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Plumes in a convecting mantle

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Plumes originate as convective instabilities from thermal boundary layers within the Earth's mantle. The most prominent boundary layers are the 670km discontinuity and the Core-mantle boundary at 2900 km depth. The fluid dynamics of plumes, i.e. their spatiotemporal evolution and their transport properties are only understood under conditions which are oversimplified,as compared to the mantle. Laboratory experiments can hardly take into account features which can critically influence the formation and evolution of plumes. Mantle convection is likely to be partially powered by internal radioactive heat sources. Further, the viscosity of the mantle material is known to strongly depend on temperature and pressure. Also there is clear evidence for a decrease of the coefficient of thermal expansivity with increasing pressure throughout the mantle. All those effects have an effect on the generation and the evolution of plumes. By means of numerical experiments we investigate the plume evolution in different mantle-relevant scenarios. It is demonstrated that plumes do not exist in purely internally heated convection. as long as constant material properties are assumed. A viscosity, increasing with pressure and/or a coefficient of thermal expansion decreasing with pressure have been proposed ti suppress the formation of plumes. We show that these effects lead to a focusing of buoyancy

into a few strong plumes. Such, even in internally heated systems, plume instabilities do evolve and the Core-mantle boundary seems a likely location for plumes to nucleate. A strong temperature dependence of the viscosity leads to episodic plumes. Initially a massive plume heads develops and travels upwards. Subsequently pulses of hot material can rise through the established low viscosity channel. Plumes evolving selfconsistenly from a thermal boundary layer, do hardly entrain material during their ascent. Instead they transport mostly material from the boundary layer.