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Effects of mineral grain size variation on fluid migration in the mantle wedge

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In this study, we investigate the effect of mineral grain size on the migration paths of aqueous fluids in the mantle wedge. Grain size is an important parameter that controls the grain-scale permeability of the mantle; in general, the smaller the grain size, the less permeable the mantle is, provided that the pores between grains are connected. The migration paths of aqueous fluids are therefore dependent on the grain size distribution, influencing the location and the degree of hydrous melting in the mantle wedge and the location of arc volcanism. We develop a 2-D fluid migration model with generic subduction zone geometry. In the model, we adopt grain size distributions calculated by coupling a subduction zone thermal model with a laboratory-derived grain size evolution model for a range of subduction parameters (Wada et al., 2011). The fluid migration model also includes the effects of mantle flow velocities and mantle-flow-induced pressure gradients, both of which are also calculated from the thermal model. The calculated grain size immediately above the slab is on the order of 10?100 micrometers beneath the forearc region, depending on the slab thermal structure, and it increases down-dip to a few cm beneath the arc region. Our preliminary modeling results with a simplified fluid influx pattern indicate that the aqueous fluids tend to become trapped in the down-going mantle due to low permeability and dragged down-dip until permeability becomes high enough for the fluids to migrate upward. Grain size above a colder slab tends to be smaller than that above a warmer slab, and therefore fluids become dragged down-dip further in a cold-slab subduction zone than in a warm slab subduction zone. A colder slab also tends to release fluids at deeper depths than a warmer slab, influencing the pattern of fluid influx into the mantle wedge. In this study, we calculate the fluid influx along the base of the mantle wedge, using the thermal modeling results and thermodynamic calculations based on Perple_X, and quantify fluid migration in the mantle wedge with the grain size and fluid influx distributions that are consistent with a given slab thermal structure.

Keywords: subduction zone, mantle wedge, aqueous fluid migration, grain size, slab dehydration, arc volcanism