More Evidence for a Plume-Fed Asthenosphere

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There is increasing evidence for a well-developed asthenosphere existing between ~80-250km depths beneath the relatively thin lithosphere found in the ocean basins and younger continental regions, and a ~100km deeper and more-viscous 'asthenosphere' (if we want to use the same term) found beneath ~200+km-thick continental cratons. Sub-oceanic seismic velocity and attenuation observations are most easily explained if the sub-oceanic asthenosphere is hotter — at least in terms of potential temperature — than underlying mesosphere (cf. Phipps Morgan et al., JGR, 1995; Yamamoto et al., 2007)). If the sub-oceanic asthenosphere is fed by concentrated upwelling from regions hotter than typical mantle (e.g., thermal plumes), then sub-oceanic asthenosphere should typically be hotter than underlying mantle. If so, the asthenosphere layer will resist downwards entrainment by subducting slabs, resulting in its consumption through accretion into overlying oceanic lithosphere that eventually cools, densifies, and subducts into the deeper mantle. The well-known geochemical differences between MORB and OIB can also be explained as a consequence of small amounts of OIB melt-extraction from the lower-melting components of a plum-pudding mantle that first melts a small amount above plumes and later melts to a much larger degree beneath mid-ocean ridges (cf. Phipps Morgan and Morgan, EPSL, 1999). We show recent numerical experiments of the anticipated flow patterns in a plume-fed asthenosphere (cf. Phipps Morgan et al., 2007; Yamamoto et al., 2007). One prediction of these experiments is that the mantle wedge will have partial recirculating flow in the sub-arc region as the asthenosphere resists being subducted, as well as the potential for strong trench-parallel flow.