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. (6) 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. (9) of text, is close to undrained conditions, and as a result, the response is strongly stabilized. For $\dot{P}_{\infty} = 10^{-3}$, there is one slow slip event with a peak velocity of about $3.7v_0$

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(which may be affected by the initial condition). The velocity quickly decays and levels off at about $2.6v_0$. (The velocity does not decay completely back to v_0 because the pressure rate is non-zero.) For $\dot{P}_\infty = 10^{-4}$, the maximum slip velocity is only $1.15v_0$. After a few small, slow events the velocity levels off at $1.15v_0$. Stress drops are not discernible on the scale of the graph. 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. Because the effective stress goes to zero at $T = 80$ the simulation is stopped there. Compared with $k = 0.1$, the results for $k = 0.5$ have lower maximum velocities and stress drops and higher frequencies. As for $k = 0.1$, maximum velocities increase and frequencies decrease with decreasing $\dot{P}_\infty$

The upper panel of Figure S2 shows that the slip events are frequent but the maximum velocities are small, no greater than about 2.7 v_0. For $\dot{P}_\infty = 10^{-3}$ the velocity is strongly damped because of the rapid decrease of the effective stress. For $\dot{P}_\infty = 10^{-4}$ and 10^{-5}, the velocities initially increase. They appear to reach a steady oscillation but they will eventually decline because of the increasing pore pressure. The amplitudes slowly increase and decrease. The lower panel shows the stress. The stress drops for $\dot{P}_\infty = 10^{-3}$ are indiscernible on the scale of the graph. For $\dot{P}_\infty = 10^{-4}$ and 10^{-5}, the pore pressure increases so slowly that the stress appears to be nearly constant and the drops in stress appear as small ripples.

For Figure S3 $\hat{c} = 10$. Conditions are nearly drained and there is little stabilization due to dilatant hardening. Maximum slip velocities are about 30 v_0. As in Figure S2, the more rapid decrease of the effective stress for $\dot{P}_\infty = 10^{-3}$ damps the response. For $\dot{P}_\infty = 10^{-4}$ and 10^{-5} the velocity appears to become periodic and the stress appears nearly constant but both will eventually decline. Stress drops are very small.

For $\dot{P}_\infty = 10^{-2}$ in Figure S4 the response is strongly damped. For $\hat{c} = 10$, there is a series of events with the peak velocities decaying from a maximum of 30 v_0 to 4.3 v_0 at $T \approx$. For $\hat{c} = 1$ there are only one or two small, slow events. Stress drops are not discernible for $\hat{c} = 1$ and only small ripples for $\hat{c} = 10$.

