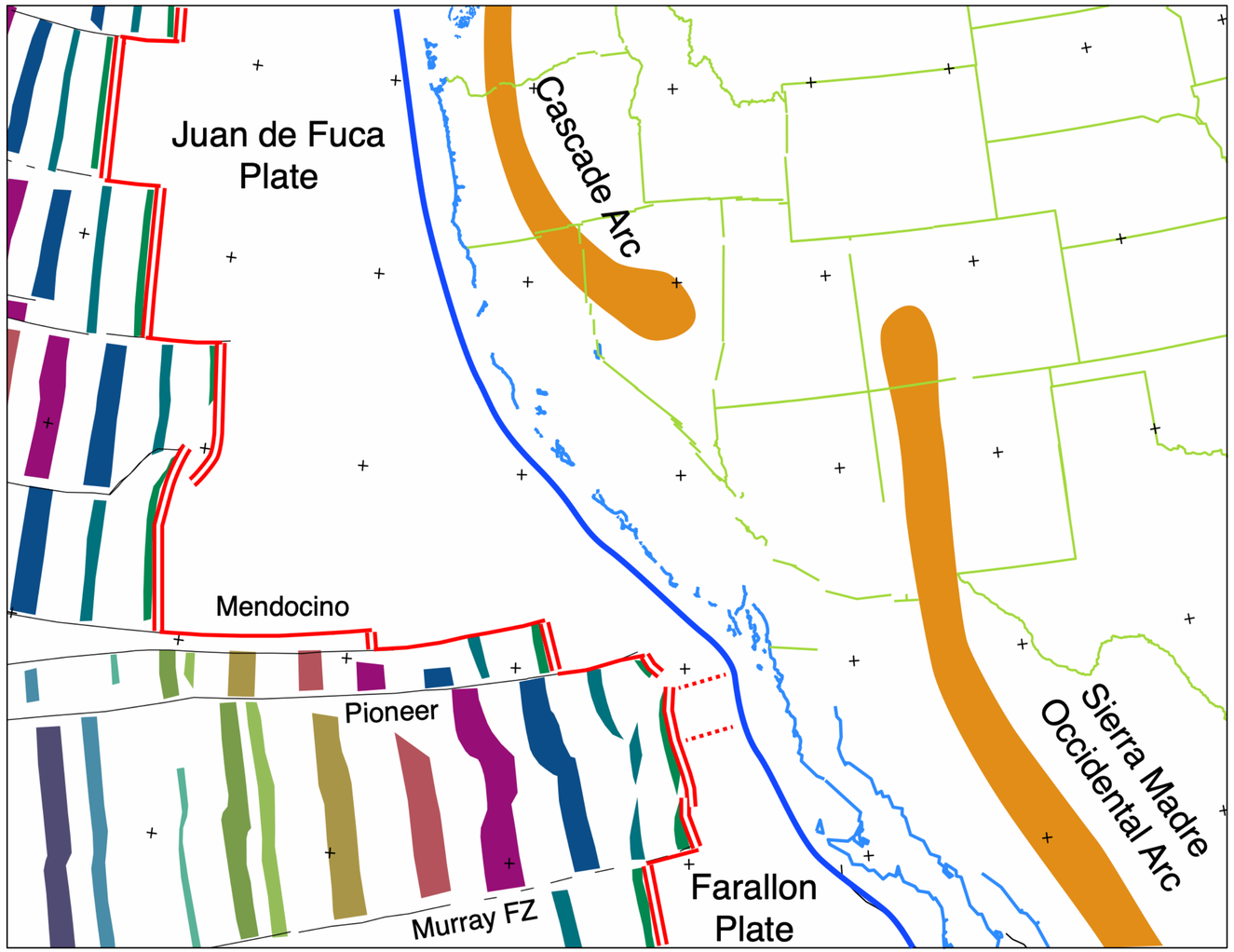
Slab window volcanism and the Pioneer-Mendocino corridor

