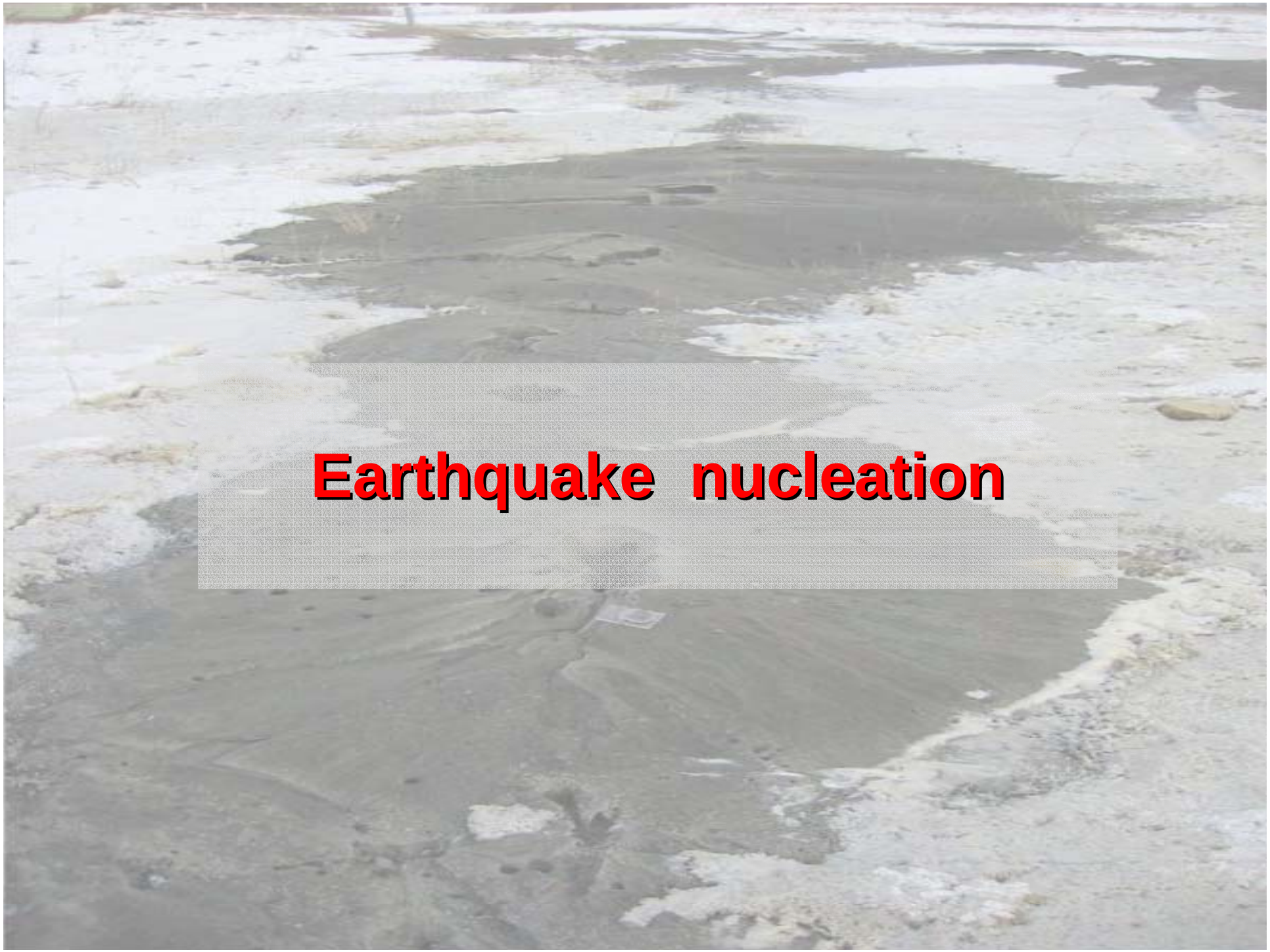

Earthquake nucleation

Nucleation Models

1. SELF – SIMILAR MODEL

- Allways fully dynamic process
- Slip velocity linearly increases with time
- Waves emission since initial stages of nucleation

2. CASCADE MODEL

- Small events with mutual triggering accumulate up to a big event
- Only the final stage is fully dynamic with waves emission

