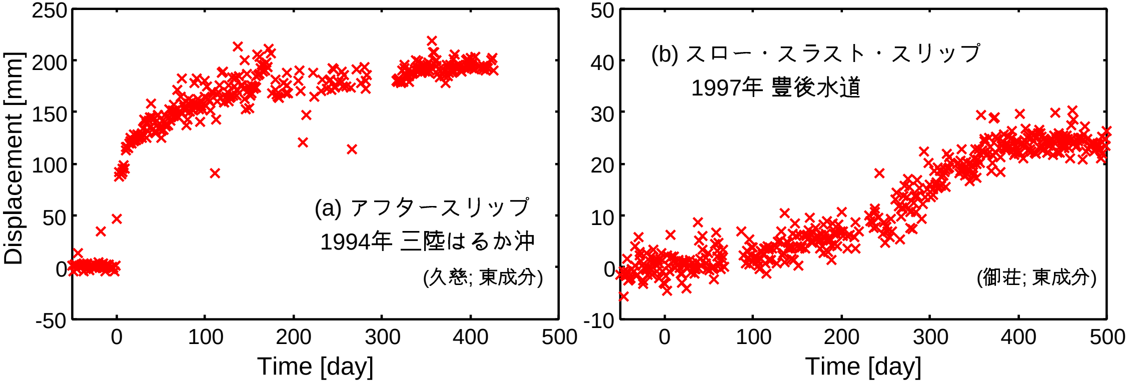
GJ seminar 2002年6月18日

速度・状態依存摩擦則に基づく沈み込み帯3次元地震サイクルシミュレーション

— 地震断層の有限性・すべり現象の多様性の一解釈 —

廣瀬 仁

GPS 地表変位データ


Displacement [mm]
Time [day]
(a) アフタースリップ
1994年 三陸はるか沖
(久慈; 東成分)
(b) スロー・スラスト・スリップ
1997年 豊後水道
(御荘; 東成分)

東北地方のアスペリティマップ by 菊地 & 山中 (2001)

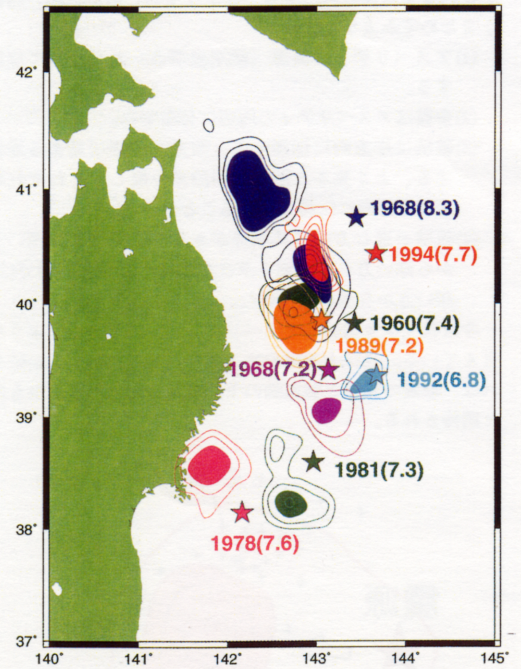


図2　三陸沖の地震（1960年以降）のアスペリティ分布。図のかっこ内の数字はモーメントマグニチュード（Mw）を示す。

ブロック・バネモデルによる SOC (Kumagai et al., 1999)

