Reconstructing the Northern Gulf of California-Salton Trough Oblique Rift

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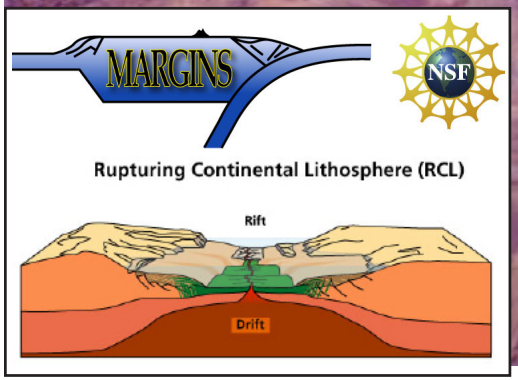
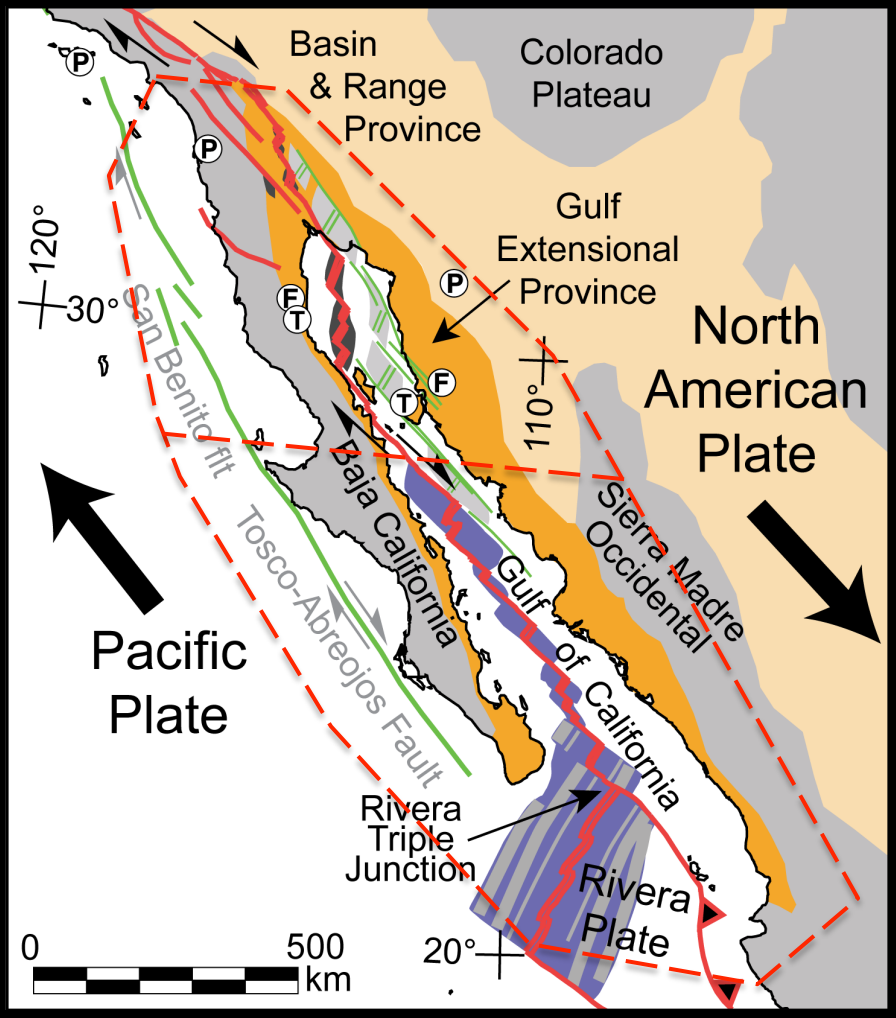


Paper 3 - 8
GSA Cordilleran Section Meeting
Queretaro, Mexico
April 29, 2012

UCDAVIS
DEPARTMENT OF GEOLOGY

Gulf of California-Salton Trough Reconstruction



Oskin & Stock (2003), Arregón-Arreola & Martín-Barajas (2007), Fletcher et al. (2007)

GOALS

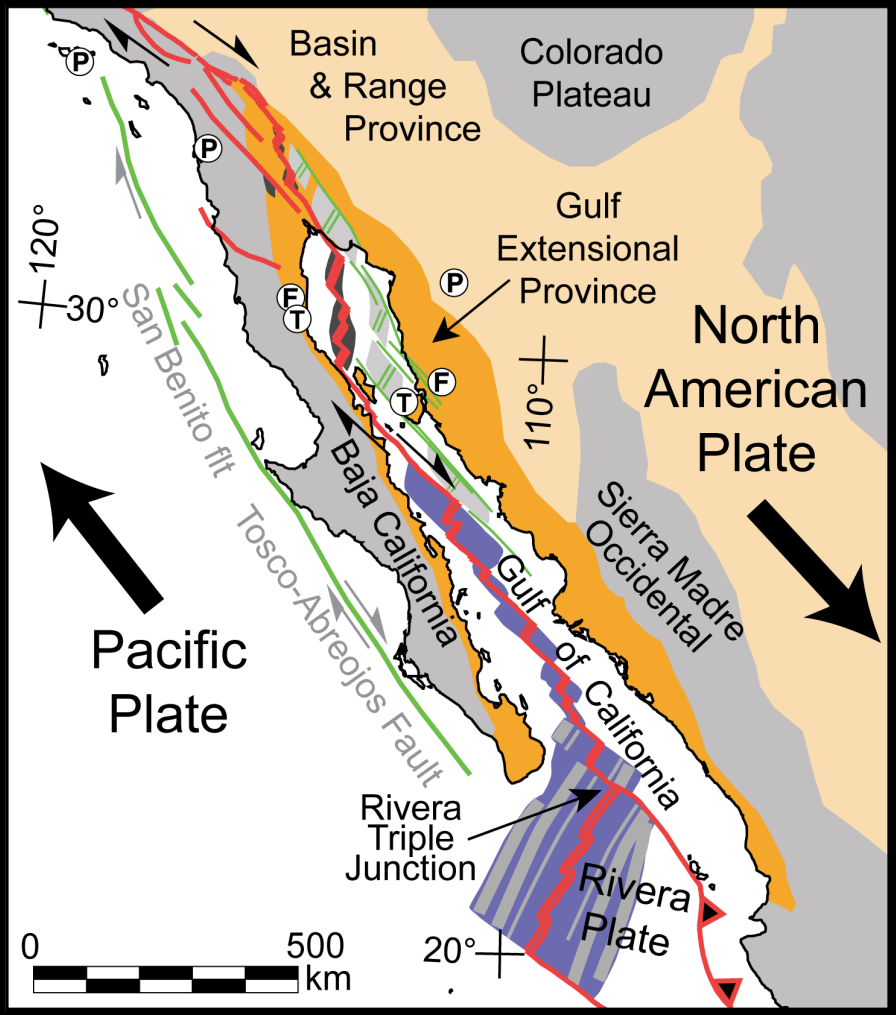
- MARGINS integrative/synthesis activity
- Summarize current state of knowledge for MARGINS focus site
- highlight recent advances in understanding in 4-D strain evolution
- highlight unresolved controversies
- visual tool for Earth Science educators

METHODS

- GIS-based
- 0 - 2 Ma (every 1 myr)
- 2 - 16 Ma (every 2 myr)

See Skinner et al. poster for Southern Gulf Reconstruction
Paper 10 - 1, Booth # 38 (This Afternoon)

Gulf of California-Salton Trough Reconstruction

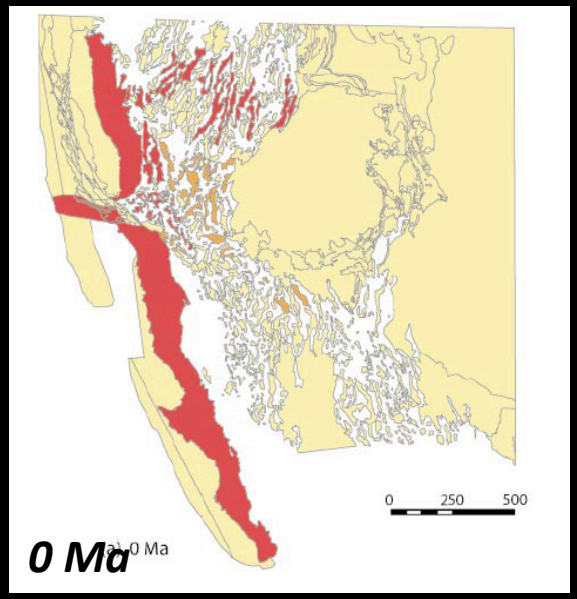


Oskin & Stock (2003), Arregón-Arreola & Martín-Barajas (2007), Fletcher et al. (2007)

