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Understanding the transport of a fluid rich layer in a granular material by an analogy with thermal convection

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Mixture of granular material and fluid is ubiquitous and governs numerous phenomena on the Earth. Understanding how a fluid rich layer is transported in the granular material is one of a fundamental problem. When a slab subducts, hydrous minerals break down, which may generate a fluid (water or magma) rich layer bellow a wedge mantle. The mantle is composed of minerals with finite sizes and may behave as a granular material. The lighter fluid should be transported to the surface through the granular mantle but its mechanism has not yet been understood well. When a fresh basaltic magma intrudes in a phenocryst rich magma chamber, thermally lighter magma should ascend in the phenocryst rich layer, again its mechanism has not yet been understood well. Shibano and Sumita (Poster presentation in the session `Geofluid and Dynamics of Subduction Zone') perform a series of idealized experiments of these phenomena, in which an oil rich layer ascends in a glass beads layer. They find that glass beads descend in the oil rich layer as plumes, resulting the oil rich layer convects. The ascending velocity of oil rich layer with internal convection is faster than that estimated by classical permeable flow. The observed convection pattern inside the oil rich layer resembles that of the thermal convection. Here we discuss why the fluid rich layer convects by using an analogy with thermal convection. In the case of thermal convection, a thermal boundary layer grows by thermal diffusion, the boundary layer makes plumes by instability, then convection is driven. In the case of convection inside the fluid rich layer, a boundary layer grows by permeable flow which also can be described by diffusion equation. This may explain why the convection pattern inside the fluid rich layer located in the granular material resembles that of thermal convection.

Keywords: granular material, convection