A holistic view of the thermal structure of subduction zones

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Since the discovery of plate tectonics it has been puzzling that phenomena such as arc volcanism that require significant amounts of heat are located where cold oceanic lithosphere subducts. The apparent discrepancy between cold subduction and hot arc conditions has historically been explained by large arbitrary amounts of shear heating along the plate interface and viscous dissipation in the mantle. While it has become apparent that the arc conditions can be explained naturally by asthenospheric counterflow, there remains a puzzling discrepancy below the forearc. Exhumed blueschists and eclogites that are thought to have been part of the subducting oceanic crust tend to record maximum pressure-temperature conditions that tend to be, on average, significantly warmer than is predicted from the average thermal models of present-day subduction zones. It is reasonable to ask whether the thermal models are missing important heat sources (such as shear heating along the plate interface), whether the maximum rock conditions are overpredicted, or whether exhumation just occurs naturally under conditions that are warmer than the present-day average predicted conditions.

We provide a holistic view of subduction zone thermal structure that effectively puts the brakes on the importance of shear heating. Most important aspects include the important observation that forearc heatflow indicates that the underlying lithosphere is among the coldest on the planet, limitations of the shear heating effect past the brittle-ductile transition, the rather poor ability of shear heating to warm the subducting oceanic crust below the plate interface, as well as signficant dynamic limitations on the ability of the plate interface to create significant shear heating.

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