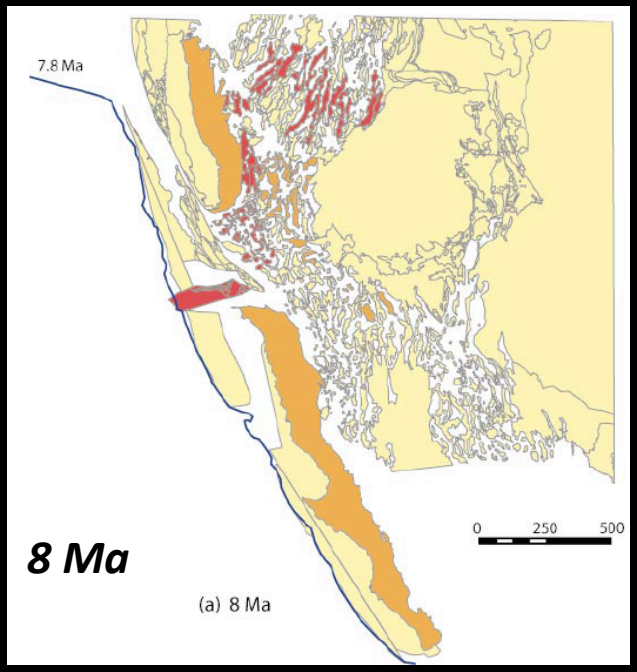
DATA CONSTRAINTS

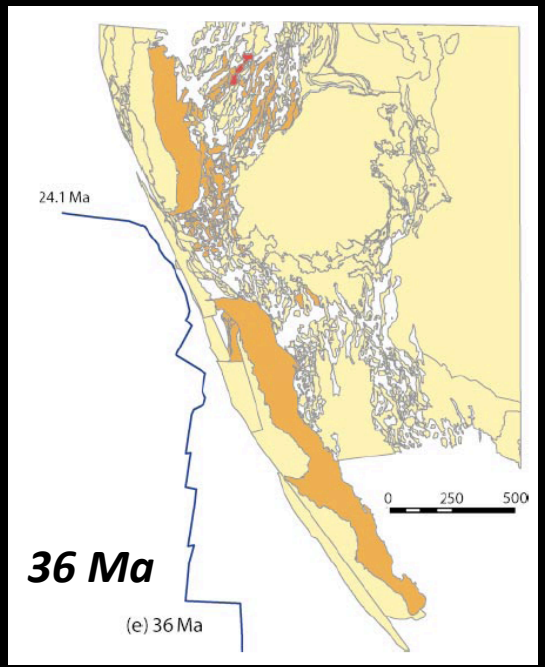
- location of major shear zones and extensional basins
- plate boundary studies
  - e.g. Atwater & Stock (1998), DeMets (1995)
- geodetic studies
  - e.g. Plattner et al. (2007)
- cross-Gulf tie points
  - e.g. [T] Oskin et al. (2001)
    - [F] Bryant (1986) and Gastil & Krummenacher (1977)
    - [P] Poway conglomerate outcrops in NW Sonora and SoCal
- Since ~6.1 Ma, >90% of PAC-NAM motion in GOC
  - similar to modern-day GPS budget
- detailed geologic studies
  - e.g. Bennett (2009), Seiler et al. (2010), many others
- Westward Migration of deformation
  - e.g. Aragon-Arreola & Martin-Barajas (2007), Bennett et al. (submitted, GSABull)

Previous Reconstructions



McQuarrie & Wernicke (2005)





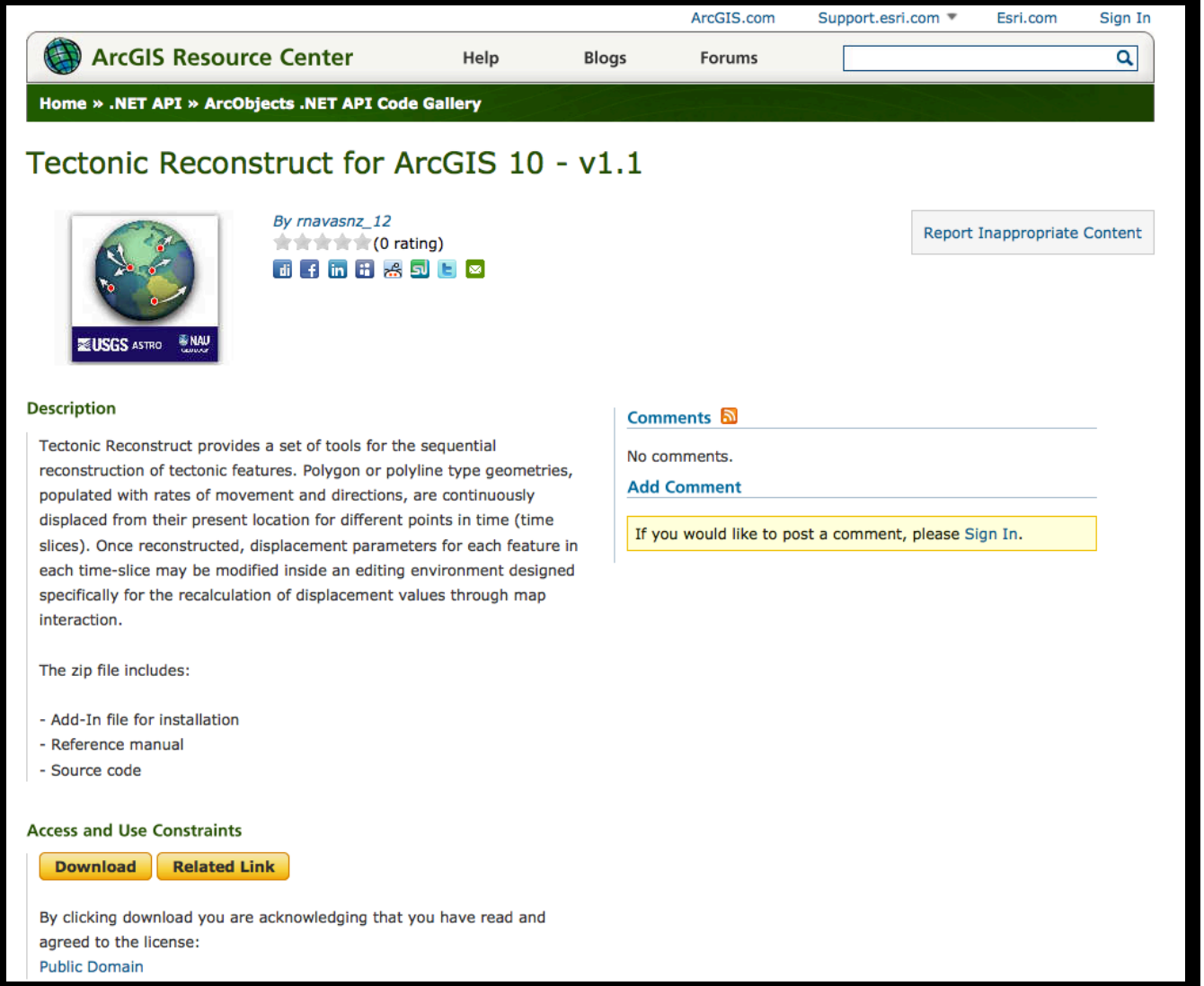
GIS Reconstruction Tool

"Tectonic Reconstruct" by Richard Nava (USGS)

GIS v10

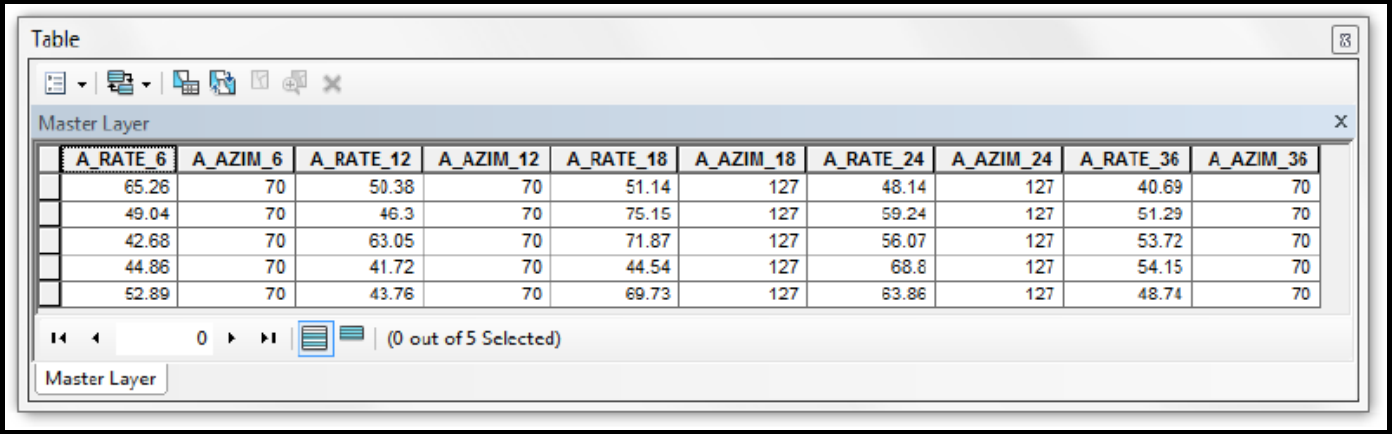
Install Add-In File

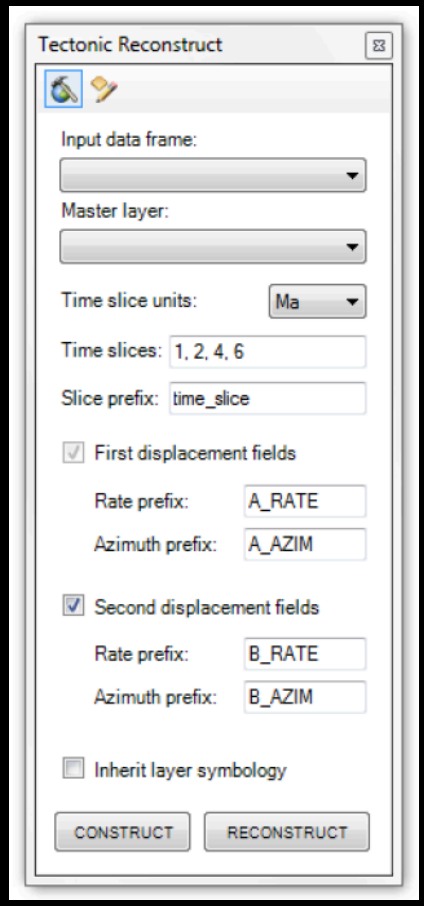
<u>Excellent</u> Reference Manual



GIS Reconstruction Tool

"Tectonic Reconstruct" v1.1





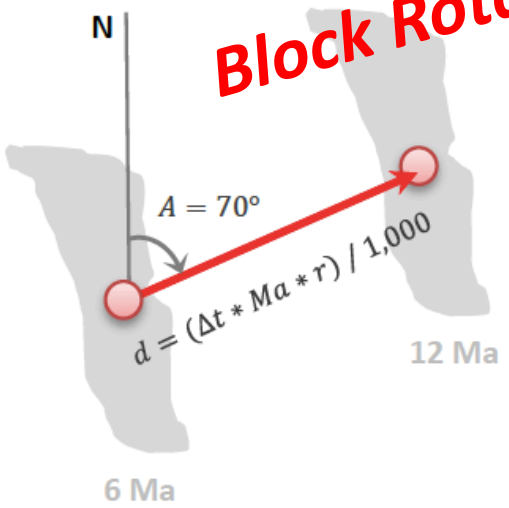
GIS Reconstruction Tool

"Tectonic Reconstruct" v1.1

Master Layer

A_RATE_6	A_AZIM_6	A_RATE_12	A_AZIM_12	A_RATE_18	A_AZIM_18	A_RATE_24	A_AZIM_24	A_F
65.26	70	50.38	70	51.14	127	48.14	127	
49.04	70	46.3	70	75.15	127	59.14	127	
42.68	70	63.05	70	71.87	127	67.7	127	

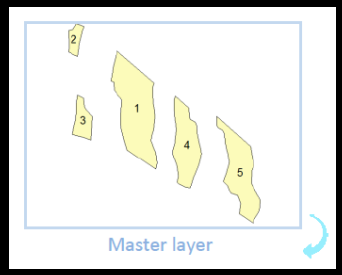
Block Rotation Coming Soon!