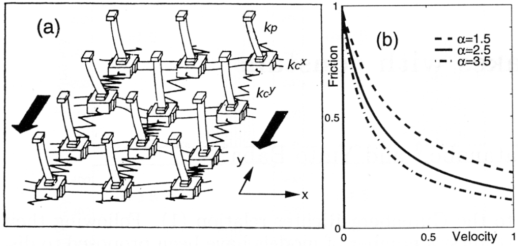
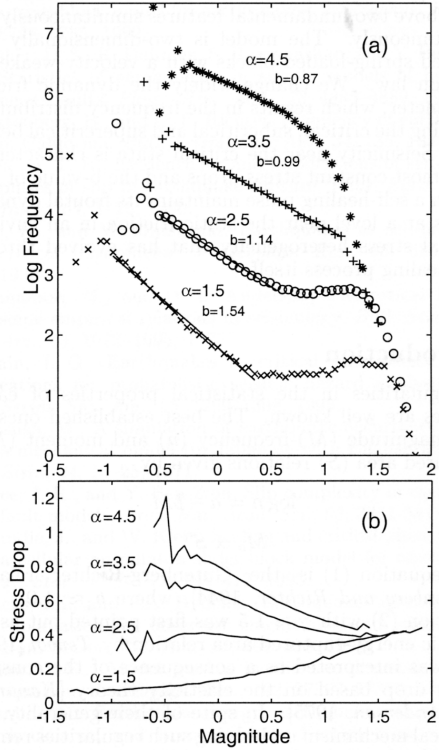


Figure 1. (a) Schematic diagram of the two-dimensional spring-block model (*Otsuka* [1971] with a modification). (b) Velocity-weakening curves for different α (see equation 4). We solved numerically the finite difference equation (3) by the Runge-Kutta method. The integration was begun with a slightly perturbed initial condition. We used the events occurring after an initial period during which clear transitions have subsided so that the statistics may not be influenced by the initial condition. The free boundary condition was adopted. The block configuration was fixed to 100 × 25 on the (x,y) plane. Throughout this study, σ in the equation (4) was fixed to 0.01.



連続モデルでは固有地震的な挙動

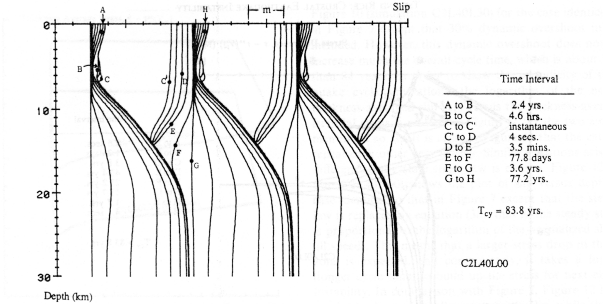
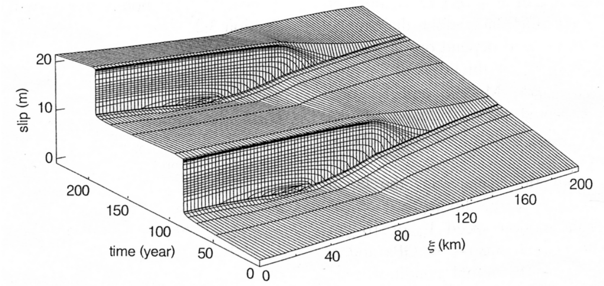


Fig. 7. Plot of slip vs depth through a time history of three earthquake cycles. The simulation is based on the steady state stress law (5), such that the steady state stress becomes velocity independent when velocity is above 0.1 mm/s, and L = 40 mm; dynamic overshoot in stress is not included. Depth distributions of A and B are denoted by case 2 in Figures 1 and 3. Other parameters used for the calculation are indicated in the text. This simulation is coded C2L40L00; see Table 1 for explanation. Each line represents a constant time, but the time interval between any two adjacent lines is not uniform. The time intervals between some representative lines are indicated.

