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Earthquake Tectonics and Hazards on the Continents

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Recognizing and characterizing strike-slip faults and earthquakes in USA

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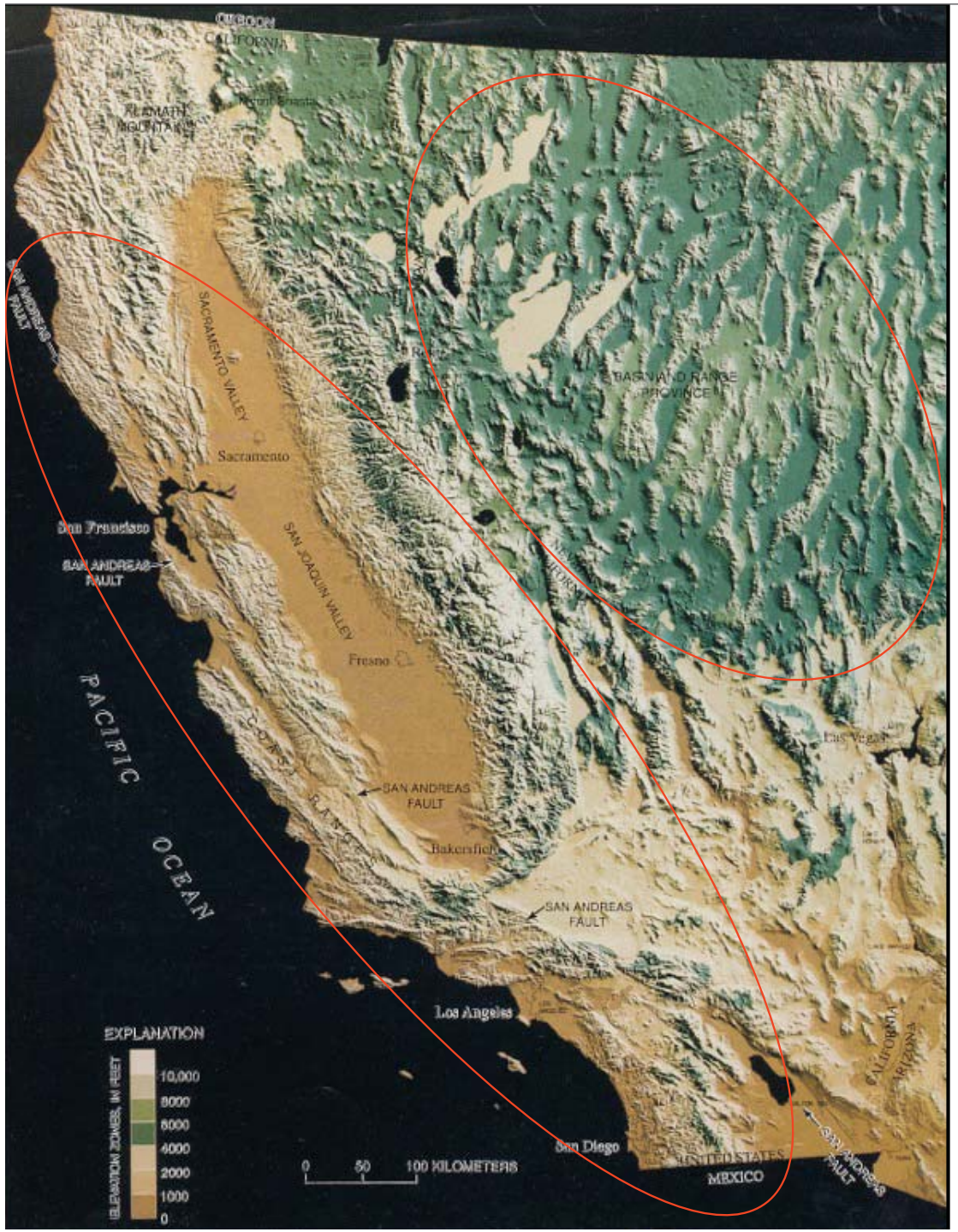
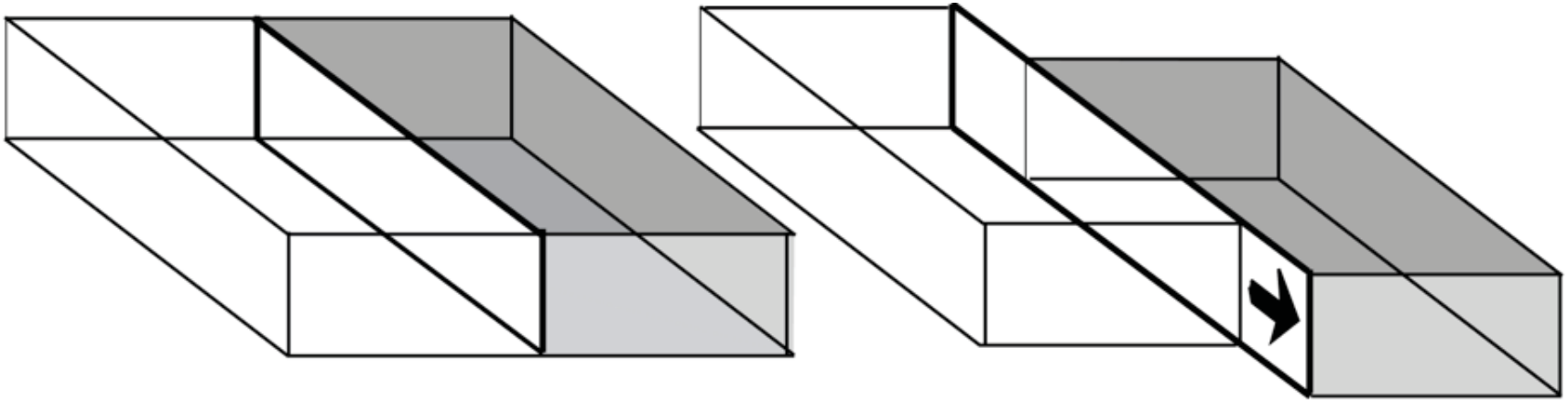
Strike-slip Faults
Geomorphic Expression, Slip Rate, and Repeat Time