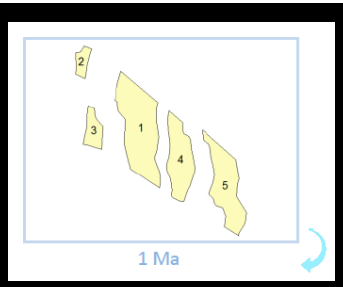


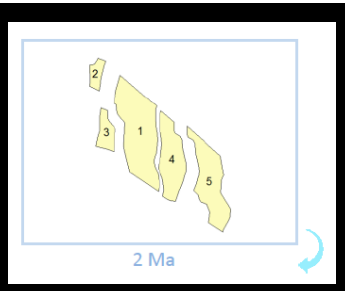
Feature centroid

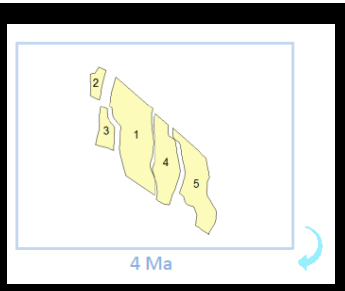
Displacement vector

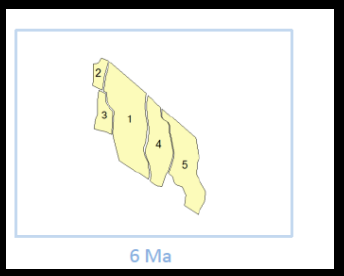
$\Delta t = slice - prev\ slice = 12 - 6 = 6\ Ma$
$r = 50.38\ mm/a$
$Ma = 1{,}000{,}000\ a$
$d = (\Delta t * Ma * r) / 1{,}000$
$\boldsymbol{d = (6 * 1{,}000{,}000 * 50.38) / 1{,}000 = 30{,}228\ m}$



