Frictional properties of the San Andreas Fault determined from dynamic modeling of afterslip

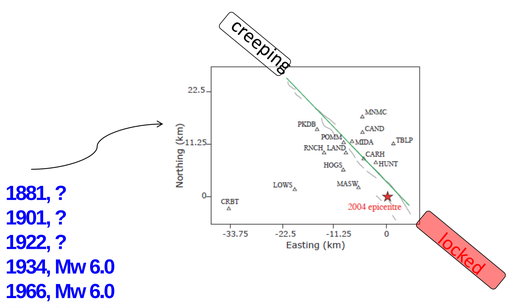
Shu-Hao Chang[1 2], Sylvain Barbot[1], Jean-Philippe Avouac[1] and Jian-Cheng Lee[2]

[1]Geological and Planetary Sciences, California Institute of Technology

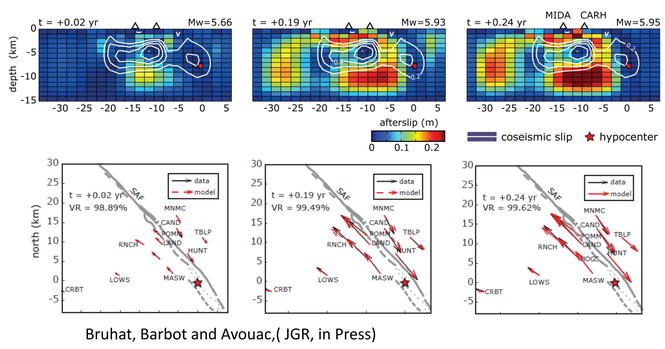
[2]Institute of Earth Sciences, Academia Sinica

Introduction

The Parkfield Mw6 earthquakes Sequence

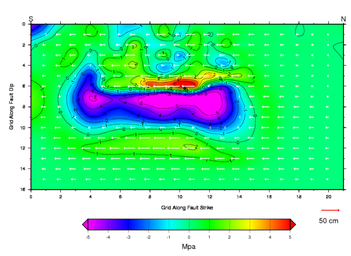


Coseismic and Afterslip following he 2004, Mw 6.0 Parkfield earthquake derived from the inversion of GPS and inSAR data.



Bruhat, Barbot and Avouac,(JGR, in Press)

Dynamic modeling of afterslip



Input:
Coseismic stress change

Output:
Afterslip

Model parameters:

- 'Static friction'
- Preseismic stress
- rate-dependency of friction

$\mu_{ss}= \tau/\sigma= \mu_*+A \ln(V/V_*)$

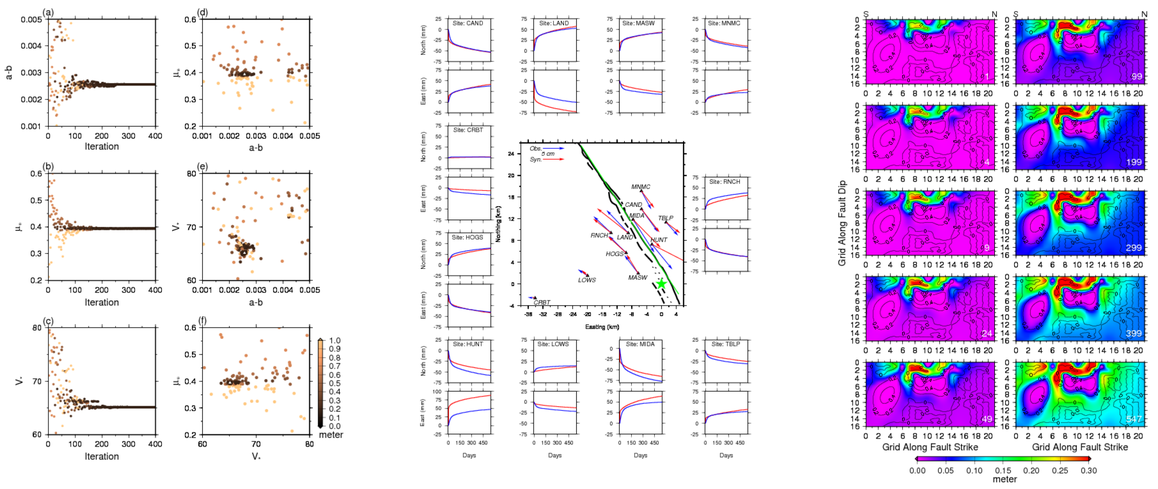
A= a-b

$$V = V_* \exp(\frac{cff_0 + \Delta cff_e + \Delta cff_c}{A(\sigma_0 + \Delta\sigma_e + \Delta\sigma_c)})$$

