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Numerical modeling of thermal structure and fluid flow in accretionary prisms

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We develop a numerical model of heat transport and fluid migration in plate subduction zones aiming at estimating the thermal structure in accretionary prisms. We consider a two-dimensional model composed of three layers (sediment, oceanic plate, and underlying mantle). The three layers moves coherently before subduction, and after subduction the sediment layer is separated from the others and forms a accretionary prism. We assumed that the grain velocity in an accretionary prism and the resultant spatial distribution is given by a two-dimensional analytic solution provided by Bekins and Dreiss (1992); the sediment thickens uniformly and the porosity distribution is given as a function of distance and depth. The fluid migration in a sediment layer occurs as a permeable flow, and we ignored the effect of channel-like flow which may take place along faults or decollements. The thermal structure in the model is controlled not only by thermal conduction but also by an advection due to the motion of solids (sediments, plate, mantle) and fluid. The temperature is fixed at the top (ocean bottom) and the bottom (deep mantle), and the thermal structure of the incoming plate and sediment before subduction is determined by a thermal conduction in the vertical direction.

We carried out several preliminary steady-state calculations. The results show that the overall features of thermal structure in an accretionary prism are mainly determined by basal heat flux from the underlying oceanic plate and thermal conduction within the prism, implying that the pore fluid migration plays only a minor role in determining the thermal structure in accretionary prisms. We also found that, under the present assumptions for the formation of accretionary prisms, the rate of pore fluid migration is independent of the permeability. This result suggests that a detailed modeling on the accretion process itself is required in order to thoroughly estimate the fluid migration in accretionary prisms.