Supporting Information for "Effect of Pressure Rate on Rate and State Frictional Slip"

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This supporting information presents additional simulations not included in the text. The first is the same as Figure 2 of the text, but for a smaller value of the diffusivity $\hat{c} = 0.1$. The three others are the same simulations as in Figures 2, 3, and 4 of the text for a larger value of the ratio of the spring stiffness to the critical value for drained deformation (eqn. (7) of the text), in particular, $\hat{k} = 0.5$.

The results for $\hat{c} = 0.1$ and $\hat{k} = 0.1$ are shown in Figure S1. The value of $K = 0.09$, eqn. (10) of text, is close to undrained conditions, and as a result, the response is strongly stabilized. For $\dot{P}_\infty$ equal to 10^{-5} and 10^{-4}, there are no discrete slip events. Increases

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of the velocity are slow and small in magnitude. For $\dot{P}_\infty = 10^{-3}$, there is one slow slip event with a peak velocity of about $4v_0$ which then decreases and levels off to a velocity of about $2.5v_0$. For $\dot{P}_\infty = 10^{-3}$, as for other values of $\hat{c}$, there is still a significant downward trend to the stress. Responses for smaller values of $\hat{c}$ will be even more strongly damped.

The results for $\hat{k} = 0.5$ are shown in Figure S2 for $\hat{c} = 1$ and in Figure S3 for $\hat{c} = 10$. Figure S4 shows results for $\dot{P}_\infty = 10^{-2}$ and two values of $\hat{c}$: 1.0 and 10.0 and a simulation only up to $T = 60$.

The upper panel of Figure S2 shows that the slip events are not abrupt. The amplitudes slowly increase and decrease. The amplitudes increase for $\dot{P}_\infty = 10^{-5}$ and 10^{-4} but do not get above $2v_0$. These slow events are nearly periodic and more frequent than those in Figure 2 of the text for $\hat{k} = 0.1$. Because $\hat{k}$ is smaller, the stabilizing effects of dilatant hardening at $\hat{c} = 1$ are more effective at damping the response than for $\hat{k} = 0.1$.

The results for the stress are shown in the lower panel. For $\dot{P}_\infty = 10^{-5}$ the stress is nearly constant. For 10^{-4} a slight downward trend begins to emerge and for 10^{-3} the downward trend becomes steeper and leads to a Coulomb failure. For all three values of $\dot{P}_\infty$, the variations of slip rate due to RS effects cause only small ripples in the stress.‘

The slip events in Figure S3 are similar to those in Figure 3 of the text. The velocity peaks ($v/v_0 \approx 55$) and stress drops (≈ 0.3) are smaller than for $\hat{k} = 0.1$, but more frequent. For $\dot{P}_\infty = 10^{-5}$ and 10^{-4} the trend of the stress is roughly constant. As in all other cases, for $\dot{P}_\infty = 10^{-3}$ the stress trends distinctly dowward.

In the upper panel of Figure S4 the velocity variations for $\hat{c} = 10$ are not so abrupt as for the smaller values of $\dot{P}_\infty$ in Figure S3. The biggest peak is about $40v_0$ but the peaks decay in roughly periodic fashion. For $\hat{c} = 1$ there is little change in the velocity and it remains slightly above v_0. This reflects the stabilizing effect of the proximity to undrained conditions. The stress variation is dominated by the linear downward trend for both $\hat{c} = 10$ and $\hat{c} = 1$ that brings the frictional resistance to near zero by the end of the simulation.

