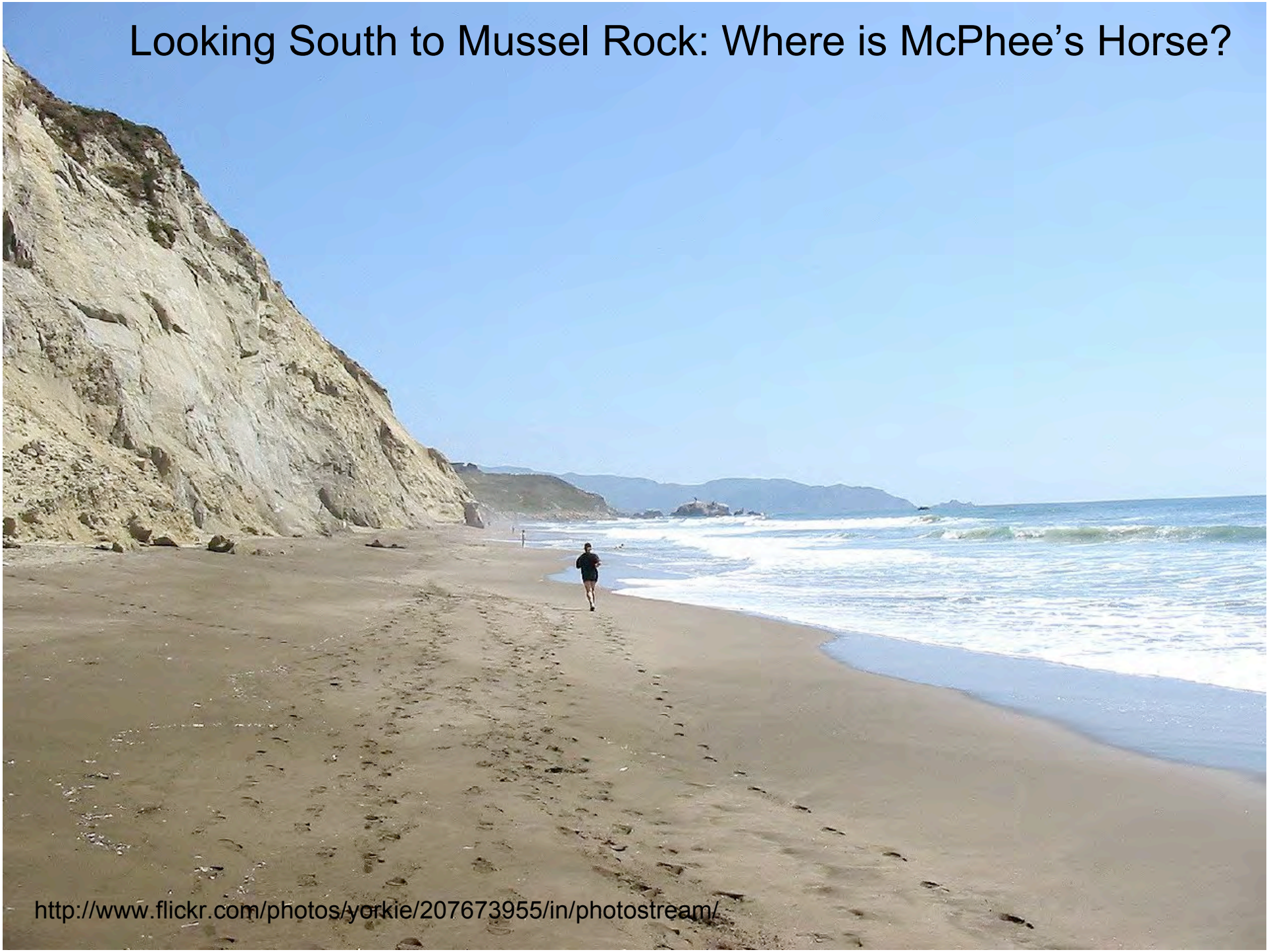
Looking South to Mussel Rock: Where is McPhee's Horse?

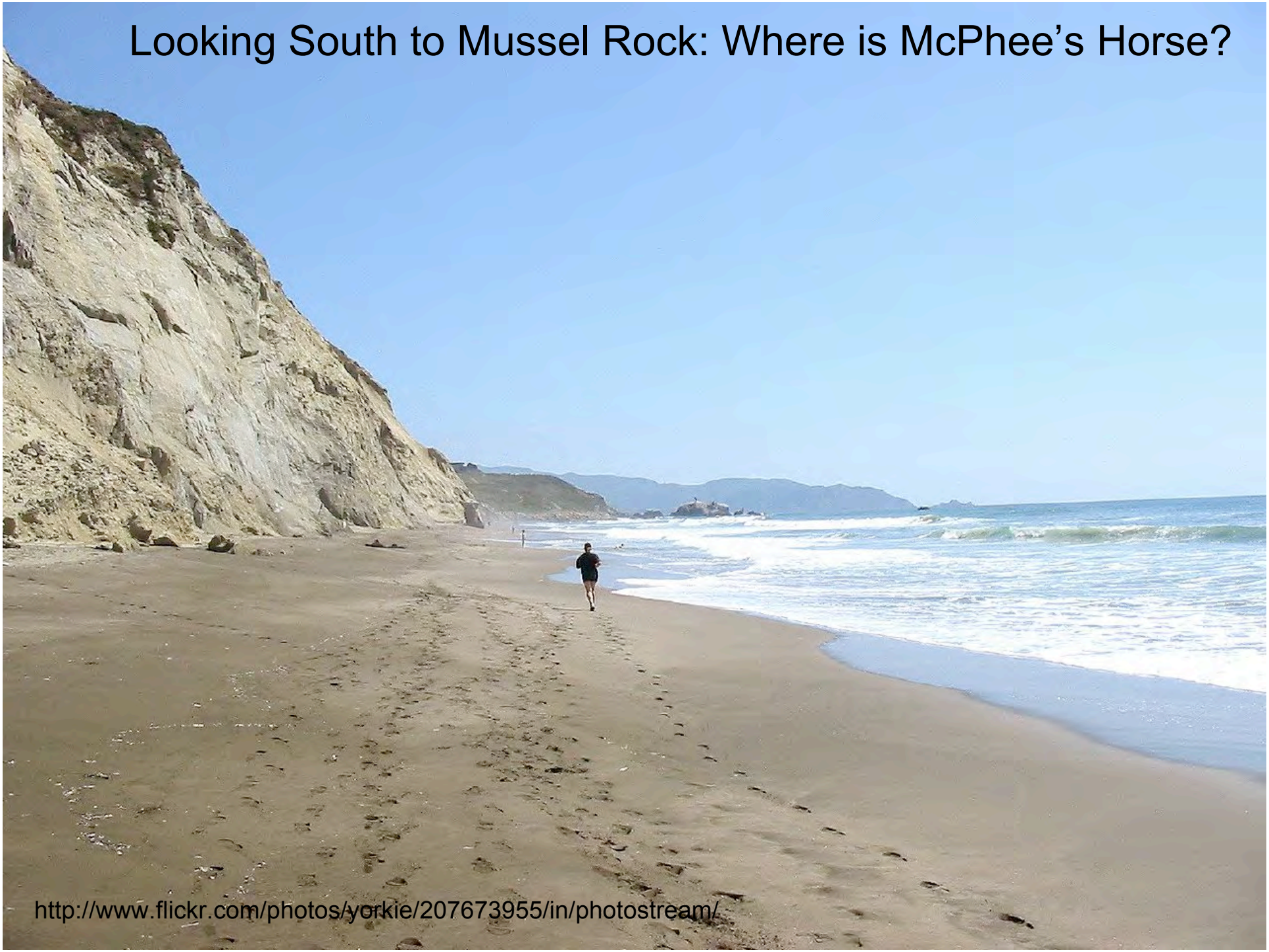


http://www.flickr.com/photos/yorkie/207673955/in/photostream/


Looking South to Mussel Rock
Pliocene-Quaternary Merced Formation
San Andreas Fault
Franciscan Fm
http://www.flickr.com/photos/yorkie/207673955/in/photostream/

Imbricate Thrusts and Horses

Looking South to Mussel Rock: Where is McPhee's Horse?



http://www.flickr.com/photos/yorkie/207673955/in/photostream/

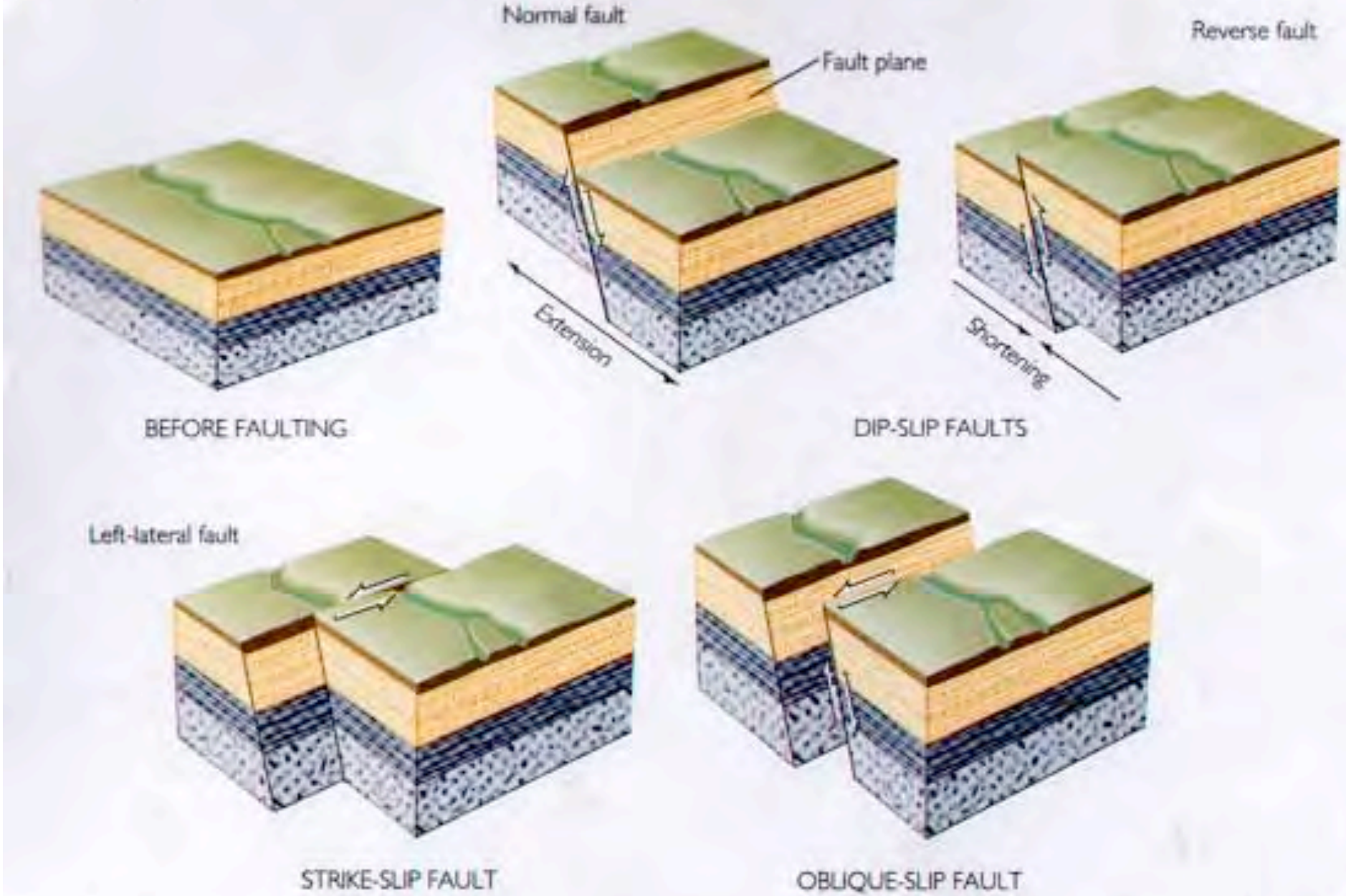
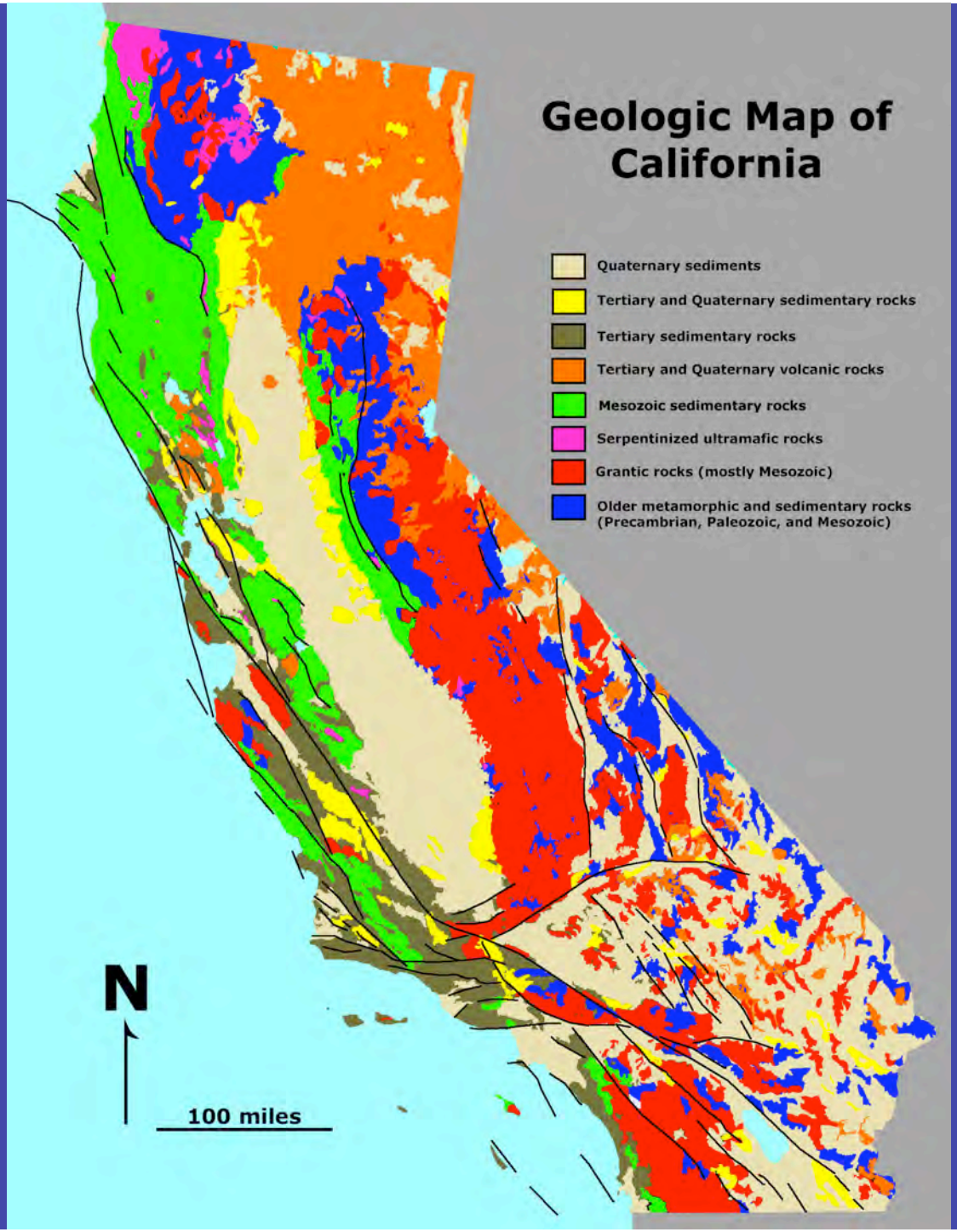


Figure 10.22
Press and Siever: ***Understanding Earth***

OHT 54


Geologic Map of California
Quaternary sediments
Tertiary and Quaternary sedimentary rocks
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Grantic rocks (mostly Mesozoic)
Older metamorphic and sedimentary rocks (Precambrian, Paleozoic, and Mesozoic)
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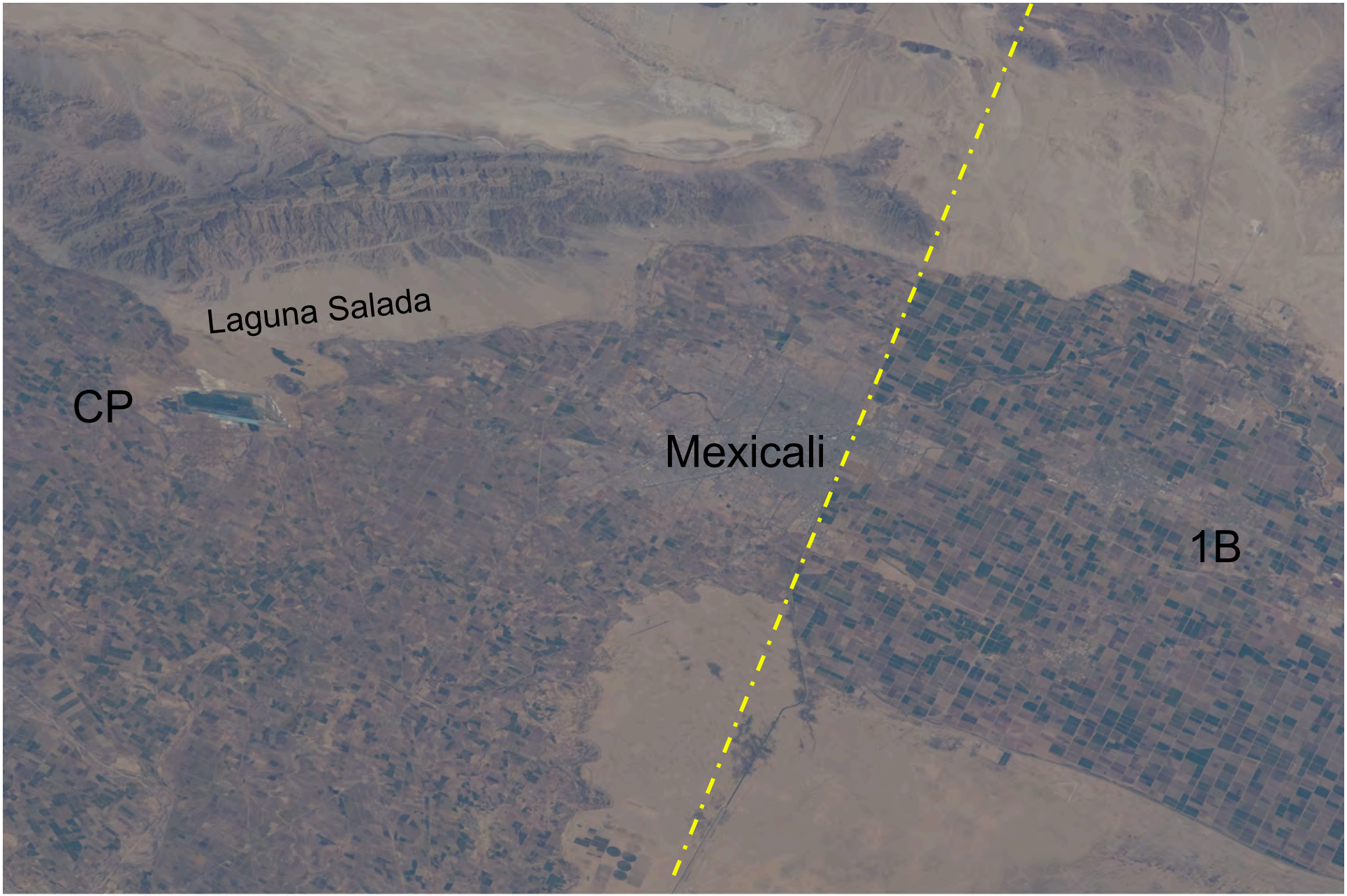


