

Heat flow at the Cascadia, USA, and the Hikurangi, New Zealand, margins

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At subduction zones, temperature influences both aseismic and seismic deformation along the subduction thrust. To better understand these processes we collected a series of heat flow measurements seaward of and continuing across the deformation front at the Cascadia subduction zone, USA, and the Hikurangi margin, New Zealand. All measurements were made using a 3.5 m violin bow probe at relatively close spacing (1-2 km) along seismic reflection profiles that provide environmental context for understanding the measured values. Analytical uncertainties are estimated to be $\pm 5\%$.

The Cascadia subduction zone (CSZ) is both a seismic and thermal end member of global subduction zones, having one of the lowest rates of seismicity and among the highest plate boundary temperatures worldwide. The high temperatures on the plate boundary are attributed to the young age of the subducting Juan de Fuca plate (5-11 Ma at the deformation front), its slow convergence rate (30-40 mm/yr), and the presence of a thick blanket of insulating sediment both seaward and landward of the deformation front. Just seaward of the deformation front, heat flow varies between 105 and 115 mWm⁻². Over the outer accretionary wedge, at distances up to 30 km landward from the deformation front, heat flow varies between about 85 and 90 mW m⁻², reflecting the depression of heat flow due to thickening sediment and downward heat advection by the subducting plate. At landward and seaward forearc basin edges heat flow increases by 10 to 25 mW m⁻², suggesting upward fluid flow. We also surveyed heat flow over a buried seamount ~25 km seaward of the deformation front. Heat flow over the seamount varies between 116 and 438 mW m⁻² and is inversely proportional to the overlying sediment thickness. These values suggest that the top of the oceanic crust is approximately isothermal, indicating active hydrothermal circulation within the 8 My upper oceanic crust. Modeling results suggest that the temperature at the sediment-basement interface at the deformation front is approximately 200° C. Mineral dehydration reactions that can generate fluid overpressures in impermeable sediments and are often invoked to explain the transition from stable sliding to stick-slip behavior are likely to have been completed before the sediments have reached the deformation front.

At the Hikurangi margin, the 120 Ma Hikurangi Plateau, a large igneous province on the Pacific plate, is subducting beneath the Australian plate. Large along-strike variations in interseismic coupling and slow slip event behavior along this margin offer an important opportunity to address processes affecting slip behavior. In particular, slow slip is observed at much shallower depths (<5-15 km) along the northern Hikurangi margin than in Cascadia, where slow slip is observed in a distinct band along the plate boundary at depths of 30-50 km. The background thermal regime seaward of the deformation front is ~50 mW m⁻² for both the northern and southern regions, respectively. These values are consistent with cooling plate models for this age of oceanic lithosphere. However, heat flow transects in the northern Hikurangi trough show evidence for crustal fluid flow associated with basement relief. Heat flow transects in the southern Hikurangi trough do not require crustal fluid flow, but this could be due to a lack of basement relief. The contrast in slow slip depth between the northern and southern Hikurangi margin does not appear to be directly linked to temperature.

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