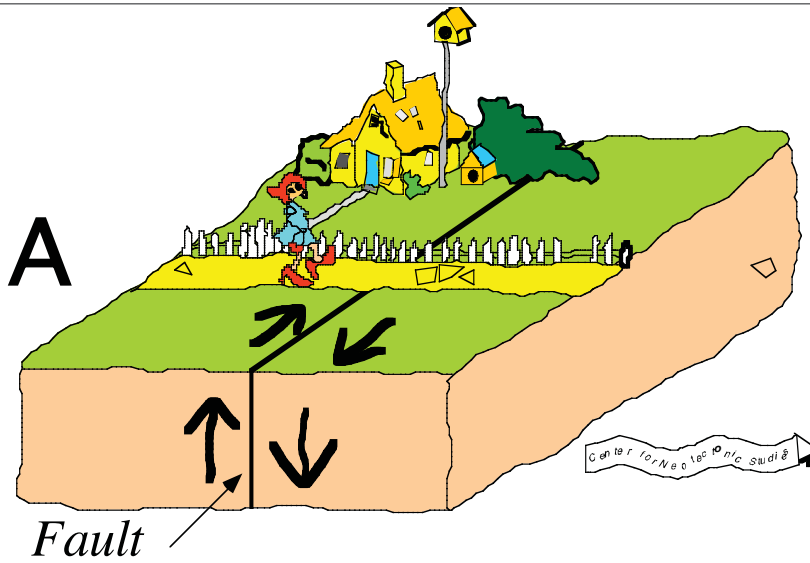
Trieste 2013 Wesnousky

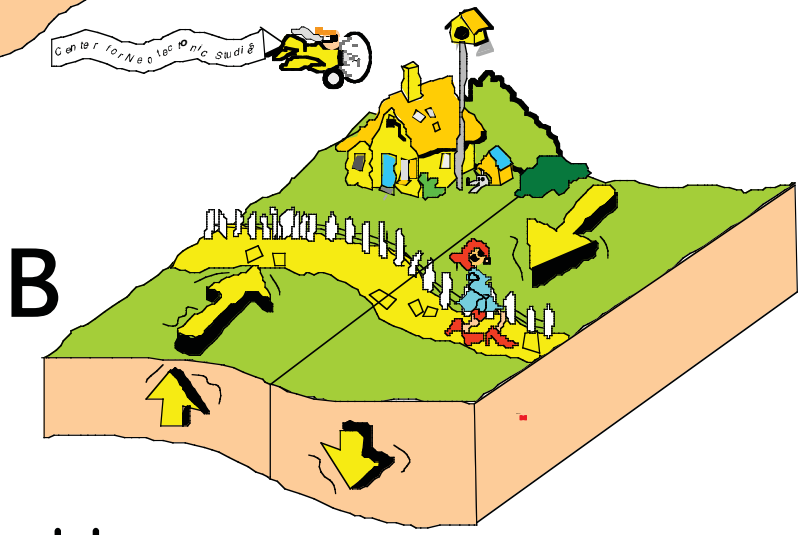


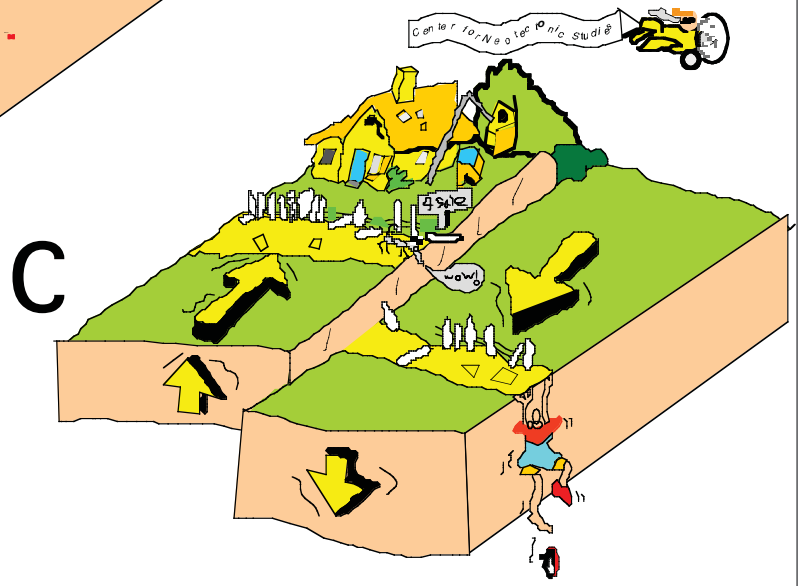
Physiograhy
Geomorphology
and
Faulting

A Strike-Slip Fault







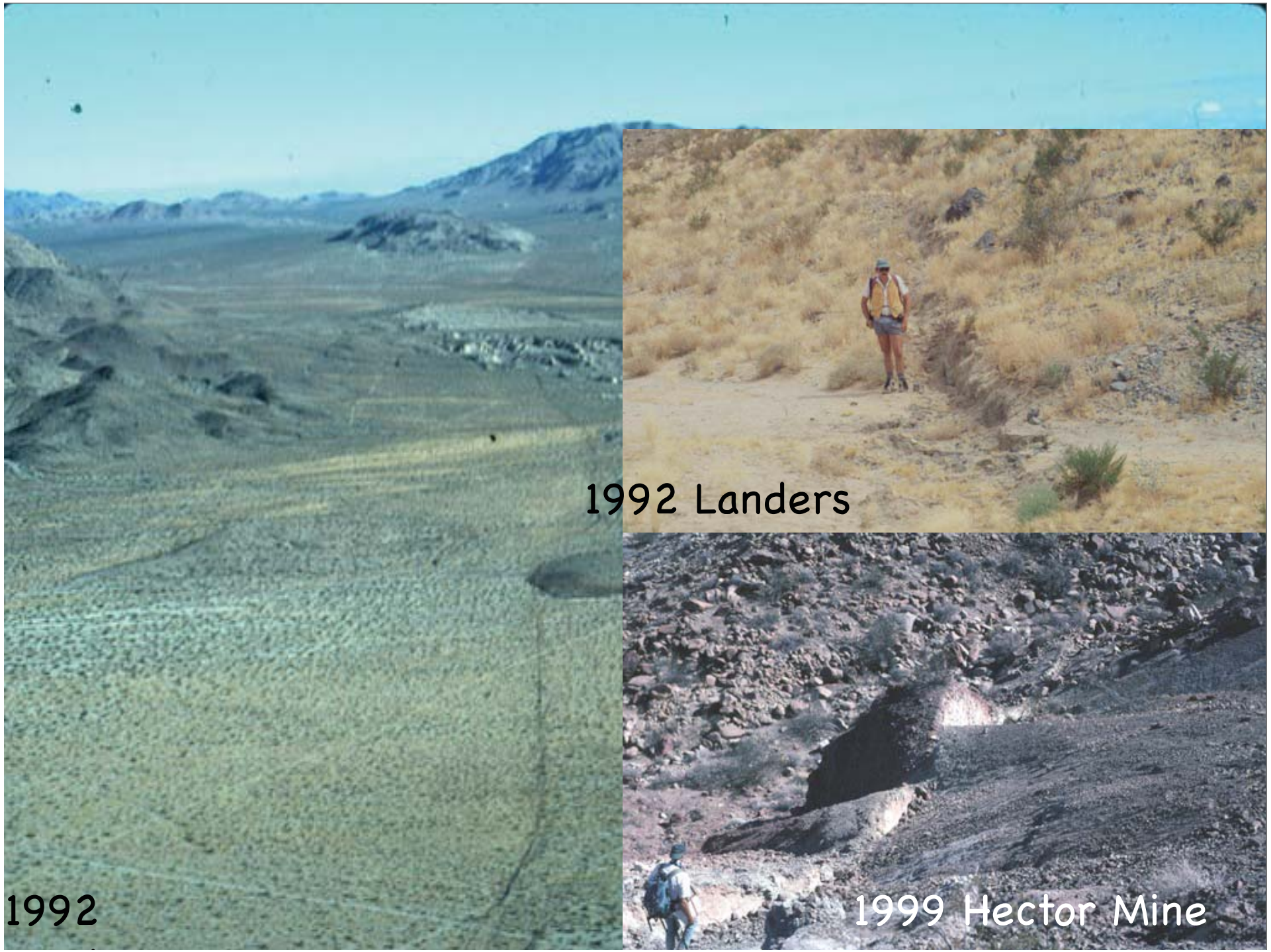


An earthquake is the result of a sudden displacement across a fault that releases stresses that have accumulated in the crust of the earth.

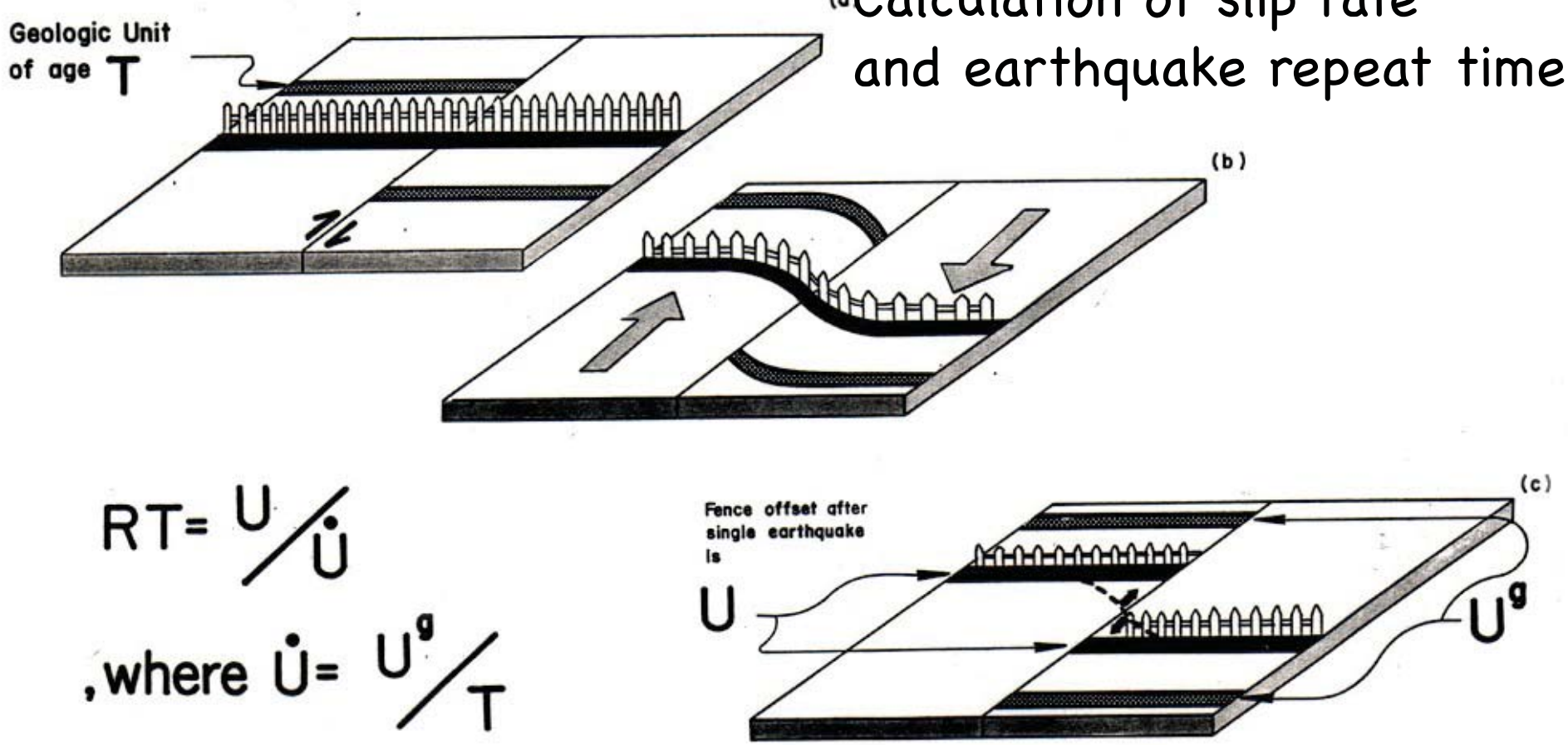
Mckay's 1890 report on the 1888 Hope Fault Earthquake, NewZealand

Koto's 1893 report on the 1891 Neodani Earthquake, Japan

Gilbert's 1884 paper on theorey of earthquakes in the Great Basin and 1910 account of the 1906 San Francisco earthquake, United States.


