**Abstract**

We perform laboratory experiments to study the effect of the variable basal thermal anomaly on convection. For Rayleigh number $Ra = 5 \times 10^5$, which is the regime of cellular convection, the response of the convection pattern changes when the horizontal temperature variation in the bottom boundary increases. When the temperature variation is less than critical, there is no effect to the convection pattern. Above critical, an upwelling is fixed at the site of the anomaly, which for a larger temperature variation, develops into a wide upwelling with a horizontally elongated cell. For this case, the time-averaged temperature above the thermal anomaly becomes higher than that in the other regions. For Rayleigh number $Ra = 10^7$, which is the regime of plane dominant convection, the horizontal temperature variation which exceeds critical, similarly affects the location of the dominant hot plumes generated by the thermal anomaly. The time-averaged temperature above the thermal anomaly becomes larger than that in the other regions. For Rayleigh number $Ra < 10^7$, which is the regime of cellular convection cases, the temperature variation less than critical is also capable of generating intermittent hot plumes but they do not dominate the convection pattern. The critical horizontal temperature variation to affect the convection pattern is scaled by the maximum standard deviation of the time variation of the temperature around the thermal anomaly.

**1. Motivation**

- Spatial correlation between ULVZ and hotspots has been suggested.
- ULVZ might supply high temperature anomaly by its low viscosity.

**Question**

Can a low viscosity ULVZ which act as a thermal anomaly generate a hot plume?

**2. Experimental apparatus**

- Thermocouple probes
- Stripping meter
- Acrylic plate
- Large heater supplies heat $Q_h$
- Small heater supplies anomalous heat $Q_s$
- Video camera

**3. Results**

- $Ra = 2.5 \times 10^5$
  - Effect to the right above the small heater
  - Temperature
  - Variance

- $Ra = 10^7$
  - Effect to the right above the small heater
  - Temperature
  - Variance
  - Horizontal effects

**4. Regime diagram**

- $\Delta T_h^*$: Normalized horizontal temperature anomaly by vertical temperature difference across the convecting layer
- $\sigma_{\text{max}}^*$: Maximum standard deviation of temperature around the bottom boundary layer

**5. Implications for the Earth’s mantle**

Assuming this structure for the mantle...

**From the heat balance,**

$$k_m \Delta T_m = k_s \frac{\Delta T_d}{\delta_m}$$

Among the physical properties $k, \alpha, \rho, \kappa$, and $\Delta T_d$ only viscosity $\eta$ can vary by an order of magnitude at the CMB. Assuming $k, \alpha, \rho, \kappa$ are similar we can get

$$\Delta T_m^* = \frac{\Delta T_d^*}{\eta_m}$$

**Applying this equation hot and cold regions and assuming**

$$\Delta T_m^{\text{Hot cold}} \sim \Delta T_m^{\text{Hot tot}}$$

$$\Delta T_h^* = \Delta T_d^{\text{Hot cold}} / \Delta T_d^{\text{Hot tot}} = \eta_{\text{Hot cold}}^{1/4} / \eta_{\text{Hot tot}}^{1/4}$$

Using $\eta_{\text{Hot cold}} / \eta_{\text{Hot tot}} \sim 10^3$

$$\Delta T_h^* = 0.078 > \sigma_{\text{max}}^* \approx 0.06 \text{ (for thermal convection $Ra=10^7$)}$$

**Answer**

Plausible amount of partial melt can generate a hot plume.

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**Influence of a basal thermal anomaly on mantle convection**

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