How Do Transient Loading or Change of Fault Properties Affect Secular Slip Rate on Major Strike-Slip Faults?

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Secular variations of fault slip rate are common [Chevalier et al., 2005]. The hypothesized causes include glacial-interglacial changes in surface loads [Hetzel and Hampel, 2005], ocean loading on glacial timescales [Luttrell et al., 2005], and change of fault properties. These causes may be quantified and tested by their impact on the Regional Coulomb Failure Stress, which causes different secular variations of fault slip rate. We demonstrate this approach using a generic 3-D visco-elasto-plastic finite element model for major strike-slip faults [Li and Liu, 2006], and show that this approach may be used to differentiate various causes of secular variation of fault slip rates.

The secular slip rates of major strike-slip faults depend on long-term tectonic loading rates, but can be perturbed by the change of loading mechanisms (change of regional shear stress and normal stress) and/or fault properties (frictional coefficient, pore pressure, and cohesion). These changes can be represented by a proper change of Regional Coulomb Failure Stress (ΔRCFS):

$$\Delta\sigma_{RCFS} = \Delta\tau - \mu(\Delta\sigma_n - \Delta p) - \Delta\mu(\sigma_n - p) - \Delta C$$

where $\Delta\tau$ and $\Delta\sigma_n$ are changes of regional shear and normal stress due to external loading, respectively, $\Delta\mu$ is change of frictional coefficient, Δp is change of pore pressure, and ΔC is change of cohesion on a fault plane. ΔRCFS perturbs the fault slip rate until a new equilibrium is reached. The resulting changes of slip rates depend on the duration over which the change process of ΔRCFS is accomplished, and its magnitude (Figures 1 and 2).

Different loading mechanisms and/or change of fault properties may be represented by their resulting change of Regional Coulomb Failure Stress with different magnitudes and durations of changing processes, which lead to different secular variations of fault slip rates. With a well-constrained fault slip history and lithospheric rheology, we may test and quantify different causes of secular fault slip variations.

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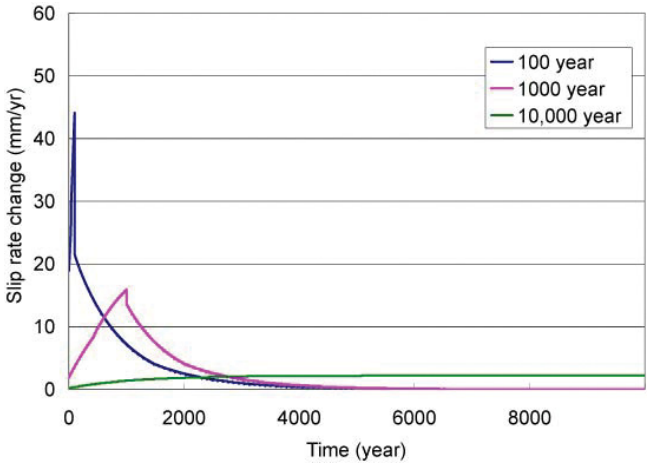
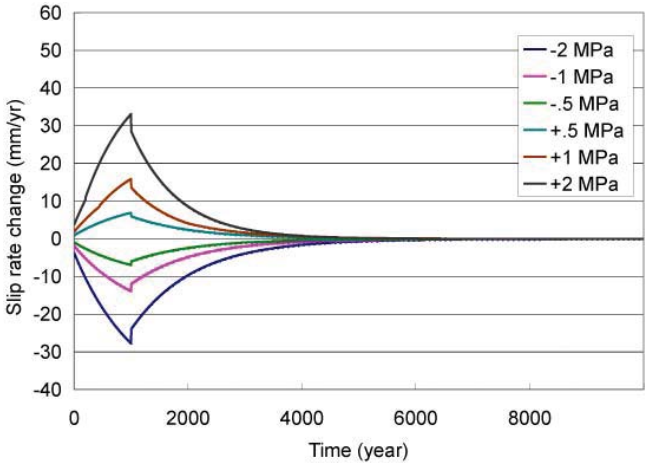


Figure 1. Predicted evolution of slip rates as 1 MPa ΔRCFS increase is accumulated over a period of 100 years, 1000 years, and 10,000 years, respectively. Slip rate decays afterwards. The peak of slip rate change is higher when the increase of the ΔRCFS is accomplished over a shorter period.

Figure 2. Slip rate changes caused by ΔRCFS at various magnitudes, which is accomplished in a period of 1000 years.



References

Chevalier, M.-L., F.J. Ryerson, P. Tapponnier, R.C. Finkel, J. Van Der Woerd, H. Li, and Q. Liu, Slip-rate measurements on the Karakorum fault may imply secular variations in fault motion, Science, 307, 411-414, 2005.

Hetzel, R., and A. Hampel, Slip rate variations on normal faults during glacial-interglacial changes in surface loads, Nature, 435, 81-84, 2005.

Li, Q., and M. Liu, Geometrical impact of the San Andreas Fault on stress and seismicity in California, Geophys. Res. Lett., 33, L08302, doi:08310.01029/02005GL025661, 2006.

Luttrell, K.M., D.T. Sandwell, and B.R. Smith, Slip rate modulation caused by ocean loading on glacial timescales, Eos Trans. AGU, 86 (52), Fall Meet. Suppl., Abstract G53A-0866, 2005.