3. PRE – SLIP MODEL

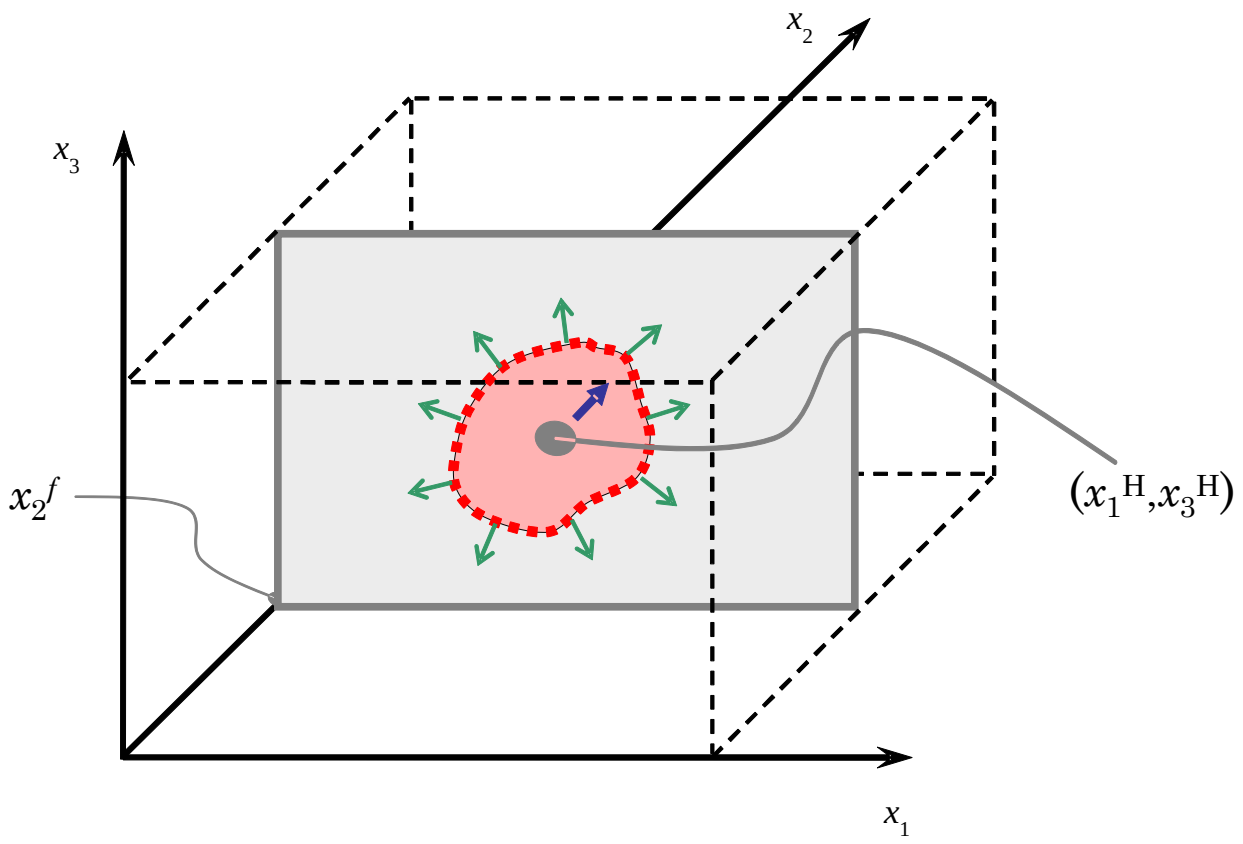
- Initially an asismic process increases the total crached area
- When a critical dimension is reached the process is spontaneous
- Dieterich and Andrews models

How to simulate the earthquake nucleation?

1. SLIP – WEAKENING CONSTITUTIVE EQUATION

- Linear SW is unable to model the nucleation stage and therefore rupture initiation has to be prescribed (i. e. imposed)
- Different nucleation strategy have to be compared in order to see what are the effects of the initialization parameters on the following rupture propagation
- In order to correctly represent a physical process nucleation strategies have to be equivalent results
- The Ohnaka' s SW contain the slip – hardening phase and is able to account for nucleation