ISS021E008259

Note shape of Laguna Salada Basin. CP= Cierro Petro Geothermal plant

ISS021E008254

1. Telephone poles showing minor displacement from recent EQ, north of Brawley, CA.

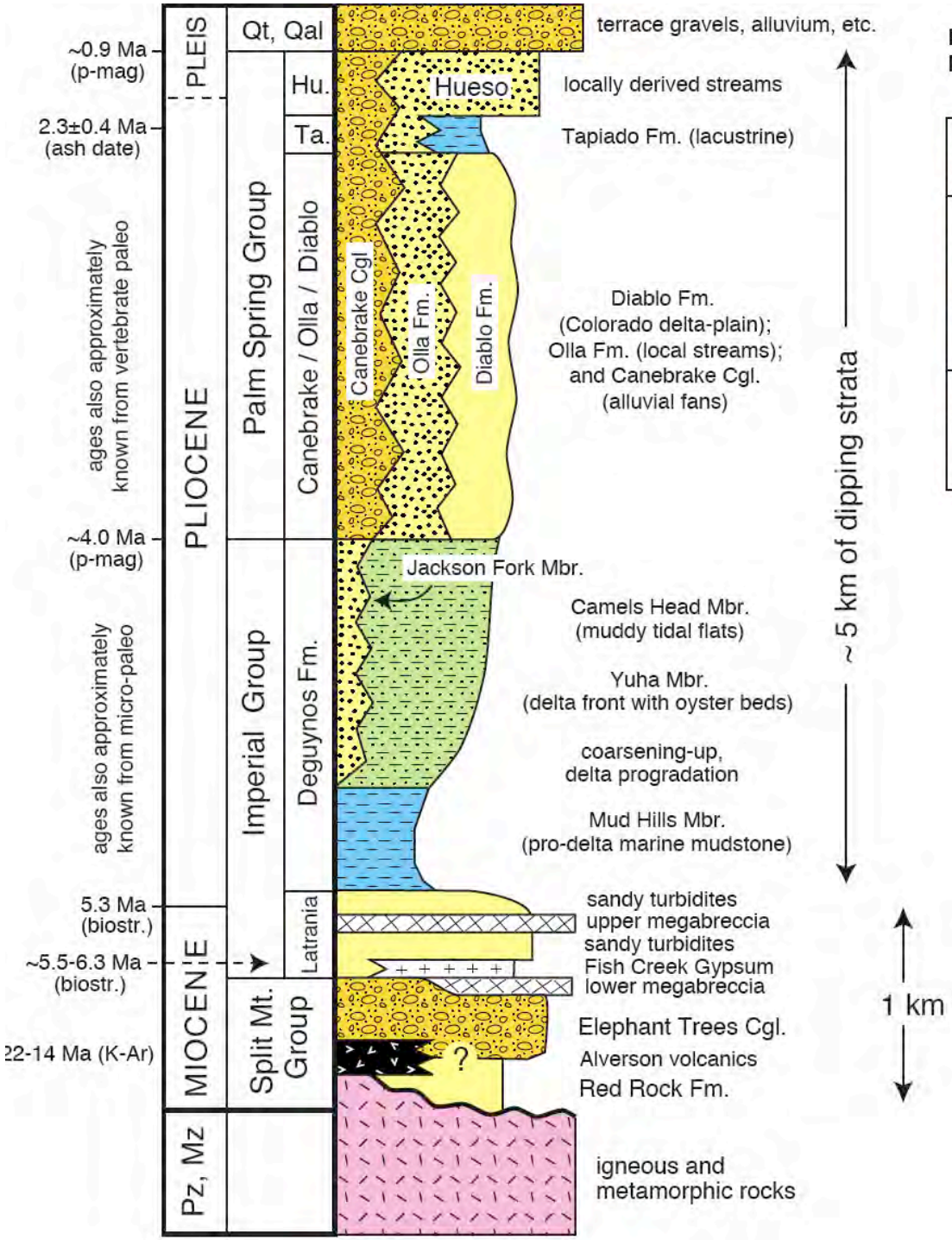
2. Southern end Salton Sea, Rhyolite Vents

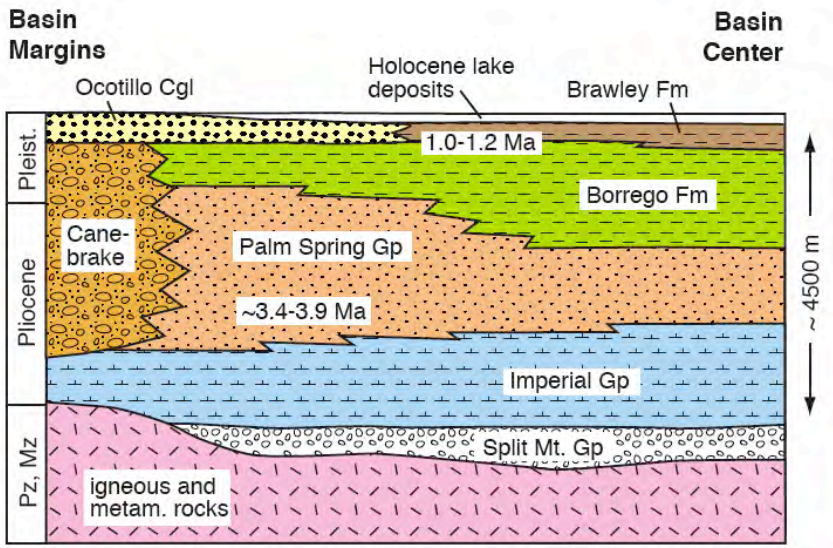
3. Split Mountain, Anza-Borrego, Salton Trough west side

Tor Nilsen: alluvial fan facies, Miocene Anza Fm, Split Mountain

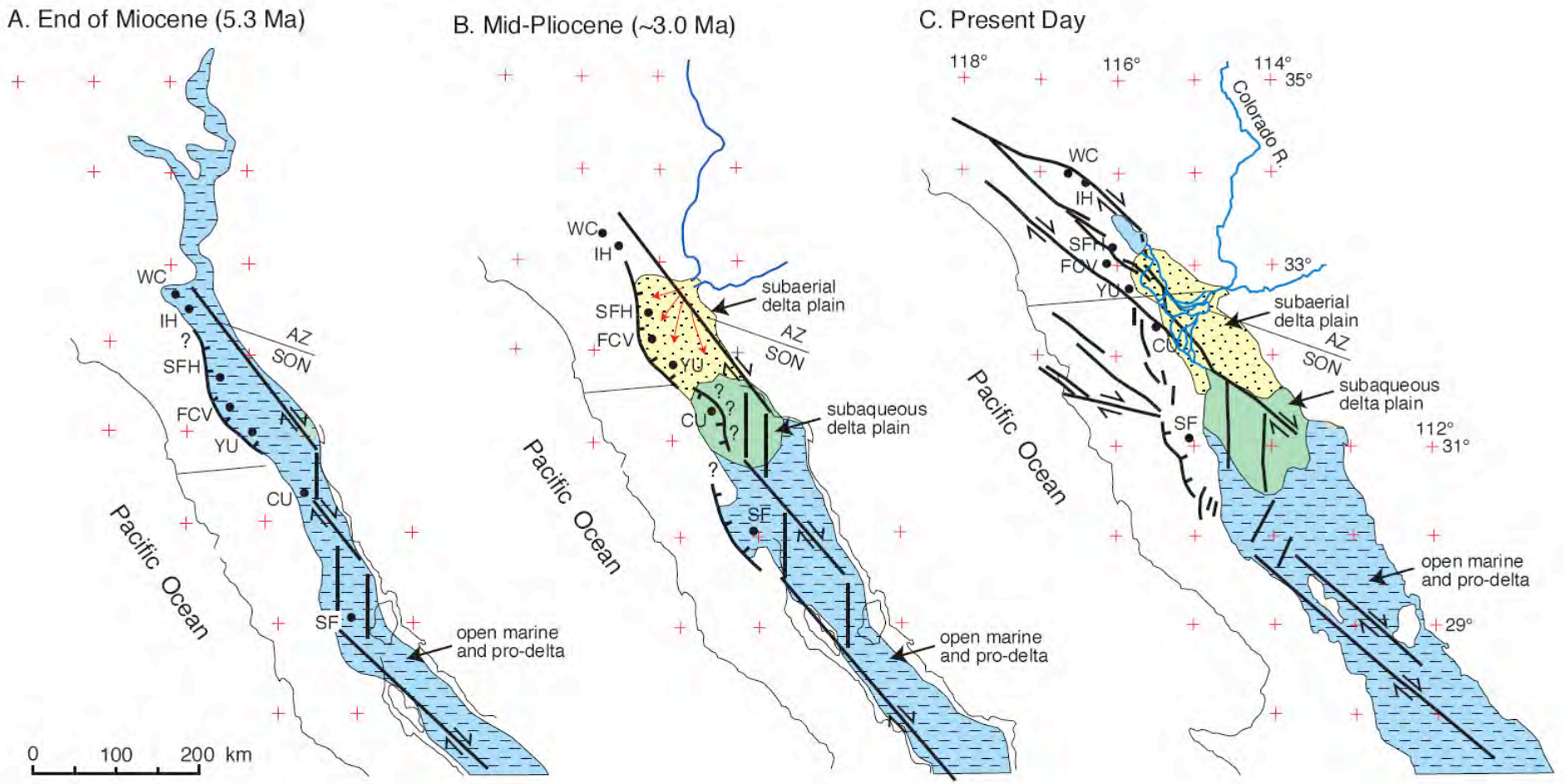
Split Mountain Gorge at Fish Creek: Pliocene Imperial Fm

Split Mountain Gorge at Fish Creek: Pliocene Imperial Fm


~0.9 Ma
(p-mag)
2.3±0.4 Ma
(ash date)
~4.0 Ma
(p-mag)
5.3 Ma
(biostr.)
~5.5-6.3 Ma
(biostr.)
22-14 Ma (K-Ar)
PLEIS
PLIOCENE
MIOCENE
Pz, Mz
Qt, Qal
Hu.
Ta.
Palm Spring Group
Canebrake / Olla / Diablo
Imperial Group
Deguynos Fm.
Latrania
Split Mt. Group
ages also approximately known from vertebrate paleo
ages also approximately known from micro-paleo
terrace gravels, alluvium, etc.
Hueso
locally derived streams
Tapiado Fm. (lacustrine)
Canebrake Cgl.
Olla Fm.
Diablo Fm.
Diablo Fm.
(Colorado delta-plain);
Olla Fm. (local streams);
and Canebrake Cgl.
(alluvial fans)
Jackson Fork Mbr.
Camels Head Mbr.
(muddy tidal flats)
Yuha Mbr.
(delta front with oyster beds)
coarsening-up,
delta progradation
Mud Hills Mbr.
(pro-delta marine mudstone)
~ 5 km of dipping strata
sandy turbidites
upper megabreccia
sandy turbidites
Fish Creek Gypsum
lower megabreccia
Elephant Trees Cgl.
Alverson volcanics
Red Rock Fm.
?
igneous and
metamorphic rocks
1 km


Basin
Margins
Basin
Center
Ocotillo Cgl
Holocene lake
deposits
Brawley Fm
Pleist.
Pliocene
Pz, Mz
1.0-1.2 Ma
Borrego Fm
Cane-
brake
Palm Spring Gp
~3.4-3.9 Ma
Imperial Gp
Split Mt. Gp
igneous and
metam. rocks
~ 4500 m

Dorsey 2005


A. End of Miocene (5.3 Ma)
B. Mid-Pliocene (~3.0 Ma)
C. Present Day
WC
IH
SFH
FCV
YU
CU
SF
AZ
SON
Pacific Ocean
subaerial delta plain
subaqueous delta plain
open marine and pro-delta
Colorado R.
118°
116°
114°
112°
35°
33°
31°
29°
0
100
200 km

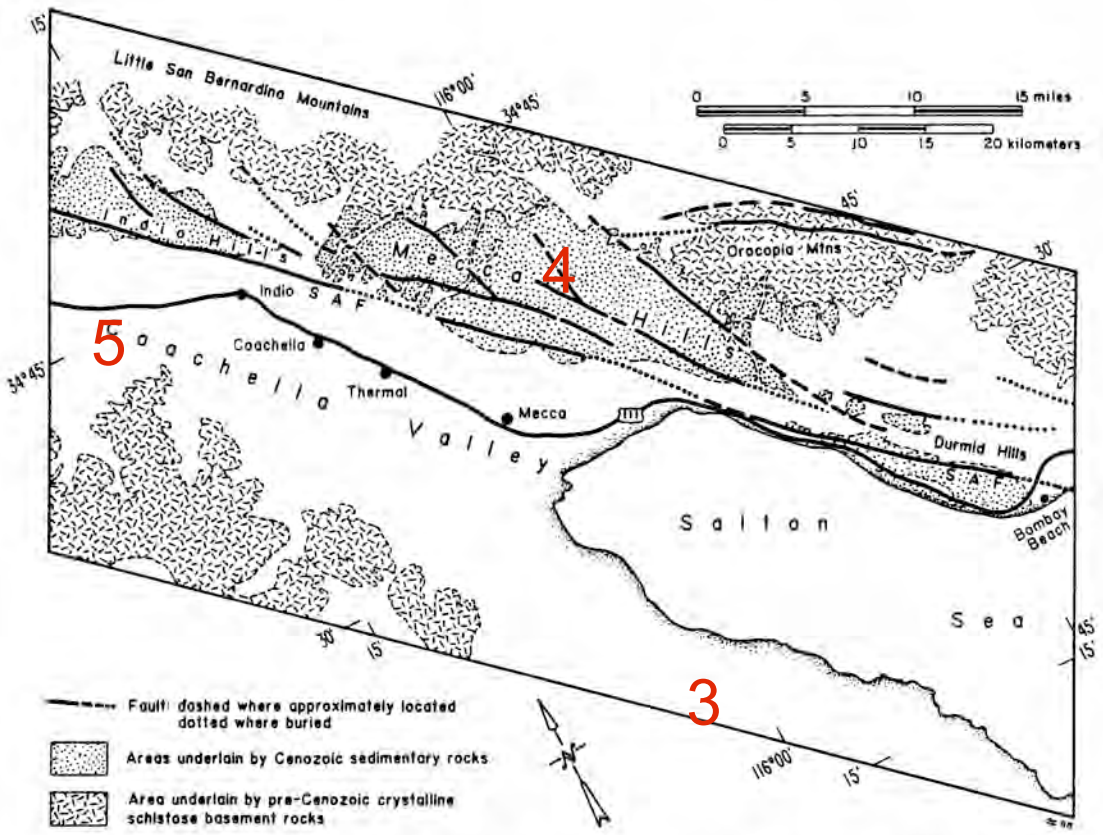
Dorsey 2005

4. Painted Canyon, Mecca Hills,
Mesozoic Orocopia Schist, Mio-Pliocene Mecca Fm

Painted Canyon, Mecca Hills, Orocopia Schist and Mecca Fm

Painted Canyon, Mecca Hills, Orocopia Schist and Mecca Fm

Painted Canyon, Mecca Hills, Mecca Fm



Simplified geologic map of the San Andreas fault zone (SAF), Coachella Valley. Tectonic culminations are represented by the Indio Hills, Mecca Hills, and Durmid Hills.

Sylvester and Smith 1987

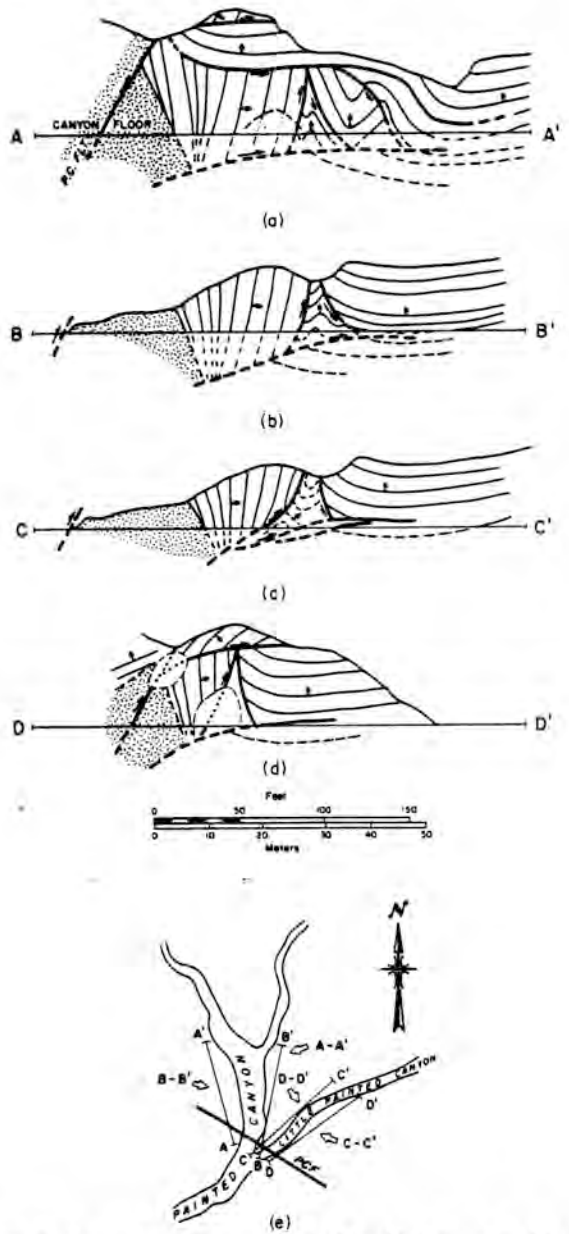


Figure 4. Generalized cross-sections of buckled strata and low- to high-angle faults in the footwall of the Painted Canyon fault. (a) Northwest wall, Painted Canyon; (b) southeast wall, Painted Canyon; (c) northwest wall, Little Painted Canyon; (d) southeast wall, Little Painted Canyon; (e) index map showing locations of cross sections. In (a), (b), (c) and (d) arrows indicate tops of beds. In (e) open arrows indicate locations of view points and view directions for each cross section.

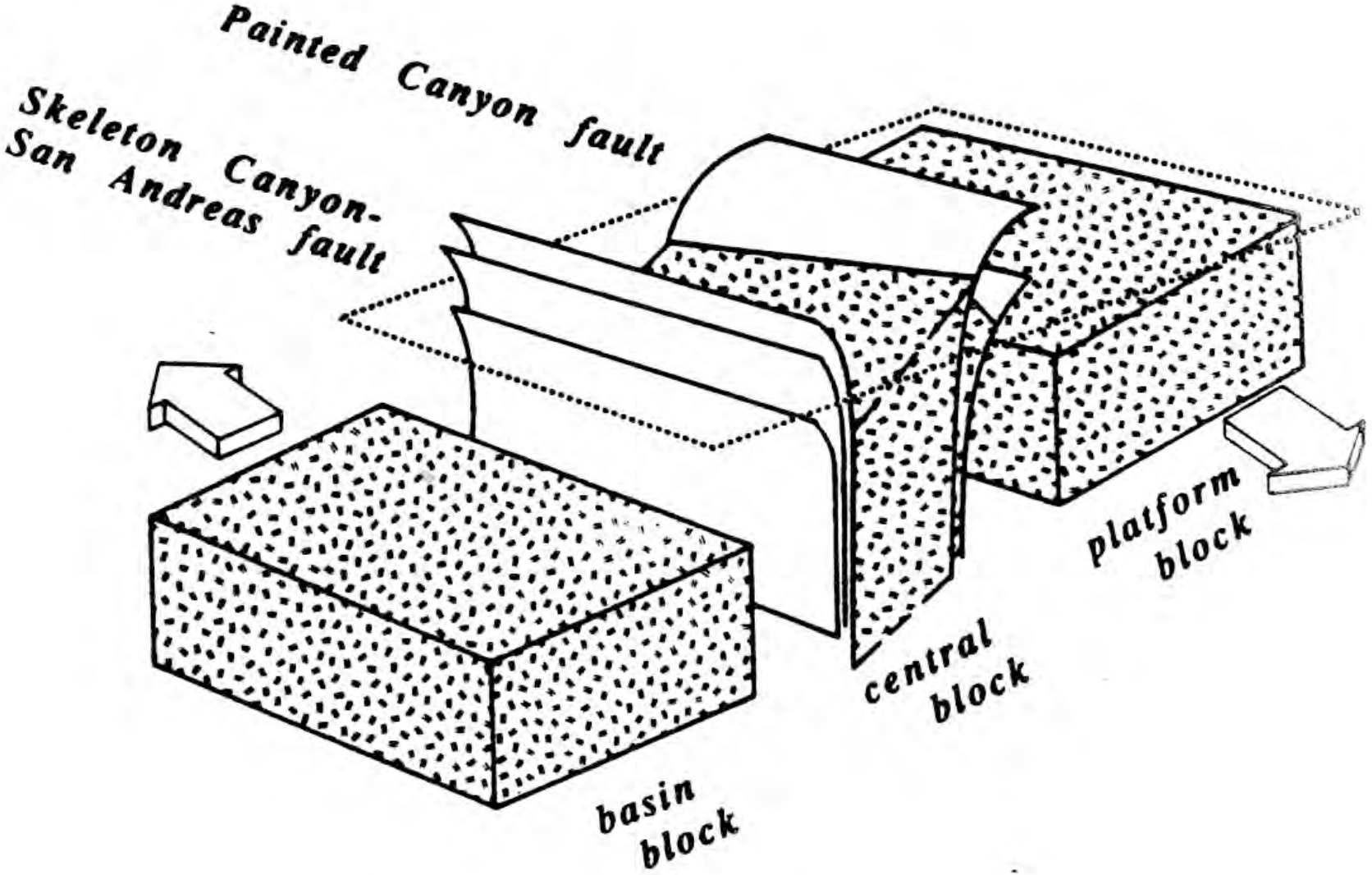


Figure 2. Idealized block diagram of the basement and principal faults in the Painted Canyon part of the Mecca Hills. Dotted parallelogram represents the surface. By permission of American Association of Petroleum Geologists.

