Megathrust slip controlled by metasomatic reactions in subduction mélanges

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Megathrust slip down-dip of the seismogenic zone is accommodated by either steady creep or episodic slow slip events (SSEs). However, the geological conditions defining the rheology of megathrust slip remain elusive. Here, we show that subduction mélanges deformed at ~370–500 °C in warm-slab environments record fluid release and shear localization associated with metasomatic reactions between pelitic and basaltic rocks. Metasomatic reactions resulted in albitization of pelite, with its rheological behavior changing with depth. In a mélange deformed at ~370 °C, near the down-dip limit of the seismogenic zone, very fine-grained albite facilitated grain boundary diffusion creep in addition to quartz dislocation creep, contributing to decreased megathrust strength. In a mélange deformed at ~500 °C, near the mantle wedge corner, metasomatic reactions led to hydrofracturing and incorporation of albitized pelite blocks into a viscous matrix deforming at elevated strain rate. We suggest that metasomatic reactions lead to localized changes in megathrust slip mode with depth, potentially controlling downward change from creep or long-term SSEs to SSEs with tremor. Specifically, very fine-grained albite enhances low-shear stress, viscous shear near the seismic-aseismic transition, whereas fluid release and coarse-grained albite promote hydrofractures coincident with localized viscous shear at greater depth.

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