Mafic high-pressure rocks are preferentially exhumed from warm subduction settings

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Subduction of oceanic lithosphere cools the forearc mantle and the low temperature of the subducting oceanic crust below the forearc is a natural consequence of the advection of cold lithosphere. Almost all of the subducting crust is recycled to greater depth but in rare and punctuated episodes some blueschists and eclogites are exhumed. Their prograde P-T-t paths provide important insights into the conditions of the oceanic crust in which they subducted. We revisit the observation that the record of exhumed rocks indicates significantly warmer conditions below the forearc (~300 K difference on average between 0.8 and 2.7 GPa) than predicted by thermal models. This could be due preferential exhumation of rock from young and warm oceanic lithosphere or exhumation during the warm early stages of subduction. Alternatively, the models might underestimate the subduction zone thermal structure by neglecting certain putative heat sources.

By comparing models that include frictional and viscous shear heating as constrained by heat flow and other observations to those that ignore these heat sources we show that the average thermal effect of reasonable shear heating on the oceanic crust is only 50 K. We also show that the crustal PT conditions for young subducting lithosphere are quite similar to those inferred from the rock record.

Adding arbitrarily high heating below the forearc can create conditions similar to the rock record, but the resulting thermal structure is in conflict with a large number of geophysical and geochemical observations including surface heatflow, arc geochemistry, and seismology.

We infer that exhumation preferentially occurs after subduction under relatively warm conditions, such as those occur during subduction of young oceanic lithosphere or the early stages of subduction. This is supported by dynamical arguments due to the greater buoyancy and mobility of rocks under warmer conditions.