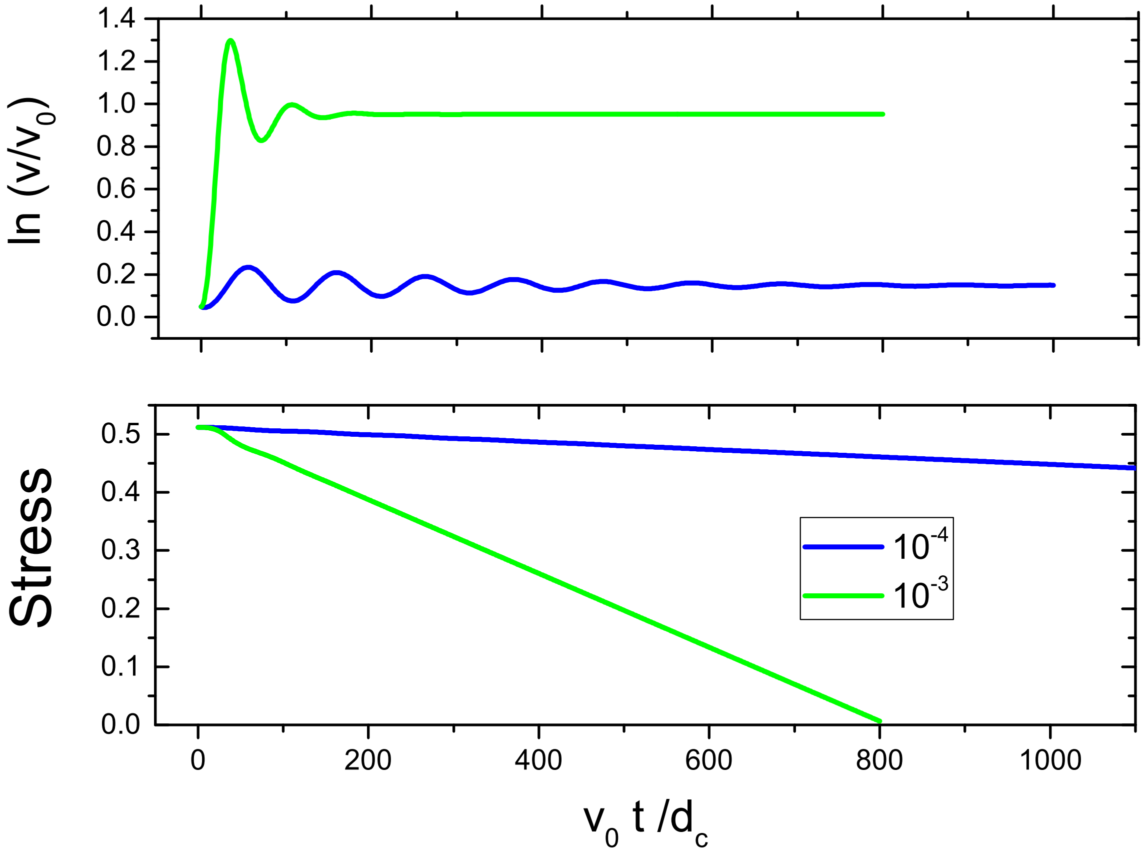

Figure S1. Upper panel shows logarithm of velocity (divided by v_0) and lower panel shows stress (divided by σ), $\Sigma = \mu_0\,(1 - p/\sigma)$, for two values of $\hat{P}_\infty$: 10^{-4} and 10^{-3} The abscissa is $T = v_0 t/d_c$ and $\hat{c} = 0.1$ and $\hat{k} = 0.1$.