Implications for the Pioneer Fragment hypothesis

Doug Wilson
Dept. Earth Science, UCSB

30-Ma Reconstruction

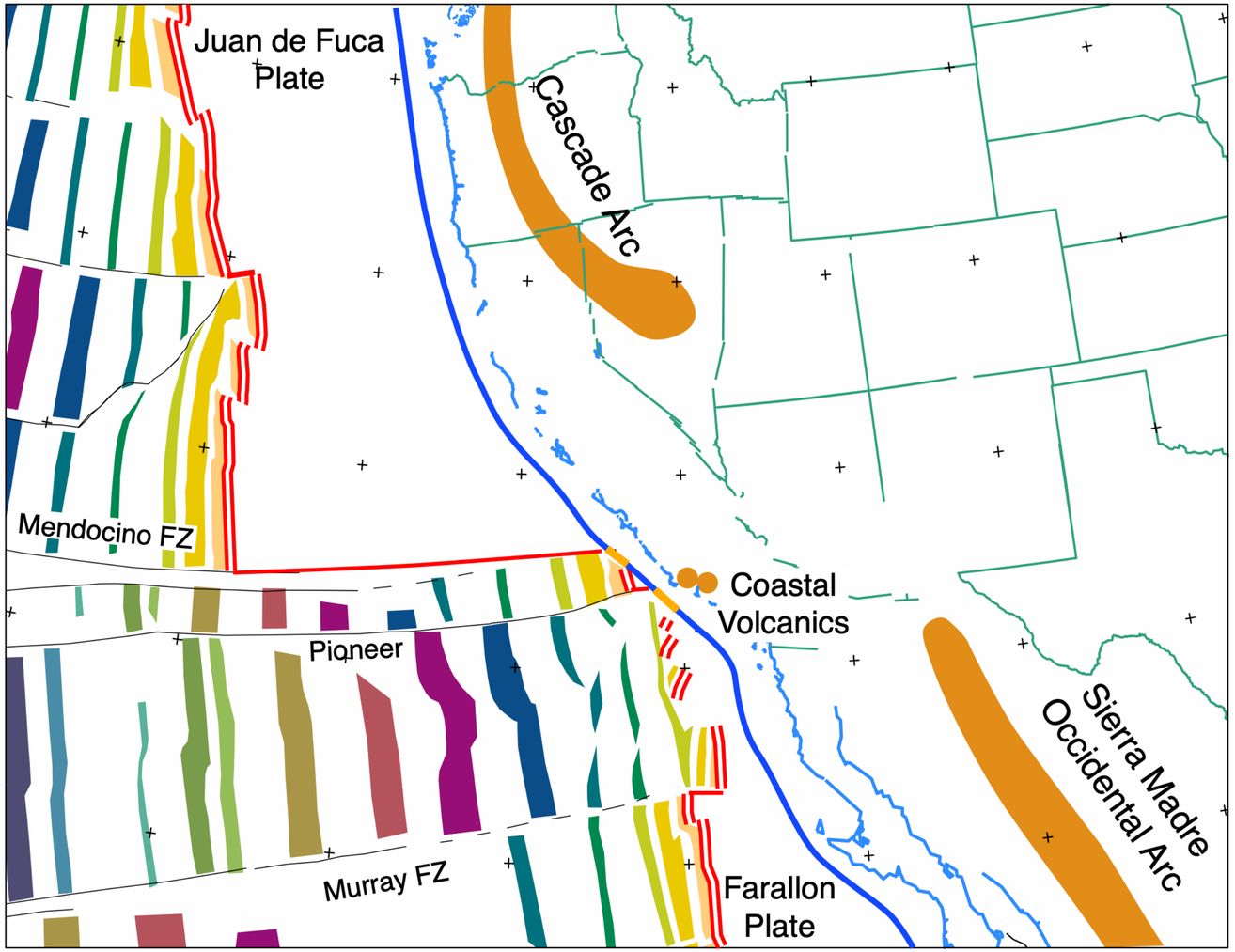


Continuous subduction along Lower 48 and Mexico

Low-angle subduction of Juan de Fuca plate under southern California, with arc volcanics in western New Mexico

No magmatism in southern California or western Arizona for previous 20+ Myr

25-Ma Reconstruction



Subduction no longer continuous as Pacific plate has grown to meet North American plate at 28 Ma

Subducted slab has gaps (slab windows) resulting from conversion of eastern edge of Pacific plate from spreading ridge to transform fault.