1992 Landers
1992
1999 Hector Mine

(a Calculation of slip rate and earthquake repeat time

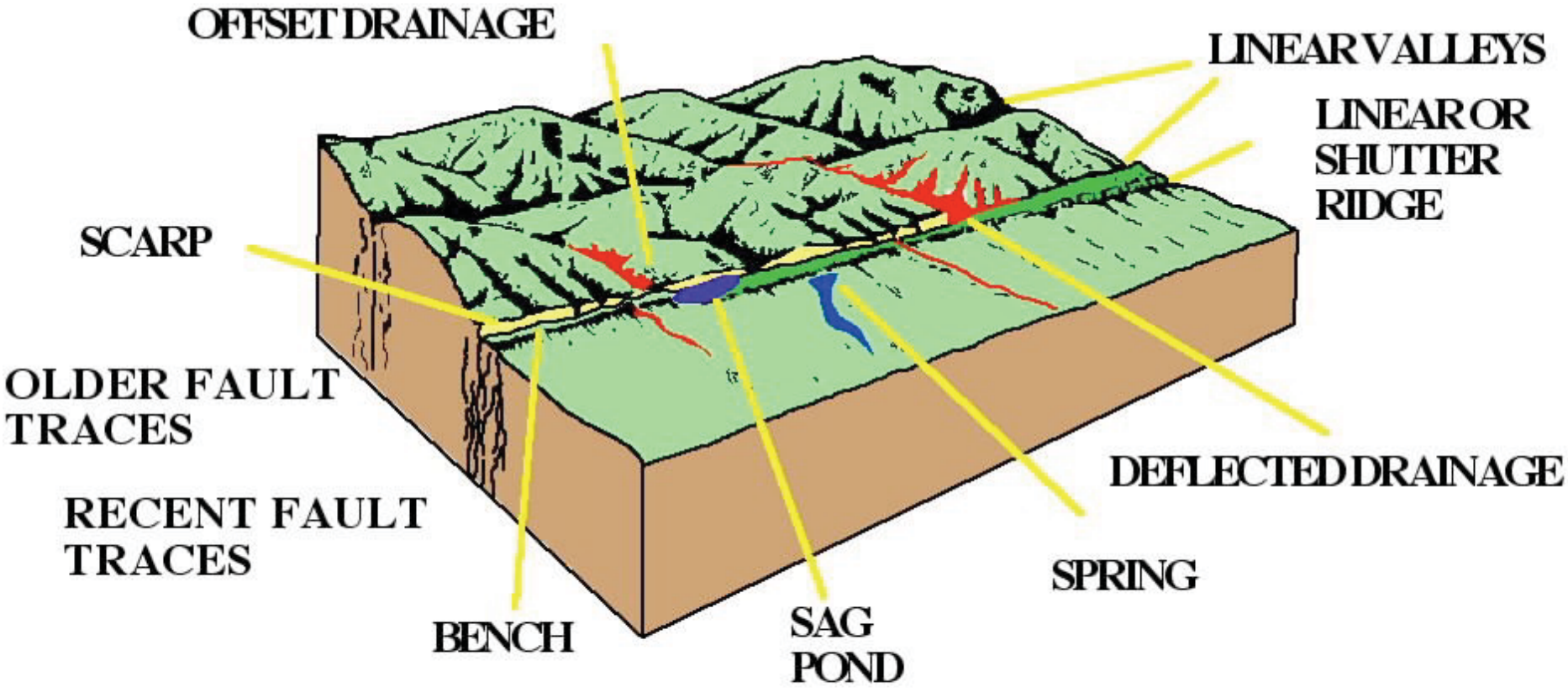


$RT = U/\dot{U}$

, where $\dot{U} = U^g/T$

The repetition of this process results in distinct geomorphic features along fault zones that may be interpreted by geologists

To determine the rate, style, and magnitude of fault slip



MORPHOLOGY OF STRIKE-SLIP FAULT ZONES

San Andreas "Rift"

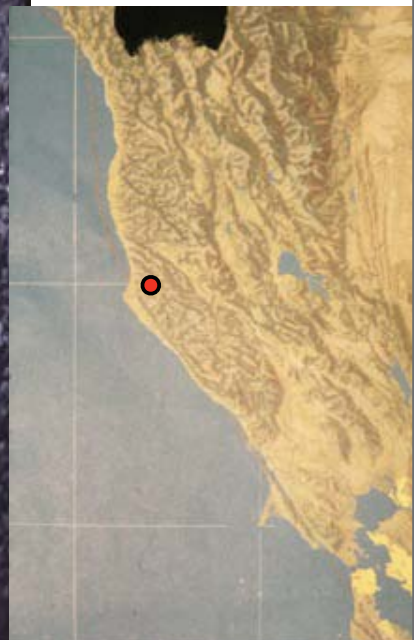
Strike-slip displacement

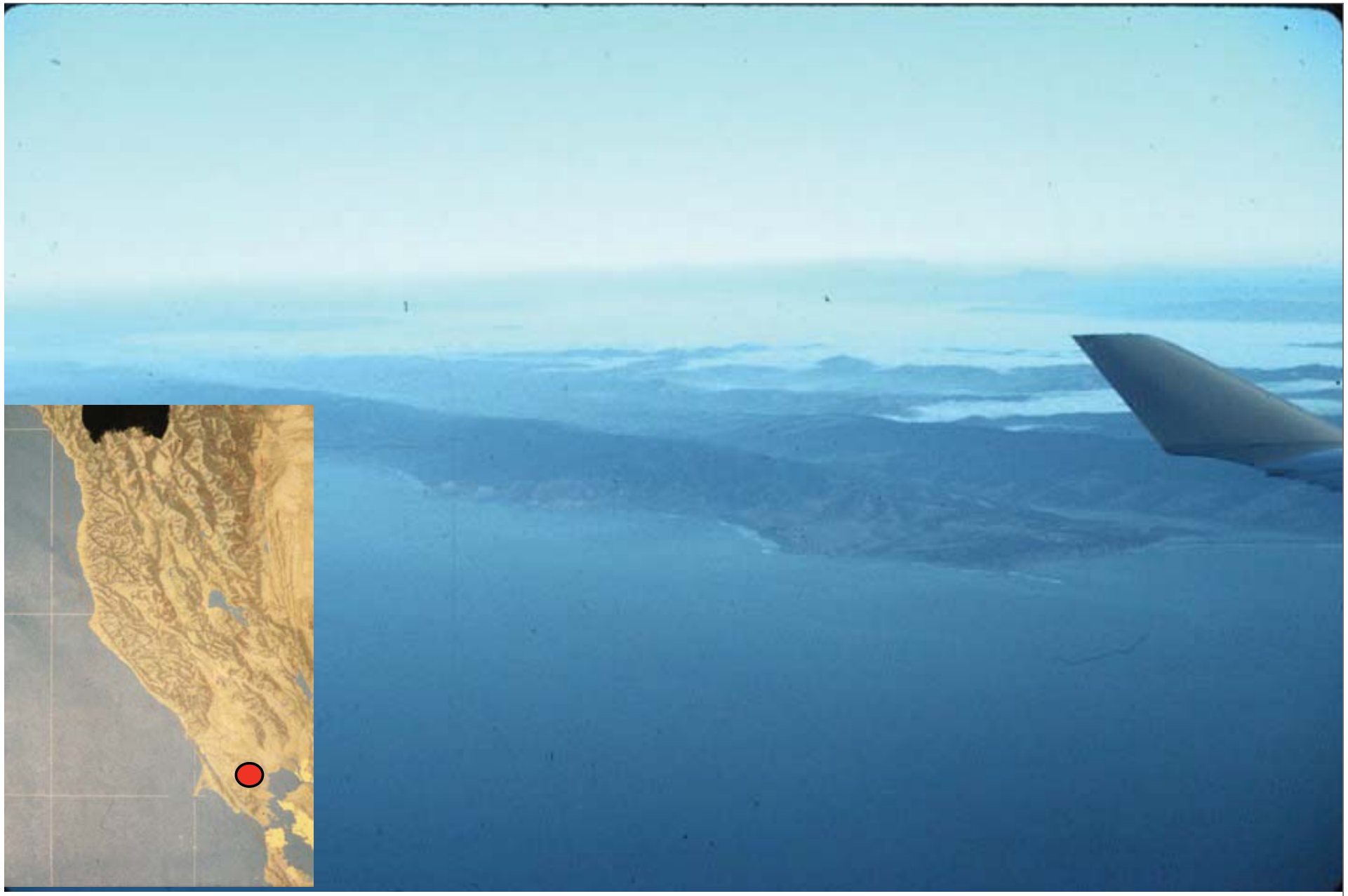
- juxtaposition of topography
- cataclasis and weakening of rock in fault zone
- stream capture along fault
- preferential erosion along fault

leads to long linear ridges and valleys...