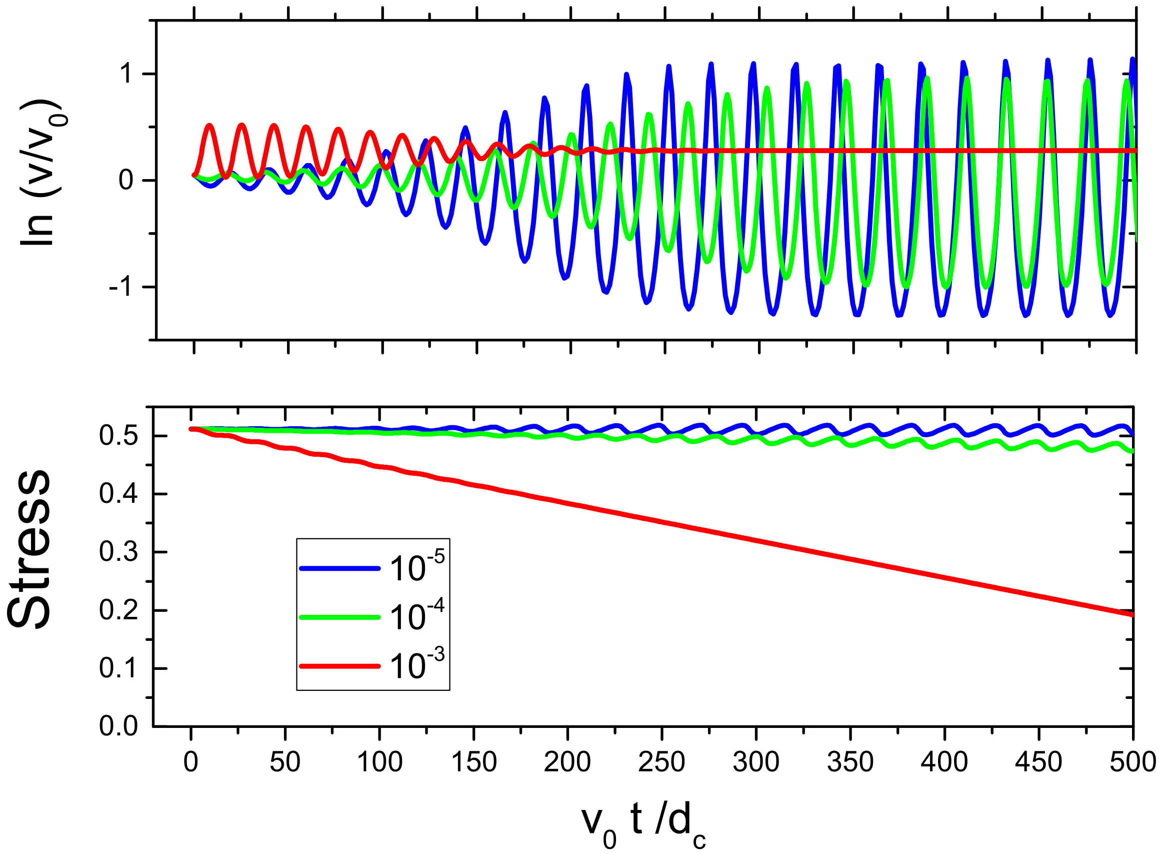

Figure S2. Same as Figure 2 of text except $\hat{k} = 0.5$. Upper panel shows logarithm of velocity (divided by v_0) and lower panel shows stress (divided by σ), $\Sigma = \mu_0 (1 - p/\sigma)$, for three values of $\hat{P}_\infty$: 10^{-5}, 10^{-4} and 10^{-3} The abscissa is $T = v_0 t/d_c$ and $\hat{c}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

