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The global range of subduction zone thermal models: consequences for slab devolatilization

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Two- and three-dimensional thermal models provide insight into the dehydration and melting processes that occur in subduction zones. The wide range of slab geometries, ages, convergence velocities and upper plates result in an array of thermal structures that share many common features. We model forty-six arc sections in two dimensions using kinematically-defined slabs based on updated geometries from Syracuse and Abers [2006] to obtain a comprehensive suite of thermal models for the global subduction system. All models feature partial coupling between the slab and the overriding plate directly downdip of the thrust zone, invoked to replicate the cold nose observed in heat flow measurements and seismic attenuation. Four separate cases are tested with four separate sets of assumptions about the causes of the partial coupling: the downdip end of the partial coupling is at a constant depth, it is at constant distance trenchward from the arc, is defined by a critical surface slab temperature, or is adjusted such that the hottest part of the mantle wedge beneath the arc is at a constant temperature for all subduction zones. In all of these models, slabs reach temperatures where the top of the crust and sediments dehydrate before they reach sub-arc depths, and the overlying mantle wedge is too hot for hydrous minerals to be stable at sub-arc depths. The exceptions are cases where subduction is fast and coupling is controlled by a critical slab surface temperature (550°C); these cases also do not produce wedges hot enough to generate primitive arc magmas so probably underestimate temperatures. By contrast, the mantle within the downgoing plate remains cold enough for serpentine to be stable beyond the arc in all but the hottest subduction zones, allowing water to be carried beyond the arc in the slab.