Sylvester and Smith 1987

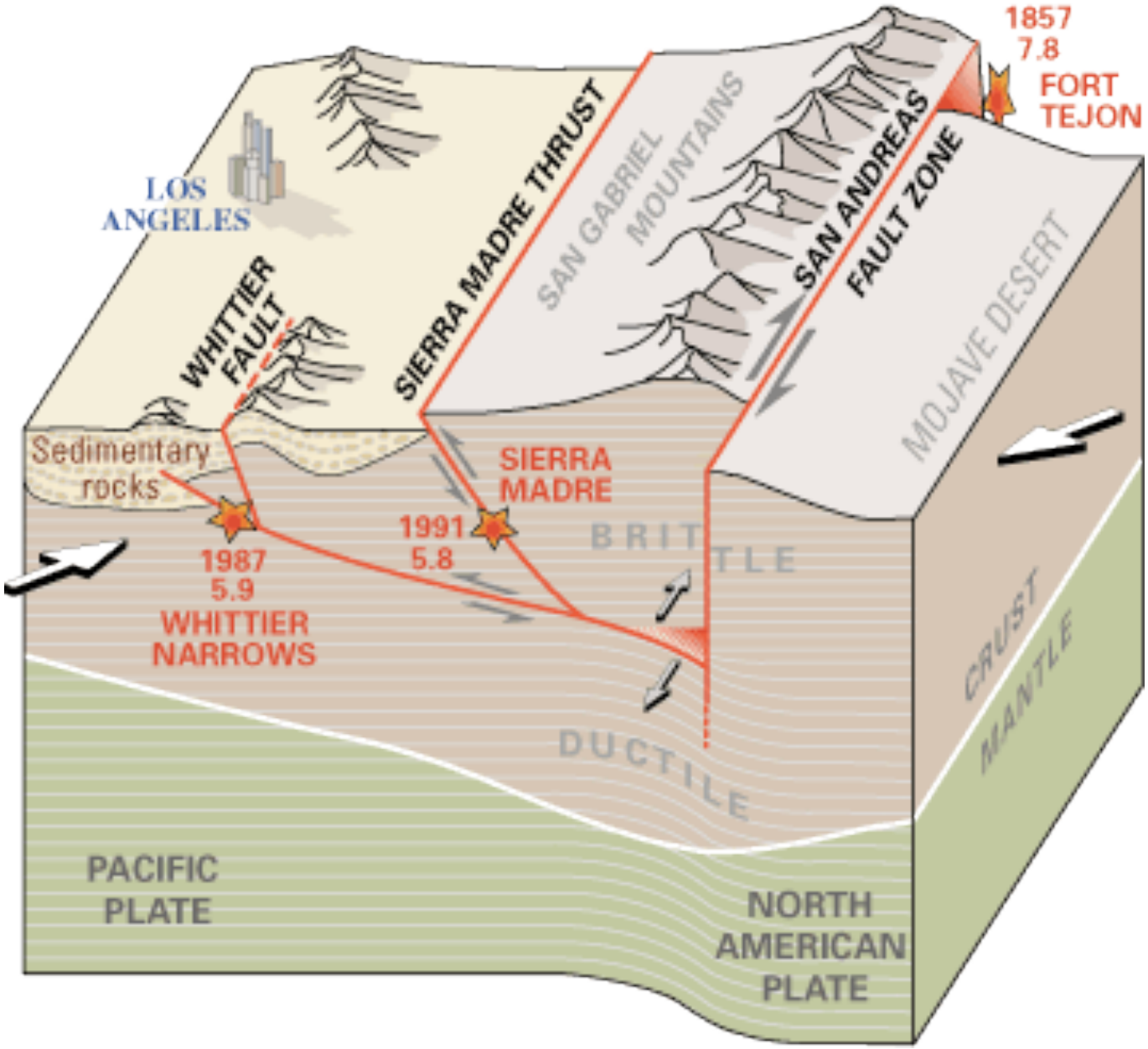
5.Coachella Valley, San Jacinto Mountains & San Andreas Faults

West side of Coachella Valley, San Jacinto Mountains

San Gorgonio Pass, Banning Fault at base of Transverse Rge

El Cajon Pass

Miocene
Cajon Fm
Fluvial sandstone
& fanglomerates


1857
7.8
FORT
TEJON
LOS
ANGELES
SIERRA MADRE THRUST
SAN GABRIEL
MOUNTAINS
SAN ANDREAS
FAULT ZONE
MOJAVE DESERT
WHITTIER
FAULT
Sedimentary
rocks
SIERRA
MADRE
1991
5.8
1987
5.9
WHITTIER
NARROWS
BRITTLE
DUCTILE
CRUST
MANTLE
PACIFIC
PLATE
NORTH
AMERICAN
PLATE

Palmdale, CA: Home of the Palmdale Bulge (1975 - 1983): Where's the fault?

Palmdale, CA: Home of the Palmdale Bulge (1975 - 1983)

Lower Middle Pliocene Anaverde Formation
(non-marine sandstone & gypsiferous mudstone

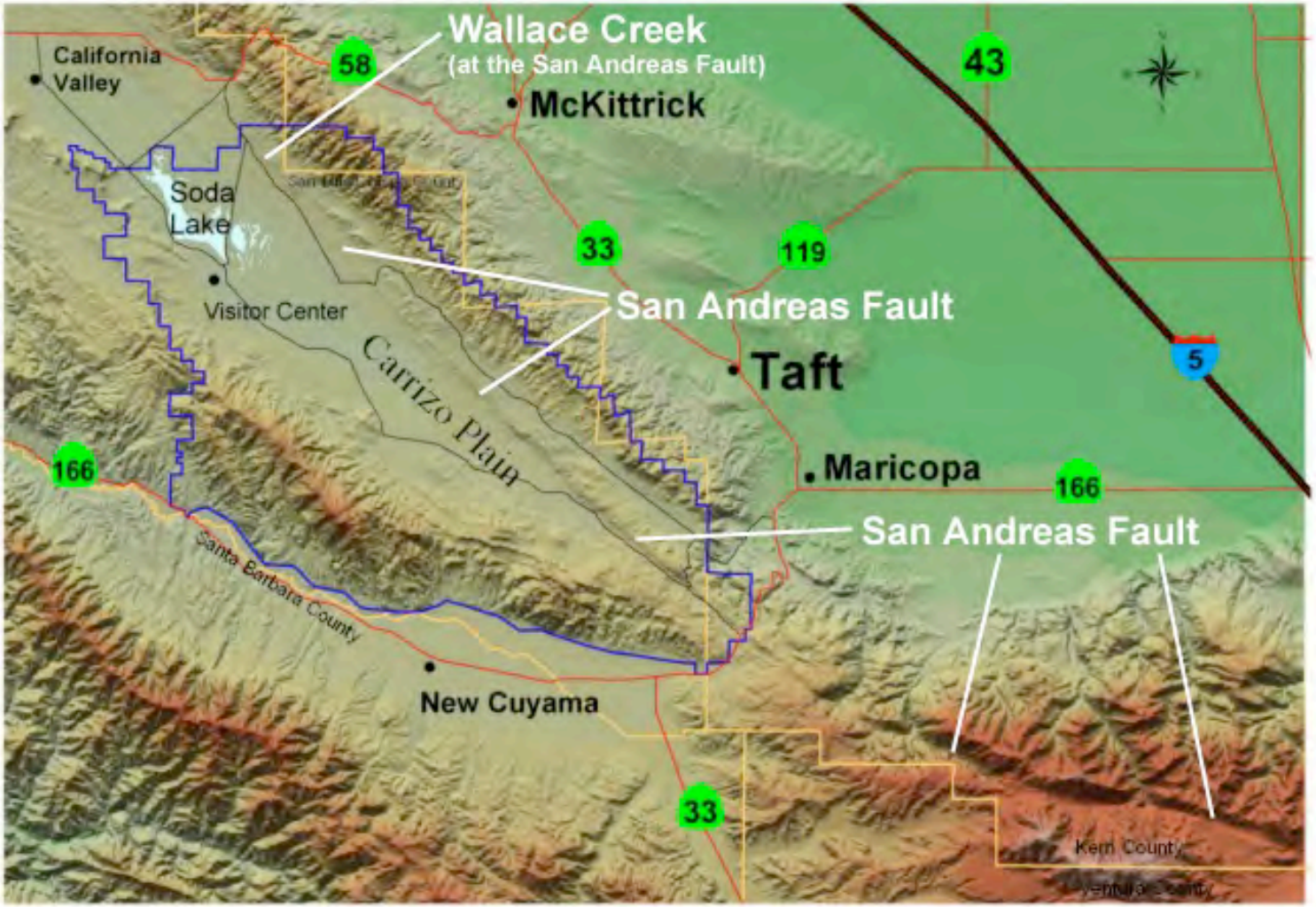
Lower Middle Pliocene Anaverde Formation
(non-marine sandstone & gypsiferous mudstone

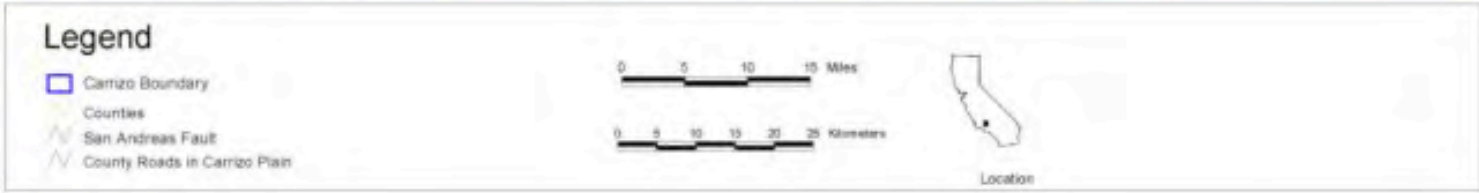
Lower Middle Pliocene Anaverde Formation
(non-marine sandstone & gypsiferous mudstone

Outcrop on Cal 14 west of Palmdale, California

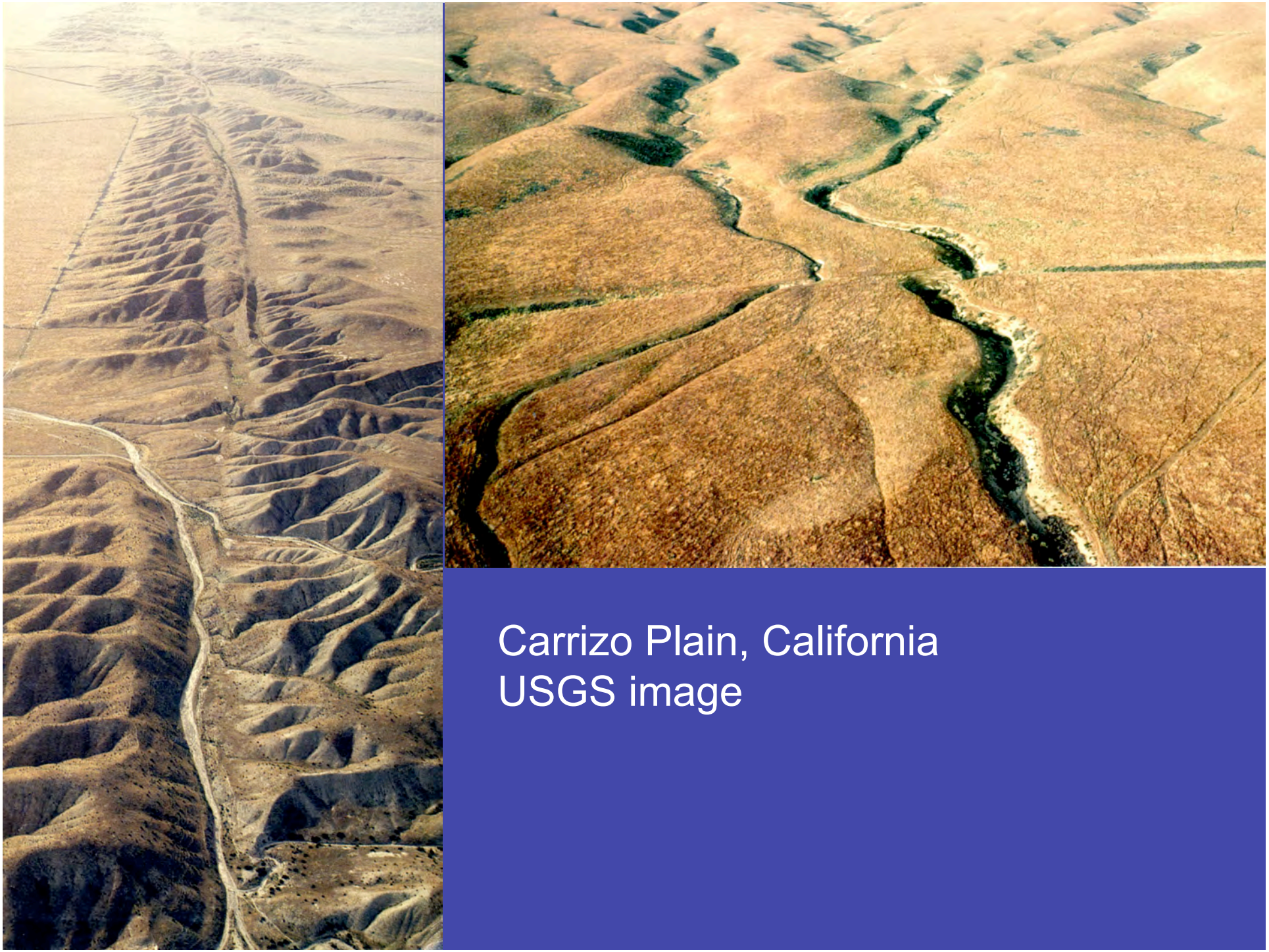
Lower Middle Pliocene Anaverde Formation
(non-marine sandstone & gypsiferous mudstone)

Carrizo Plain National Monument

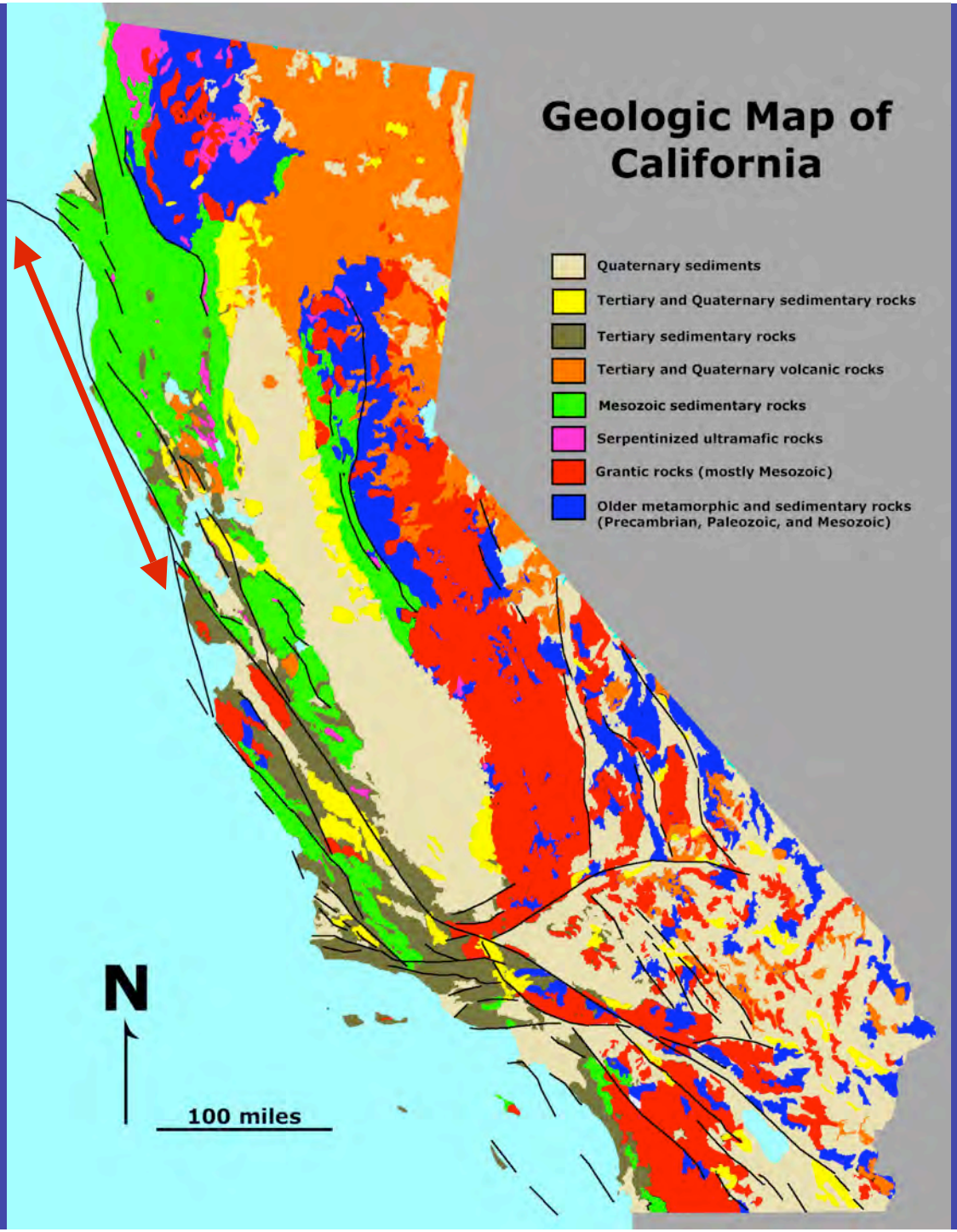




http://www.scec.org/wallacecreek/

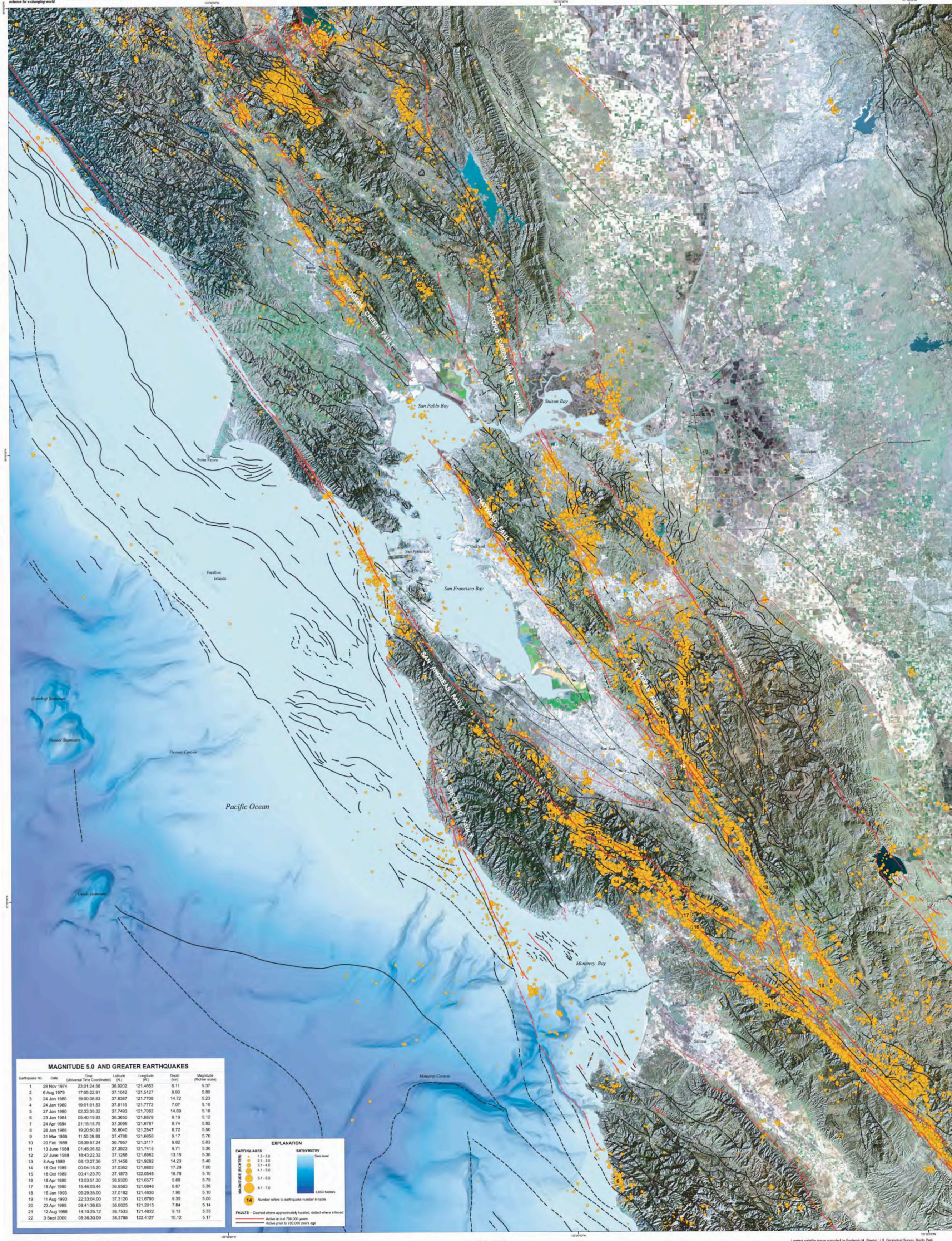


Carrizo Plain, California
USGS image


Geologic Map of California
Quaternary sediments
Tertiary and Quaternary sedimentary rocks
Tertiary sedimentary rocks
Tertiary and Quaternary volcanic rocks
Mesozoic sedimentary rocks
Serpentinized ultramafic rocks
Grantic rocks (mostly Mesozoic)
Older metamorphic and sedimentary rocks (Precambrian, Paleozoic, and Mesozoic)
N
100 miles

