Are Mantle Plumes Adiabatic?

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We have examined in a cartesian box with an aspect-ratio six The issue concerning the state of adiabaticity of mantle plumes. We have investigated in the quasi steady-state regime high Rayleigh number convection (Ra 10^7) . with both depth-dependent viscosity and thermal expansivity for both the Boussinesq and the extended Boussinesq approximations. We have also assessed the influence of various forms of thermal conductivity and internal heating. For a rapid local scanning of the conditions of adiabaticity, we have generalized the classical Bullen's parameter equation from one-dimension to multi-dimensions. This is analogous to what the oceanographers do with their construction of the local Brunt-Vaisaila frequency maps. For assessing the local state of adiabaticity inside plumes and in their surroundings, we have extracted from the local geotherms and the local thermodynamic properties the corresponding Bullen's parameter profiles and the 2-D maps portraying the state of adiabaticity in the mantle. Histograms characterizing the frequency of adiabaticity are also employed for quantification purposes. In general, superadiabatic thermal gradients are found inside the thick plume limbs and sometimes along the central part of the plume. The centers of plume heads are subadiabatic or nearly adiabatic, but the edges of the plume heads are strongly subadiabatic. Alternating strips of subadiabaticity and adiabaticity are found in the downwellings. The ambient mantle outside the plumes is generally adiabatic and is sometimes perforated with islands of marked deviations from adiabaticity.