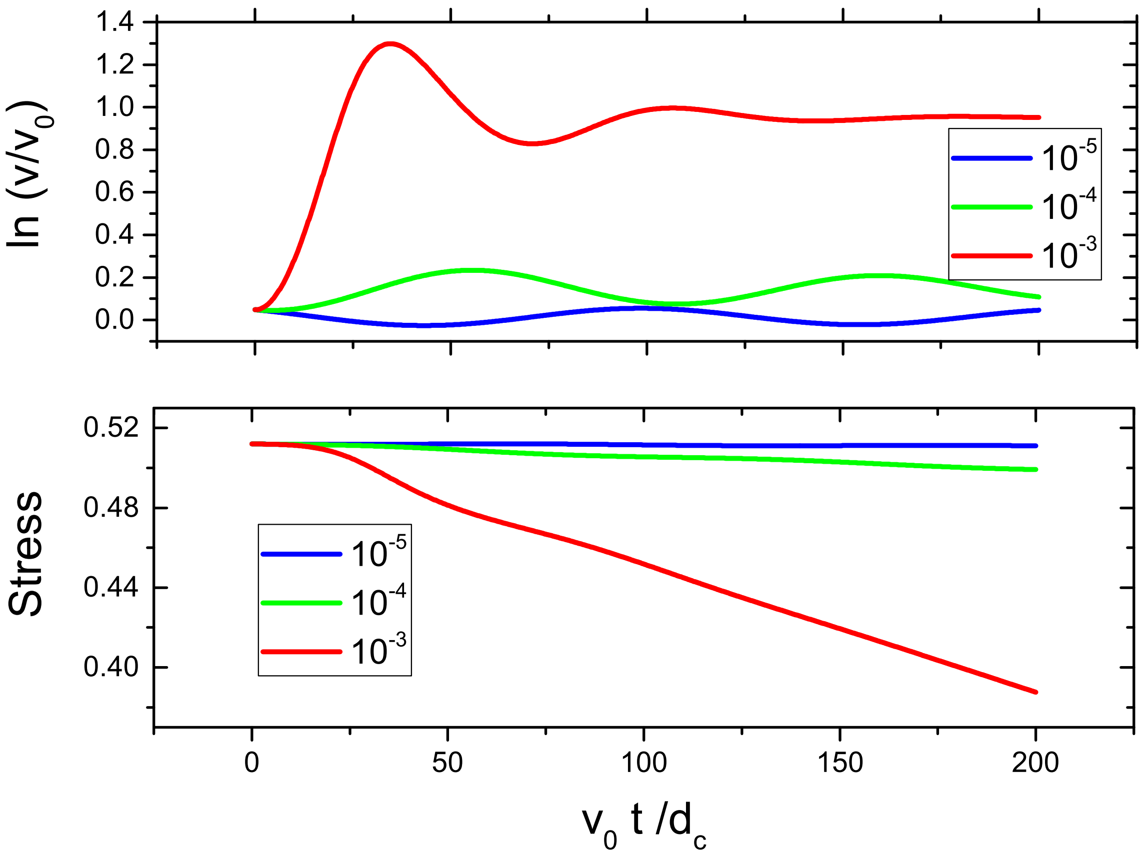

Figure S1. Upper panel shows logarithm of velocity (divided by v_0) and lower panel shows stress (divided by σ), $\Sigma = \mu_0 (1 - p/\sigma)$, for three values of $\hat{P}_\infty$: 10^{-5}, 10^{-4} and 10^{-3} The abscissa is $T = v_0 t/d_c$ and $\hat{c} = 0.1$ and $\hat{k} = 0.1$.