Notations and symbols



→ *Local crack enlargement*

→ $T(x_1, x_3, 0)$

Time - weakening

`inuclstrat = 1`

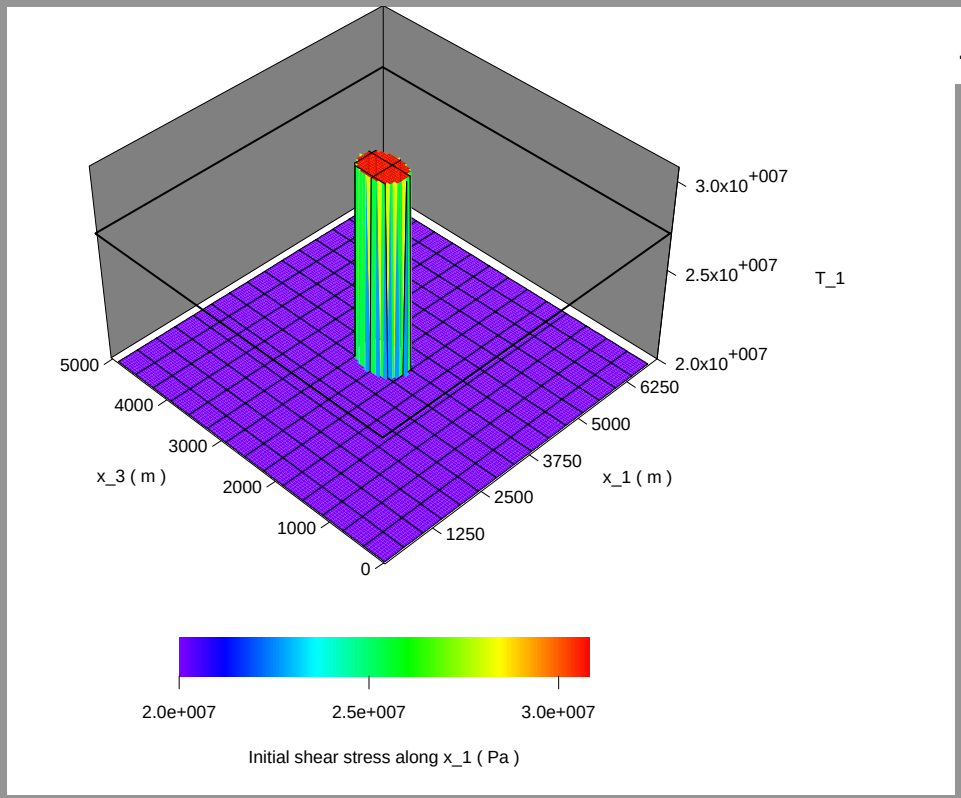
$$\tau = \begin{cases} \left[\mu_u - (\mu_u - \mu_f) \dfrac{\left(t - t_{force} \right)}{t_0} \right] \sigma_n^{\,eff} & , t - t_{force} < t_0 \\ \mu_f \sigma_n^{\,eff} & , t - t_{force} \geq t_0 \end{cases}$$

t_{force} = $t_{force}(\xi)$ is the forced rupture onset time in every fault point ξ.

Andrews (1985), *Bizzarri et al. (2001)* and other following Bizzarri' s papers

t_0 is the characteristic time – weakening duration.

Pre - stress asperity




```
inuclstrat = 2
```

i_nucl is the asperity radius. In general, arbitrary distribution of $T(x_1,x_3,0)$ is read from input files.

Bizzarri and Cocco (2005c, 2005d) and other following Bizzarri' s papers

Slip velocity perturbation

```
inuclstrat = 3
```

$$V\begin{Bmatrix}1\\2\\3\end{Bmatrix}(x_1,x_2,x_3,0)=\frac{1}{2}\,\mathrm{sign}\left(x_2-{x_2}^f\right)v_{init}\begin{Bmatrix}\cos\varphi\\0\\\sin\varphi\end{Bmatrix}\mathrm{e}^{\frac{\left(x_1-{x_1}^{\mathrm{H}}\right)^2}{\left(x_1-{x_1}^{\mathrm{H}}\right)^2-\left(i_{nucl}\,\Delta x_1\right)^2}}\,\mathrm{e}^{\frac{\left(x_3-{x_3}^{\mathrm{H}}\right)^2}{\left(x_3-{x_3}^{\mathrm{H}}\right)^2-\left(j_{nucl}\,\Delta x_3\right)^2}}\,\mathrm{e}^{-\frac{\left(x_2-{x_2}^f\right)^2}{\left(r_{nucl}\right)^2}}$$

