

Are “Hot Spots” Hot? – An Overview

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The term “hot spot” is taken variously to imply a) the presence of excessive volcanism, or b) that the melt formed in an unusually hot source. Case b) is intrinsic to the plume hypothesis. Temperature anomalies of 200-300 degrees Celsius are expected, though there is widespread downward-revision of this where observations do not support it. It is not self-evident that “hot spots” are hot in the sense of case b), despite the fact that this is widely assumed. Furthermore, a hot source is not strongly supported by observations, and is at odds with many data. The temperature of the mantle have been studied using many different methods. Global oceanic heat flow values were recently assessed, but reveal no evidence for elevated temperatures around proposed plume localities. Mapping surface heat flow is only sensitive to anomalies at the level of 100 degrees Celsius, however. Seismological methods include correlating velocity with crustal thickness at LIPs, measuring transition zone thickness, and mapping velocity, e.g., using tomography. The first of these does not find evidence for elevated temperatures. The latter two are both sensitive to the presence of partial melt and variations in rock composition, in addition to temperature, which is the weakest potential effect. They thus cannot be used as thermometers. In particular, it cannot be assumed that red = hot and blue = cold in tomographic cross sections. Petrological and geochemical approaches include the “global systematics”. This has now been shown to not work for estimating temperature and its application should be discontinued. Mineralogical phase relationships are applied by comparing data from laboratory melting experiments to observations. Olivine control-line analysis has been extensively used in attempts to measure the differences in melt-formation temperature between mid-ocean ridges and melting anomalies. Difficulties arise in choosing the correct olivine geothermometer and because picrite glass is lacking from any melting anomaly except Hawaii. The results must be compared with a measure of the temperature of “normal mantle”. This is usually taken to be the temperature of melt formation beneath mid-ocean ridges, but the correct choice is controversial and this furthermore cannot be assumed to represent the potential temperature of the mantle in general. The surface conduction layer may extend much deeper than the depth of extraction of MORB, so melt extracted from greater depths, e.g., from beneath the base of the lithosphere in old parts of the ocean basins, may form at higher temperatures. It is easier to assume that the mantle beneath “hot spots” is hot than it is to show unequivocally that it is true. This endeavor is perhaps the most direct way of testing the plume hypothesis, but it is also one of the most challenging.