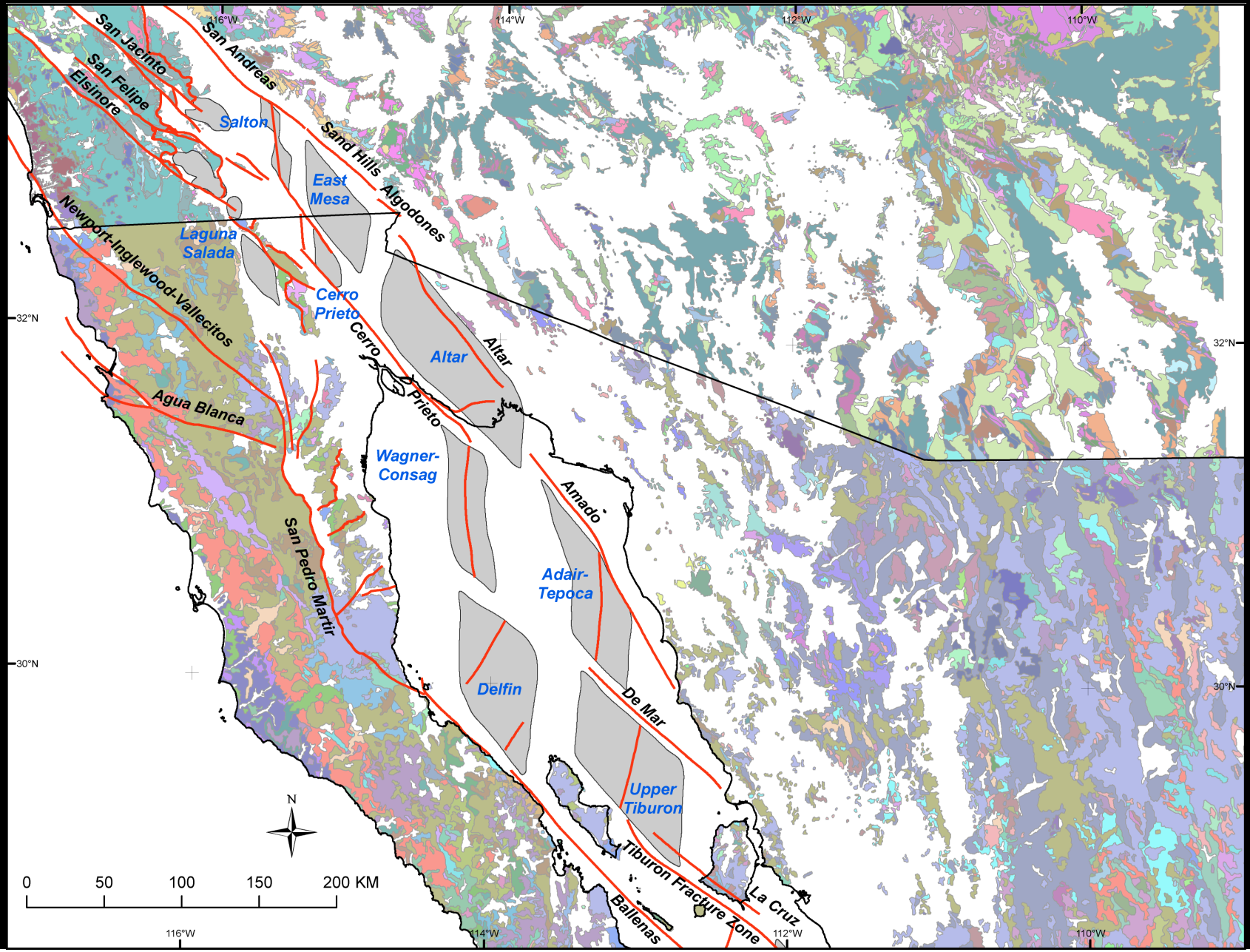




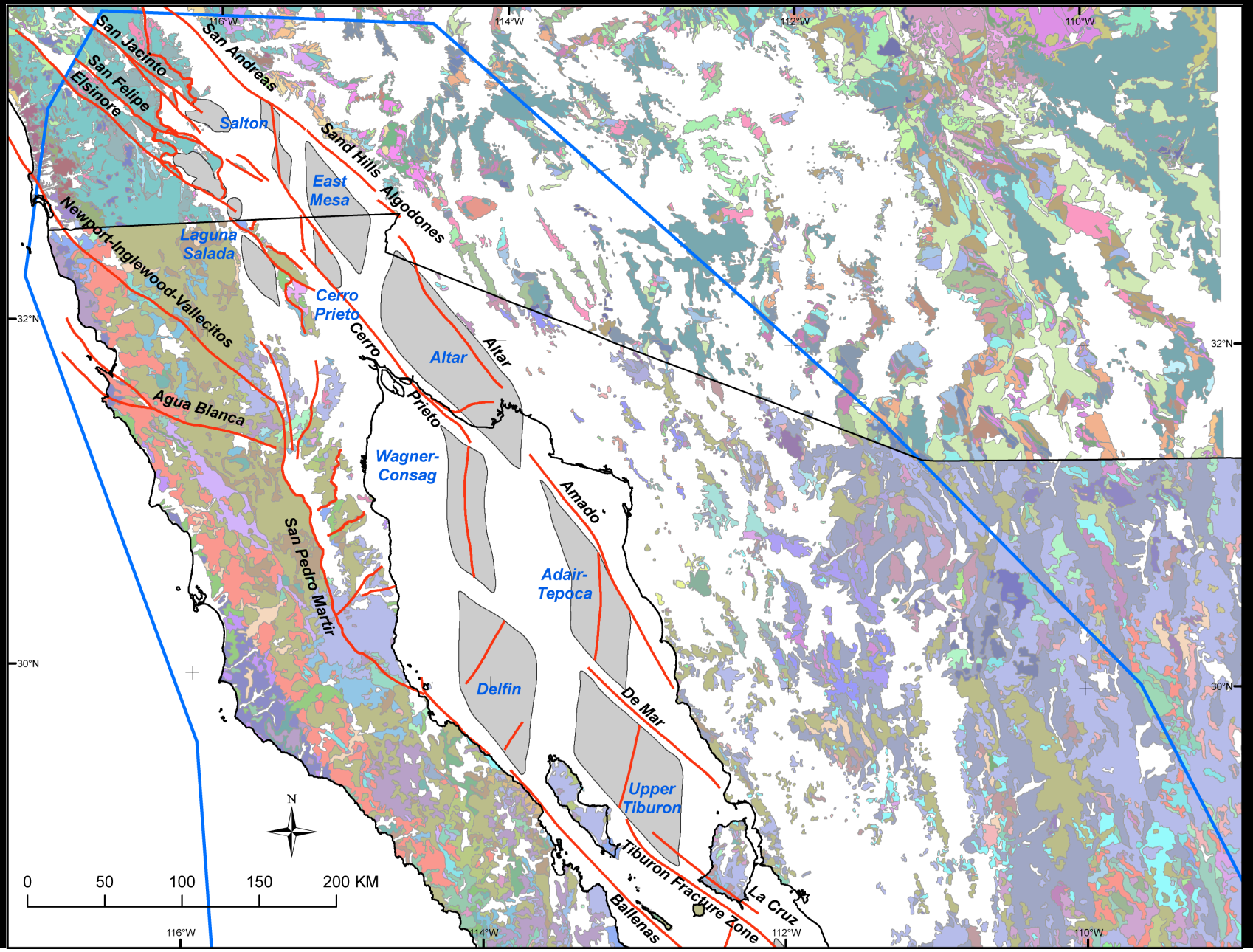




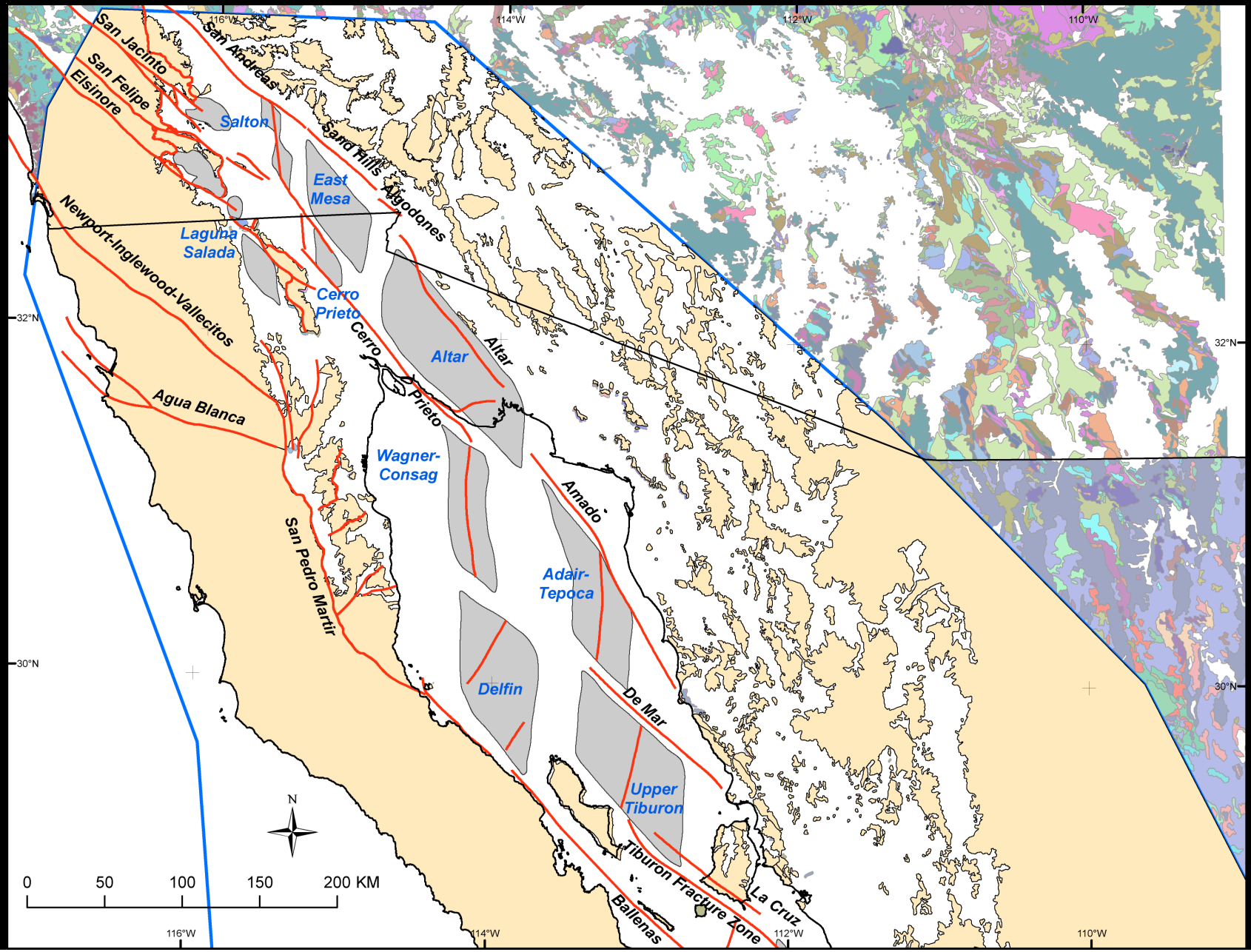
Present-Day Geology



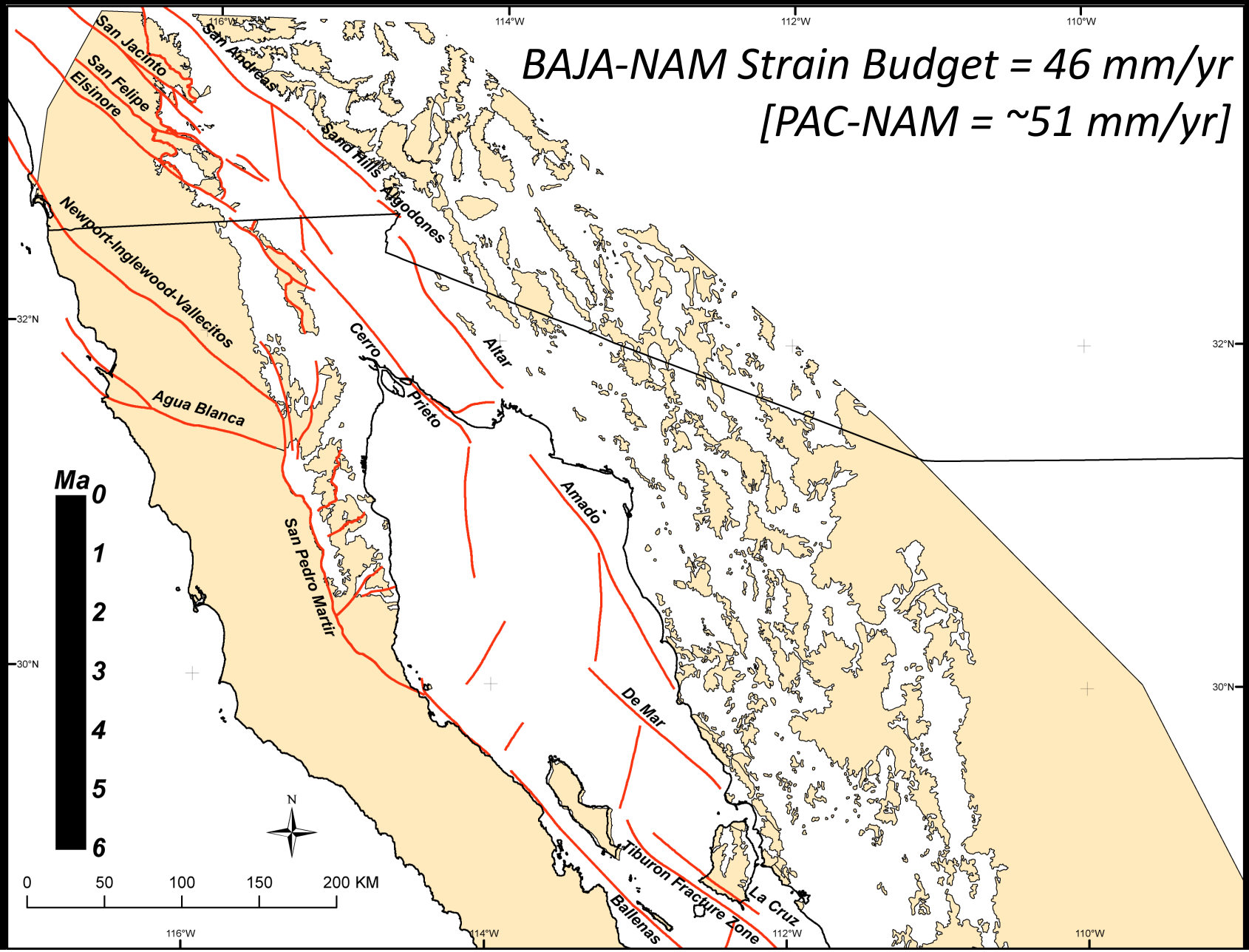
Present-Day Geology



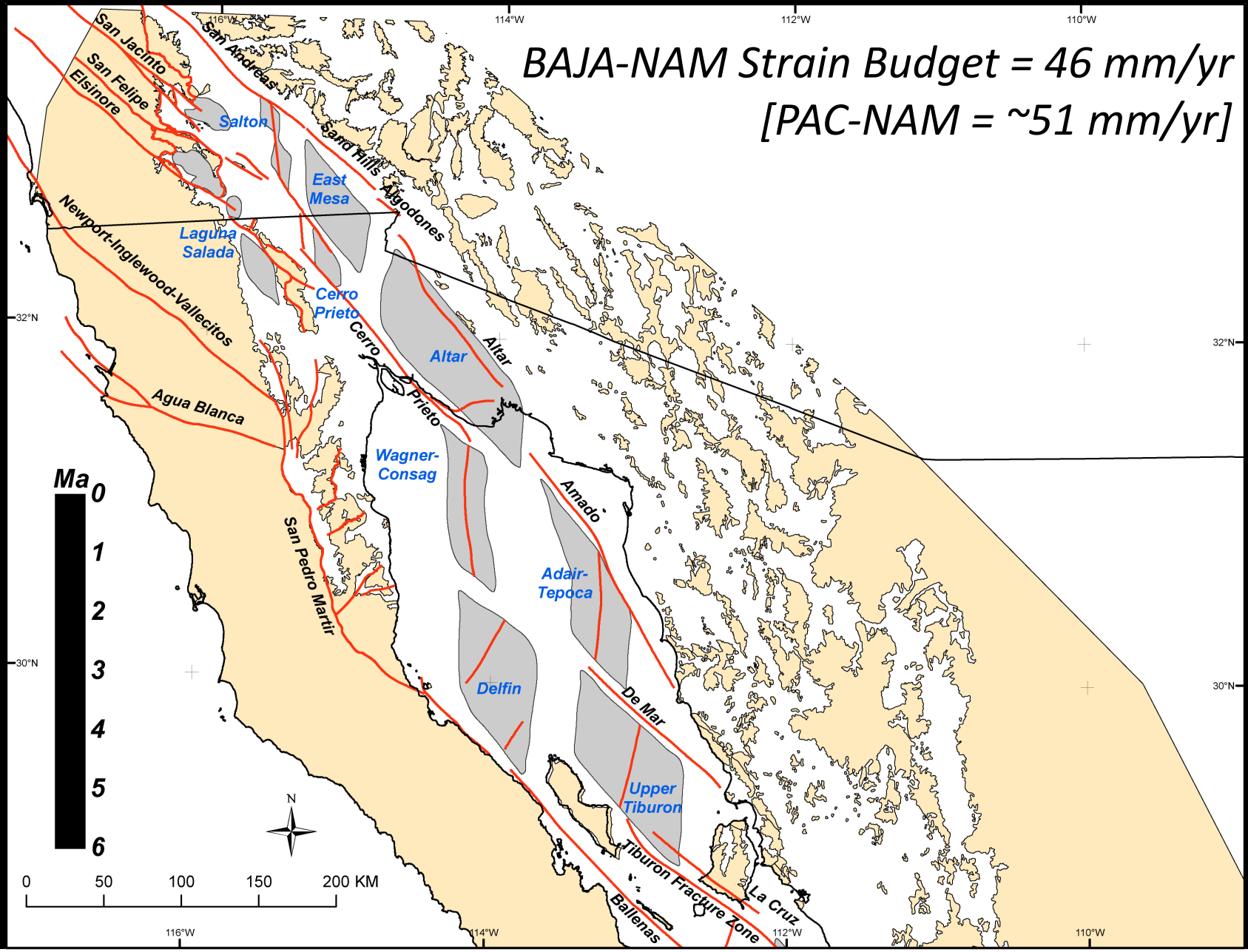
Present-Day Geology



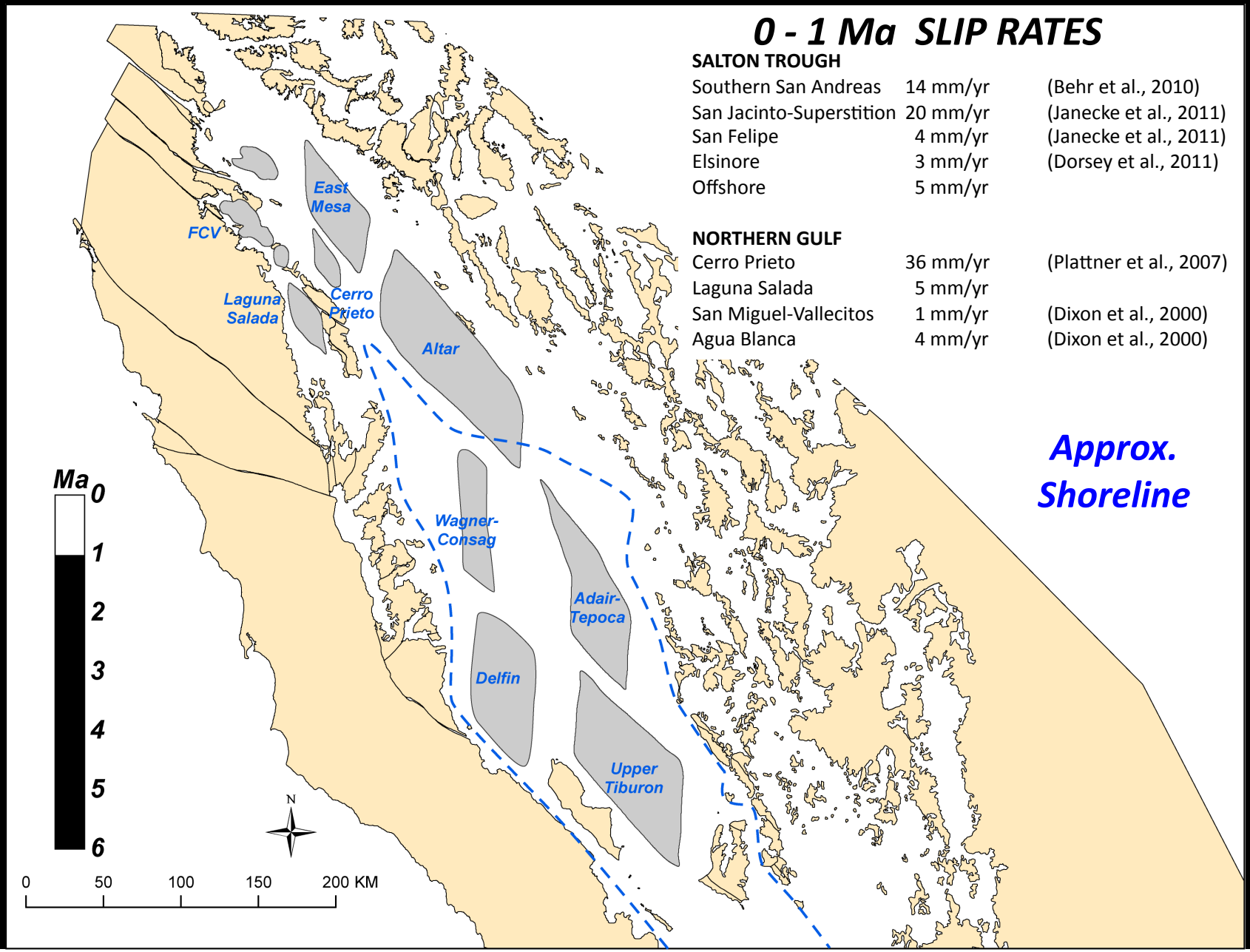
Present-Day Geology



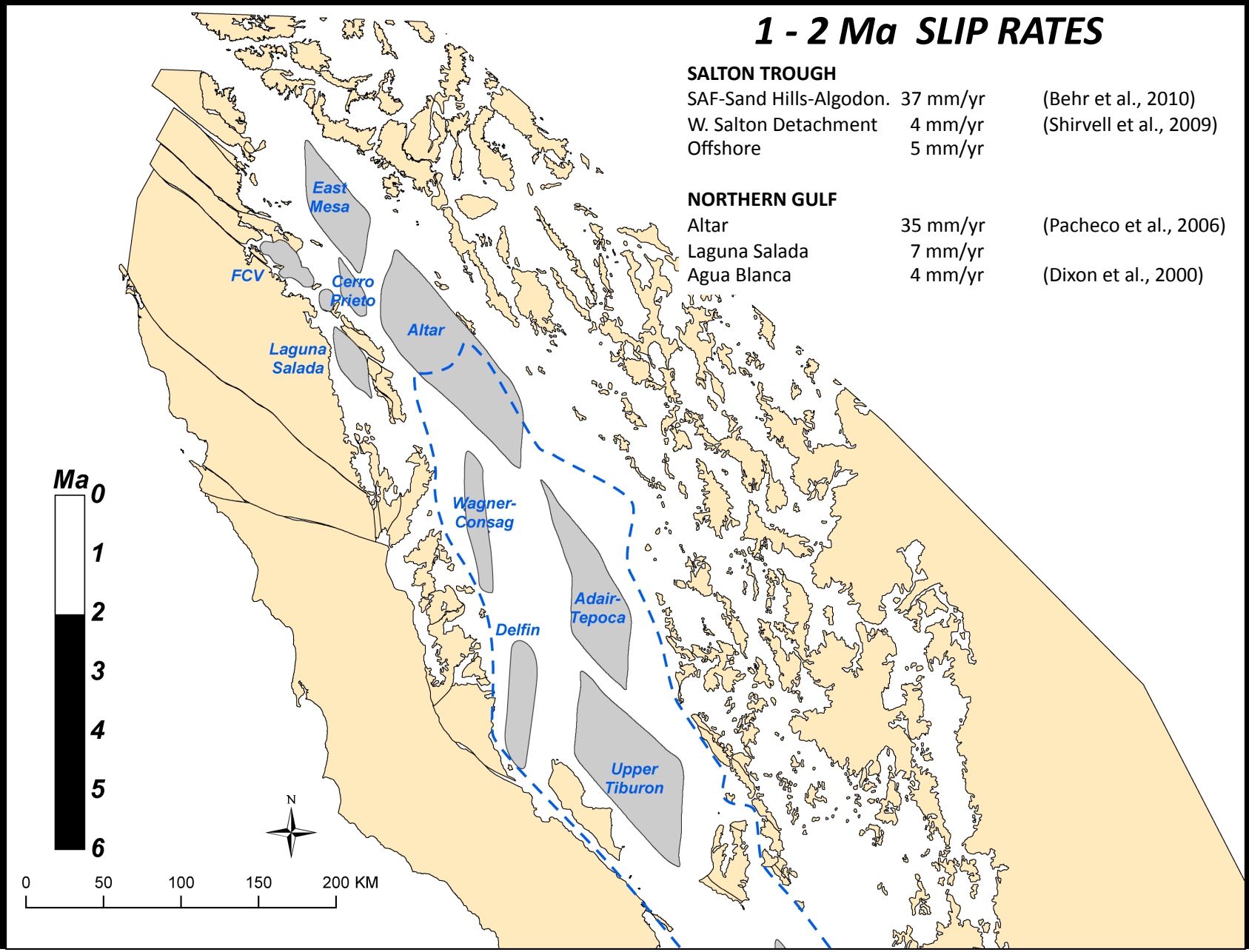
Present-Day Geology



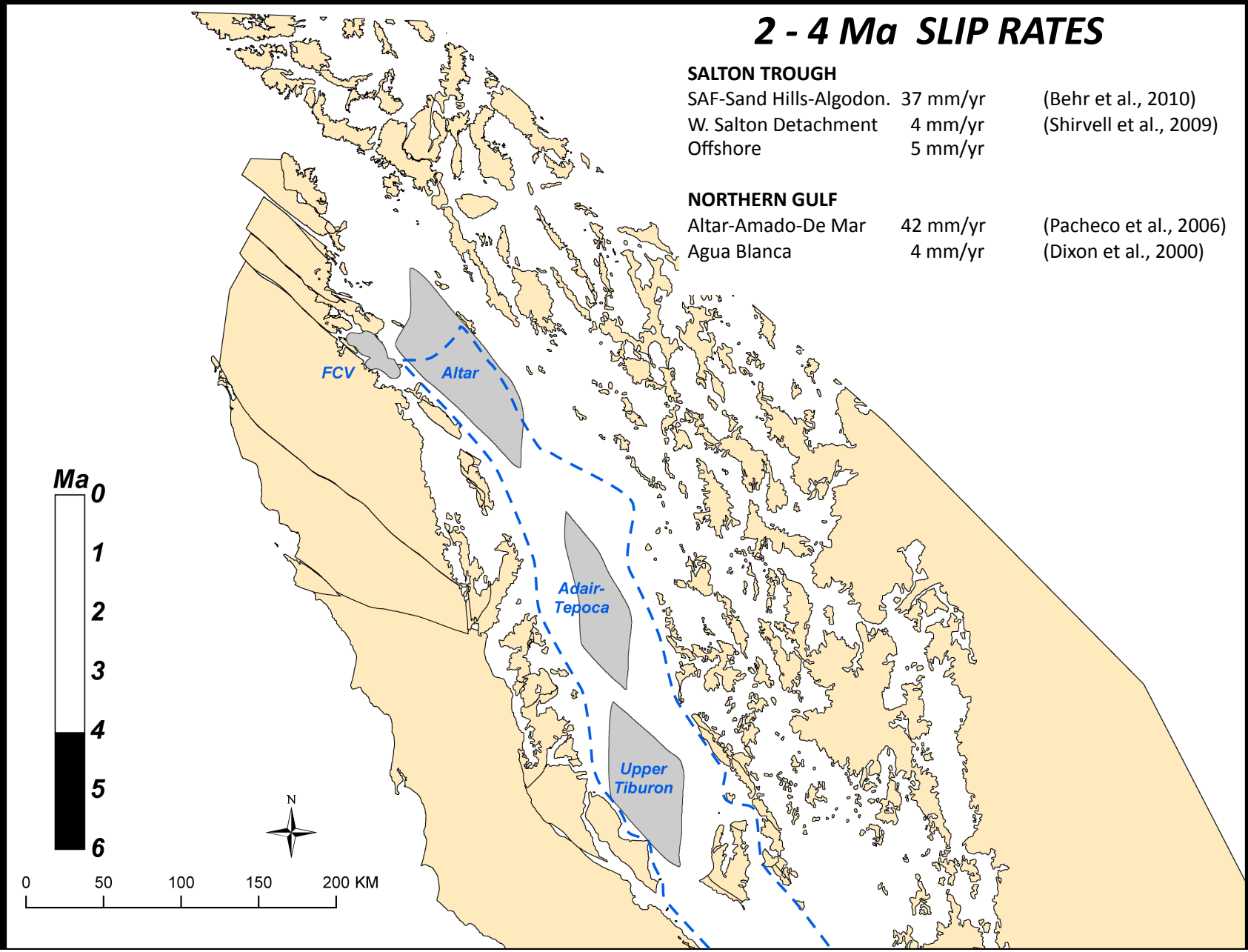
1 Ma


0 - 1 Ma SLIP RATES
SALTON TROUGH