Magmatism near continental margin starts very shortly after Pacific-NA contact

Morro Rock-Islay Hill Complex



photo: Abe Perlstein baywoodnavy.org

26.7-Ma shallow intrusives near continental margin

Pinnacles: ~24 Ma adjacent to San Andreas fault



Wikimedia

Implications of the northwestwardly younger age of the volcanic rocks of west-central California

GSA Bull. (1985)

KENNETH F. FOX, JR. } *U.S. Geological Survey, 345 Middlefield Road, Menlo Park, California 94025*
ROBERT J. FLECK }
GARNISS H. CURTIS *Department of Geology and Geophysics, University of California at Berkeley, Berkeley, California 94720*
CHARLES E. MEYER *U.S. Geological Survey, 345 Middlefield Road, Menlo Park, California 94025*

27–23 Ma cluster, reconstructed southern California

15–0.2 Ma northward younging trend, following Mendocino triple junction as predicted by slab-window model of Dickinson and Snyder (1979)

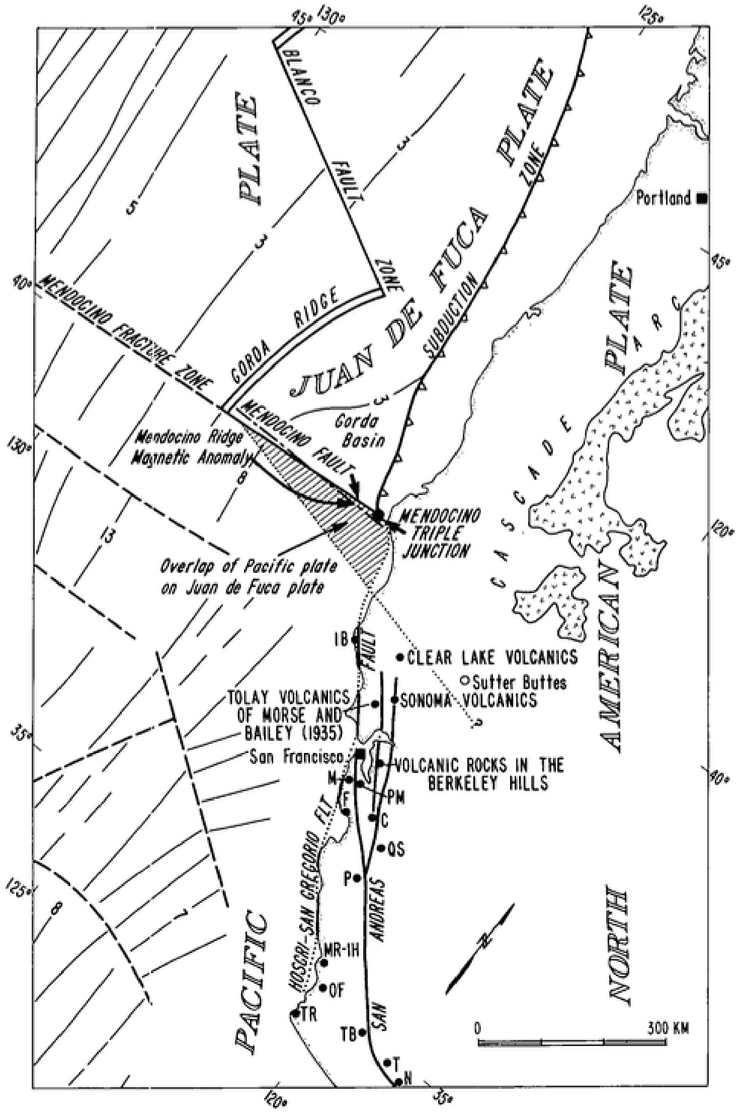


Figure 1. Index map showing distribution of northern Coastal Ranges volcanic rocks, plate geometry, and marine magnetic anomalies (numbered) and, in striped pattern, overlap of Pacific plate on Juan de Fuca plate. Other features shown as follows: IB, Iversen Basalt of Weaver (1944) and Gualala area; M, Mindego Basalt; PM, Page Mill Basalt; F, basalt near Felton; C, volcanic rocks near Coyote Reservoir; QS, Quien Sabe Volcanics of Taliaferro (1948) and Leith (1949); P, Pinnacles Volcanic Formation of Matthews (1973a); MR-IH, Morro Rock–Islay Hill complex; OF, Obispo Formation; TB, "Triple" basalt; T, Tecuya Formation; N, Neenach Volcanics; TR, Tranquillon Volcanics of Dibblee (1950).

Nd-Sr isotopic geochemistry and tectonics of ridge subduction and middle Cenozoic volcanism in western California

GSA Bull. (1995)

Ronald B. Cole*
Asish R. Basu
Department of Geological Sciences, University of Rochester, Rochester, New York 14627

Basaltic coastal volcanic rocks are chemically like East Pacific Rise seamounts; Silicic rocks consistent with MORB magmas assimilating continental wall rocks

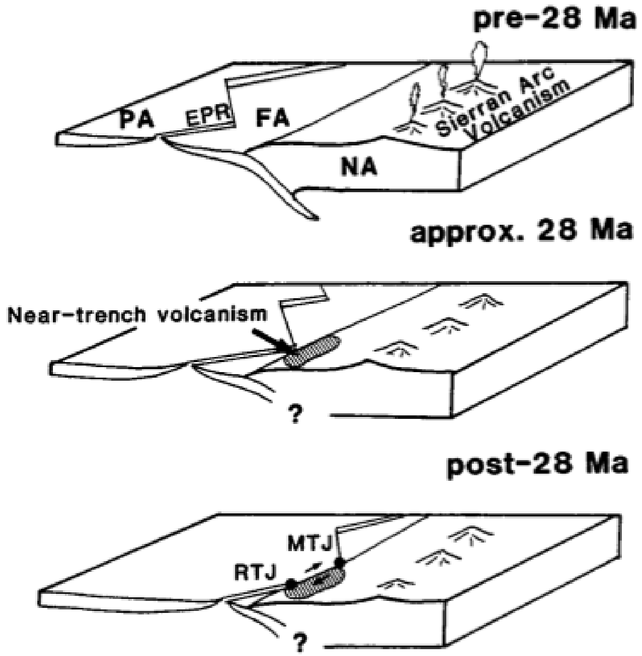


Figure 1. Model for middle Tertiary North American (NA)–Pacific (PA)–Farallon (FA) plate interactions. From Atwater (1970, 1989) and Severinghaus and Atwater (1990). Arrows show relative motion between Pacific and North American plates along the San Andreas transform boundary. EPR = East Pacific Rise; MTJ = Mendocino triple junction; RTJ = Rivera triple junction.