U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

SCIENTIFIC INVESTIGATIONS MAP 2848



MAGNITUDE 5.0 AND GREATER EARTHQUAKES

Earthquake No.	Date	Time (Universal Time Coordinated)	Latitude (N.)	Longitude (W.)	Depth (km)	Magnitude (Richter scale)
1	28 Nov 1974	23:01:24.56	36.9202	121.4663	6.11	5.37
2	6 Aug 1979	17:05:22.91	37.1042	121.5127	8.93	5.80
3	24 Jan 1980	19:00:08.63	37.8367	121.7708	14.72	5.23
4	24 Jan 1980	19:01:01.53	37.8115	121.7772	7.07	5.10
5	27 Jan 1980	02:33:35.32	37.7493	121.7062	14.69	5.18
6	23 Jan 1984	05:40:19.93	36.3650	121.8878	8.19	5.12
7	24 Apr 1984	21:15:18.75	37.3095	121.6787	8.74	5.82
8	26 Jan 1986	19:20:50.93	36.8040	121.2847	8.72	5.50
9	31 Mar 1986	11:55:39.80	37.4788	121.6858	9.17	5.70
10	20 Feb 1988	08:39:57.24	36.7957	121.3117	9.62	5.03
11	13 June 1988	01:45:36.52	37.3923	121.7415	9.71	5.30
12	27 June 1988	18:43:22.32	37.1268	121.8962	13.15	5.30
13	8 Aug 1989	08:13:27.36	37.1458	121.9282	14.23	5.40
14	18 Oct 1989	00:04:15.20	37.0362	121.8802	17.29	7.00
15	18 Oct 1989	00:41:23.70	37.1873	122.0548	16.78	5.10
16	18 Apr 1990	13:53:51.30	36.9320	121.6577	5.68	5.75
17	18 Apr 1990	15:46:03.44	36.9583	121.6848	6.67	5.36
18	16 Jan 1993	06:29:35.00	37.0182	121.4630	7.90	5.10
19	11 Aug 1993	22:33:04.00	37.3120	121.6793	9.35	5.00
20	23 Apr 1995	08:41:36.63	36.6025	121.2015	7.84	5.14
21	12 Aug 1998	14:10:25.12	36.7533	121.4622	9.13	5.35
22	3 Sept 2000	08:36:30.09	38.3788	122.4127	10.12	5.17

EXPLANATION

EARTHQUAKES

MAGNITUDE (RICHTER)
- 1.5 - 2.0
- 2.1 - 3.0
- 3.1 - 4.0
- 4.1 - 5.0
- 5.1 - 6.0
- 6.1 - 7.0

14 Number refers to earthquake number in table

BATHYMETRY

Sea level

3,650 Meters

FAULTS – Dashed where approximately located; dotted where inferred
- Active in last 700,000 years
- Active prior to 700,000 years ago

Bathymetry generated from a digital version of National Oceanic and Atmospheric Administration (NOAA) maps (Chin and others, 2001) and hydrographic data for San Francisco Bay (NOAA, 1995)

Elevation data from U.S. Geological Survey National Elevation Database (1 arc-second); sun illumination from the northwest (315°) at 60° above horizon

Landsat satellite image from seven Landsat 7 Enhanced Thematic Mapper Plus scenes collected between 1999-2001. Individual Landsat scenes processed by the U.S. Geological Survey Earth Resource Observation Systems (EROS) Data Center, Sioux Falls, South Dakota, using the National Land Archive Production System (NLAPS)

Fault data reproduced with permission, California Geological Survey, CD-ROM 2000-006 (2000), Digital database of faults from the fault activity map of California and adjacent areas

Earthquake data from the Northern California Earthquake Catalog (1970-2003)

Universal Transverse Mercator Projection, Zone 10 North

REFERENCES

Chin, John, McHendrie, Graig, Madison, Carol, and Wong, Florence L., 2001, CCALBATC - bathymetry contours for the central California region between Point Arena and Point Sur, *in* Wong, F.L., and Eittreim, S.E., compilers, Continental Shelf GIS for the Monterey Bay National Marine Sanctuary: U.S. Geological Survey Open-File Report 01-179 [available on the World Wide Web at http://geopubs.wr.usgs.gov/open-file/of01-179/].
National Oceanic and Atmospheric Administration, 1995, San Francisco Bay digital hydrographic data: National Oceanic and Atmospheric Administration (NOAA), National Ocean Service (NOS), Office of Coast Survey and Office of Ocean Resources Conservation and Assessment, Seattle, Washington. [Current version available from NOAA at http://www.ngdc.noaa.gov/mgg/fliers/03mgg03.html].

[1]U.S. Geological Survey, Menlo Park, California; [2]California Geological Survey, San Francisco, California

APPROXIMATE MEAN DECLINATION, 2004

TRUE NORTH

MAGNETIC NORTH

15°

SCALE 1:300 000

5 2.5 0 5 10 15 20 MILES

7,500 3,750 0 7,500 15,000 22,500 30,000 METERS

5 2.5 0 5 10 15 20 KILOMETERS

NORTH AMERICAN HORIZONTAL DATUM OF 1983
NATIONAL GEODETIC VERTICAL DATUM OF 1929

MAP LOCATION

EARTHQUAKES AND FAULTS IN THE SAN FRANCISCO BAY AREA (1970 - 2003)

By

Benjamin M. Sleeter[1], James P. Calzia[1], Stephen R. Walter[1], Florence L. Wong[1], and George J. Saucedo[2]

2004

Landsat satellite image compiled by Benjamin M. Sleeter, U.S. Geological Survey, Menlo Park

Bathymetry data compiled from a digital version of NOAA map sheets (Chin and others, 2001) by Florence Wong, U.S. Geological Survey, Menlo Park

Manuscript approved for publication August 18, 2004

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Digital files available on the World Wide Web at http://pubs.usgs.gov/sim/2004/2848/

125 years of science for America 1879–2004

ISBN 0-607-99029-5

View to south

Point Reyes

Flickr 2645306182_8a31ffe191_b.jpg

Flikr 3204209739_efb99083e5_b.jpg

Point Arena Gateway to Astronaut Photography

020607 003034 STS111 717 012

Shelter Cove, CA: northernmost exposure of San Andreas Fault

flickr: 72303242_0e03f67a0e_b.jpg

Measuring Displacment: Piercing Points

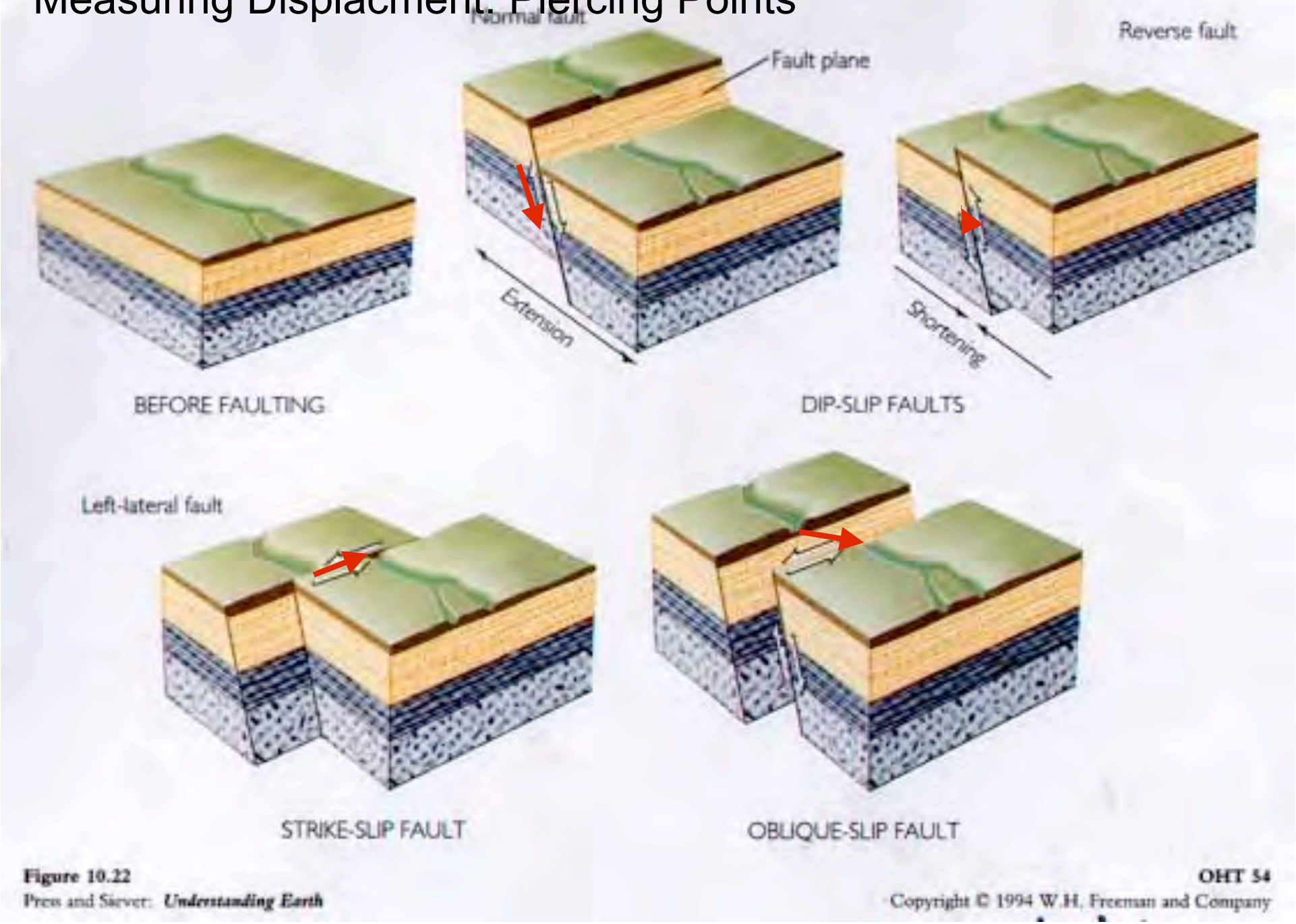


Figure 10.22
Press and Siever: ***Understanding Earth***

OHT 54

History of SAF Displacement Measurements

- 1905: Diverse names extending 400 miles south from San Francisco
- 1926: 24 miles (Noble)
- 1953: ~400 miles (Hill and Diblee)

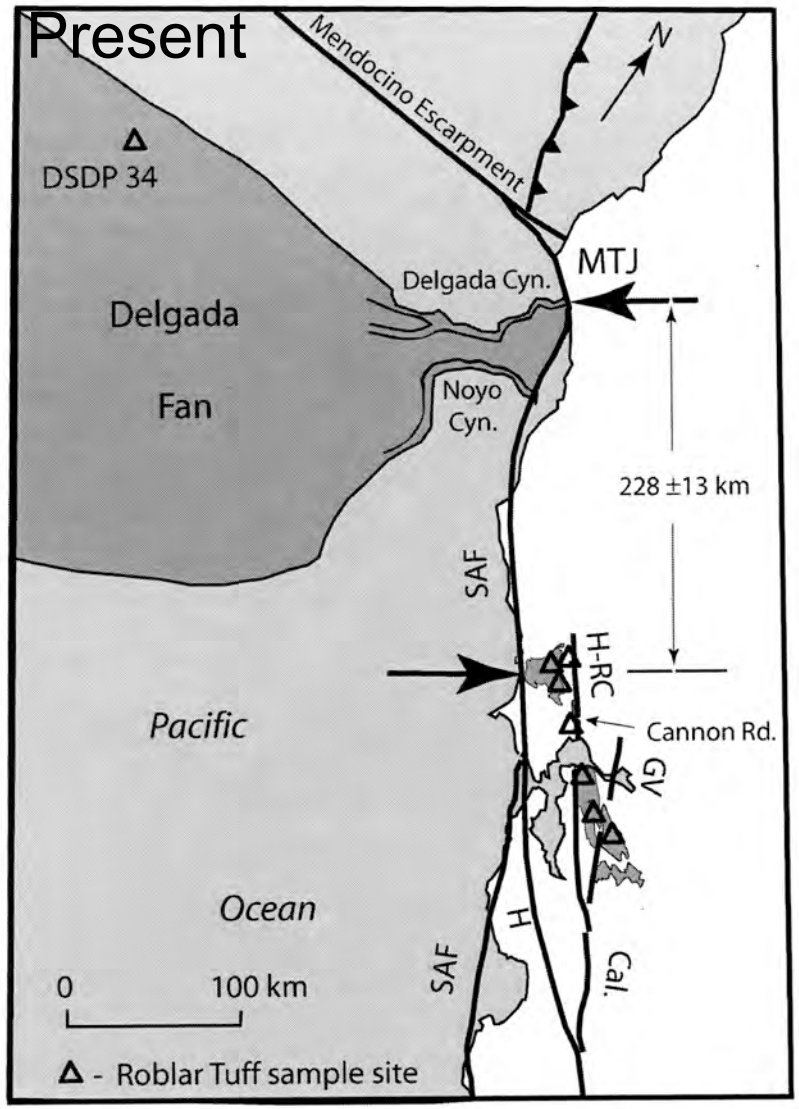


Figure 1.5. Displacement of the Roblar Tuff, 6.26 Ma, and of associated sediments. Sediments containing the Roblar tuff form a coarsening and facies progression, from SE to NW, from fluvial gravels and sands, to finer sands, silts and lacustrine deposits, to estuarine sediments, to fully marine shelf deposits, all east of the main trace San AndreasFault, and to deep-ocean fan deposits W of the main trace.

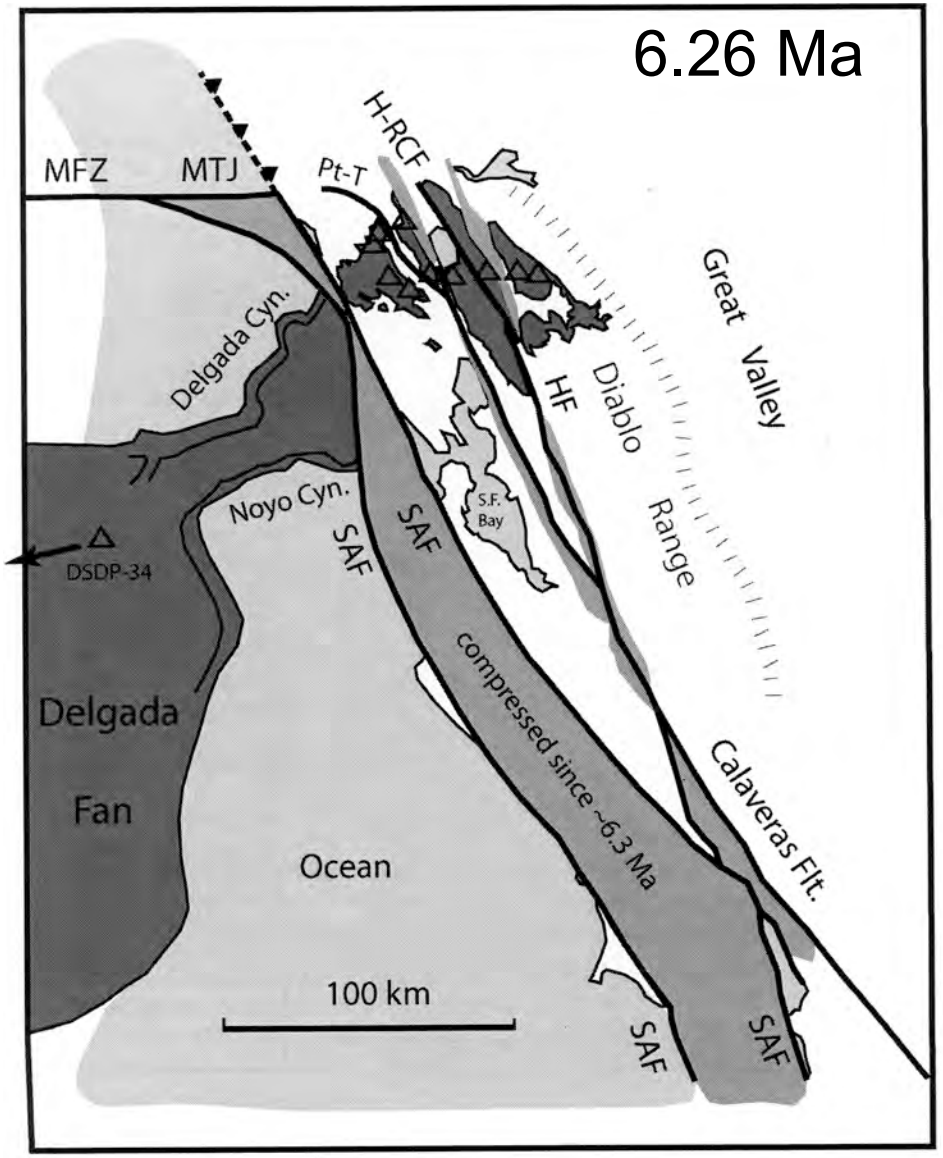


Figure 1.6. Palinspastic reconstruction of the west-central region of California based on the distribution of the Roblar tuff (6.26 Ma), and the associated sediments.