Southern San Andreas 14 mm/yr (Behr et al., 2010)
San Jacinto-Superstition 20 mm/yr (Janecke et al., 2011)
San Felipe 4 mm/yr (Janecke et al., 2011)
Elsinore 3 mm/yr (Dorsey et al., 2011)
Offshore 5 mm/yr
NORTHERN GULF
Cerro Prieto 36 mm/yr (Plattner et al., 2007)
Laguna Salada 5 mm/yr
San Miguel-Vallecitos 1 mm/yr (Dixon et al., 2000)
Agua Blanca 4 mm/yr (Dixon et al., 2000)
East Mesa
FCV
Laguna Salada
Cerro Prieto
Altar
Wagner-Consag
Adair-Tepoca
Delfin
Upper Tiburon
Approx. Shoreline
Ma
0
1
2
3
4
5
6
N
0 50 100 150 200 KM

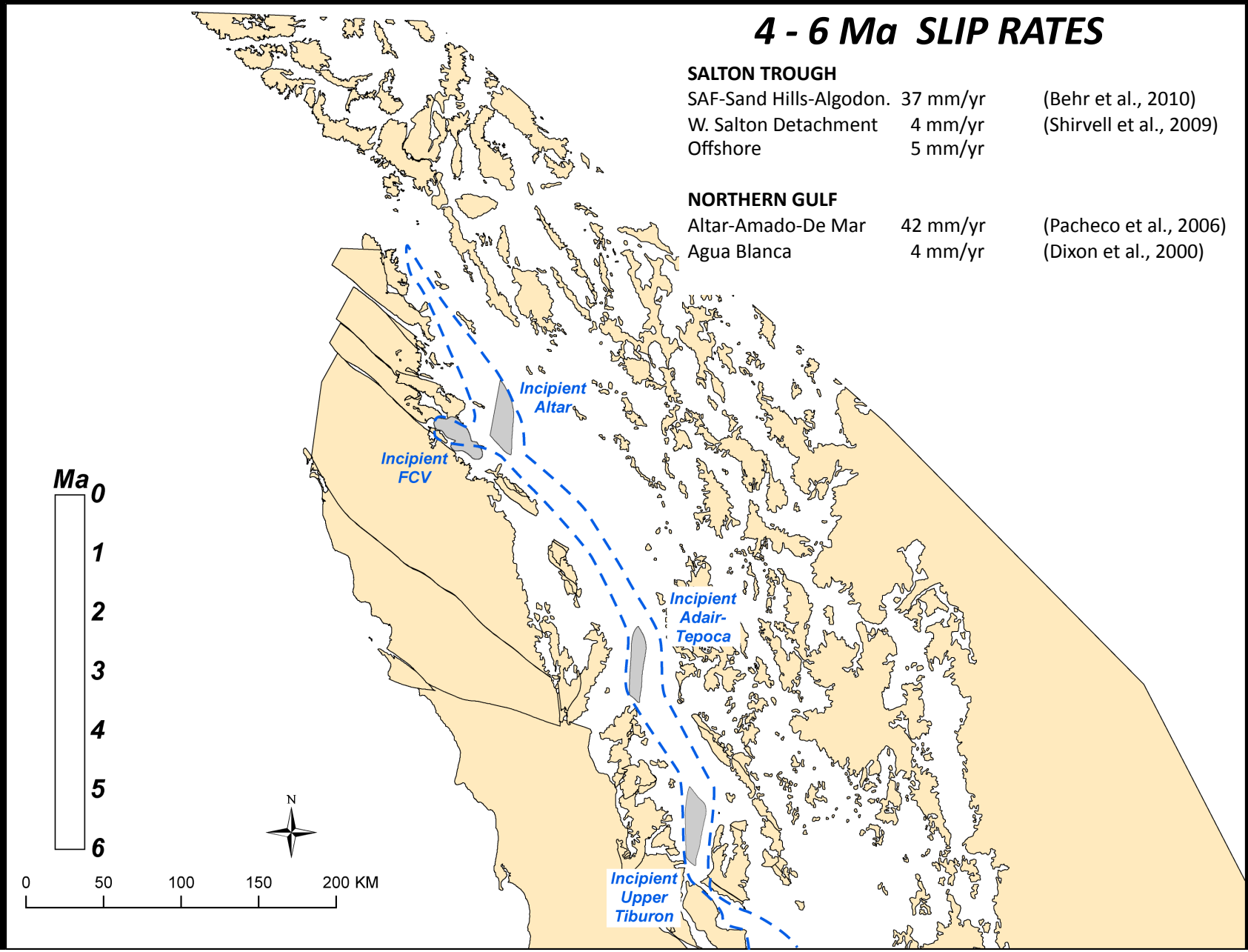
2 Ma


1 - 2 Ma SLIP RATES
SALTON TROUGH
SAF-Sand Hills-Algodon. 37 mm/yr (Behr et al., 2010)
W. Salton Detachment 4 mm/yr (Shirvell et al., 2009)
Offshore 5 mm/yr
NORTHERN GULF
Altar 35 mm/yr (Pacheco et al., 2006)
Laguna Salada 7 mm/yr
Agua Blanca 4 mm/yr (Dixon et al., 2000)
East Mesa
FCV
Cerro Prieto
Altar
Laguna Salada
Wagner-Consag
Delfin
Adair-Tepoca
Upper Tiburon
Ma
0
1
2
3
4
5
6
N
0 50 100 150 200 KM