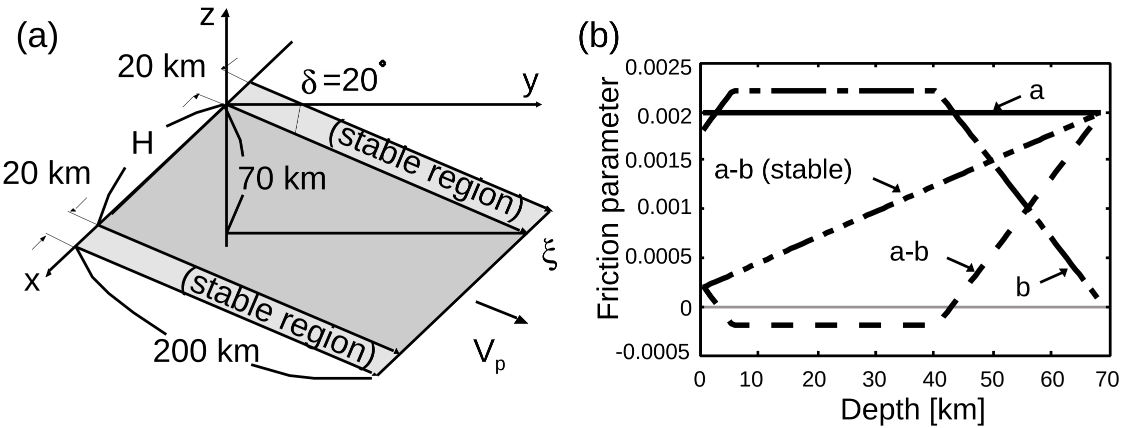


Tse & Rice (1986)

Kato & Hirasawa (1997)

シミュレーション方法

(a) モデルの geometry と座標軸の定義; (b) 摩擦パラメタの分布



準静的な力の釣り合い

$$\tau_i = \sum_j K_{ij}(V_p t - u_j) - \eta V_i \tag{1}$$

速度・状態依存摩擦則

$$\tau = \mu\sigma^{\mathrm{eff}} \tag{2}$$

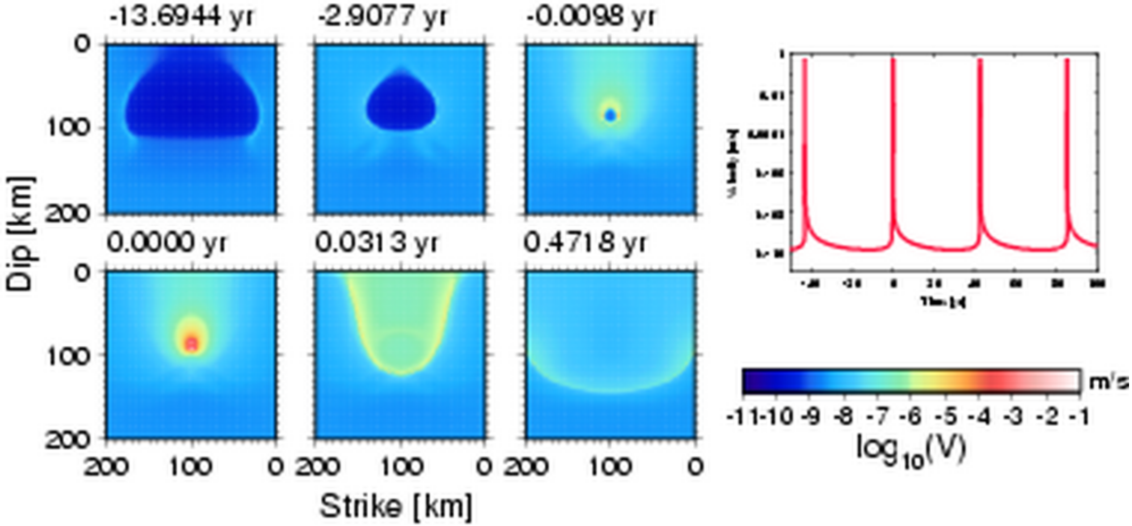
$$\mu = \mu_0 + a\ln(V/V_p) + b\ln(\theta V_p/L) \tag{3}$$