Wagner et al 2005

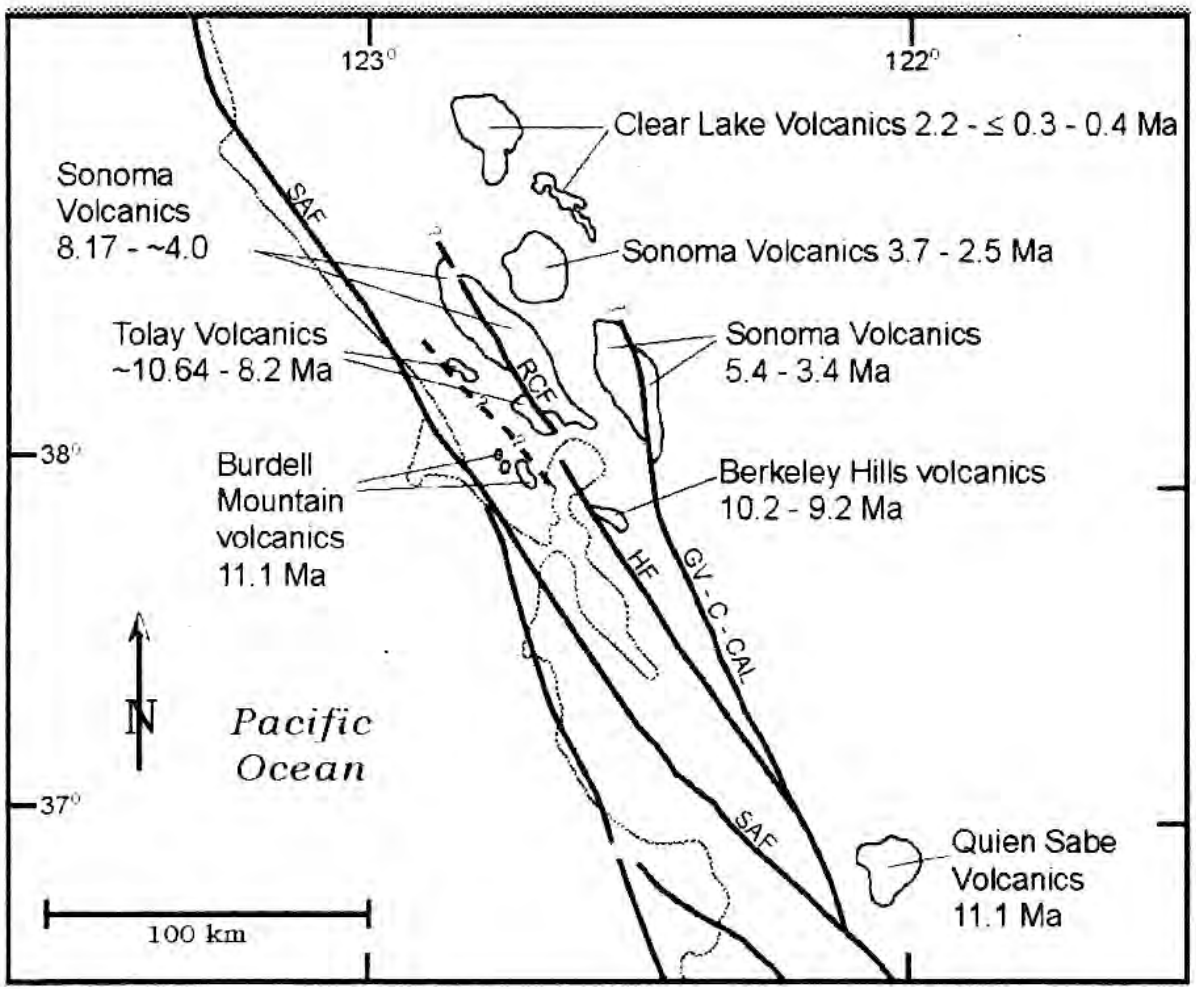


Figure 1.1. Map showing the late Miocene volcanic fields along the faults inboard of the San Andreas Fault (SAF) in the San Francisco Bay region modified from Wakabayashi (1996). The oldest fields are

Wagner et al 2005

Miocene (23.5 Ma)
Pinnacles and Neenach
Formations

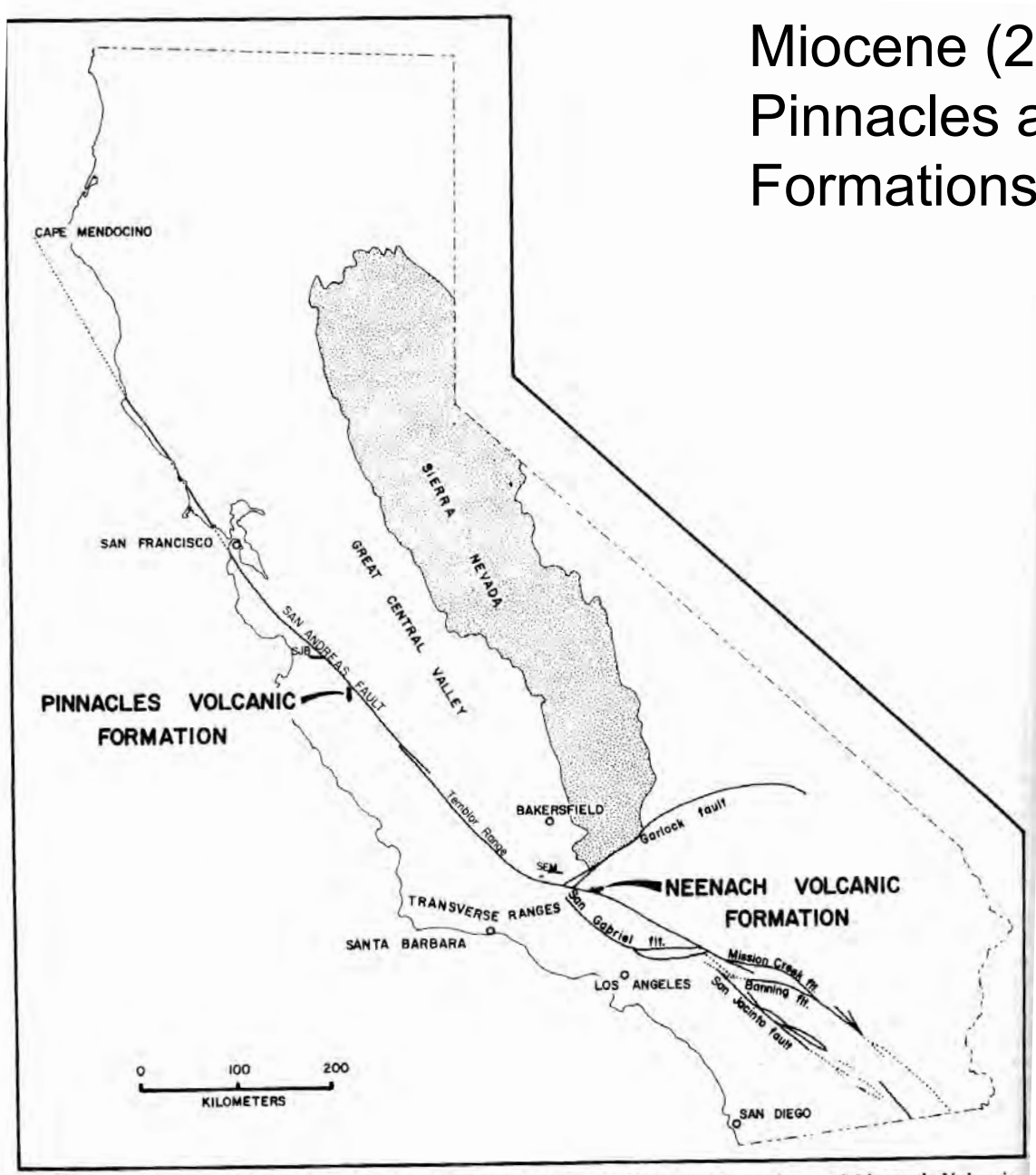
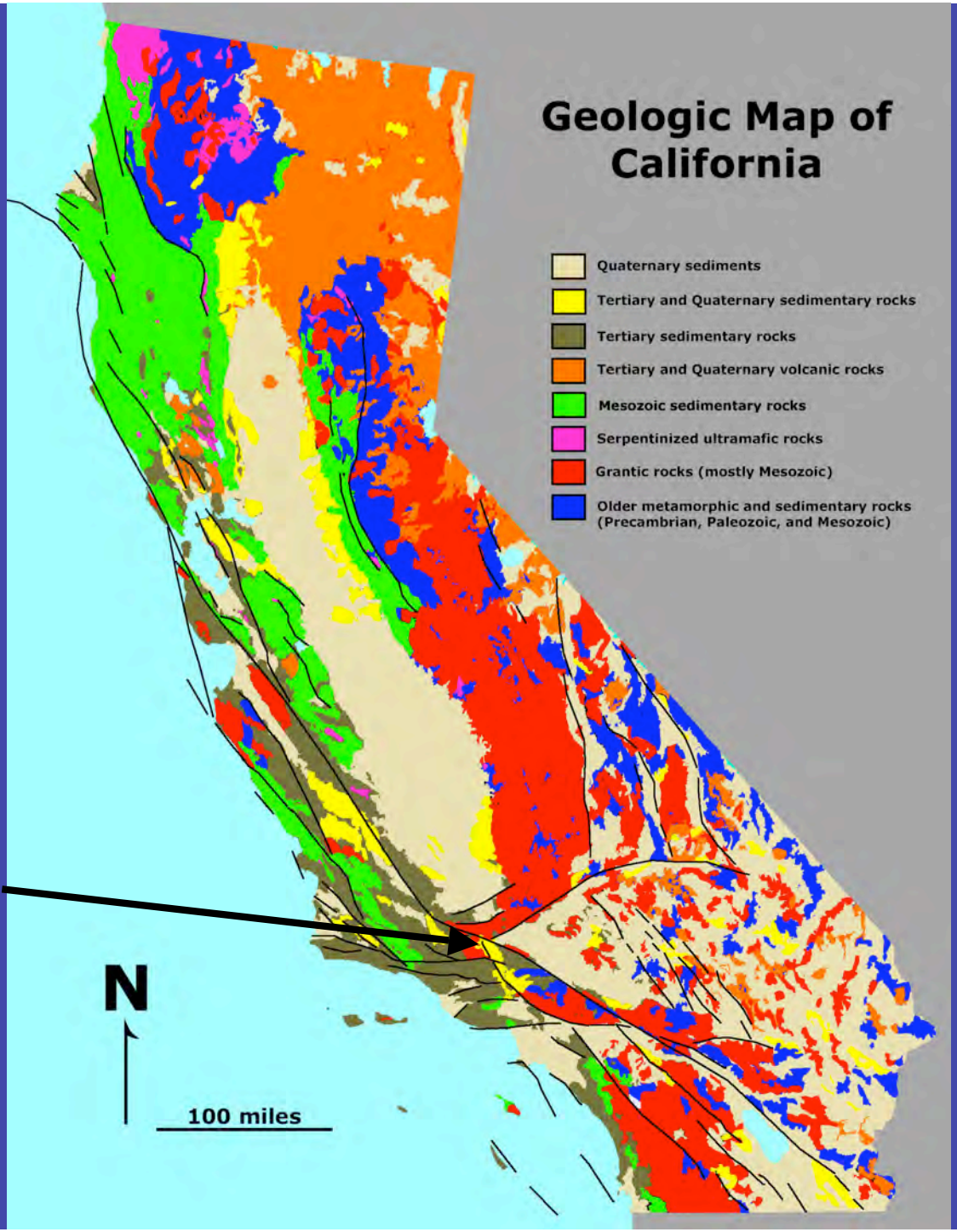


FIG. 1—Index map of California showing location of Pinnacles Volcanic Formation and Neenach Volcanic Formation. Also shown are San Juan Bautista volcanic rocks (SJB) and San Emigdio Mountains volcanic rocks (SEM).

Mathews 1976

Ridge Basin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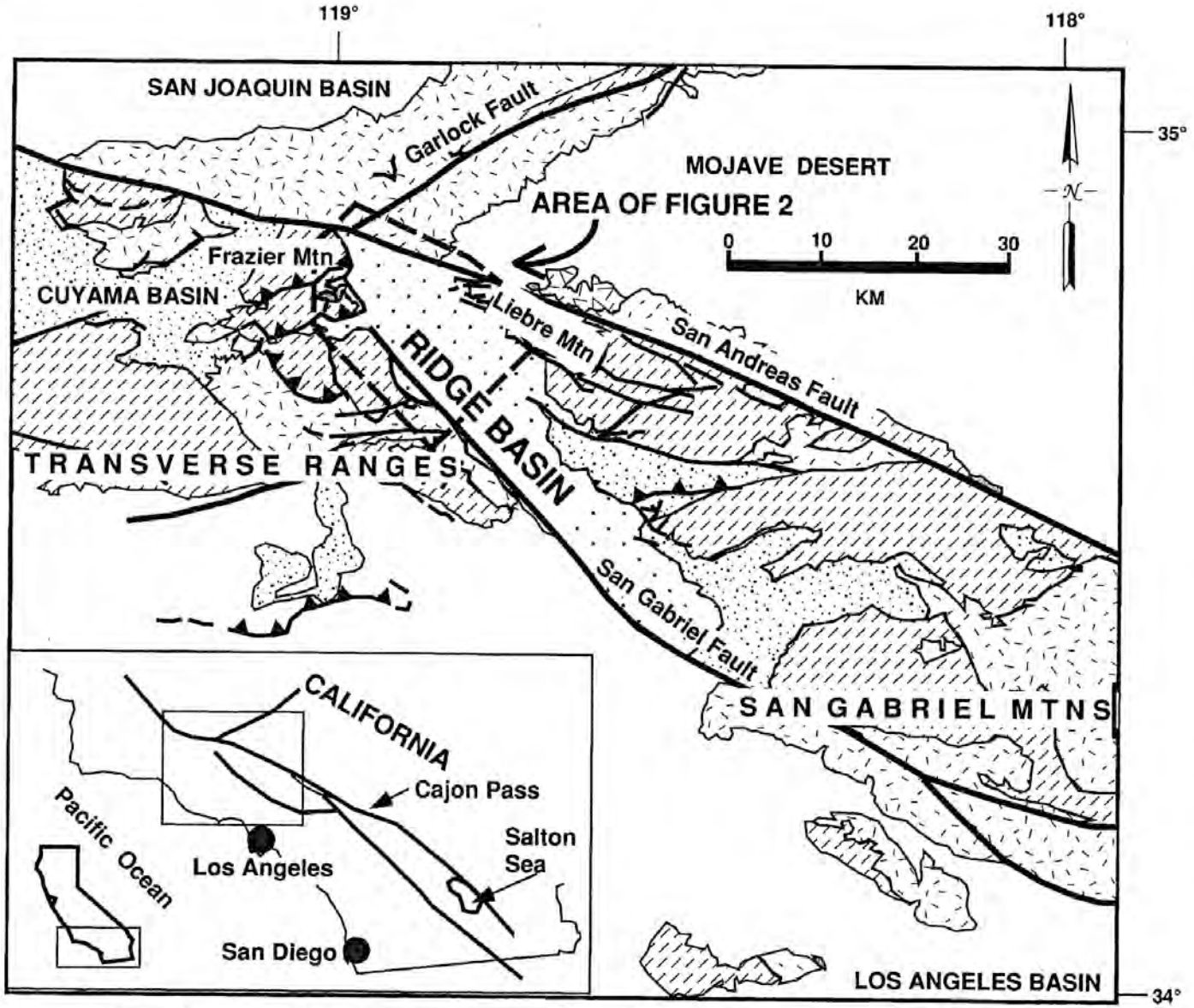
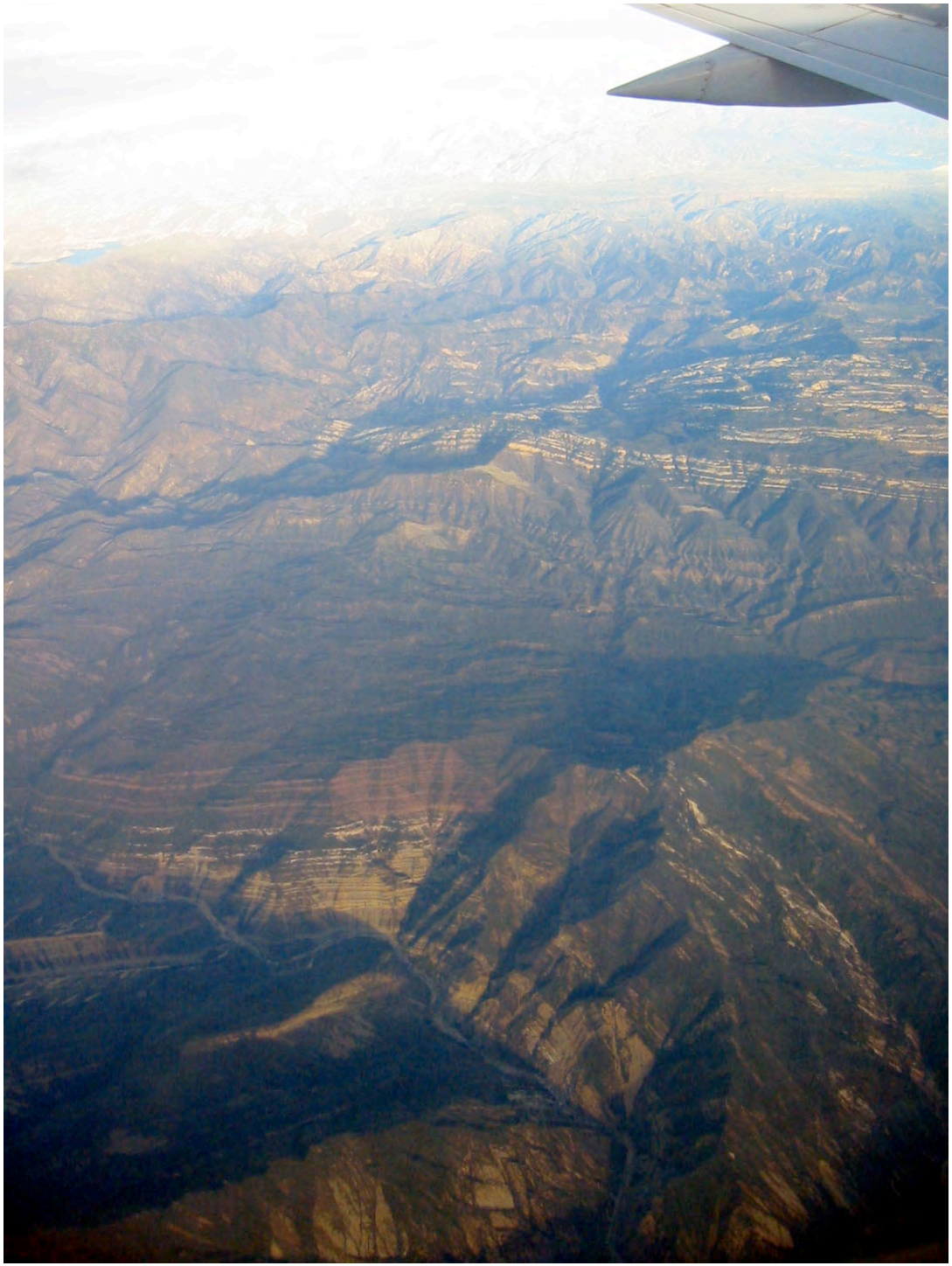
N
100 miles

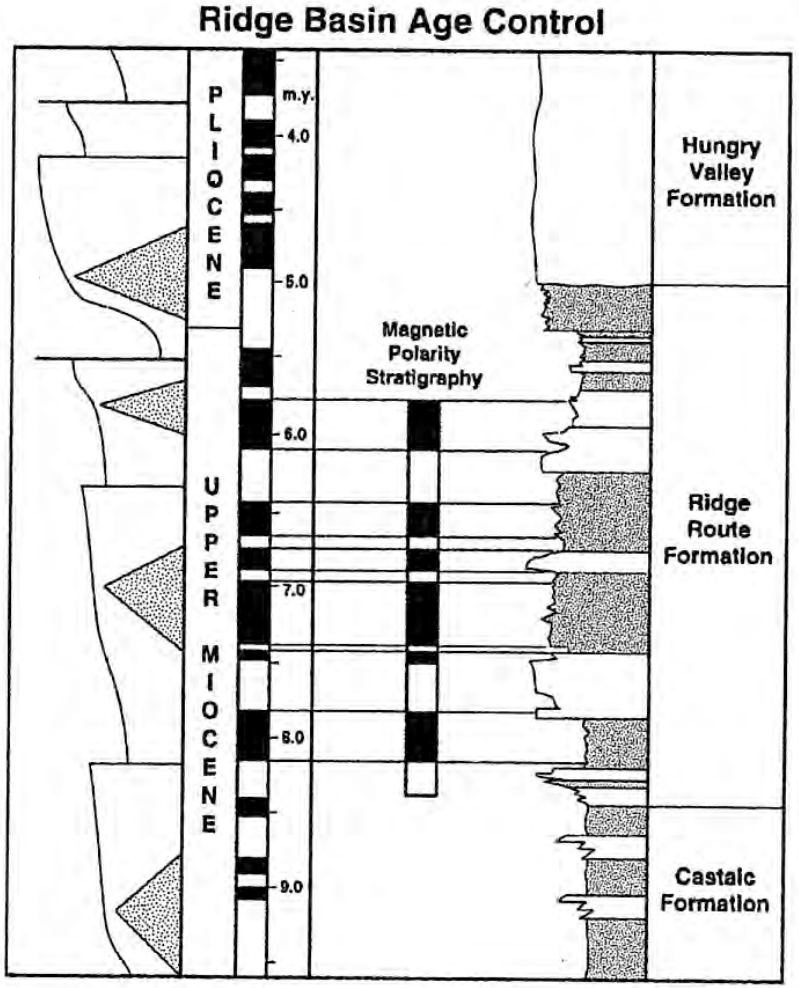

119°
118°
35°
34°
SAN JOAQUIN BASIN
Garlock Fault
MOJAVE DESERT
AREA OF FIGURE 2
0 10 20 30
KM
N
Frazier Mtn.
CUYAMA BASIN
Liebre Mtn.
San Andreas Fault
RIDGE BASIN
TRANSVERSE RANGES
San Gabriel Fault
SAN GABRIEL MTNS
CALIFORNIA
Cajon Pass
Salton Sea
Pacific Ocean
Los Angeles
San Diego
LOS ANGELES BASIN
QUATERNARY SEDIMENTS
TERTIARY STRATA OF RIDGE BASIN
TERTIARY STRATA UNDIFFERENTIATED (May Include Cretaceous)
MIOCENE VOLCANIC ROCKS
GRANITIC BASEMENT
METAMORPHIC BASEMENT