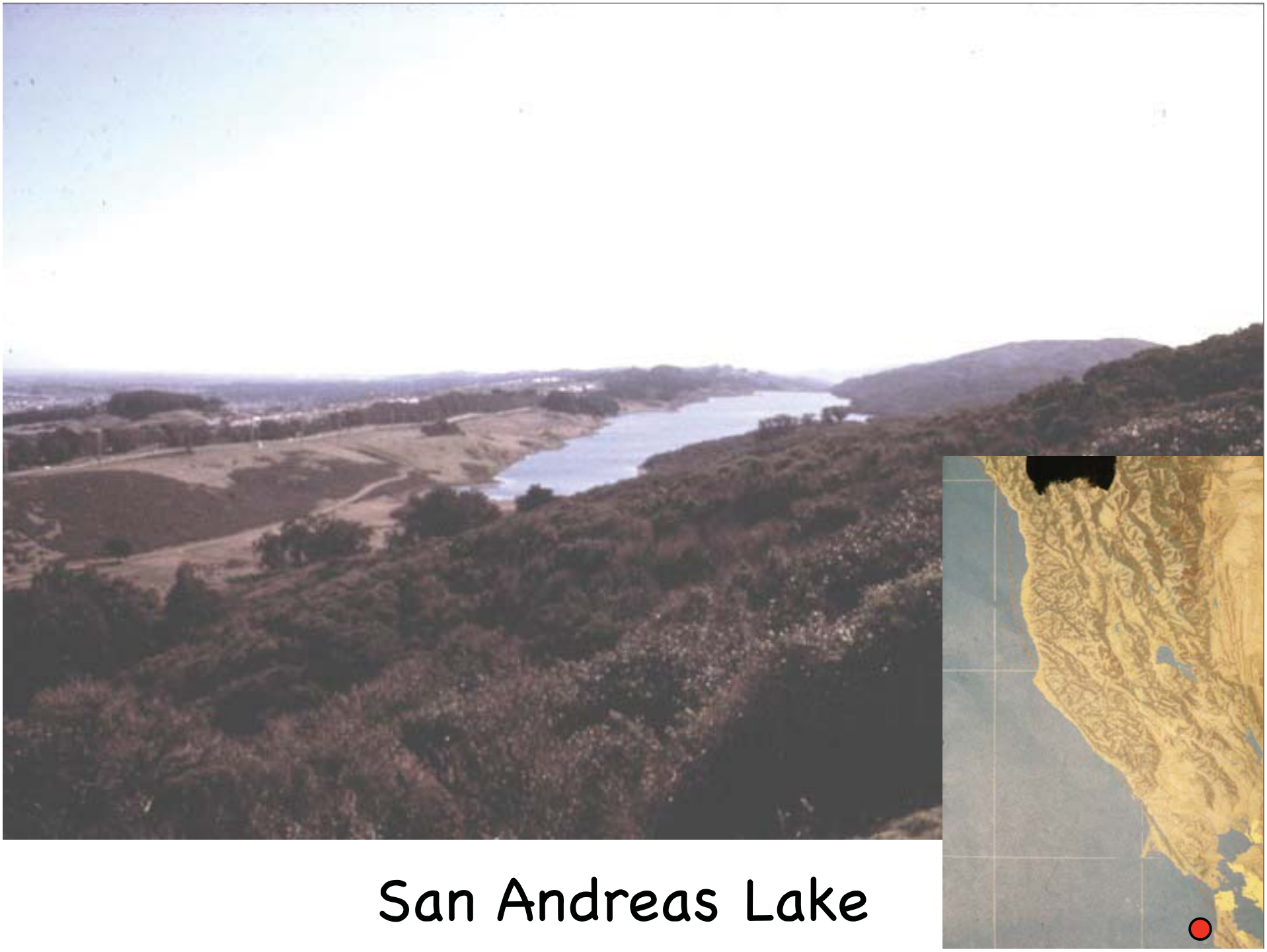
Gualala River

View North to Coast





Tomales and Bolinas Bays north of San Francisco Bay



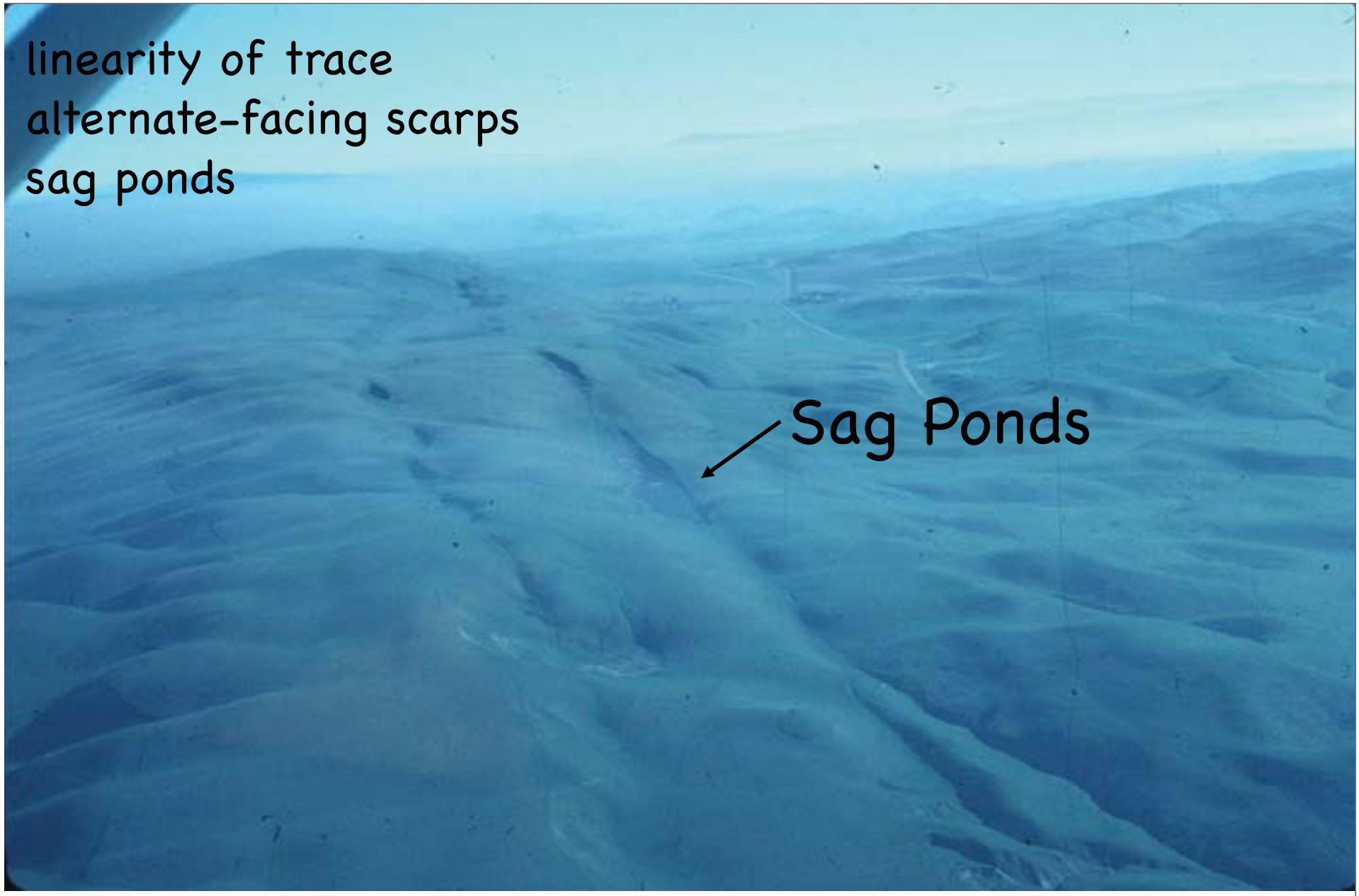
San Andreas Lake

Central San Andreas

Carrizo Plain

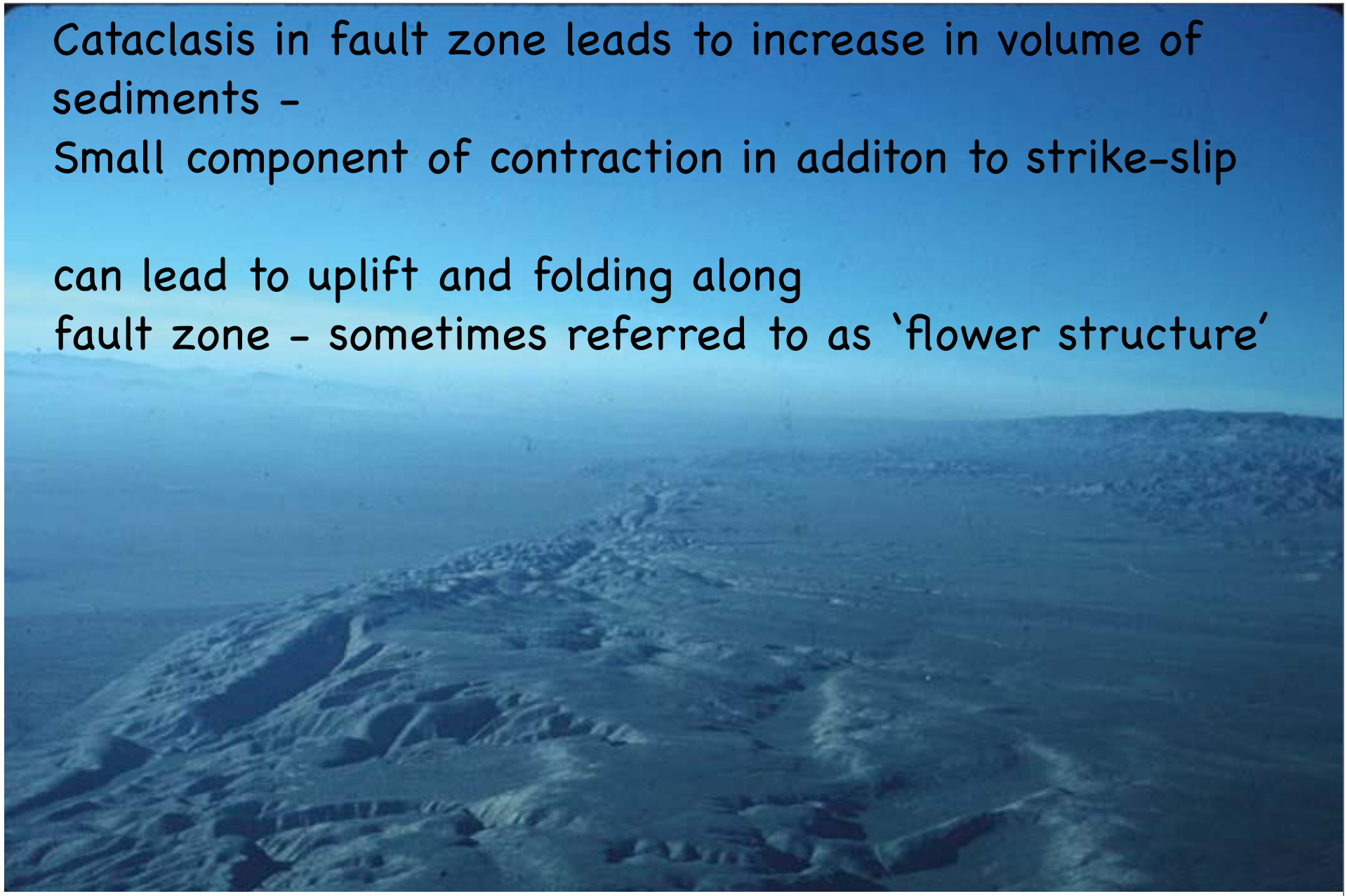
example of offset stream


San Andreas is
Carrizo Plain
linearity of trace
alternate-facing scarps
San Andreas