$$\frac{d\theta}{dt} = 1 - \frac{\theta V}{L} \tag{4}$$

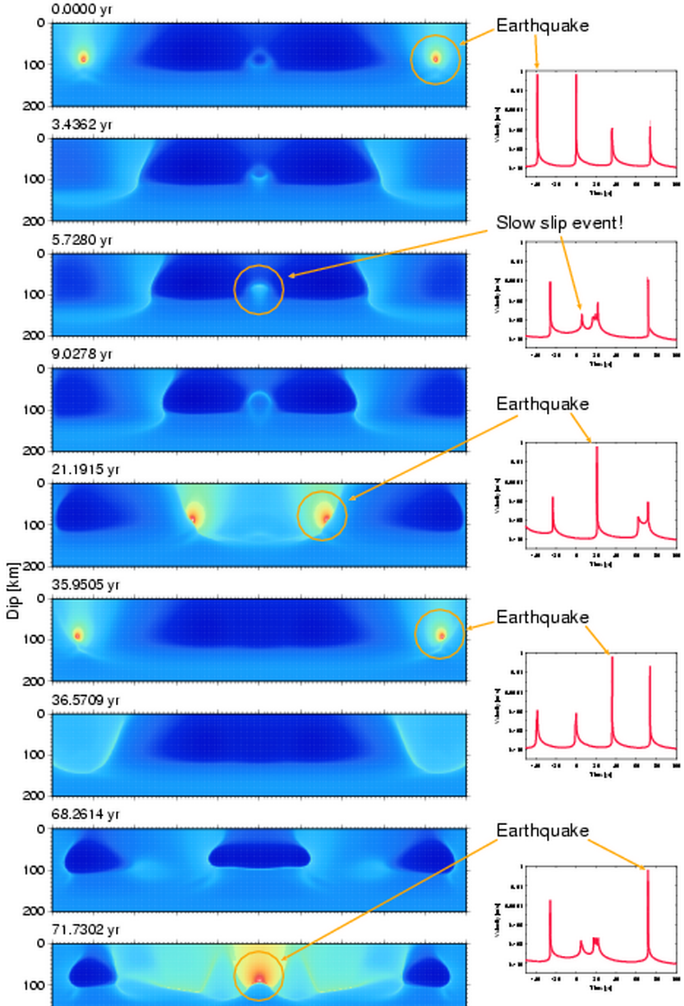
高速すべり時のカットオフ (Tse & Rice, 1986)

