and their sources

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There is general agreement that the convecting mantle is compositionally and thermally heterogeneous on different spatial scales. Differences in potential temperature and composition of mantle domains affect magma production and cannot be easily distinguished from each other. This has led to radically different interpretations of the melting anomalies that produce ocean-island basalts (OIB), large igneous provinces (LIP) and supra-subduction zone (SSZ) mantle derived melts. The way to resolve this ambiguity is an independent estimation of temperature and composition of mantle sources of various types of magma.

In this paper we report application of newly developed olivine-spinel-melt geothermometers based on partition of Al, Cr, Sc and Y for different primitive lavas of MORB, OIB, LIP, and SSZ. The results suggest significant variations of crystallization temperature for the same Fo of high magnesium olivines from different types of mantle-derived magmas: from the lowest (down to 1220ºC) for MORB and SSZ to the highest (up to over 1500ºC) for komatiites and Siberian meimechites. These results match predictions from Fe-Mg olivine-melt equilibrium and confirm the relatively low temperature of the mantle source of MORB and SSZ magmas, high H_2O contents of SSZ magmas and higher temperatures in the mantle plumes.

The established liquidus temperatures and compositions of primary melts allow estimating potential temperatures of their mantle sources. The highest potential temperatures (up to1650ºC) are found for the largest LIPs: Siberian, North Atlantic and Caribbean. The sources of OIBs yield significant range of potential temperatures: 1400-1600ºC, positively correlated with magma production rate. MORBs yield potential temperature between 1350-1400ºC except those from ultra slow spreading ridges (e.g. Knipovich ridge), which display potential temperatures down to 1250 ºC. Potential temperatures of SSZ mantle sources are typically within the range for MORB, supporting origin of SSZ primary melts by H_2O fluxing of convecting mantle wedge. Exceptions are some boninites, which require higher temperature and plume related sources.

The results strongly confirm standard mantle plume theory and prove external source of H_2O in SSZ mantle.