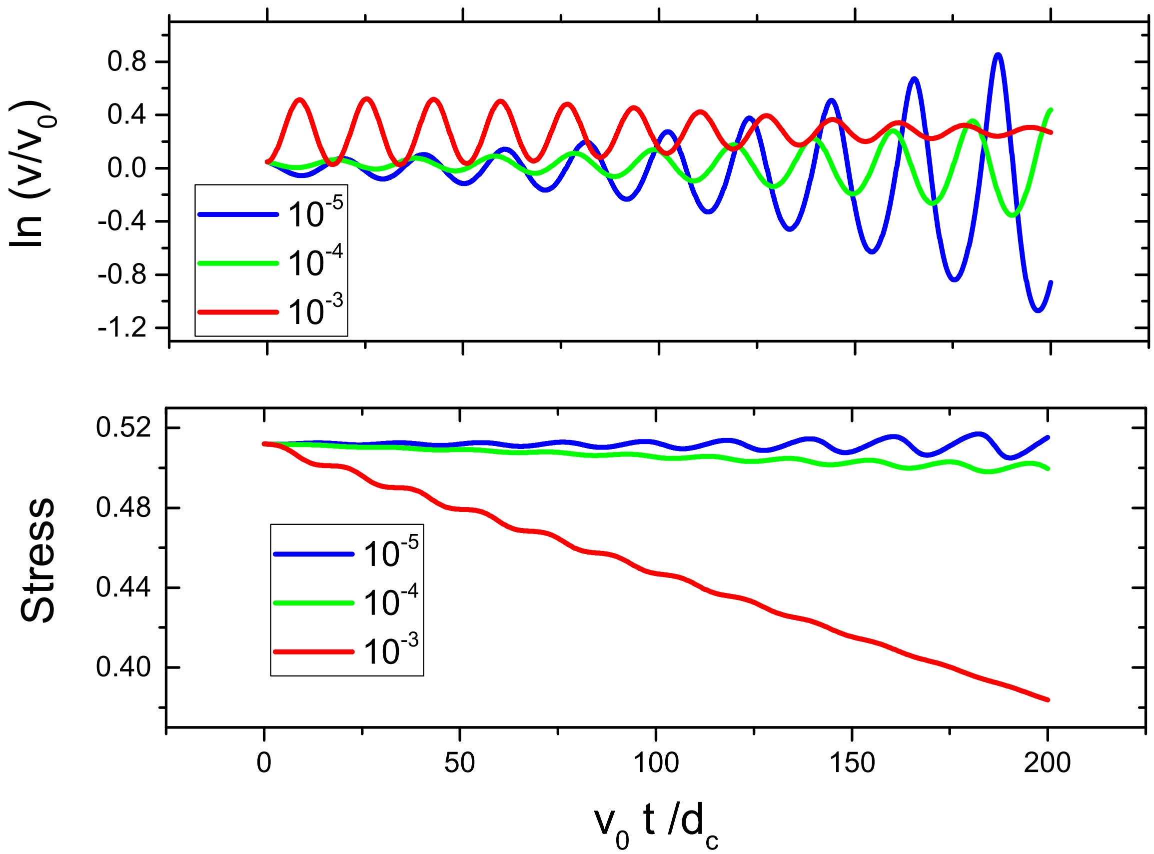

Figure S2. Same as Figure 2 of text except $\hat{k} = 0.5$. Upper panel shows logarithm of velocity (divided by v_0) and lower panel shows stress (divided by σ), $\Sigma = \mu_0\,(1 - p/\sigma)$, for three values of $\hat{P}_\infty$: 10^{-5}, 10^{-4} and 10^{-3} The abscissa is $T = v_0 t/d_c$ and $\hat{c} = 1$.

