Localized megathrust slip controlled by metasomatic reactions in subduction mélanges

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Aseismic 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 viscous shear localization associated with metasomatic reactions between juxtaposed metapelitic and metabasaltic rocks. Metasomatic reactions induced albitization of metapelite, resulting in depth-dependent rheological behavior. In a mélange deformed at ~370 °C, near the down-dip limit of the seismogenic zone, very fine-grained metasomatic albite facilitated grain boundary diffusion creep at stresses less than those in the surrounding metapelite and metabasalt, contributing to an overall decreased megathrust strength. In a mélange deformed at ~500 °C, near the mantle wedge corner, metasomatic reactions led to brittle fracturing, albite grain growth, and incorporation of strengthened albitized metapelite blocks into a chlorite-actinolite matrix deforming at locally elevated strain rate of ~10⁻¹¹ s⁻¹. We suggest that metasomatic reactions facilitate localized changes in megathrust slip mode with depth, potentially providing a mechanism for change from viscous creep to SSEs with tremor.