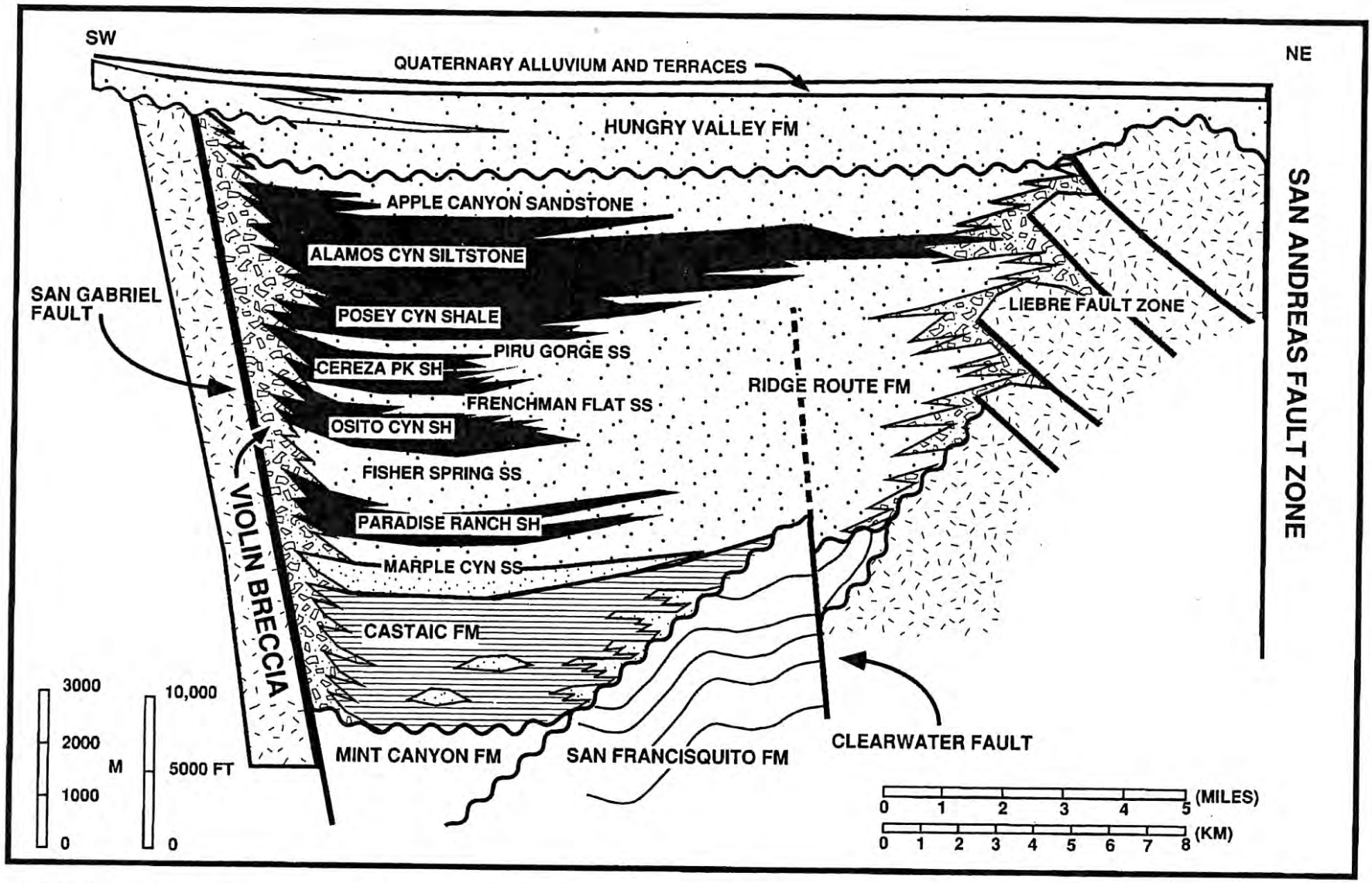


Ridge Basin

http://unrnet.seismo.unr.edu/

Aerials/Ridge-Basin.jpg




SW
NE
QUATERNARY ALLUVIUM AND TERRACES
HUNGRY VALLEY FM
APPLE CANYON SANDSTONE
ALAMOS CYN SILTSTONE
SAN GABRIEL FAULT
POSEY CYN SHALE
PIRU GORGE SS
CEREZA PK SH
FRENCHMAN FLAT SS
OSITO CYN SH
FISHER SPRING SS
PARADISE RANCH SH
MARPLE CYN SS
CASTAIC FM
VIOLIN BRECCIA
LIEBRE FAULT ZONE
RIDGE ROUTE FM
SAN ANDREAS FAULT ZONE
CLEARWATER FAULT
MINT CANYON FM
SAN FRANCISQUITO FM
3000
2000
1000
0
M
10,000
5000 FT
0
0 1 2 3 4 5 (MILES)
0 1 2 3 4 5 6 7 8 (KM)
ALLUVIAL CONGLOMERATE
LACUSTRINE MUDSTONE
FLUVIAL CONGLOMERATE, SANDSTONE AND SHALE
MARINE SANDSTONE
MARINE SHALE
CRYSTALLINE BASEMENT

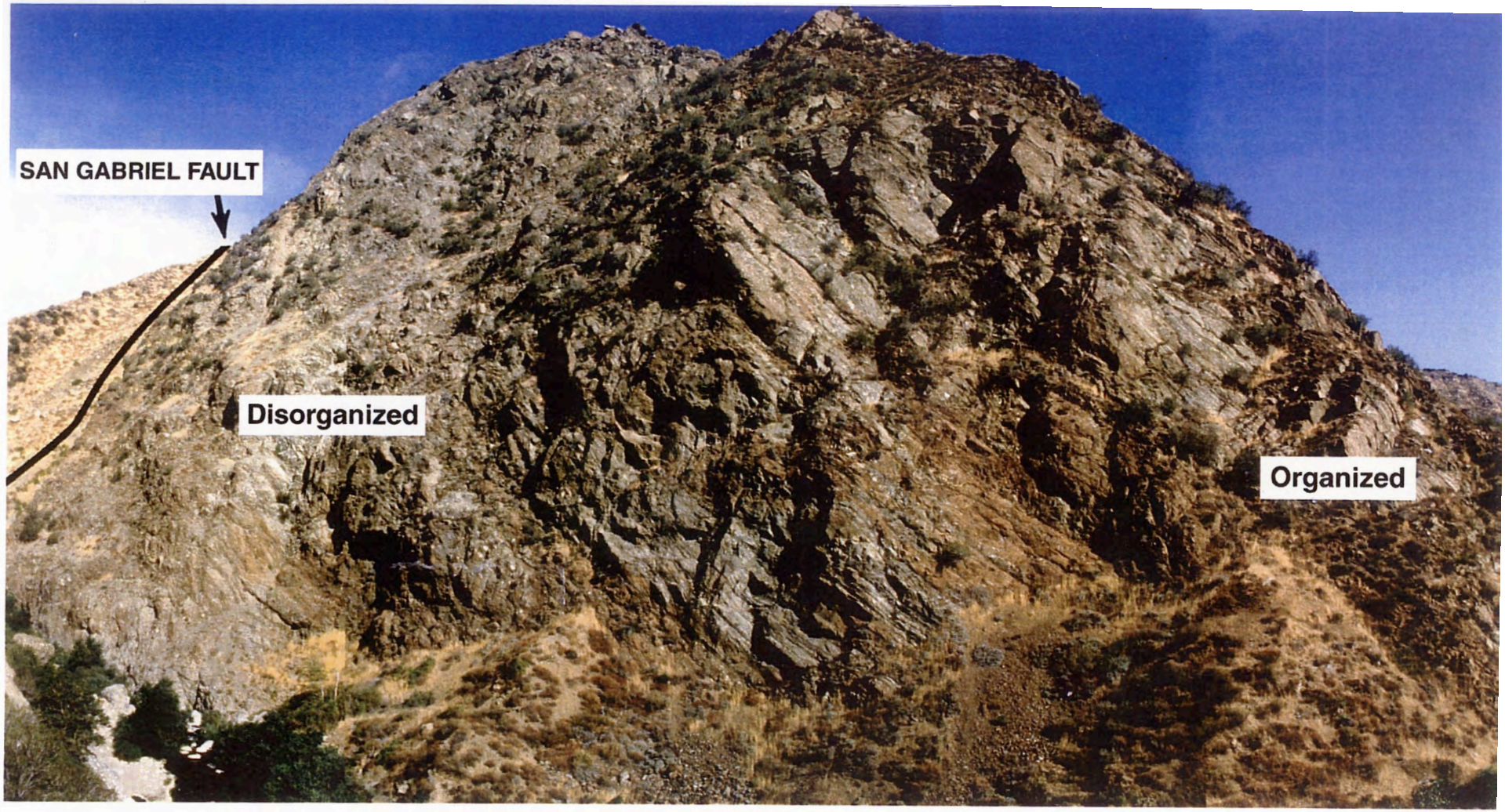


Figure 11. Photo showing the lateral facies relationship within the Violin Breccia. Note the distinct increase in the overall organization of the facies with the Violin Breccia moving in a basinward direction (away from the San Gabriel fault). **(Piru Creek/ Frenchman Flat).**

Violin Breccia

Upper Miocene: Marple Canyon Sandstone, basal Ridge Route Fm

Upper Miocene:
Marple Canyon Sandstone
Ridge Route Fm

Pebbly sandstone

Paradise Ranch Shale
Ridge Route Formation
lacustrine turbidites

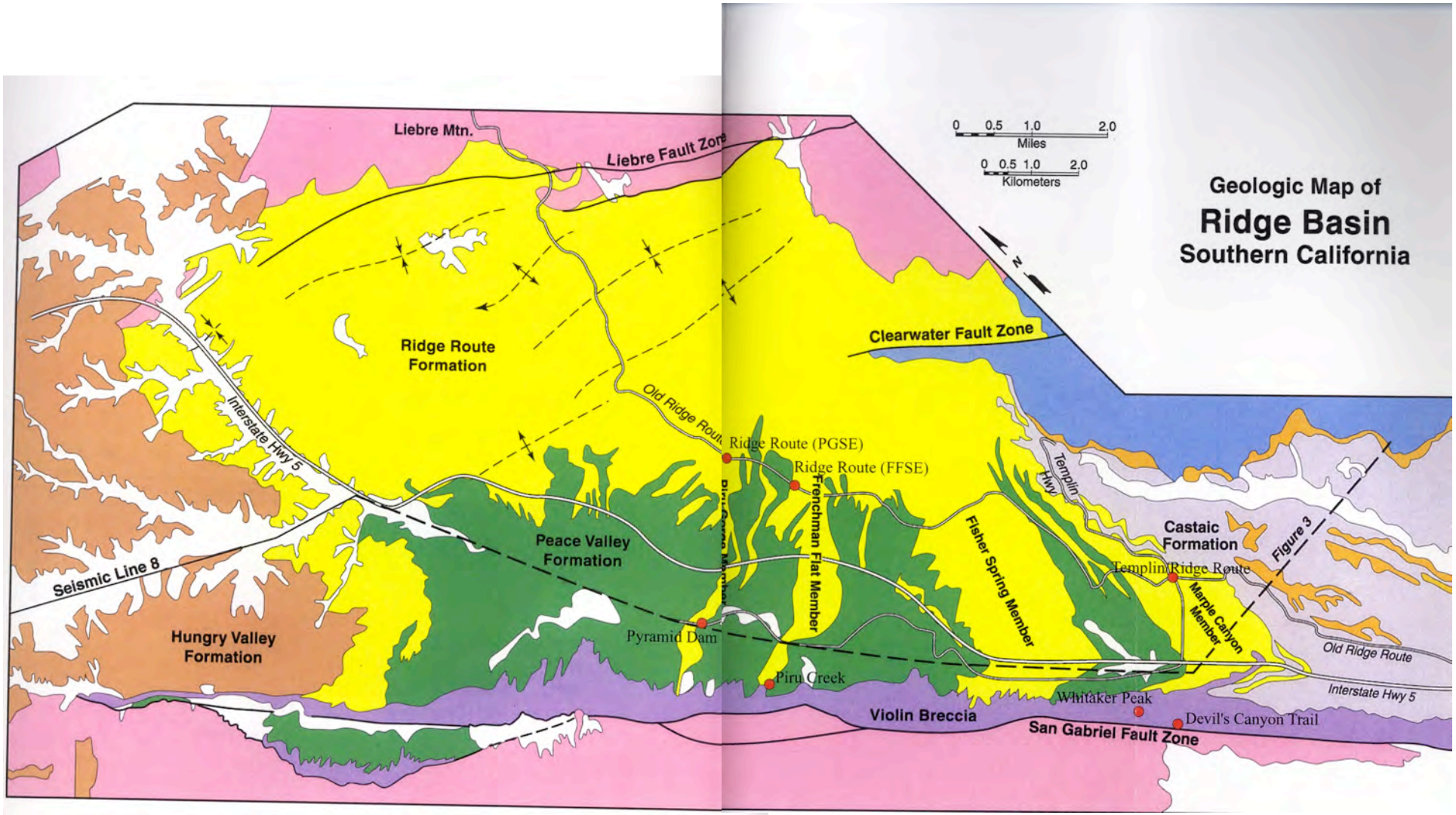
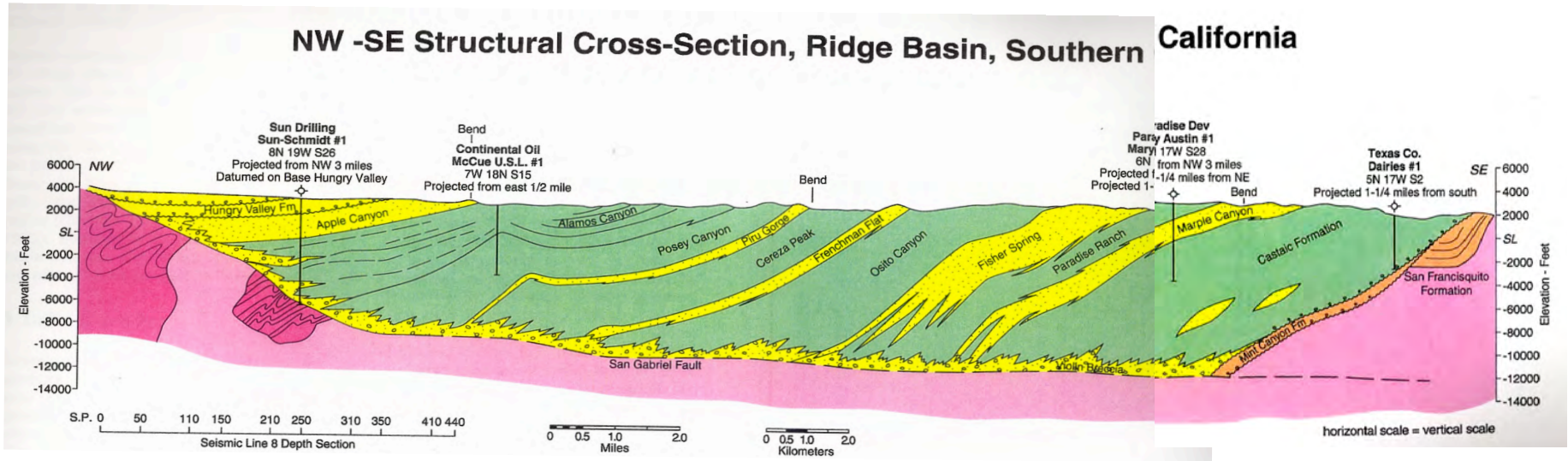
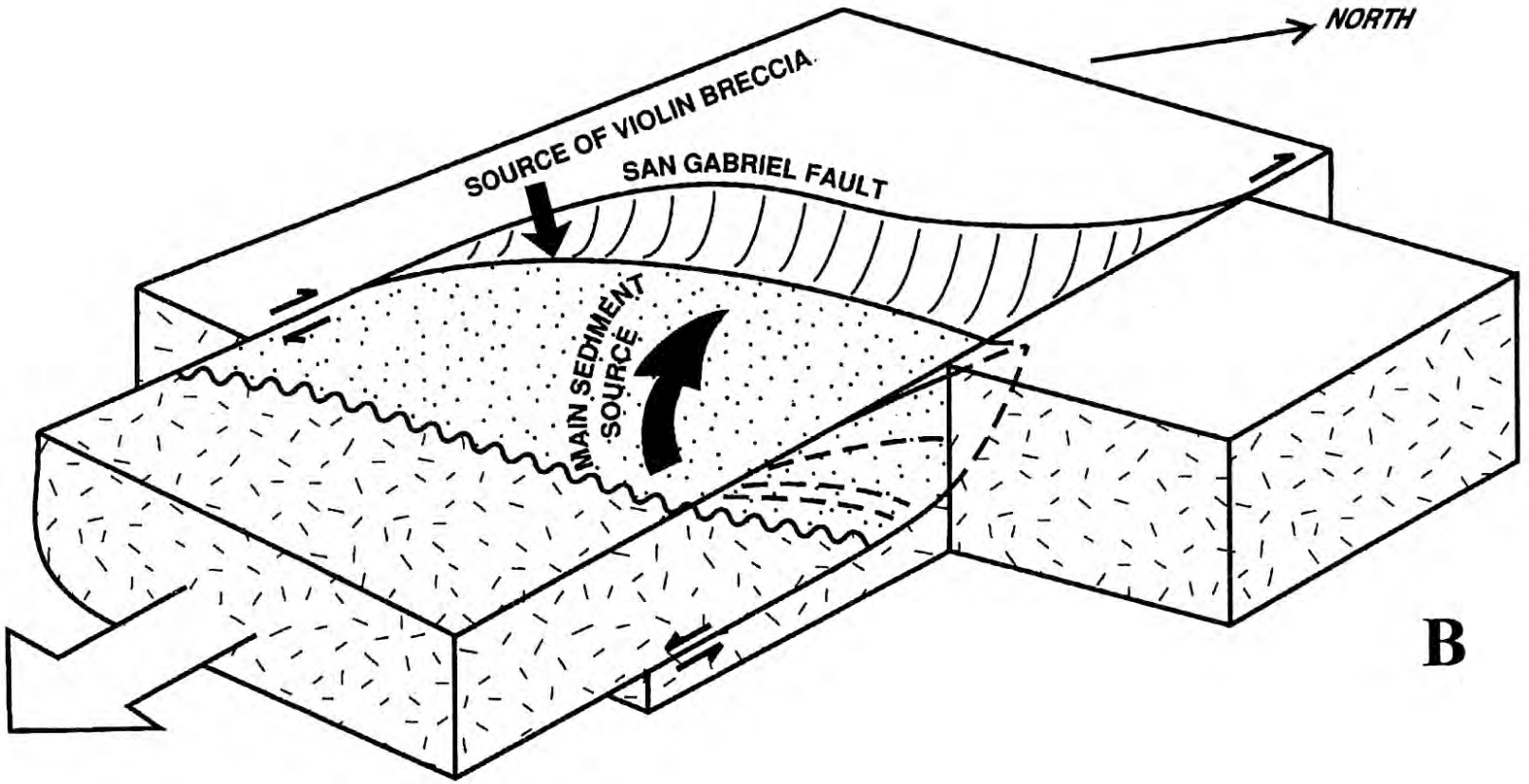
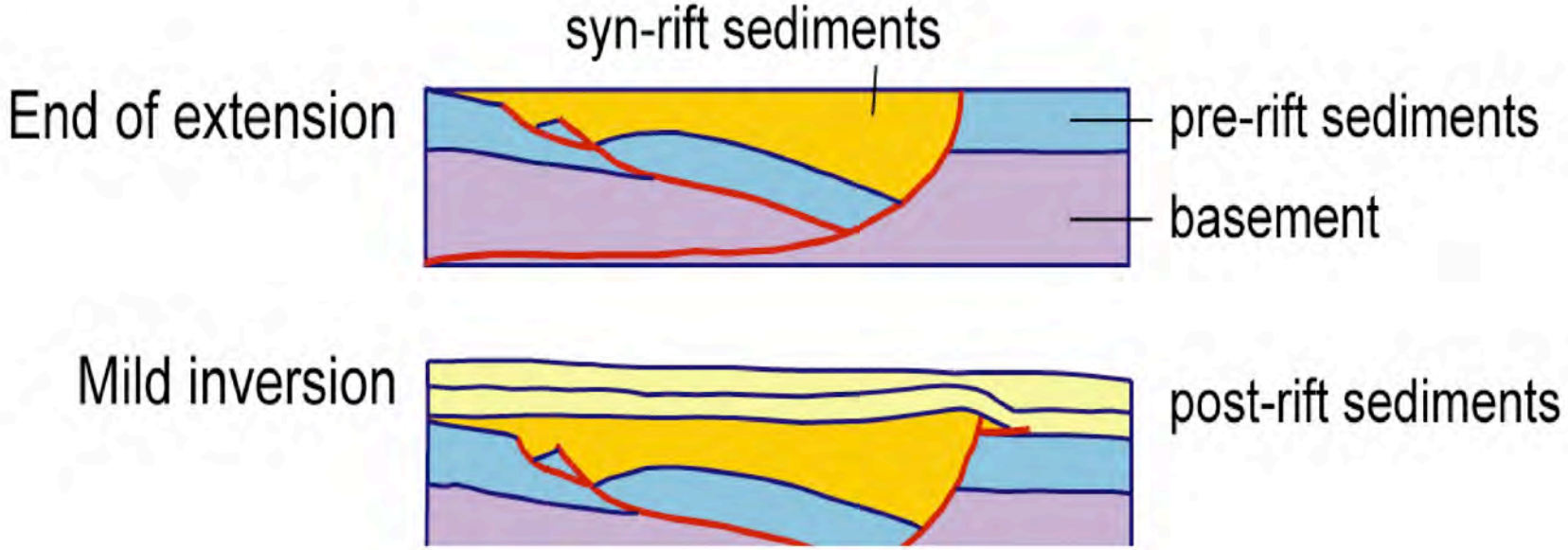