linearity of trace
alternate-facing scarps
sag ponds
Sag Ponds

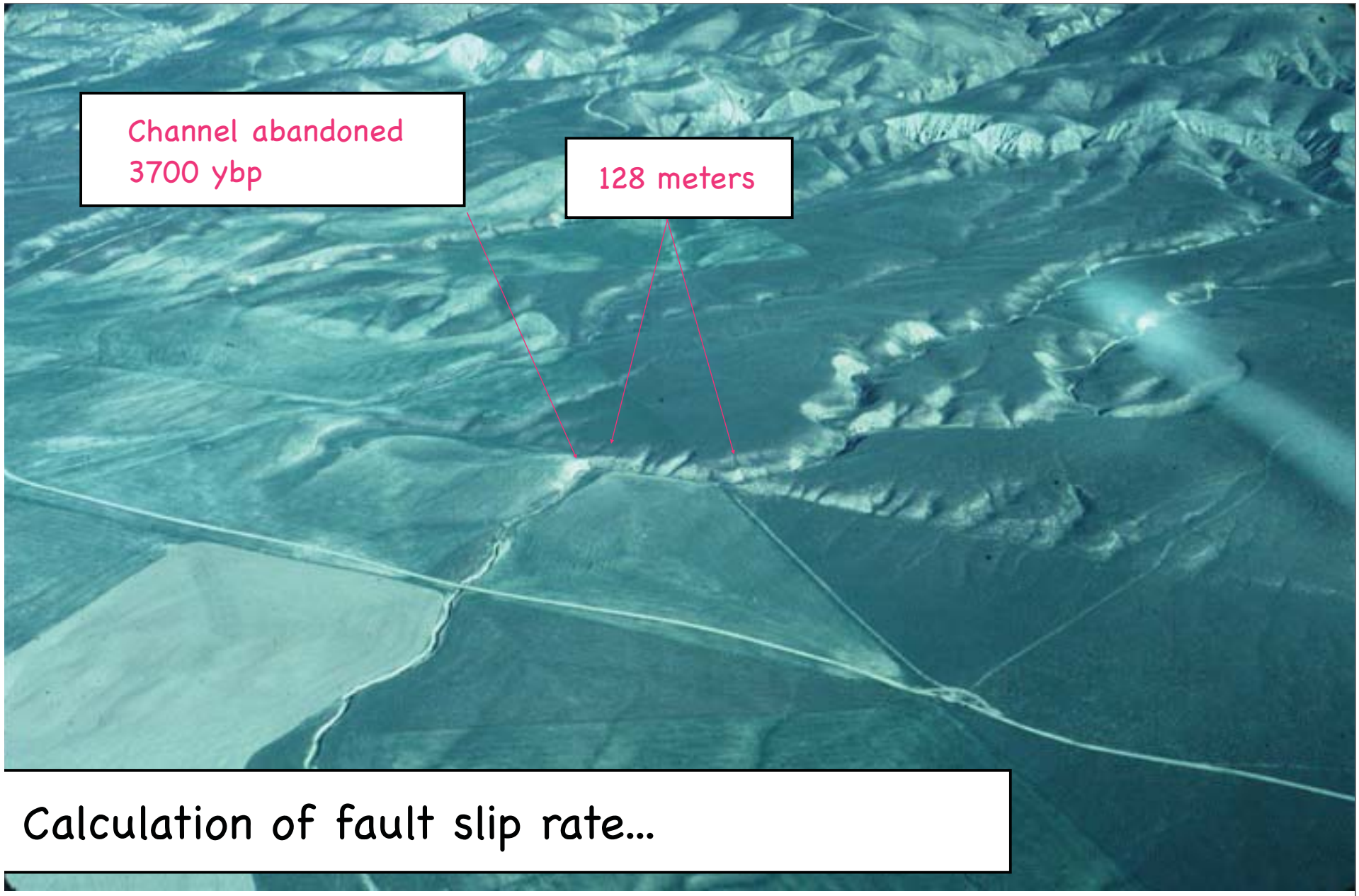
Cataclasis in fault zone leads to increase in volume of sediments -
Small component of contraction in additon to strike-slip

can lead to uplift and folding along
fault zone - sometimes referred to as 'flower structure'




linear trace
in Carrizo Plain

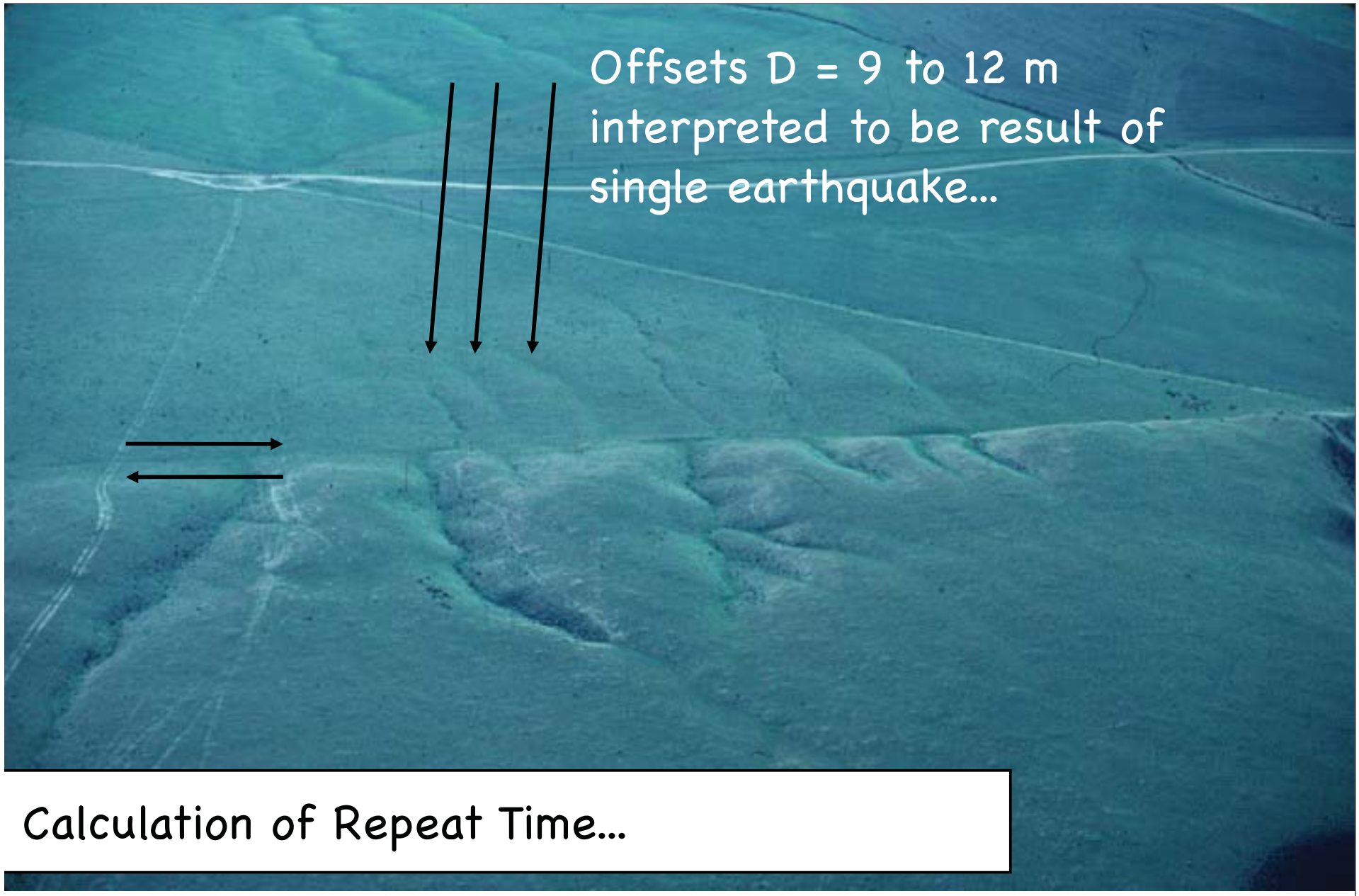

Incision on hanging/uplifted wall....
offset and abandoned streams



Calculation of fault slip rate...