$$\Delta cff_e = \Delta\tau_e - \mu_*\Delta\sigma_e$$

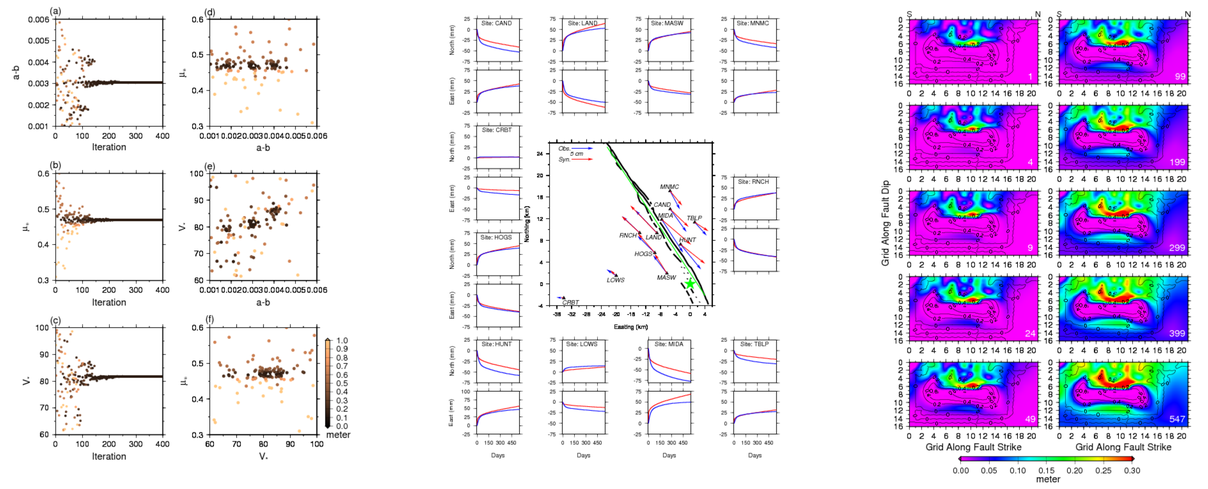
$$\Delta cff_c = \Delta\tau_c - \mu_*\Delta\sigma_c$$

Homogeneous friction models



The inverted parameters and root mean square of model A1:

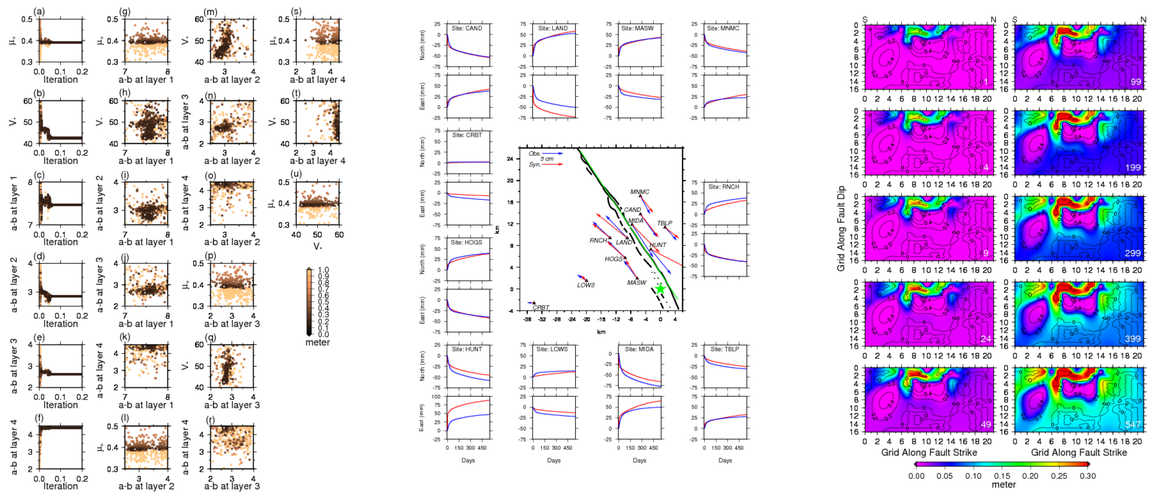
$\mu_* = 0.39 \quad a-b = 2.6\times10^{-3} \quad V_* = 65.11$ mm/yr rms=0.1625 meter.



The inverted parameters and root mean square of model A2:

$\mu_* = 0.47 \quad a-b = 3.0\times10^{-3} \quad V_* = 81.75$ mm/yr rms=0.1380 meter.

