Where do large shallow slab earthquakes occur?

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Within a shallow portion of subducting slabs, large earthquakes seldom occur. However, there have been known several regions in which large (M>=7.0) earthquakes occurred in this portion of the slab. There is a common characteristic among these regions; i.e., they have a tensional stress in the shallow portion of the slab, and yet a tensional back-arc stress. Mantle drag forces beneath the upper plate are operating to counteract the slab pull, making the fore-arc compressional and yet the back-arc tensional. The mantle drag forces beneath the upper plate would originate from the mantle convection currents. The continents or arcs driven by these currents and pushed toward the ocean suck the slab, resulting in the generation of the observed large shallow slab earthquakes.

Within a shallow portion of subducting slabs, large earthquakes seldom occur because slab stress is usually neutral between bending at the trench-outer rise and unbending at the intermediate-depth. However, there have been known several regions in which large (M>=7.0) earthquakes occurred in this shallow portion of the slab. They are: Hokkaido-S. Kuril, Kyushu-SW. Japan, Mariana, Chile, Peru, El Sarvador, Mexico, Cascadia, Manila, and Sumatra.

There is a common characteristic among these regions listed above, except for Manila and Sumtra; i.e., they have a tensional stress in the shallow portion of the slab, and yet a tensional back-arc stress. In Peru and Chile, the back-arc is in compression except high Andes, but becomes tensional towards the east coast of S. America. Generally, based on the interaction between the upper plate and the slab at subduction zones, we expect a compressional back-arc when the slab is in tension (Seno and Yamanaka, 1998). The fact that the above regions have tensional back-arcs implies some additional forces, such as mantle drag forces beneath the upper plate, are operating to counteract the slab pull force, making the fore-arc compressional and yet the back-arc tensional. In fact, we can observe a stress gradient in the upper plate in the regions above, suggesting the existence of such forces.

The inferred mantle drag forces beneath the upper plate would originate from the mantle convection currents or upwelling plumes. The continents or arcs will be driven by these currents and pushed toward the ocean. "Suction" forces would appear at the trench due to this continental or arc drift, which makes the sucked slab being in extra-tension, resulting in the generation of the observed large shallow slab earthquakes.