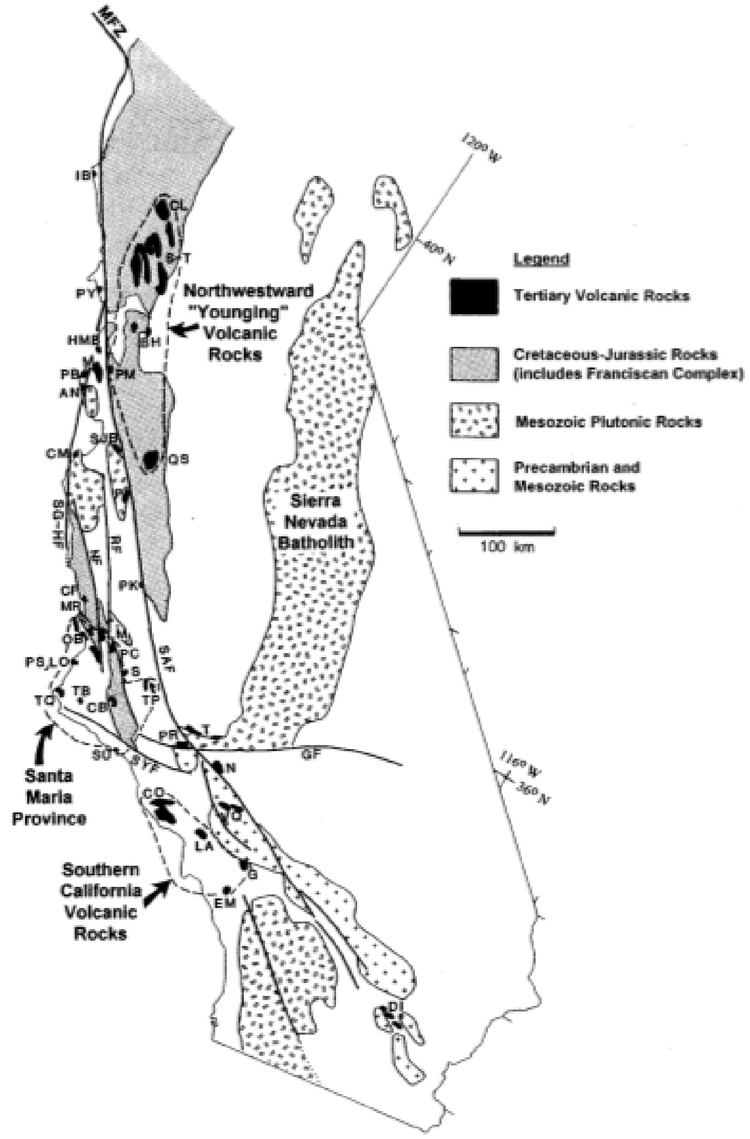
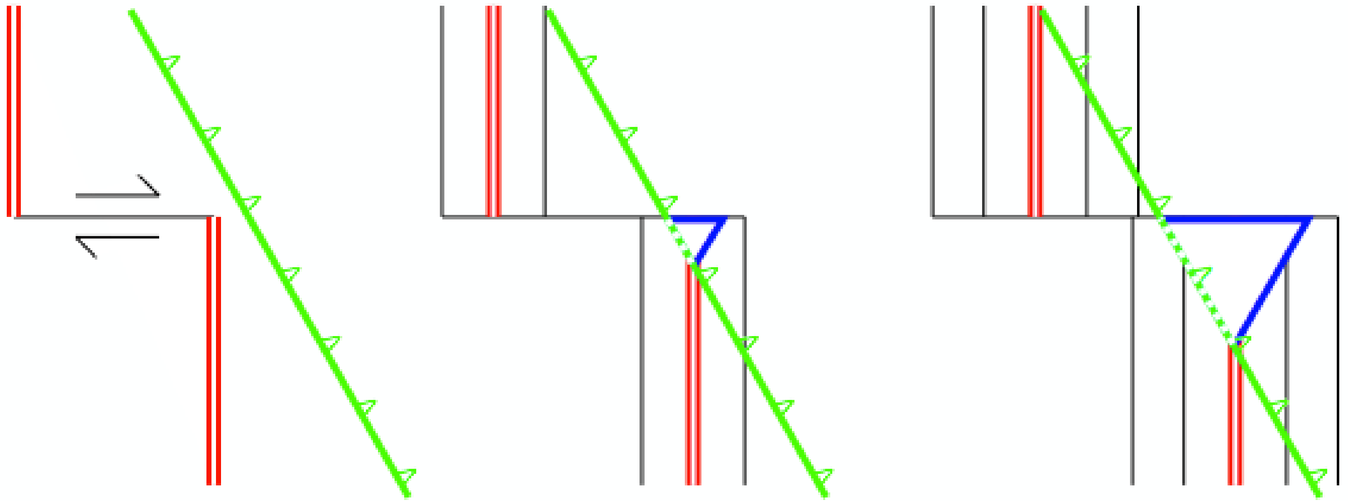


Figure 2. Study area map of Tertiary volcanic units in western California. Dashed lines define groups of volcanic units as labeled except for the Coast Range Province volcanic units, which are not outlined. Abbreviations for volcanic units are given in Table 1. SAF = San Andreas fault, SG-HF = San Gregorio–Hosgri fault, RF = Rinconada fault, NF = Nacimiento fault, GF = Garlock fault, SYF = Santa Ynez fault, MFZ = Mendocino fracture zone.

