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Lithospheric controls on fault creep: Insights from the San Andreas fault system

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Although fault creep is recognized to be an important mechanism by which fault slip can be accommodated on major faults, there are in fact relatively few examples of faults for which creep represents a significant fraction of total fault slip. Along the San Andreas fault system, there are fault segments that experience substantial fault creep, while other adjacent segments appear to experience little or no creep. A significant body of research has defined the physical properties of a frictional fault that will allow fault creep, here we rather focus on the lithospheric scale properties of the fault system that favor fault creep. Along the San Andreas system specific segments of the San Andreas fault, the Hayward fault, the Rodgers Creek fault and the Maacama fault all undergo significant fault creep. These creeping faults range in maturity from newly forming segments (northern Maacama) to segments with 10s to 100s of km of fault slip. In some cases the creeping faults are embedded within a single lithologic formation (Franciscan) while other creeping segments separate significantly different lithologies. Thus lithology alone cannot be the controlling factor. Rather numerical modeling of the conditions that allow fault creep indicate that a necessary condition for fault creep is the development of a localized shear zone within the lithospheric mantle and lower crust beneath the creeping fault segment. Without this localization, fault creep is inhibited. The evolution of the crust and lithosphere along the Coast Ranges in California in response to triple junction migration and slab window development provides a thermal-rheologic regime that favors shear localization. In particular the fault corridor of the central San Andreas-Hayward-Rodgers Creek- Maacama faults (all creeping faults) lies above the localized shear zone that develops in the slab window as it cools and becomes lithosphere. It is this necessity of having a localized

shear zone linked to the crustal fault that appears to limit the situations in which fault creep occurs.