$$\mu_{ss} = \mu_0 - (a-b)\ln(V_0/V + e^{-n}) \tag{5}$$

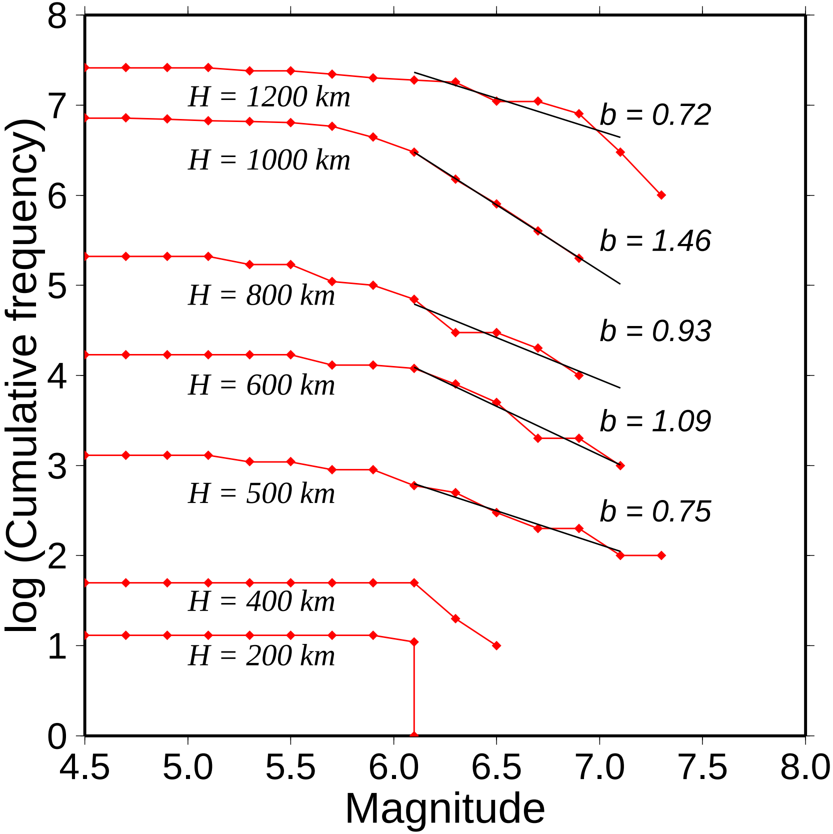
$H = 200$ km の場合のすべり速度のスナップショットと時系列



$H = 1000$ km の場合のすべり速度のスナップショットと時系列

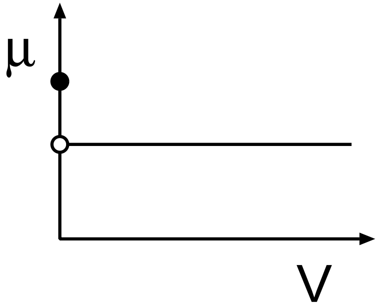


地震の規模の頻度分布

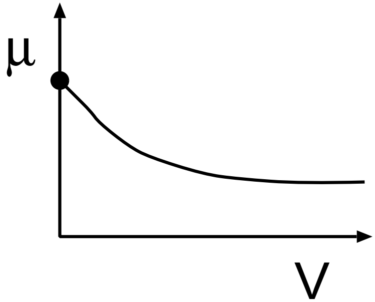


8
7
6
5
4
3
2
1
0
log (Cumulative frequency)
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
Magnitude
H = 1200 km
H = 1000 km
H = 800 km
H = 600 km
H = 500 km
H = 400 km
H = 200 km
b = 0.72
b = 1.46
b = 0.93
b = 1.09
b = 0.75

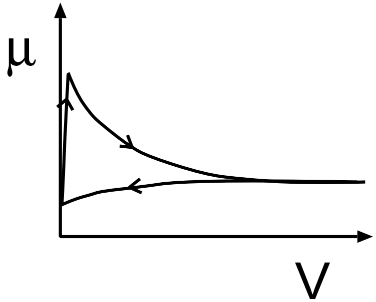
付録: 摩擦則について



静止摩擦, 動摩擦

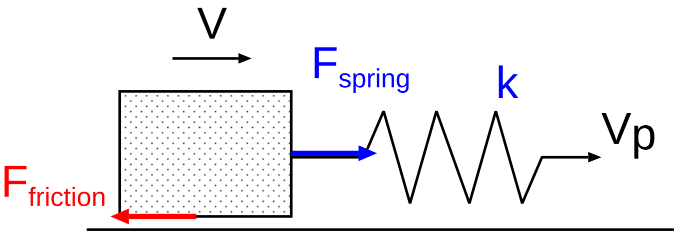


速度弱化摩擦

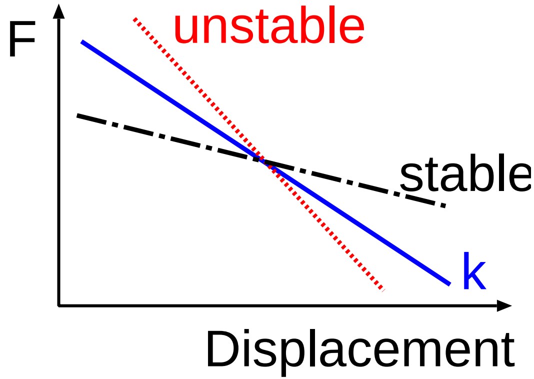


スティック–スリップ時の摩擦挙動

付録: すべりの安定性と臨界断層サイズ



ブロック–バネモデル。記号の定義。



すべり量 vs. バネの力および摩擦力。

付録: **Velocity Step Test**

Rock sliding experiment