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Shear heating inferred from heat flow data reconciles subduction zone thermal models with blueschist and eclogite P-T conditions

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Pressure-temperature (P-T) conditions determined from exhumed blueschists and eclogites are typically ~300 °C hotter than popular thermal-mechanical models at depths of 45-60 km ($P = 1.4$-1.9 GPa). Reconciling these differences is important because thermal-mechanical models serve to predict sub-arc melting conditions and delivery of volatiles to the deep mantle, while rocks provide our only direct evidence of conditions and processes occurring along the subduction interface. Here, it is shown that: **Shear stresses that have been inferred from inversion of forearc heat flow data imply significant shear heating along the subduction interface. This heat source increases temperatures of the subduction interface by 200-400 °C at 45-60 km**. That is, heat flow data and rock P-T conditions are in full agreement, but imply hotter subduction zone conditions than popular models.

Low forearc heat flow is commonly thought to indicate negligible shear stresses, but scattered heat flow observations require large datasets to resolve heat flow trends and infer shear stresses. Normally shear stresses (σ_s) are assumed to be proportional to P, with a coefficient, μ, such that $\sigma_s = \mu \cdot P$. Inversion of heat flow data implies typical μ values in the forearc of 0.025 to 0.07. Analytical solutions for subduction interface temperatures that include shear stress (age = 40 Ma; convergence = 4 to 8 cm/yr) show theoretically that the extra heat provided by shearing increases temperatures by 150-500 °C ($P=1.4$ GPa) and 300-800 °C (1.9 GPa).

Calculations assuming high μ (0.07) imply unusually high T at depths ≥ 50 km (>750 °C), but at $T > 500$-550 °C, mafic rocks transition from brittle to ductile behavior. P-T conditions determined from blueschists and eclogites imply that this temperature should occur at an average depth of 50-55 km, coincident with the seismic-aseismic transition in modern subduction zones. Increasing ductility (decreasing μ) reduces shear heating at depths greater than 40-65 km, and limits temperature increases to c. 350 °C at depths of 50-70 km.

Recent numerical models that include shear heating [1] support these calculations. Thus, shear stresses estimated from heat flow data reconcile P-T discrepancies between rocks and past numerical models, implying a hotter and drier subducting slab than commonly assumed.

[1] Gao & Wang (2014), *Science*, **345**, 1038-1041)