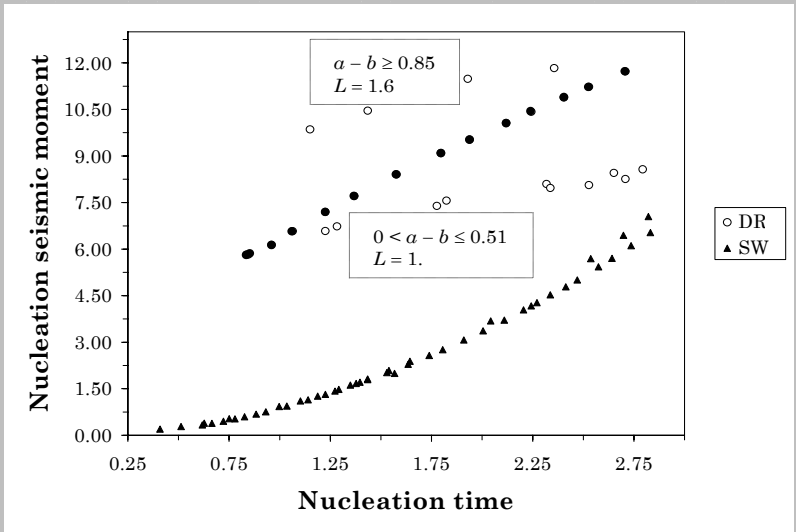
$$\mathrm{H}\left(\left(i_{nucl}\,\Delta x_1\right)^2-\left(x_1-{x_1}^{\mathrm{H}}\right)^2\right)\mathrm{H}\left(\left(j_{nucl}\,\Delta x_3\right)^2-\left(x_3-{x_3}^{\mathrm{H}}\right)^2\right)$$

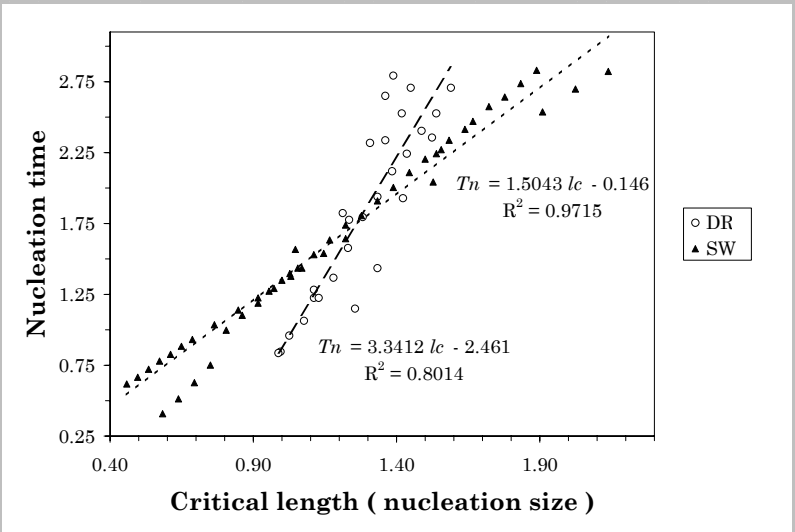
φ is the rake angle, measured from x_1 in anti – hourly sense; $\varphi = 0$ represents a left – lateral strike slip fault

With opportune corrections and modifications of *Ionescu and Campillo (1999)* and *Badea et al. (2004)*

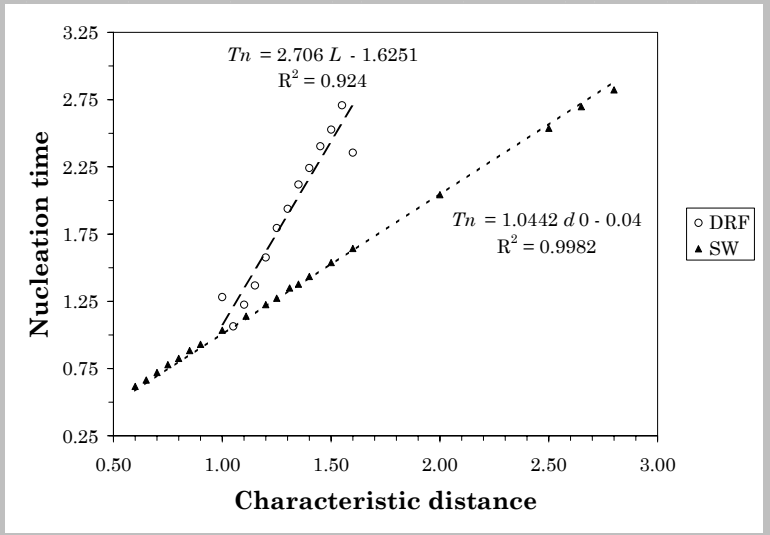
v_{init} is the maximum imposed fault slip velocity; i_{nucl} and j_{nucl} deterimine the extension of the nucleation patch and r_{nucl} is a sensitivity factor

Some correlations during nucleation





T_n is the time necessary for the rupture tip to reach a distance along x_1 equal to the critical half–length $L_c^{(II)}$



2. RATE AND STATE CONSTITUTIVE EQUATIONS

- Rate – and state – dependent friction laws are able to describe the nucleation stage
- The spontaneous rupture nucleation is modeled through the evolution of the state variable
- The earthquake initiation is promoted in a nucleation path assuming a different distribution of the contact time of the micro – asperities