San Andreas slip rate = 128m / 3700 years = ~ 34 mm/yr

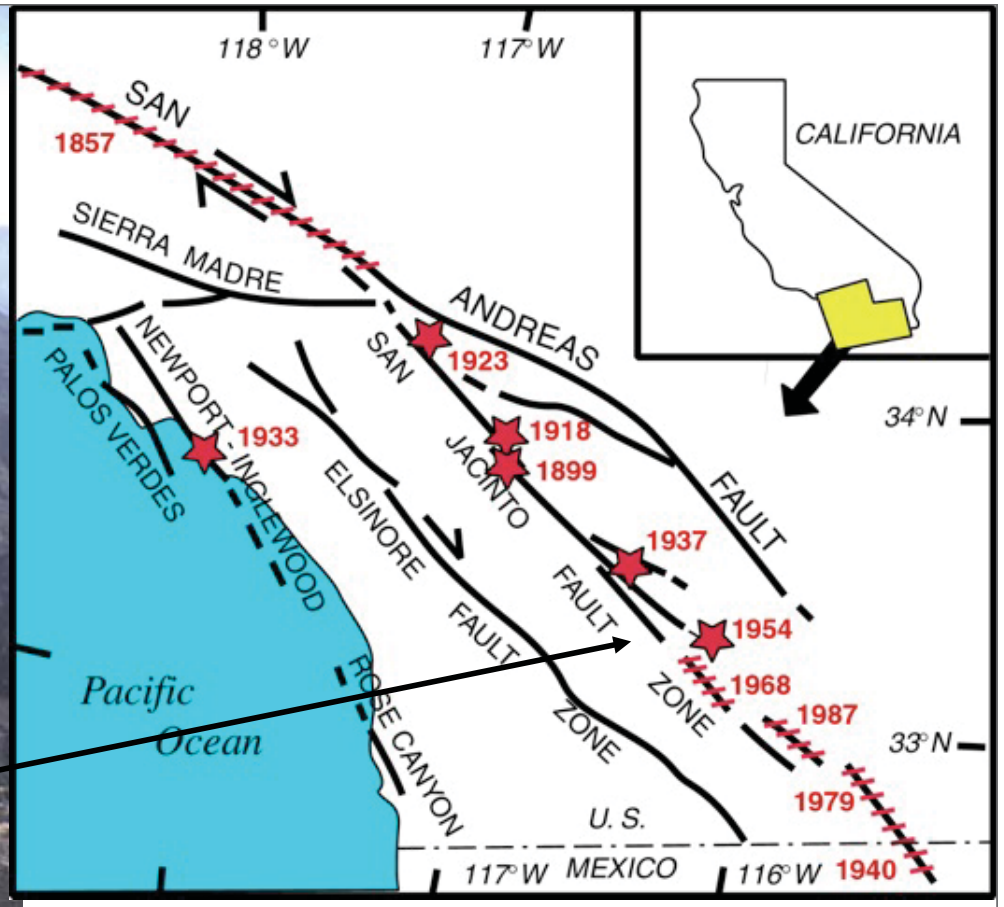
Sieh and Jahns (1984), GSAB v. 95, 883-896



Calculation of Repeat Time...

Average Repeat Time = 9 to 12 m / ~34 mm/yr = 250 to 450 years

Sieh and Jahns (1984), GSAB v. 95, 883-896



Offset and beheaded stream

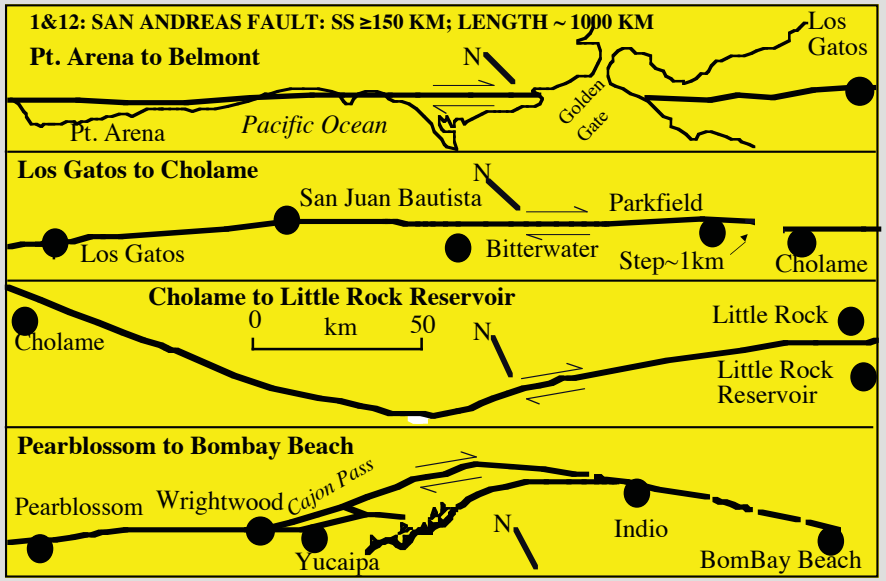
Slip Rate =

~210m / ~17kyr = ~ 12 mm/yr

Rockwell et al (1990), JGR, v. 95, 8593-8605

Strike Slip Faults are often long and quite linear - but they are not always continuous

