Migration of aqueous fluid near the subducting plate interface

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At least in several subduction zones including Tohoku, Japan, and Cascadia, low surface heat flow has been observed in the forearc, which suggests the existence of a cold fore-arc mantle. This low heat flow has been explained by a thin, low-viscosity layer (LVL) on top of the subducting slab that decouples the movement between the slab and the overriding mantle wedge. Although the formation mechanism of the LVL remains unclear, hydrous minerals such as serpentine may play an essential role in it. The effects of the LVL on solid (or rock) velocity have been extensively investigated. However, little is known of aqueous fluid migration in and around the LVL, despite its importance to our understanding of seismic activity along the subducting plate interface which includes slow earthquakes. In this presentation, I propose a mechanism of fluid flow through the LVL based on a numerical modeling of two-phase flow.

It has been shown that the equations for the solid and fluid phases can be decoupled if porosity is small. I therefore take the following two-step approach based on this assumption. I first solve for solid velocity and the dynamic pressure gradient in and around the LVL. These results are then used to solve for the porosity and compaction pressure in this region.

Preliminary results show that a large amount of fluid is trapped within the LVL by the effects of compaction, that is, the fluid cannot easily flow into the overriding mantle wedge with high viscosity. Dynamic pressure gradient within the LVL becomes large when a thin LVL or high solid viscosity within the LVL is assumed, which leads to a faster fluid flow in the updip direction. These findings suggest that the effects of compaction and dynamic pressure gradient are critical to understand the fluid flow near the subducting plate interface. I also find that the fluid tends to stay near the basal region of the LVL when a non-linear solid viscosity is applied.

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