Figure 2. Geologic map of the Ridge Basin (modified from Crowell and others, 1982). Also shown is the location of the Exxon Production Research Company seismic line in Figure 4A. Note that the most

NW -SE Structural Cross-Section, Ridge Basin, Southern California



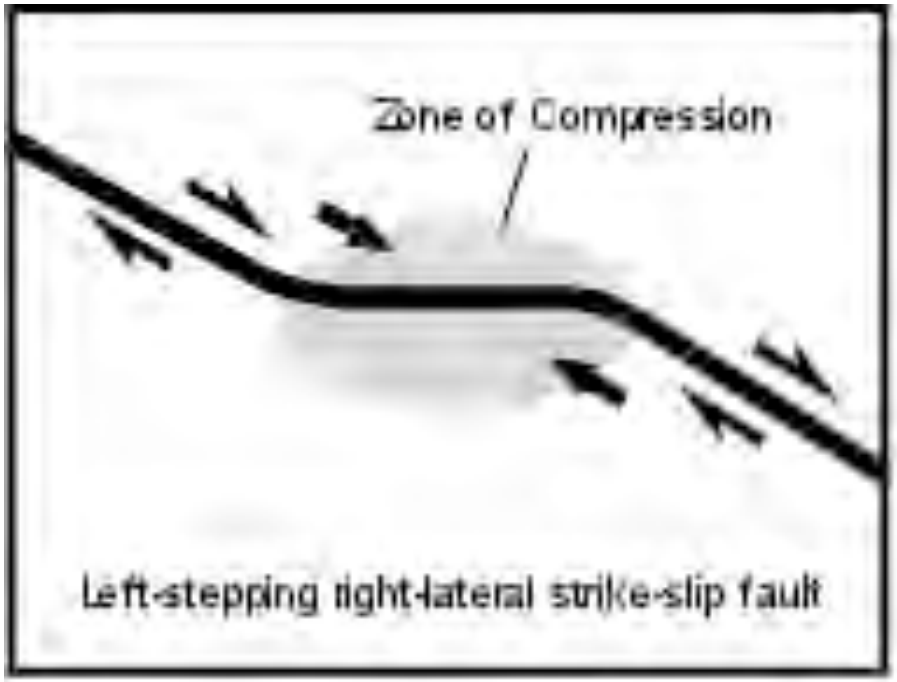

NORTH
SOURCE OF VIOLIN BRECCIA
SAN GABRIEL FAULT
MAIN SEDIMENT SOURCE
B

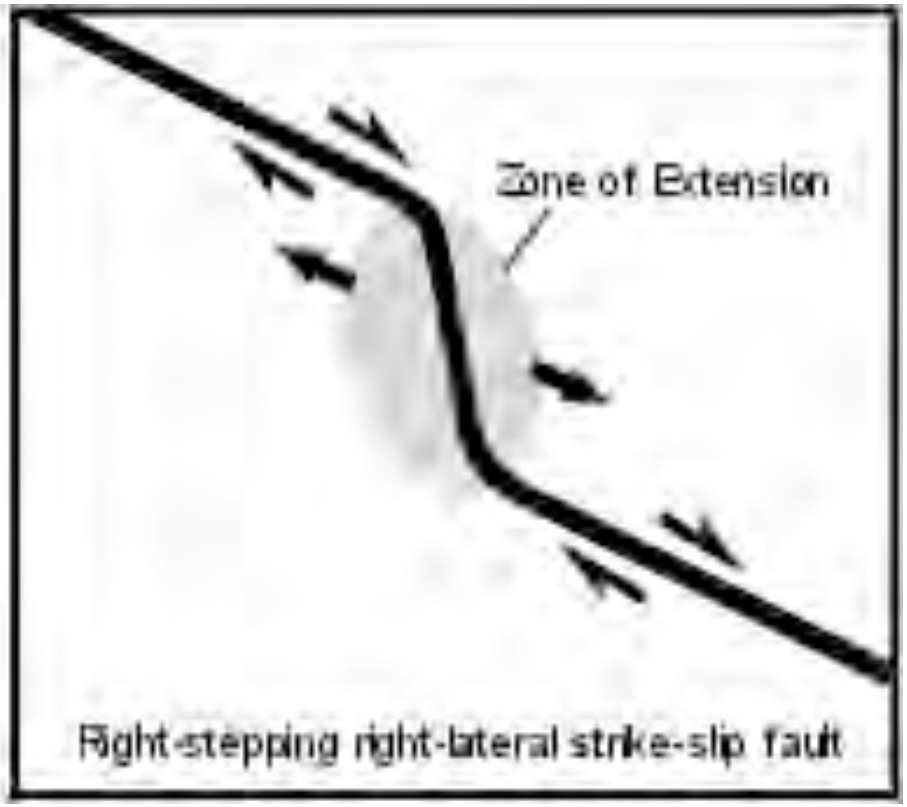


Why do we see these sediments on mountains associated with the San Andreas Fault?

Because the basins “invert”. Why?

Because the stresses changes as the SAF system changes . . .


Zone of Compression
Left-stepping right-lateral strike-slip fault


Zone of Extension
Right-stepping right-lateral strike-slip fault

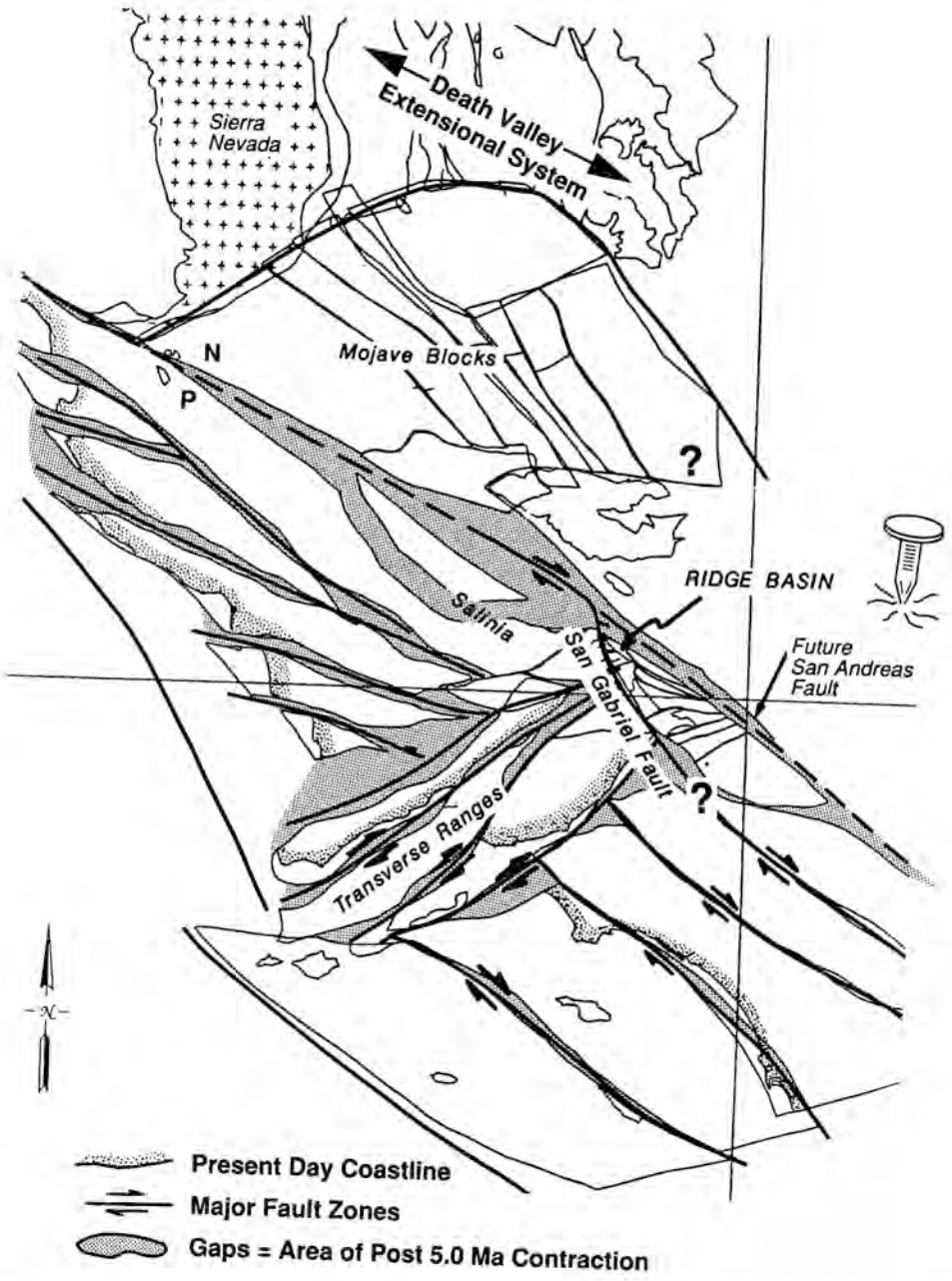
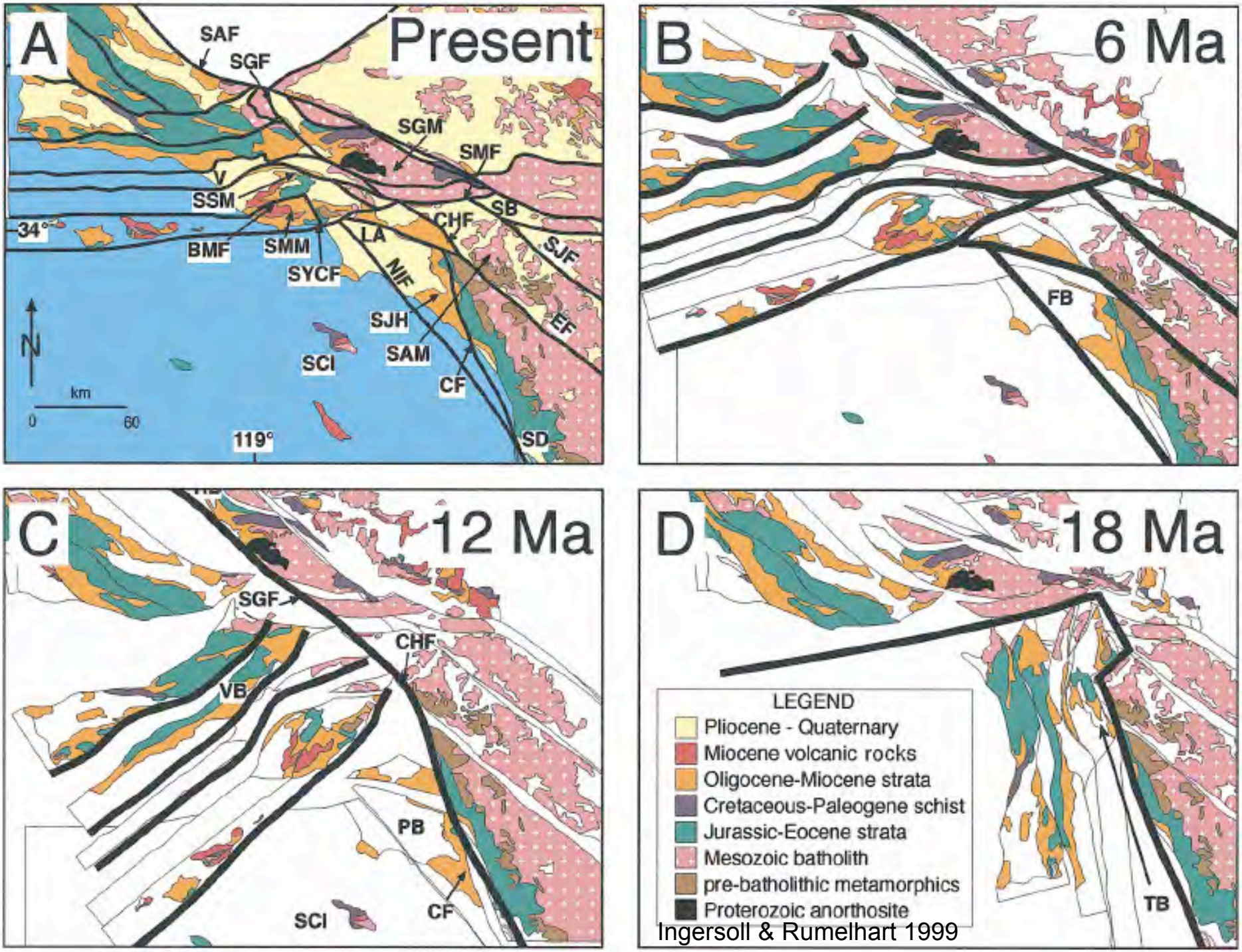
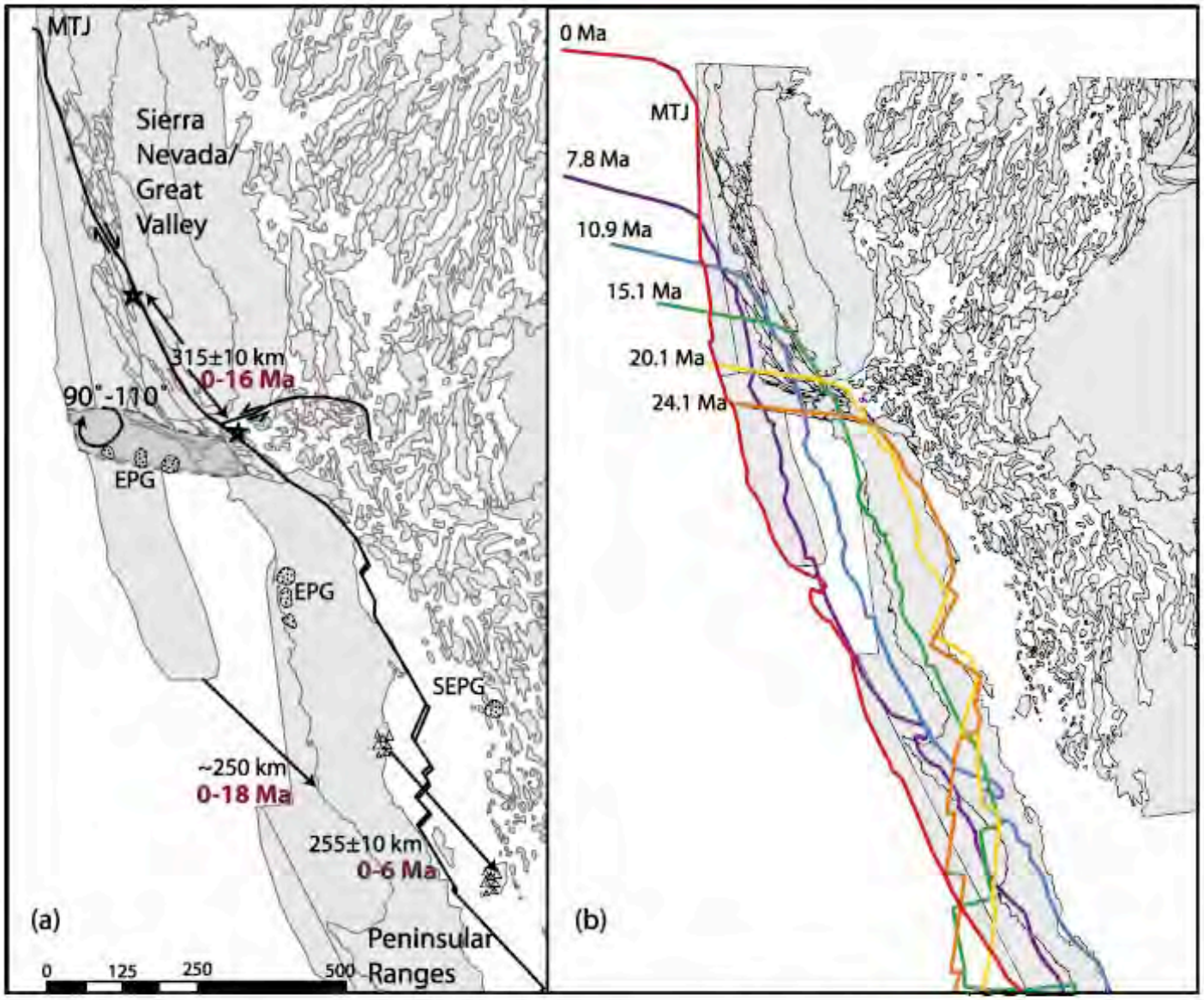


Figure 7. Plate reconstruction (at 5 MA) of southern California illustrating the origin of the Ridge Basin at a releasing bend within the San Gabriel – San Andreas fault system (from May