San Andreas D=150 km

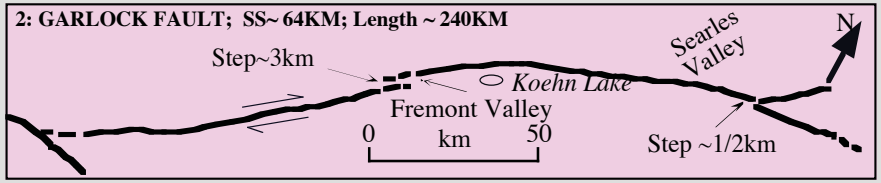


Strike-Slip Faults of California

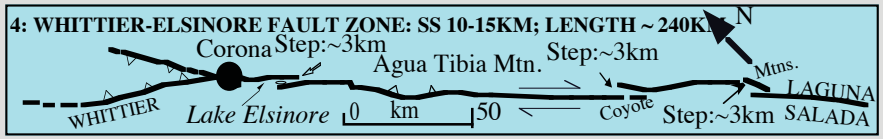
Long, linear, but NOT continuous

D is estimate of total strike-slip since birth of fault

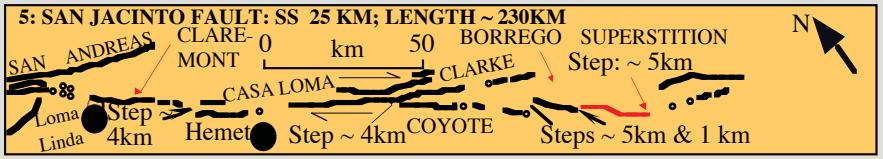
Garlock Fault D=64 km



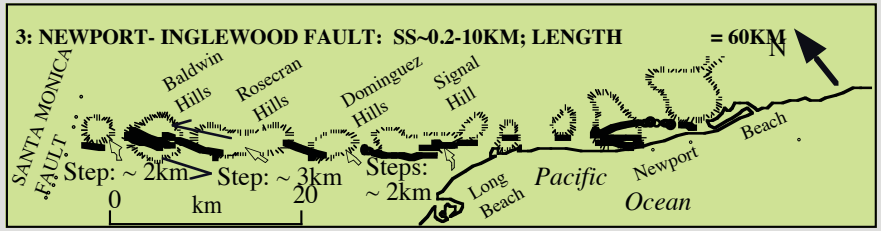
Whittier-Elsinore D~15 km



San Jacinto D=25 km



Newport-Inglewood D=10 km



Structural Evolution of Faults - tend to simplify with accumulated offset

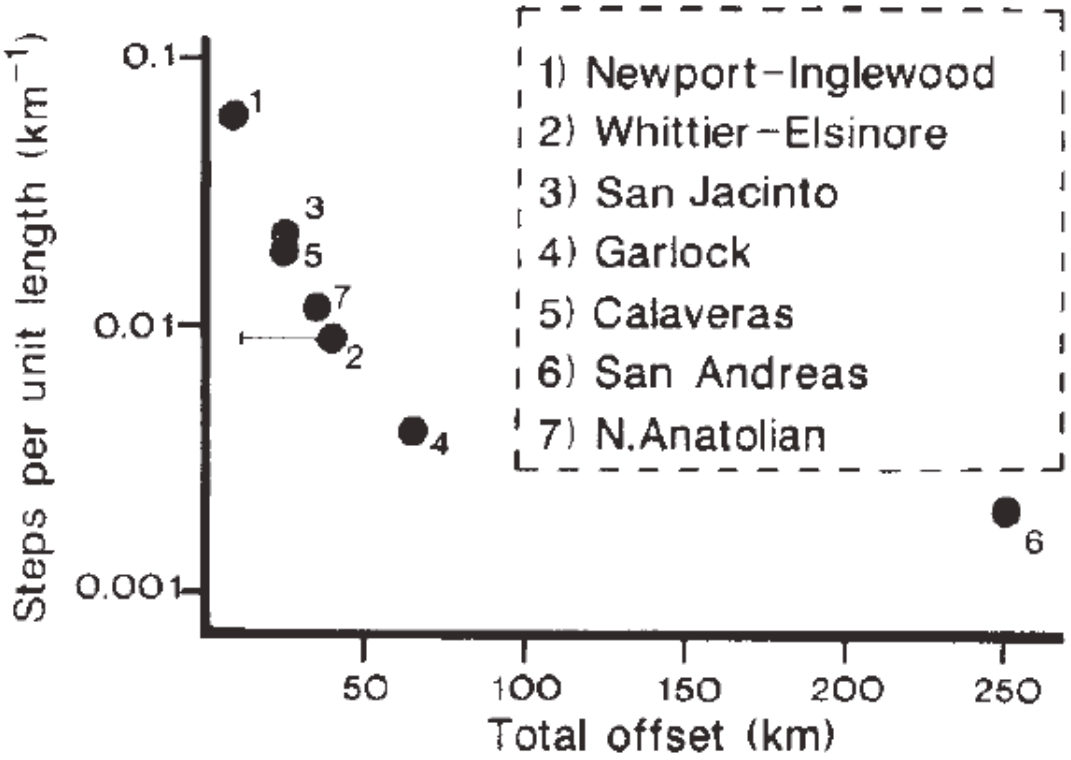
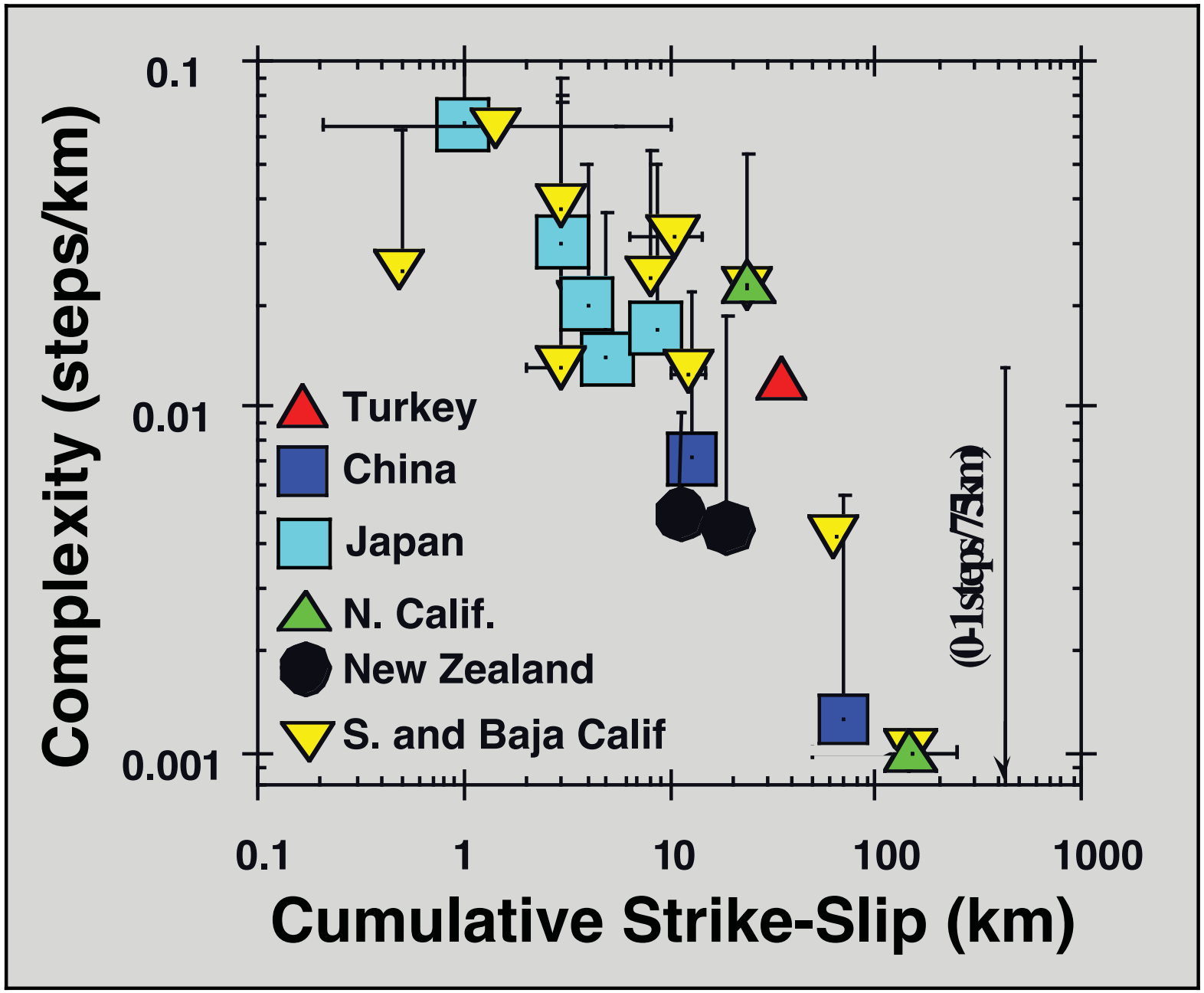
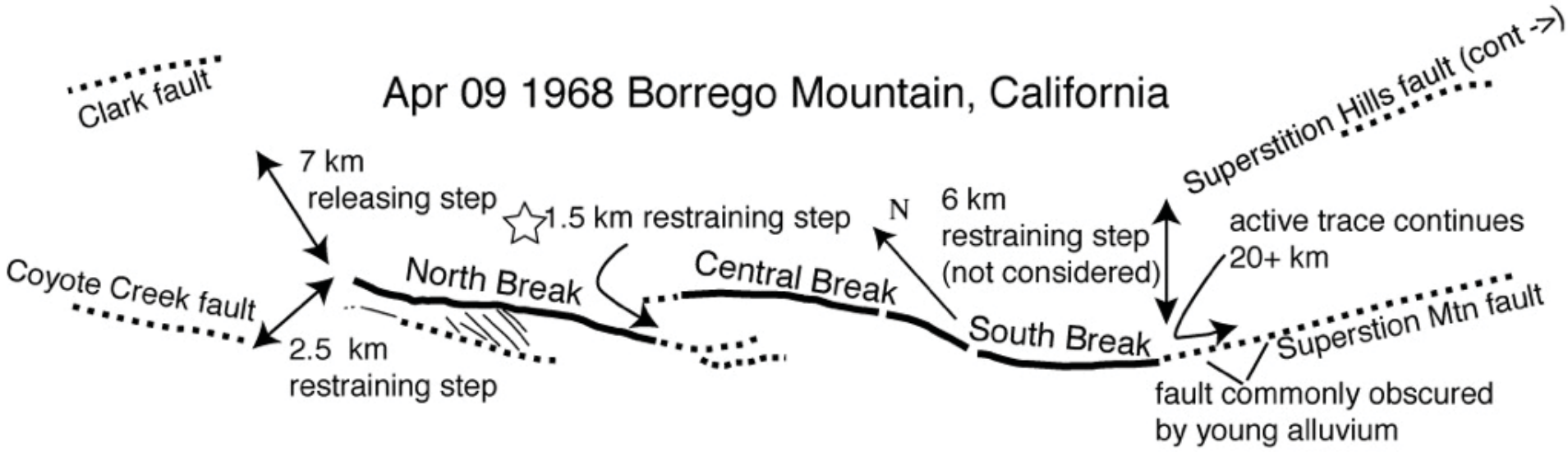
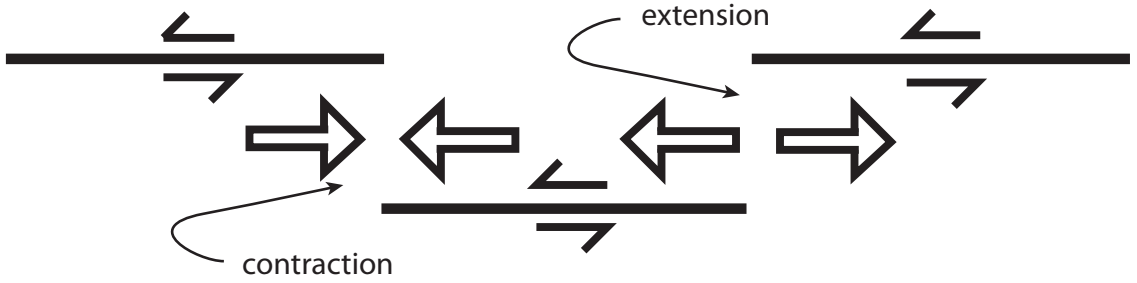


Fig. 4 The number of steps ($W_s \geq 1$ km) per unit length of mapped fault trace versus cumulative geological offset along major strike-slips faults in California and Turkey.