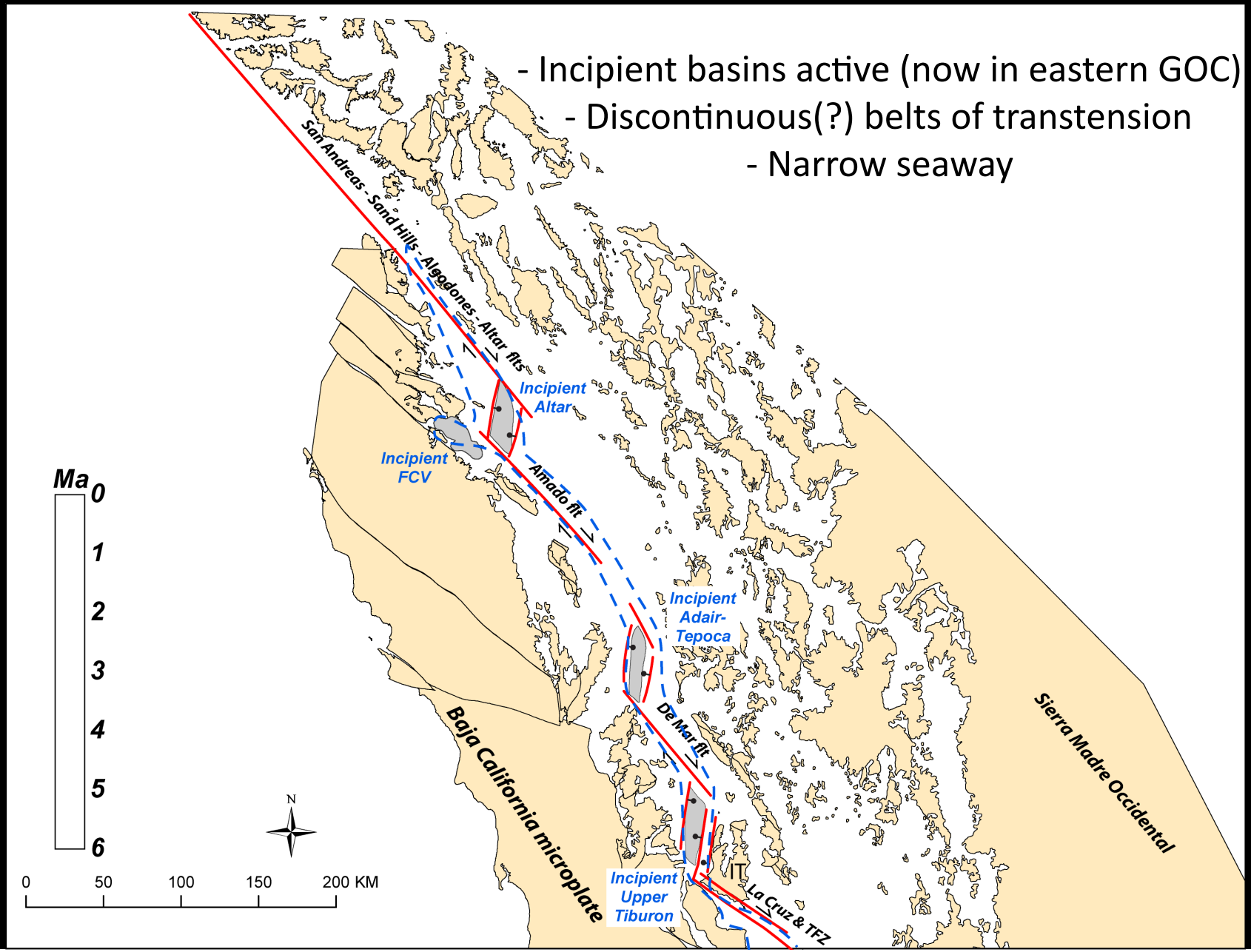
4 Ma


2 - 4 Ma SLIP RATES
SALTON TROUGH
SAF-Sand Hills-Algodon. 37 mm/yr (Behr et al., 2010)
W. Salton Detachment 4 mm/yr (Shirvell et al., 2009)
Offshore 5 mm/yr
NORTHERN GULF
Altar-Amado-De Mar 42 mm/yr (Pacheco et al., 2006)
Agua Blanca 4 mm/yr (Dixon et al., 2000)
FCV
Altar
Adair-Tepoca
Upper Tiburon
Ma
0
1
2
3
4
5
6
N
0 50 100 150 200 KM

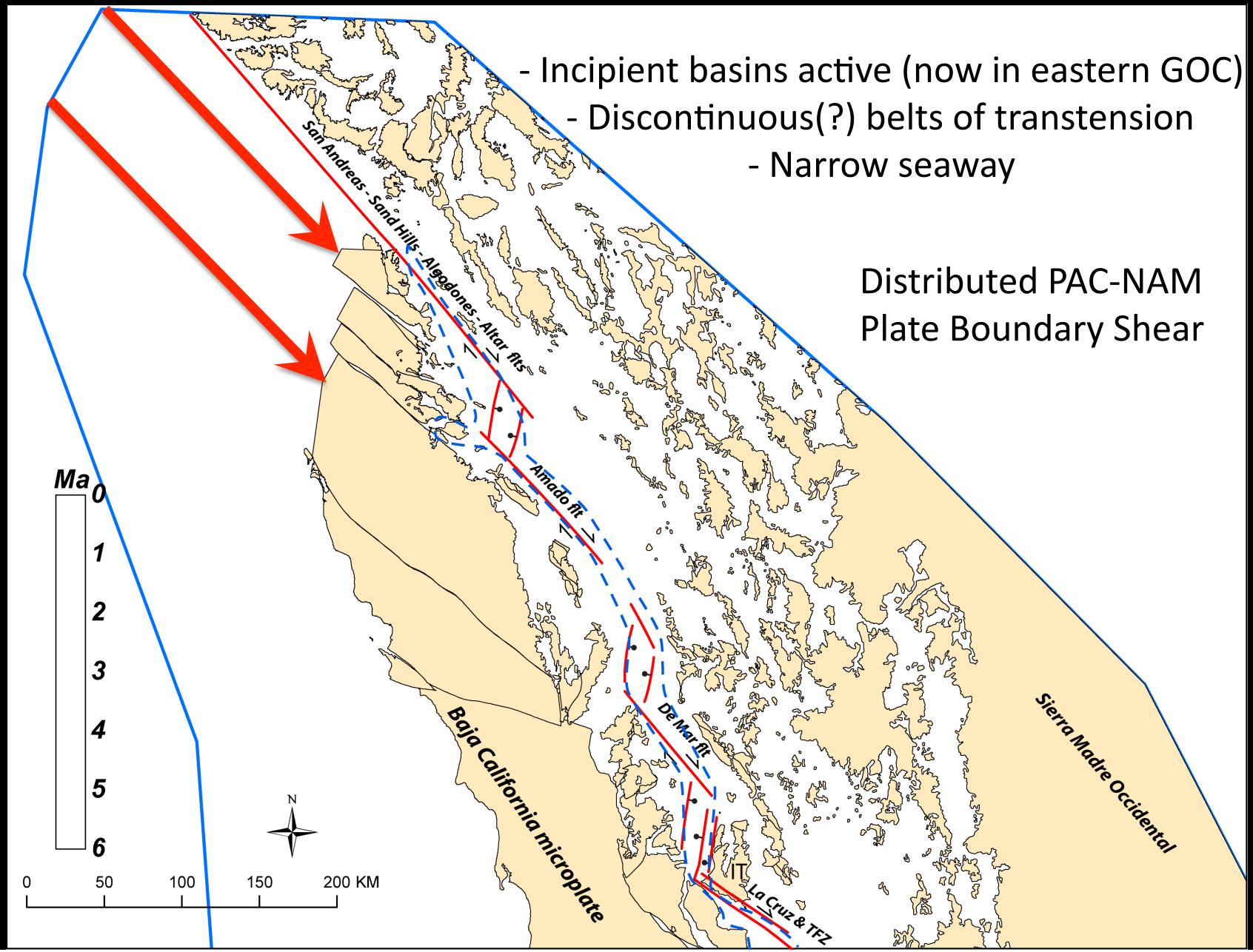
6 Ma


4 - 6 Ma SLIP RATES
SALTON TROUGH
SAF-Sand Hills-Algodon. 37 mm/yr (Behr et al., 2010)
W. Salton Detachment 4 mm/yr (Shirvell et al., 2009)
Offshore 5 mm/yr
NORTHERN GULF
Altar-Amado-De Mar 42 mm/yr (Pacheco et al., 2006)
Agua Blanca 4 mm/yr (Dixon et al., 2000)
Incipient Altar
Incipient FCV
Incipient Adair-Tepoca
Incipient Upper Tiburon
Ma
0
1
2
3
4
5
6
N
0 50 100 150 200 KM

6 Ma


- Incipient basins active (now in eastern GOC)
- Discontinuous(?) belts of transtension
- Narrow seaway
San Andreas - Sand Hills - Algodones - Altar flts
Incipient Altar
Incipient FCV
Amado flt
Incipient Adair-Tepoca
De Mar flt
Incipient Upper Tiburon
La Cruz & TFZ
Baja California microplate
Sierra Madre Occidental
Ma
0
1
2
3
4
5
6
N
0
50
100
150
200 KM

6 Ma


- Incipient basins active (now in eastern GOC)
- Discontinuous(?) belts of transtension
- Narrow seaway
Distributed PAC-NAM
Plate Boundary Shear
San Andreas - Sand Hills - Algodones - Altar flts
Amado flt
De Mar flt
La Cruz & TFZ
IT
Baja California microplate
Sierra Madre Occidental
Ma
0
1
2
3
4
5
6
N
0
50
100
150
200 KM

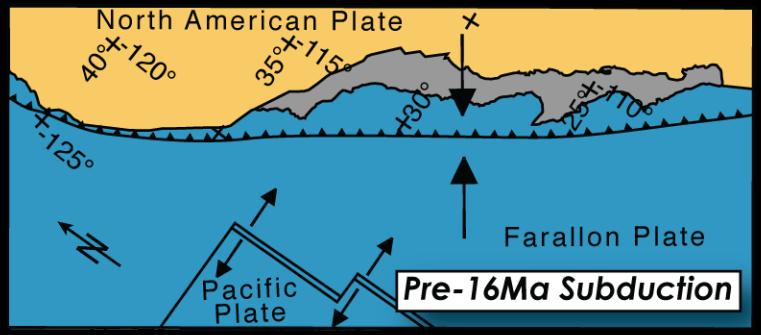
Animation of 0 - 6 Ma Reconstruction

Future Work Plan

- reconstruction steps 8, 10, 12, 14 Ma
  - 2 sets of Proto-Gulf maps
  - deformation is more diffuse
  - fewer geological constraints
- incorporate offshore faults in all model steps
  - e.g. Tosco-Abreojos fault (full 51 mm/yr)
- publish animations and GIS files of model steps
- merge with McQuarrie & Wernicke (2005) animation & GIS files (??)