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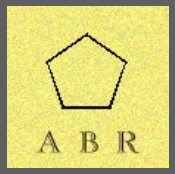
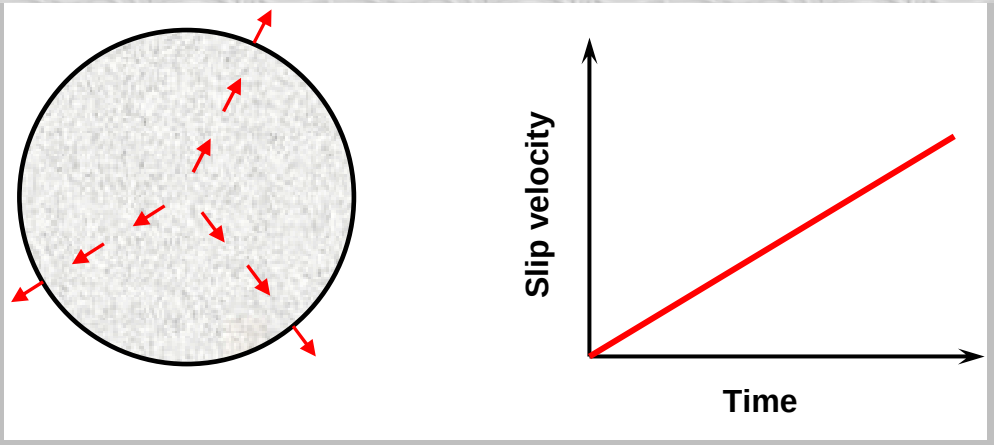
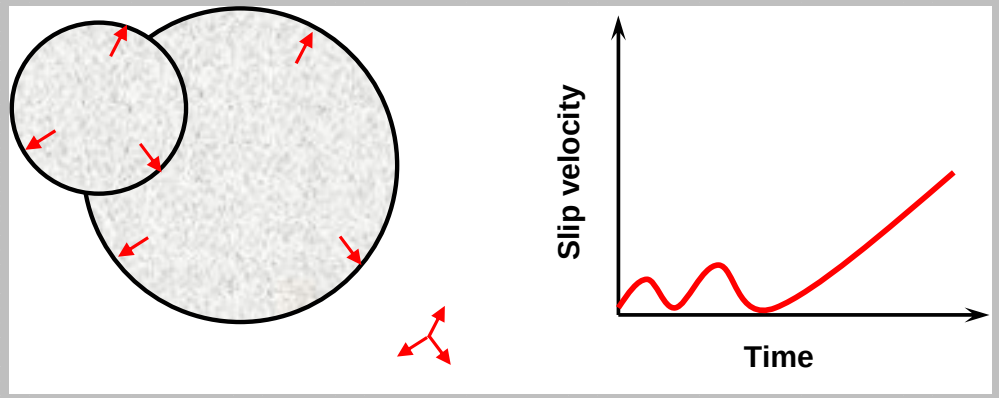
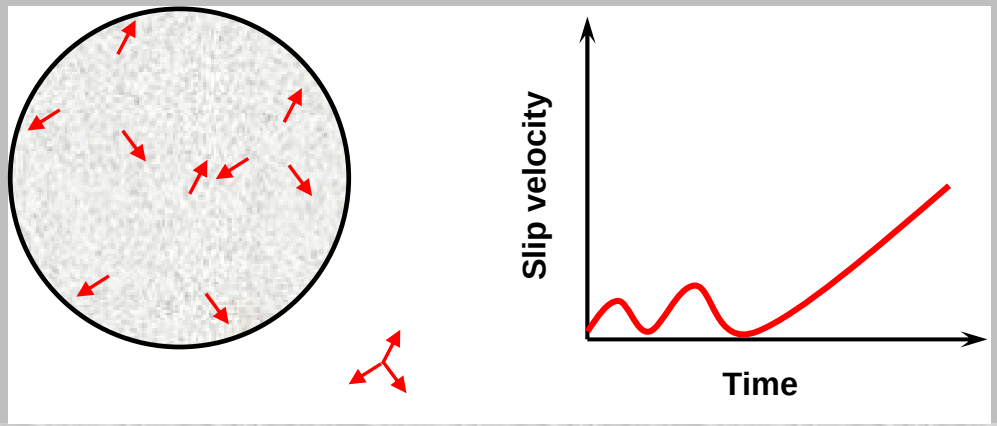


Support Slides:
Parameters, Notes, etc.

To not be displayed directly. Referenced above.


Slip velocity
Time


Slip velocity
Time


Slip velocity
Time