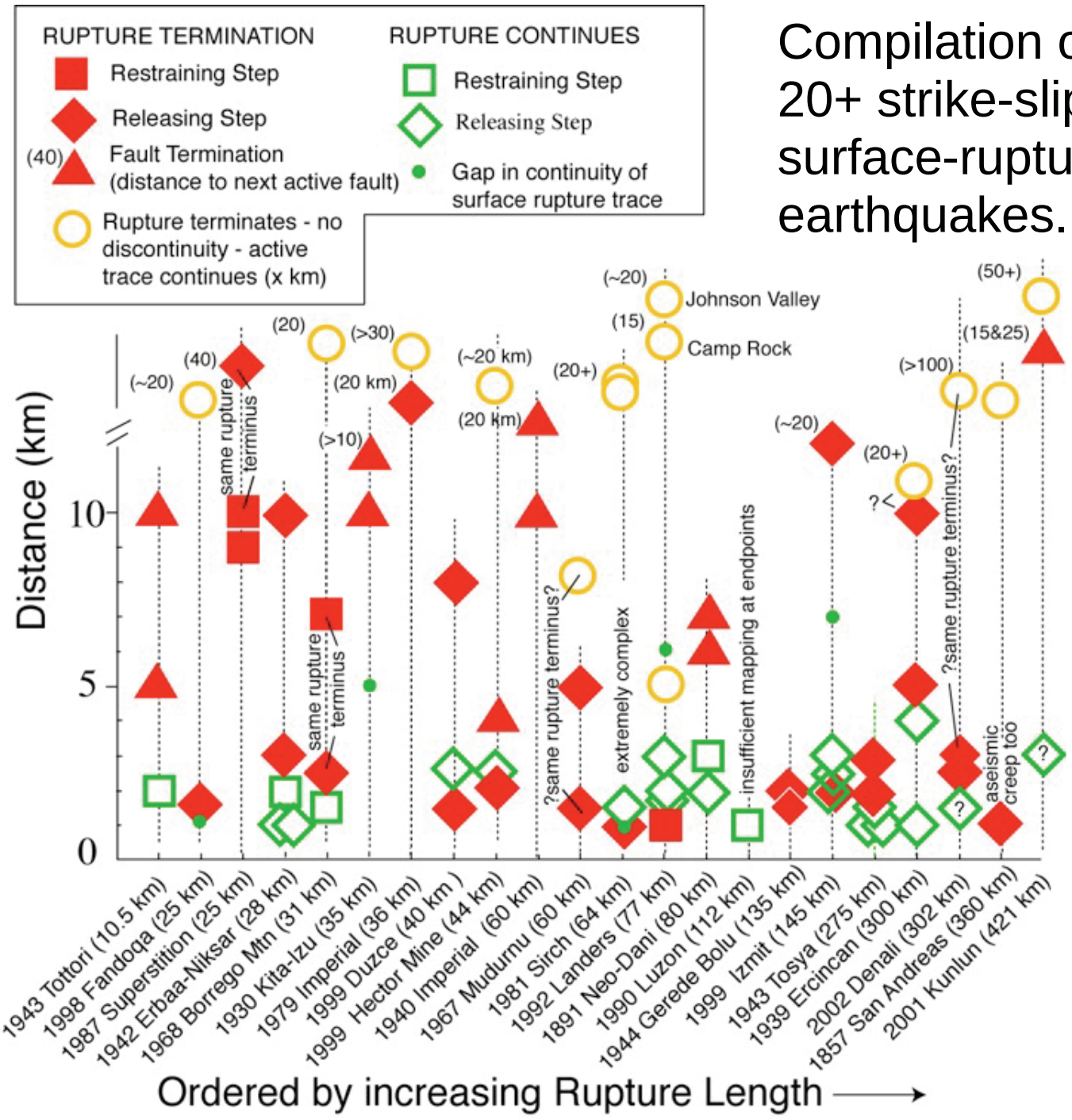

Complexity (steps/km)
0.1
0.01
0.001
0.1
1
10
100
1000
Cumulative Strike-Slip (km)
Turkey
China
Japan
N. Calif.
New Zealand
S. and Baja Calif
(0.1steps/73km)



How do discontinuities (steps) in fault trace effect the propagation of earthquake ruptures?

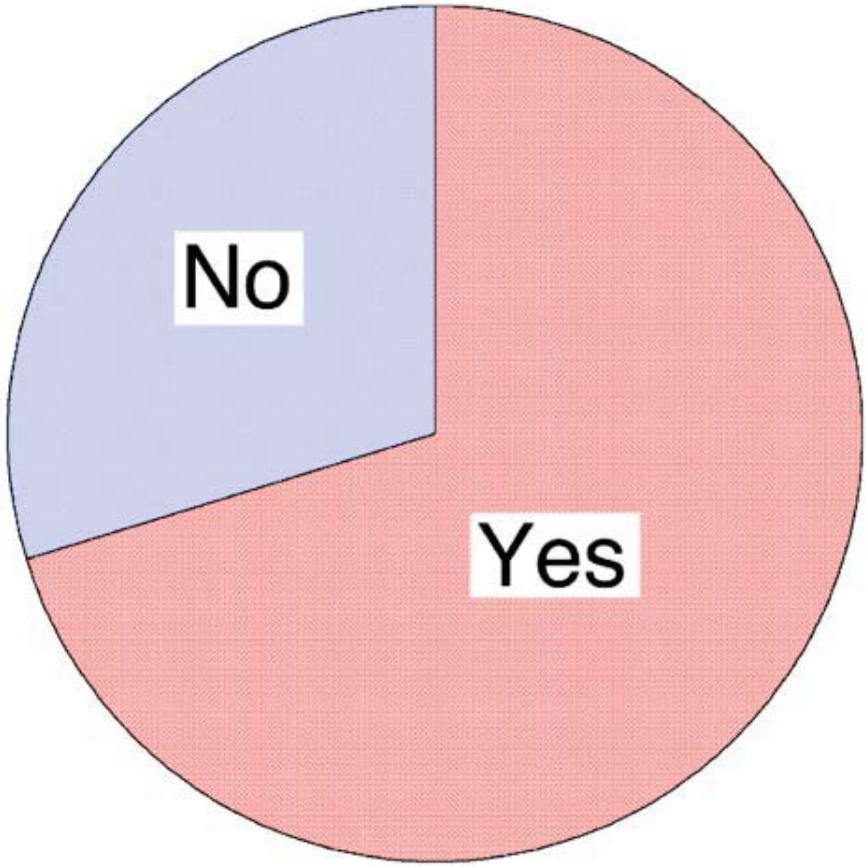


Compilation of 20+ strike-slip surface-rupture earthquakes..



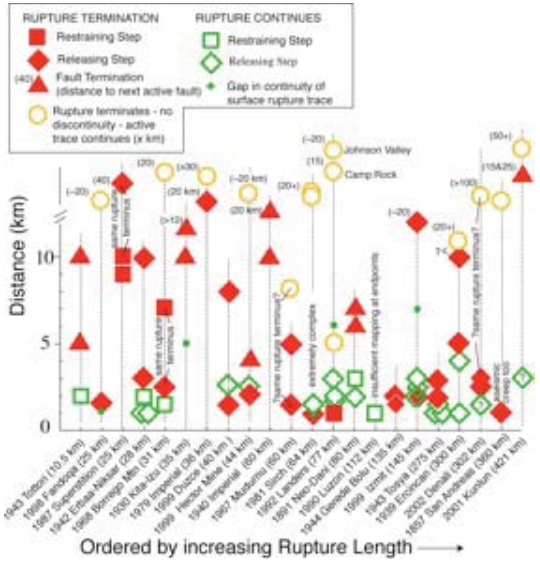
can be important to hazard analysis...

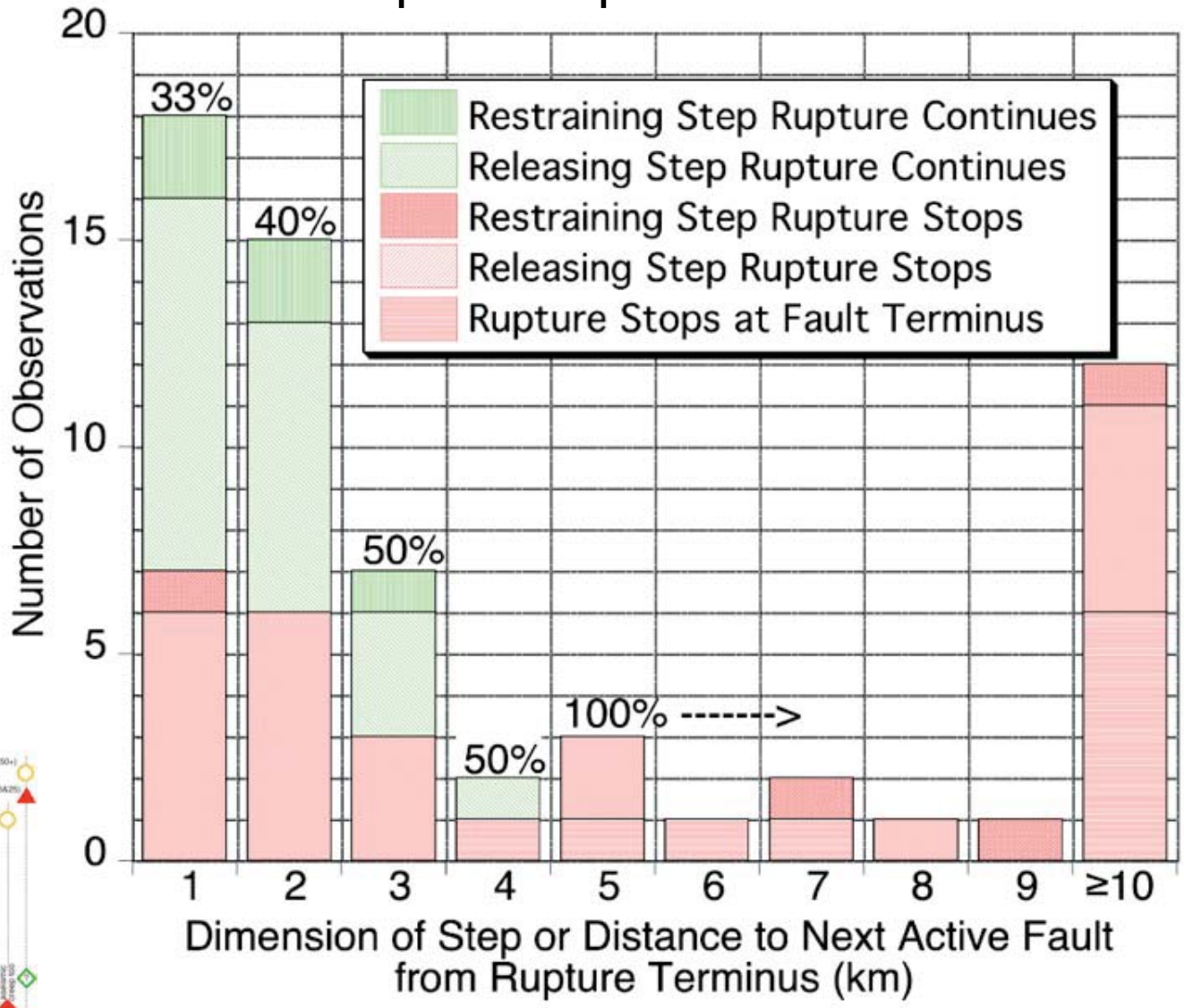
Is termination of STRIKE-SLIP rupture associated with step in fault trace of dimension >=1km or end of active fault trace ?



Pie chart of total number of rupture endpoints divided between whether (red-yes) or not (blue-no) endpoints are associated with a geometrical discontinuity (step or termination of rupture trace). About 2/3 of time rupture endpoints are associated with such discontinuities. The remainder appear to simply die out along an active fault trace. Sample Size is 46.

Summary of behavior of all discontinuities along strike of historical earthquake ruptures.





Histogram of the total number of geometrical discontinuities located along historical strike-slip ruptures binned as a function of size (≥1, ≥2, etc) and color-coded/shaded according to whether the particular step occurred at the endpoint of rupture (red) or was broken through by the rupture (green).