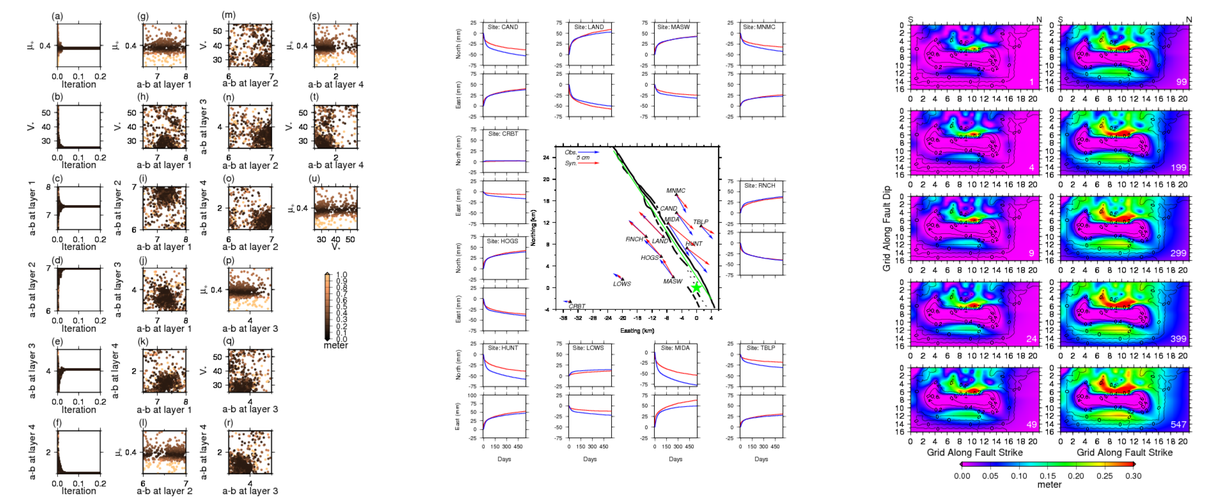
4 layers friction models



The inverted parameters and root mean square of model B1:

$\mu_* = 0.39 \quad a-b = 7.5\times10^{-3} \quad 2.8\times10^{-3} \quad 2.6\times10^{-3} \quad 4.4\times10^{-3}$ for layer 1 to 4 from shallow to deep

$V_* = 42.56$ mm/yr rms=0.1607 meter.

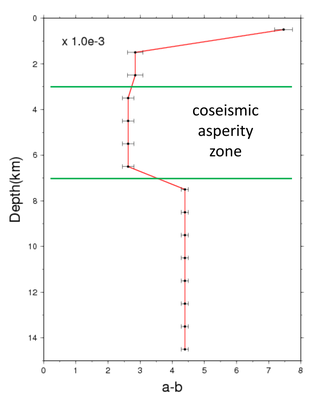


The inverted parameters and root mean square of model B2:

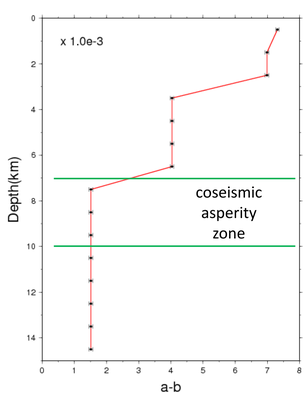
$\mu_* = 0.39 \quad a-b = 7.3\times10^{-3} \quad 7.0\times10^{-3} \quad 4.0\times10^{-3} \quad 1.5\times10^{-3}$ for layer 1 to 4 from shallow to deep

$V_* = 25.11$ mm/yr rms=0.1306 meter.

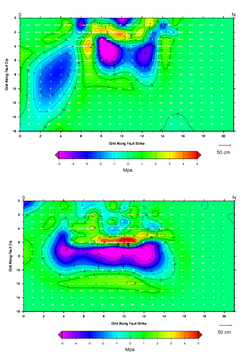
Discussion & Conclusion



Depth variation of a-b for model B1



Depth variation of a-b for model B2



Δcff_e V.S. afterslip

Model & parameters	V_0 (mm/yr)	M_0 (nt-m)	M_w	Max slip at top (meter)	Max slip at bot (meter)	RMS (meter)
Model A1	60.7	23.27	6.2	0.37	0.18	0.1625
Model A2	26.2	19.93	6.2	0.31	0.19	0.1380
Model B1	65.2	22.99	6.2	0.38	0.15	0.1607
Model B2	26.0	20.44	6.2	0.30	0.24	0.1306

$$V_0 = V_* \exp[\frac{cff_0}{(a-b)\sigma_0}]$$

- Our results are consistent with local fricational properties determined on rock samples recovered from the fault zones at 2.7 km depth thanks to the SAFOD experiment.
- The afterslip takes place at the top of coseismic asperity and then propagates to the bottom of the asperity.
- The inferred moment due to afterslip was equivalent to a magnitude Mw 6.2 earthquake over 1.5 year following the mainshock.
- The region with velocity weakening (a-b<0) could change to velocity strengthening (a-b>0).
- Both of the coseismic ruptures have similar results in our simulation.

Acknowledgments

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