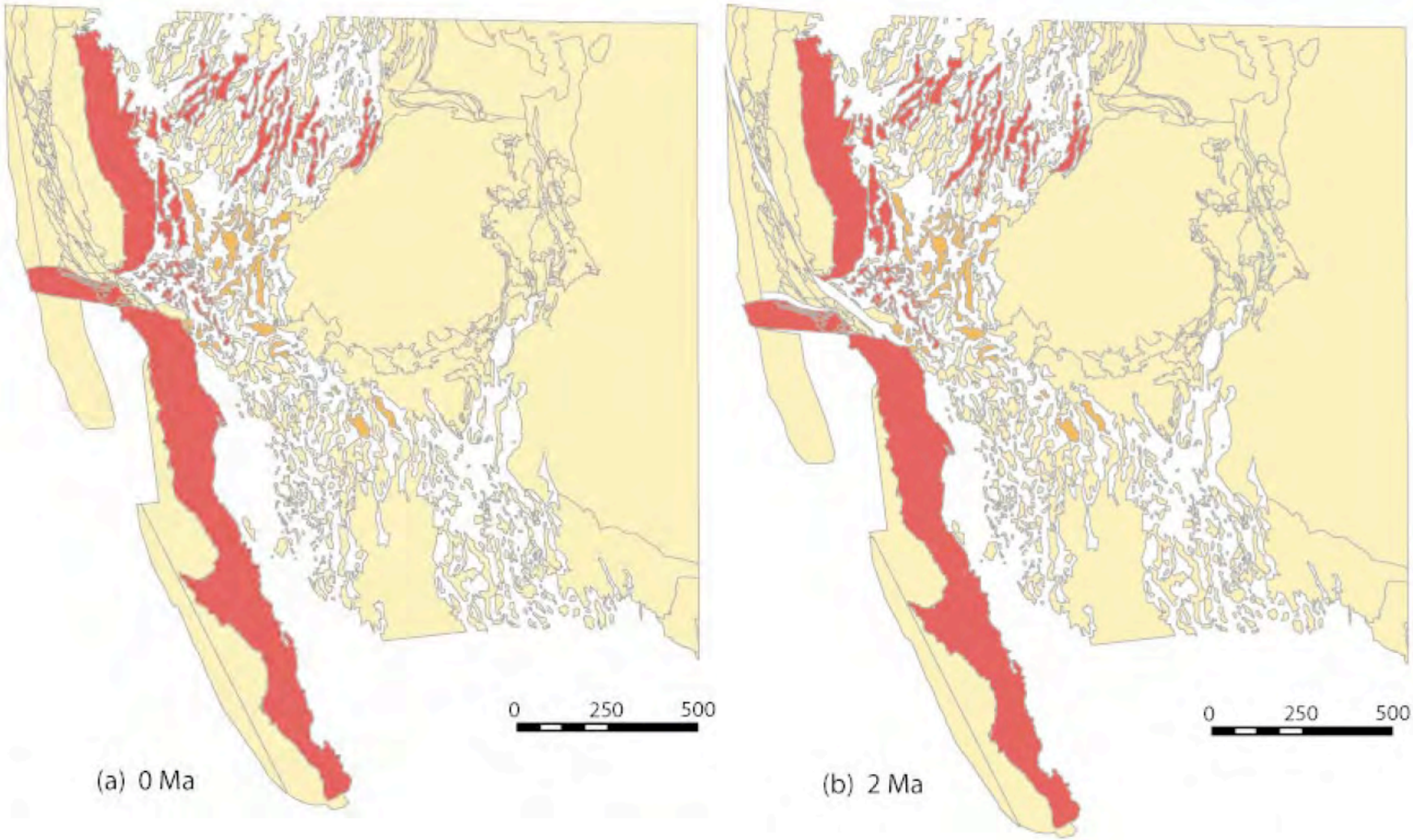


Ingersoll & Rumelhart 1999

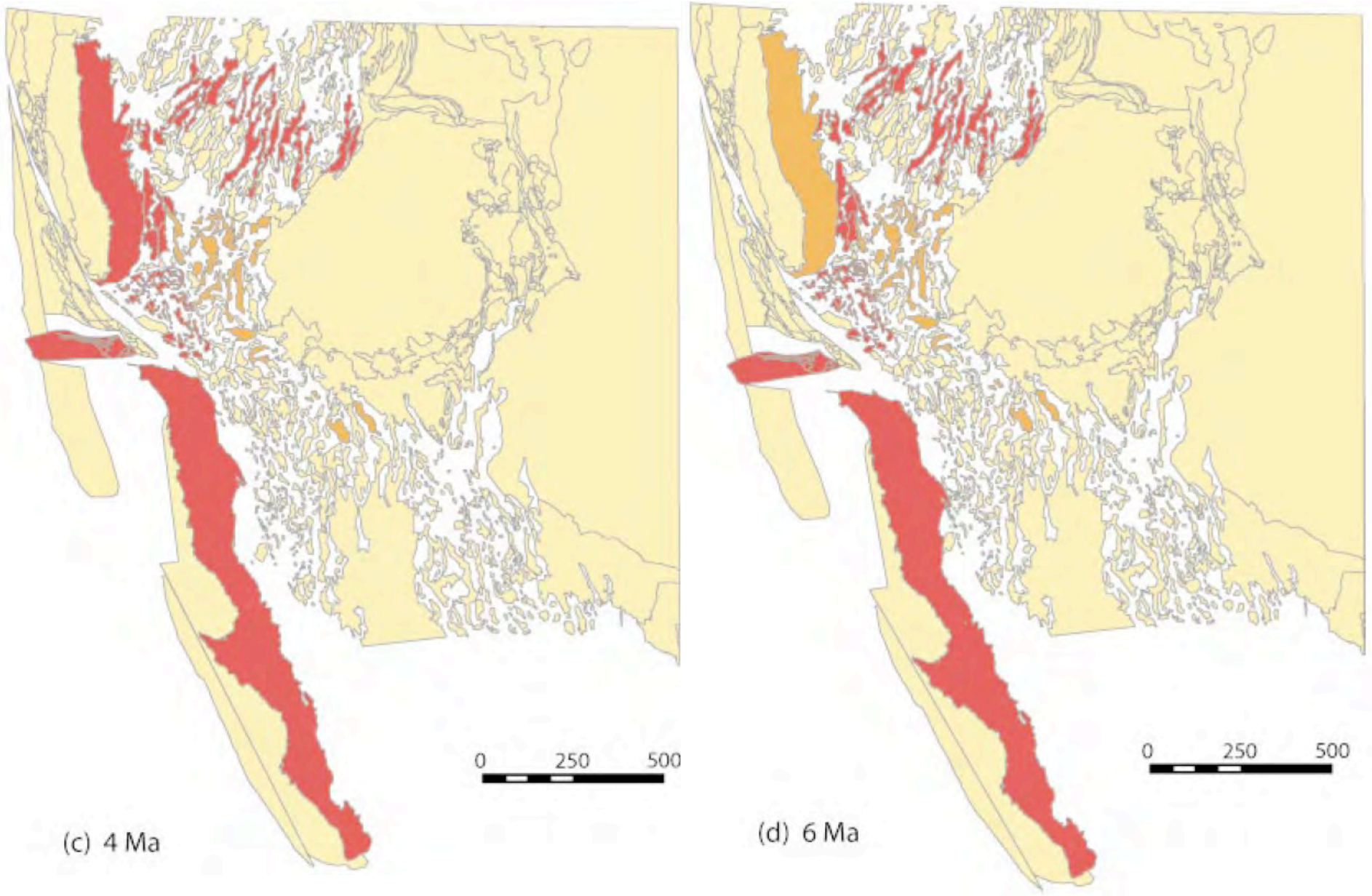


McQuarrie & Wernicke 2005

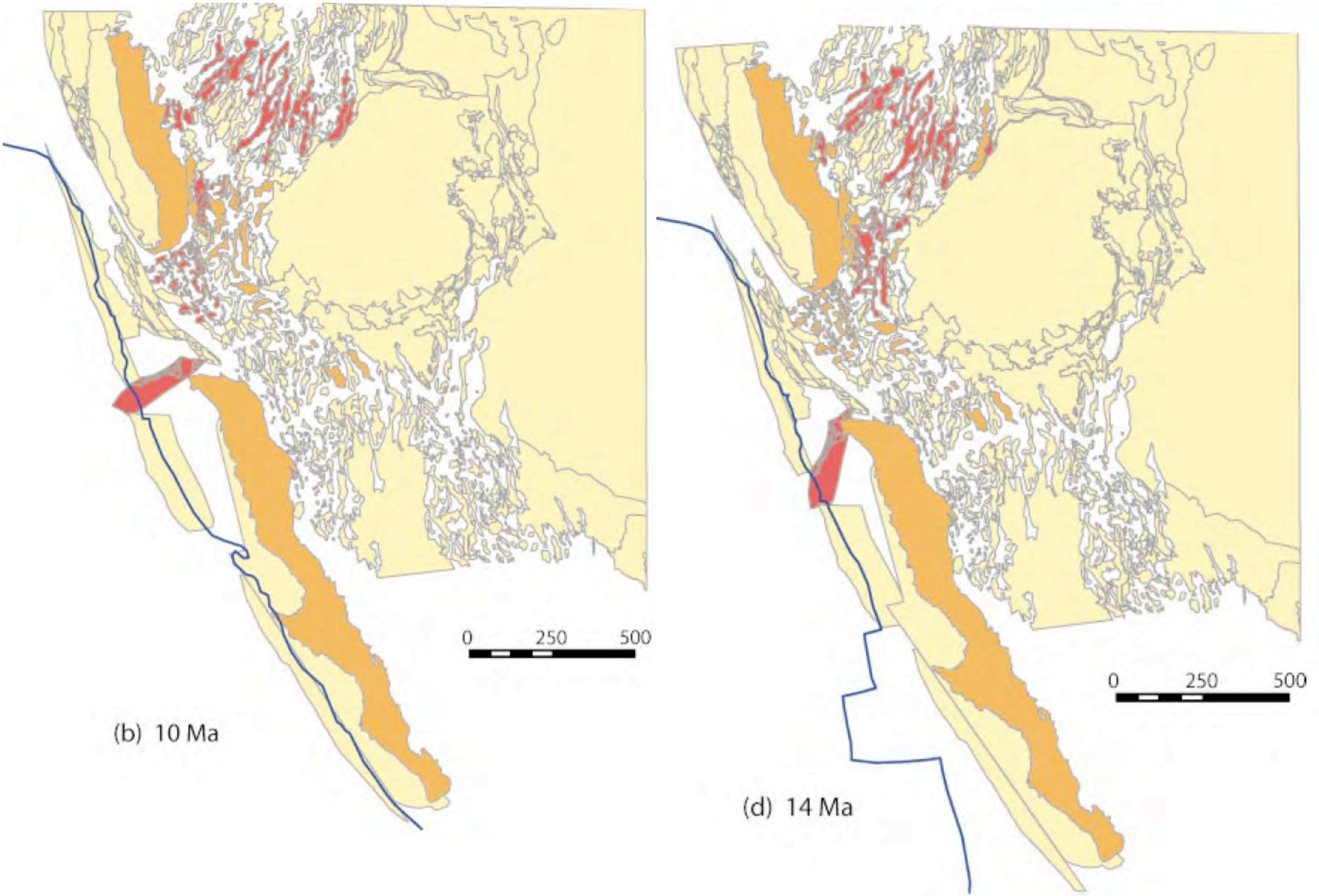
Figure 6. A: First-order constraints for displacement along the San Andreas fault and associated displacements to the west. Arrows indicate approximate magnitude and direction of individual relative displacements between polygons. Black numbers indicate horizontal displacement amount, bold red numbers indicate age range of displacement. Stippled areas labeled EPG show distribution of Eocene Poway Group and equivalents.



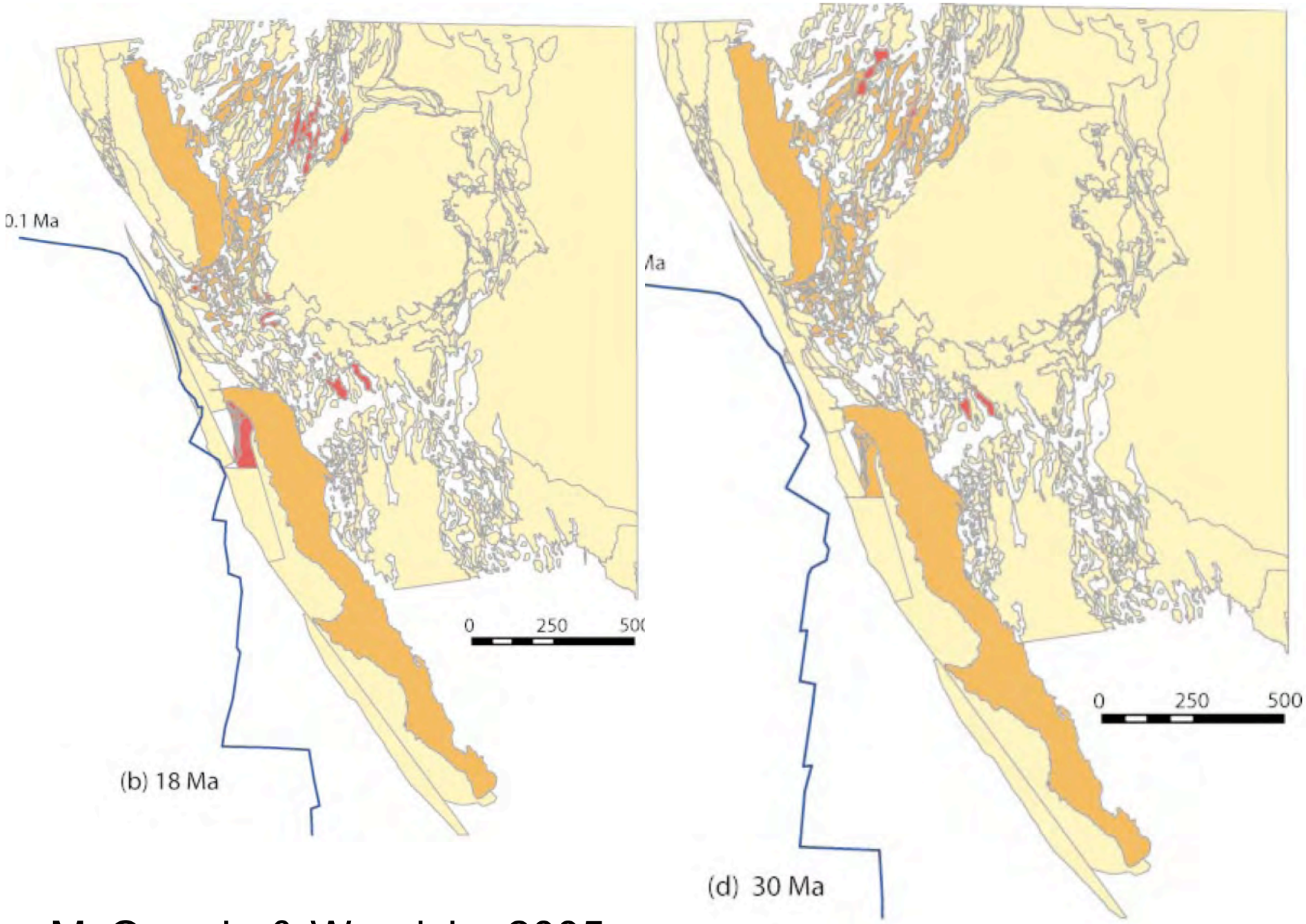
McQuarrie & Wernicke 2005



McQuarrie & Wernicke 2005



McQuarrie & Wernicke 2005



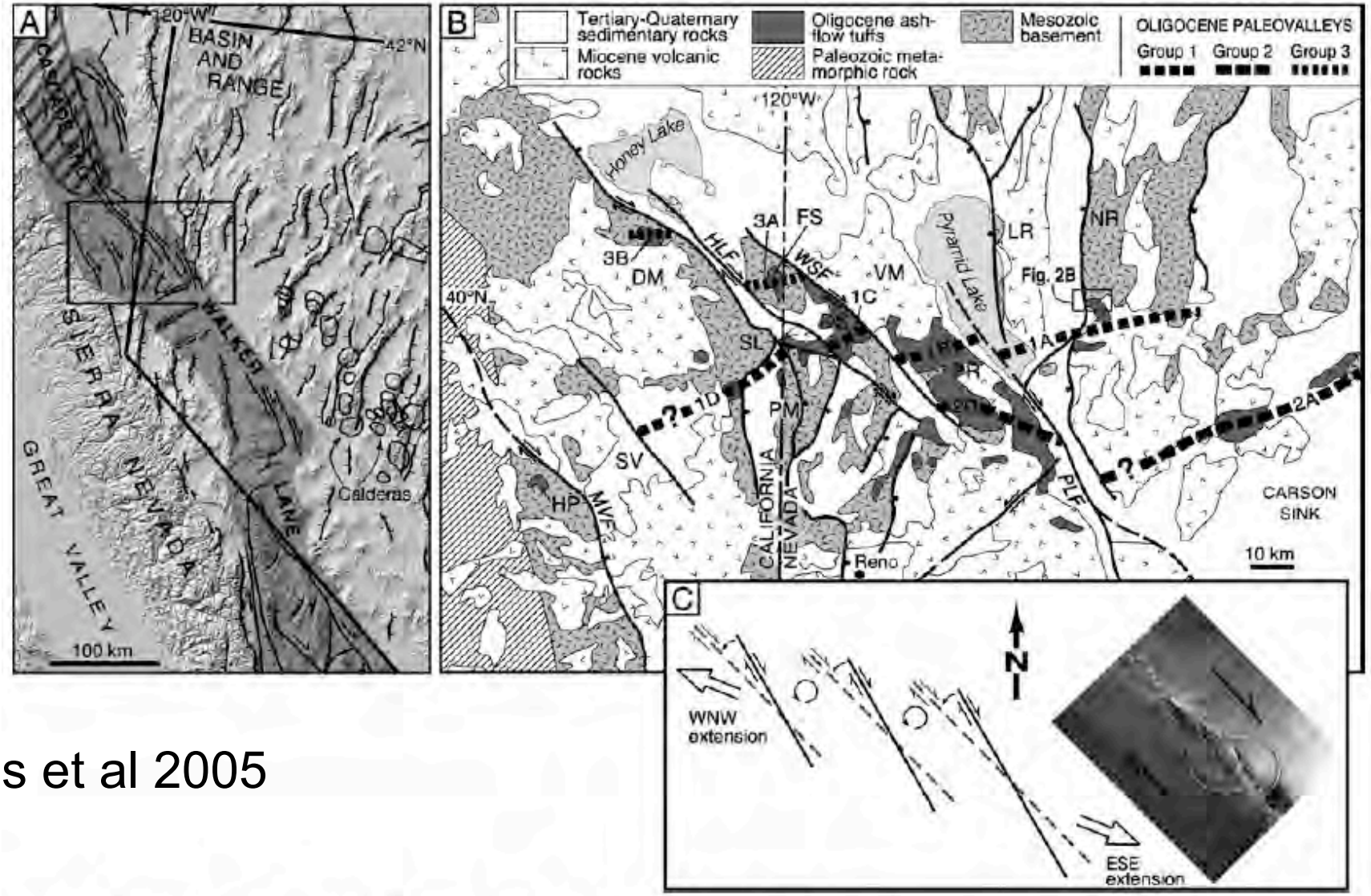
McQuarrie & Wernicke 2005

But wait: there is more

Walker Lane:

The future trace of the San Andreas Fault?

Will Reno really become a seaside community?



Faulds et al 2005

Figure 3. A: Walker Lane in relation to Sierra Nevada and western Great Basin. Box surrounds study area. Strike-slip fault system is progressively better organized to southeast, concomitant with increasing dextral displacement. B: Northern Walker Lane showing left-stepping, NW-striking dextral faults and offset paleovalley axes. Paleovalleys are grouped into three sets. Individual segments in each set are inferred to represent originally continuous paleovalley. DM—Diamond Mountains; DS—Dogskin Mountain; FS—Fort Sage Mountains; HLF—Honey Lake fault; HP—Haskell Peak; LR—Lake Range; MVF—Mohawk Valley fault; NR—Nightingale Range; PLF—Pyramid Lake fault; PM—Peterson Mountain; PR—Pah Rah Range; SL—Seven Lakes Mountain; SV—Sierra Valley; VM—Virginia Mountains; WSF—Warm Springs Valley fault. C: Riedel shear model for northern Walker Lane and analogous clay model from Wilcox et al. (1973). Coeval northwest-directed dextral shear and west-northwest extension may account for slight counterclockwise rotation of fault blocks that collapse in domino-like fashion to accommodate extension.

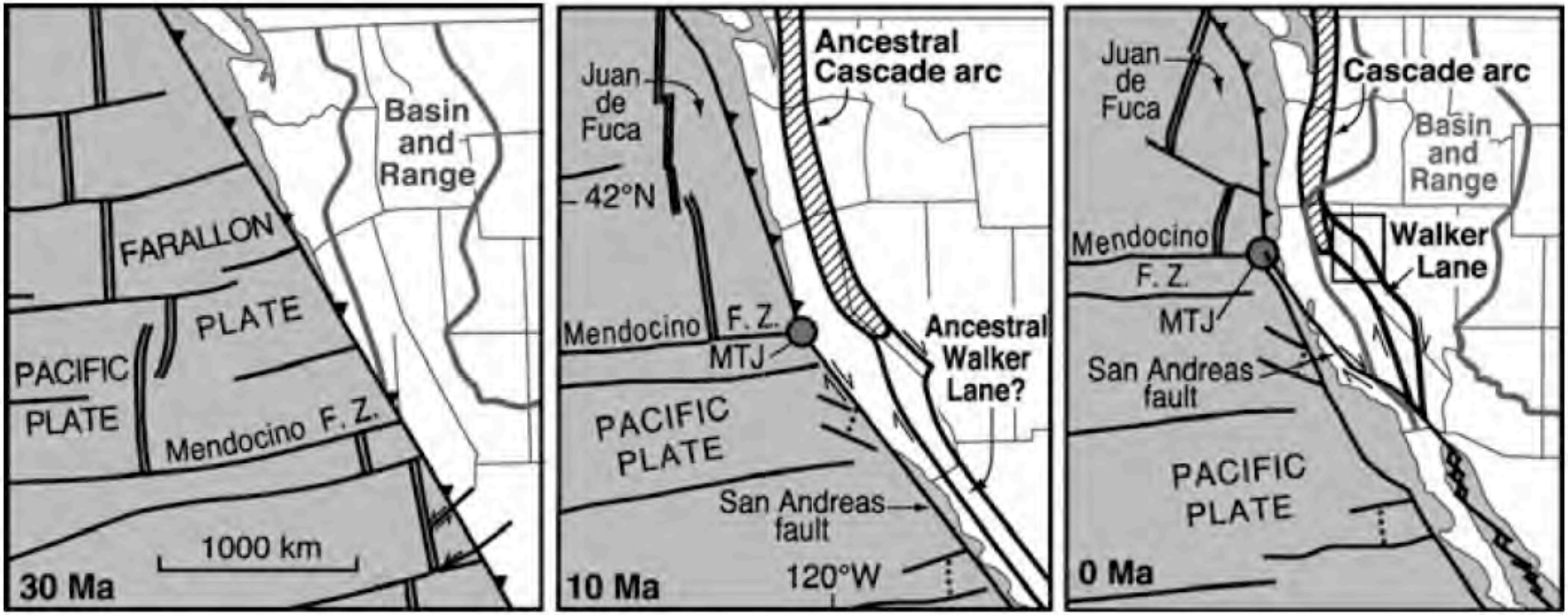


Figure 1. Cenozoic tectonic setting, western North America (after Atwater and Stock, 1998). San Andreas fault system has progressively lengthened in past 30 m.y., as more of Pacific plate has come into contact with North America. MTJ—Mendocino triple junction; F.Z.—fracture zone. In map on right, box surrounds study area.

Faulds et al 2005