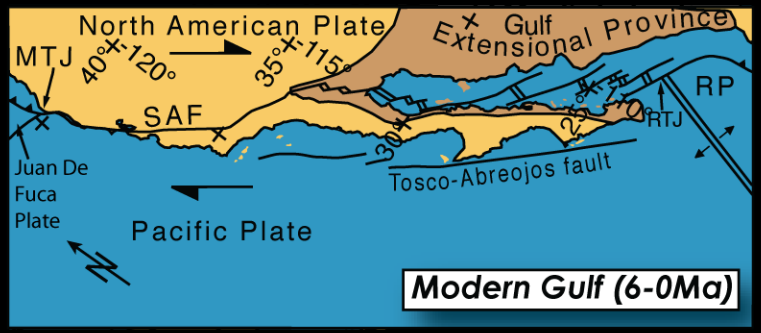
Uncertain Strain Evolution

TIME



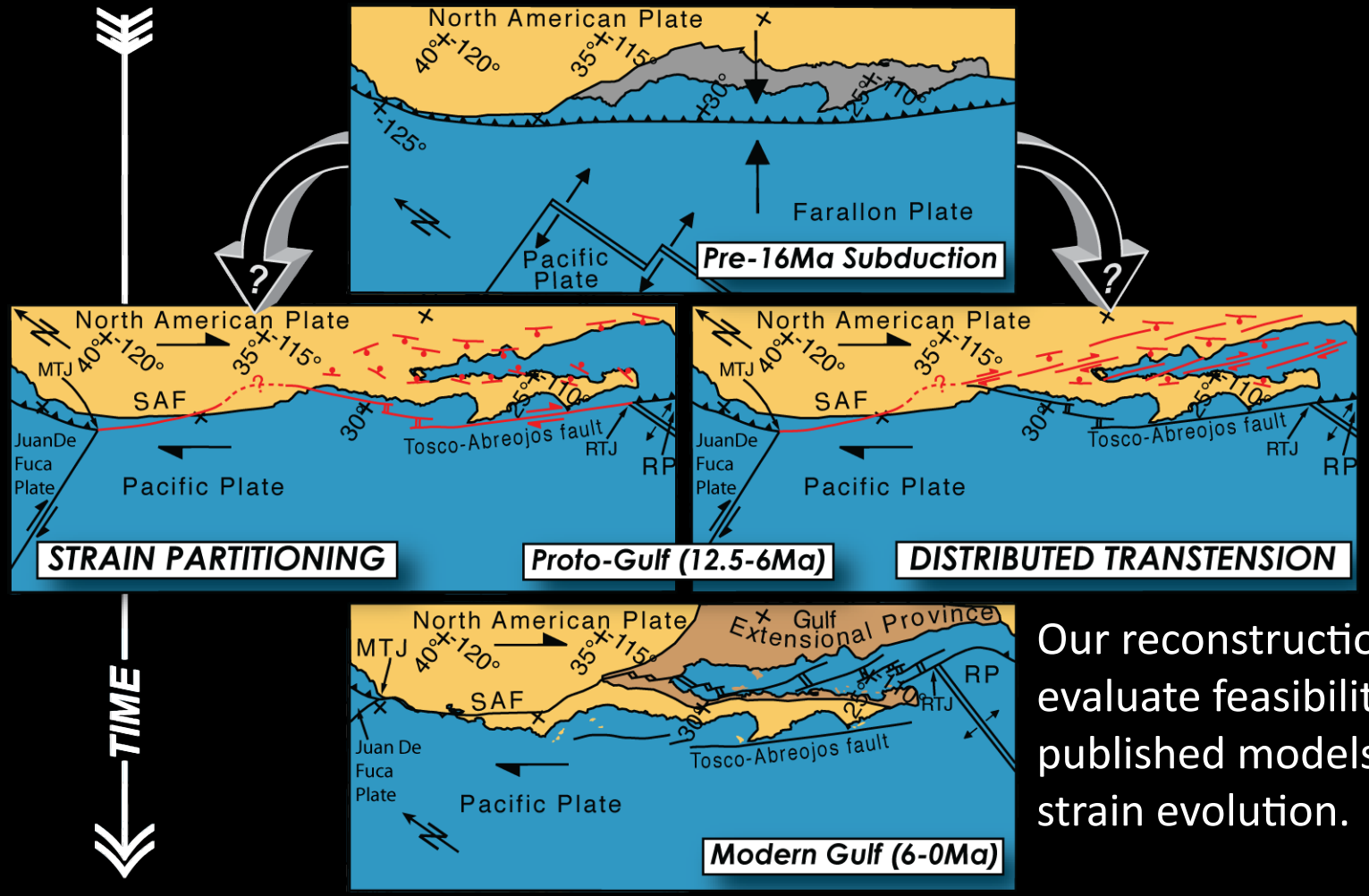
Proto-Gulf ?

(12.5 - 6 Ma)



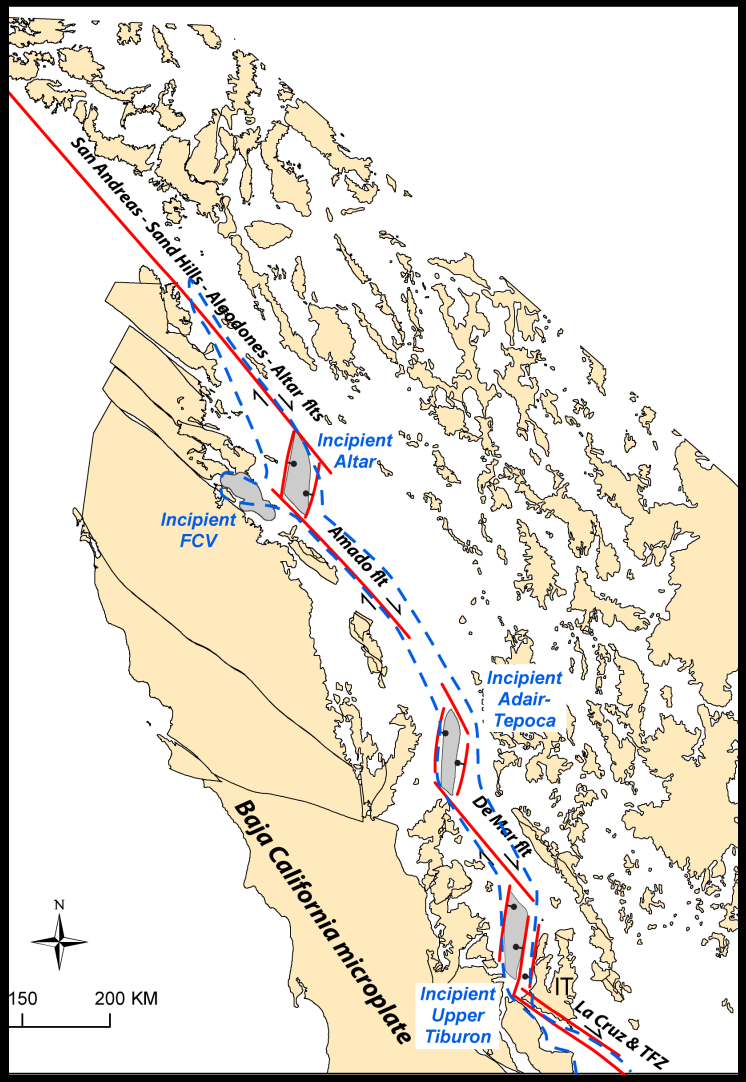
What was the style and distribution of proto-Gulf deformation that preceded plate boundary localization at 6 Ma?

Uncertain Strain Evolution

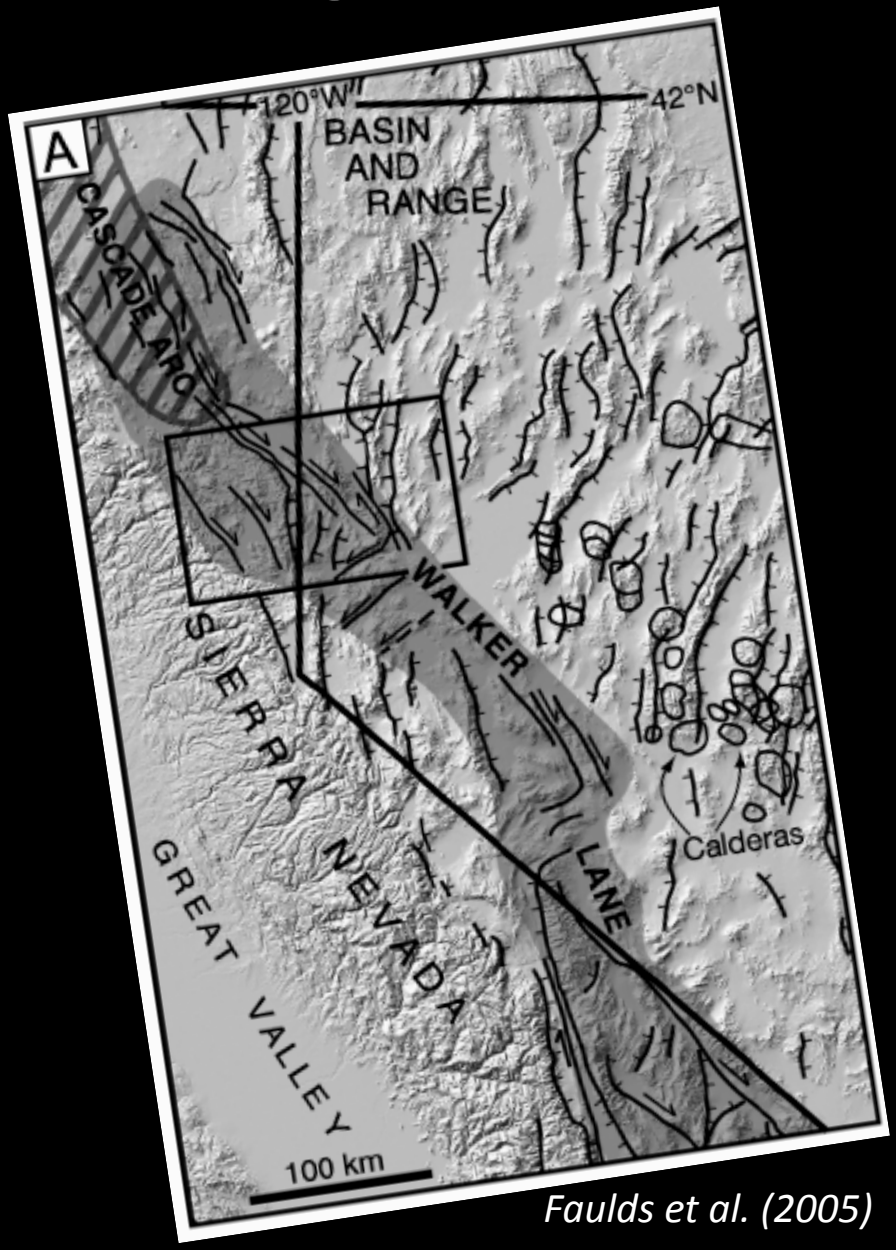


Our reconstruction can evaluate feasibility of published models for strain evolution.

Modern Analog



This Study



Faulds et al. (2005)

ACKNOWLEDGMENTS

- Richard Nava
- Gary Axen
- Southern Gulf Reconstruction Team

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  Lisa Skinner

  Jared Kluesner


Thank you.