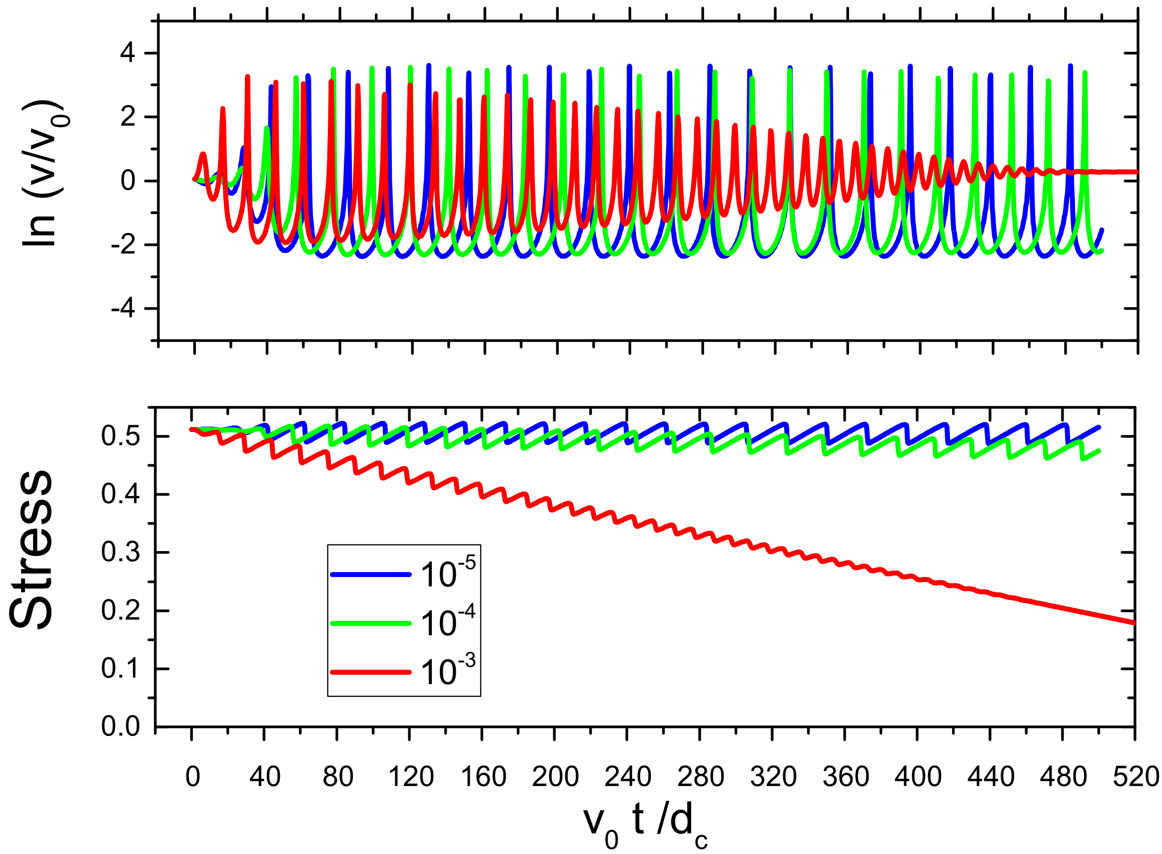

Figure S3. Same as Figure S2 for $\hat{c} = 10$.

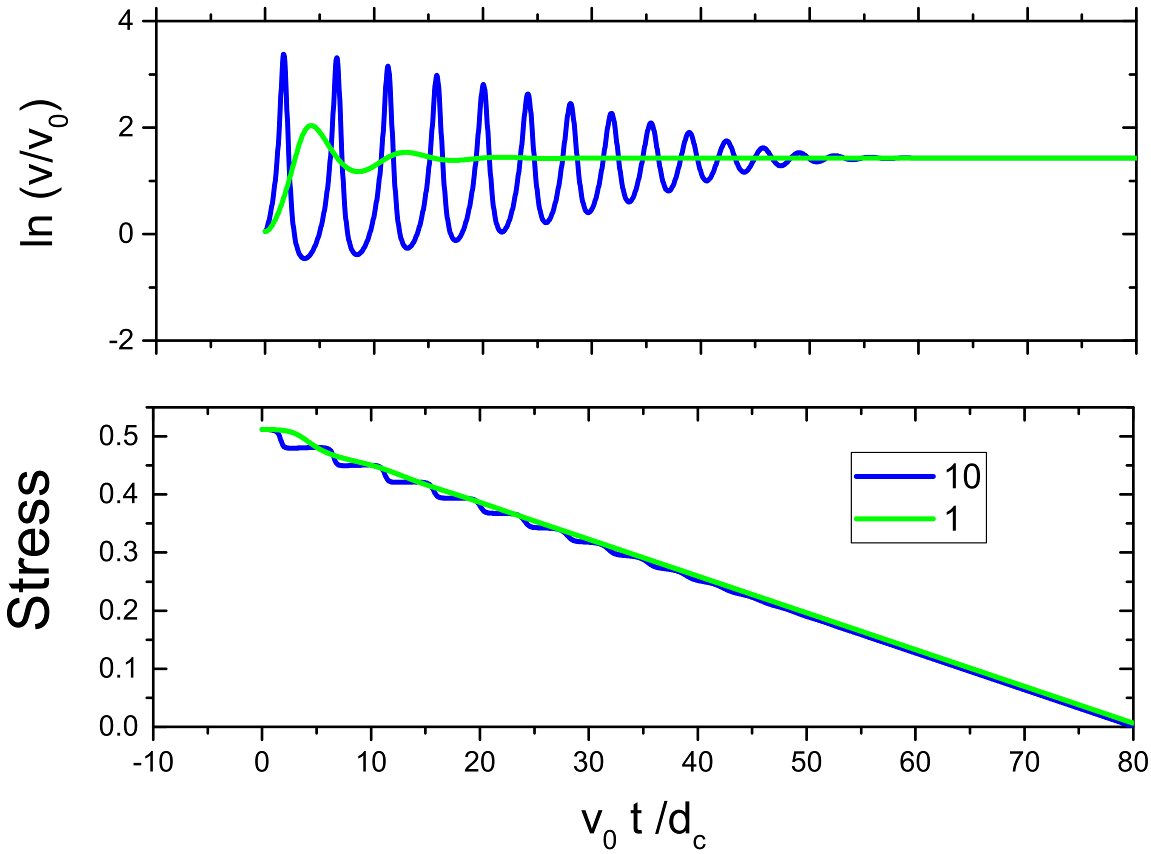

Figure S4. Same as Figure S2 for $\dot{P}_\infty = 10^{-2}$ and $\hat{c} = 1$ and 10.