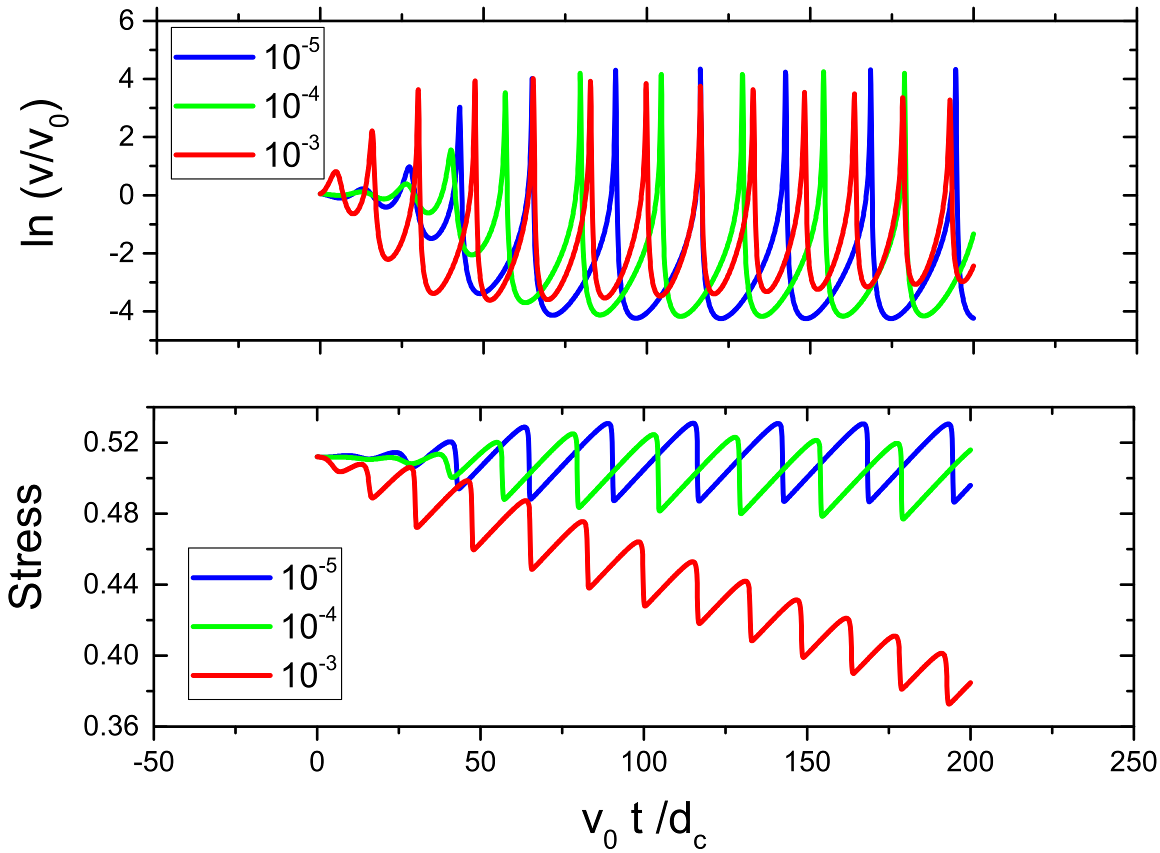

Figure S3. Same as Figure S2 for $\hat{c} = 10$.

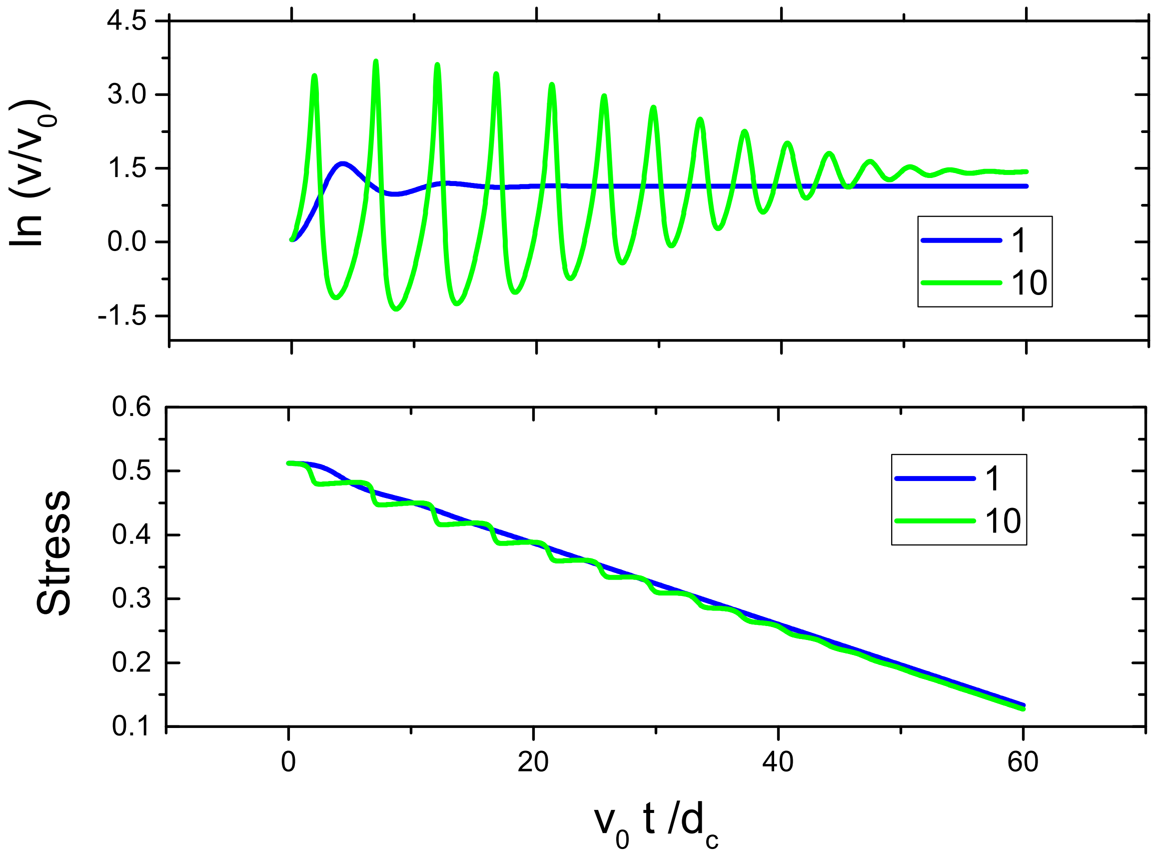

Figure S4. Same as Figure S2 for $\dot{P}_\infty = 10^{-2}$ and $\hat{c} = 1$ and 10.