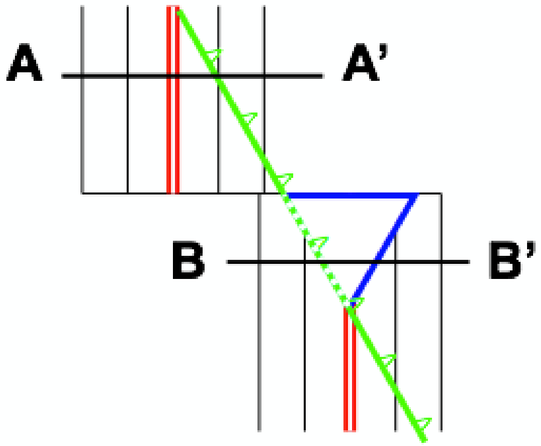
Slab Window

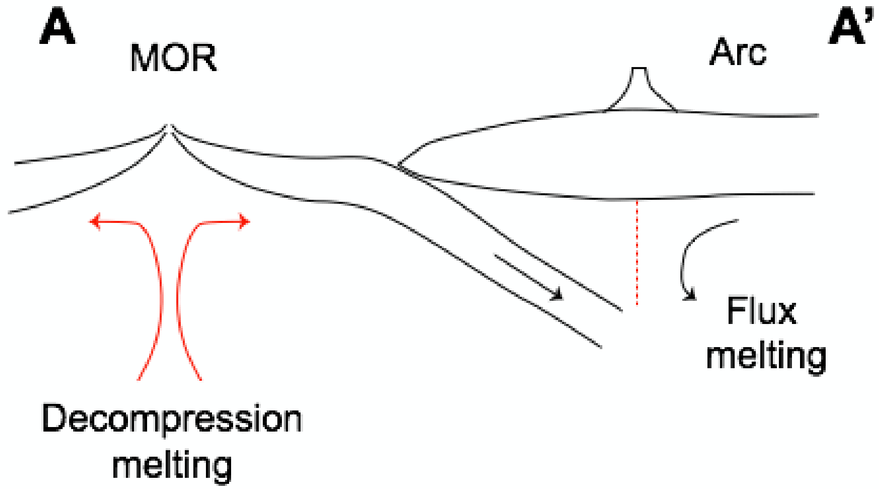
A gap in a subducted slab caused by lack of continuous supply of ocean crust at subduction zone

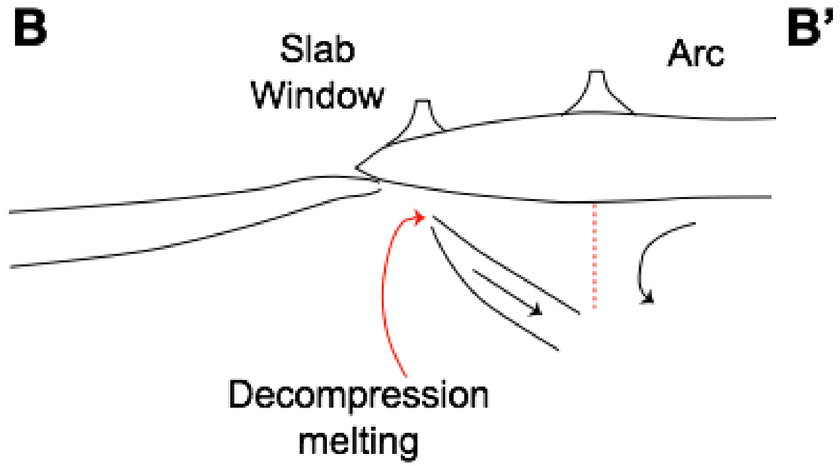


after Snyder and Dickinson (1979)

Slab-Window Volcanics:
Rift Setting, not Arc Setting







Implications of volcanism in coastal California for the Neogene deformation history of western North America

Tectonics (2005)

Douglas S. Wilson

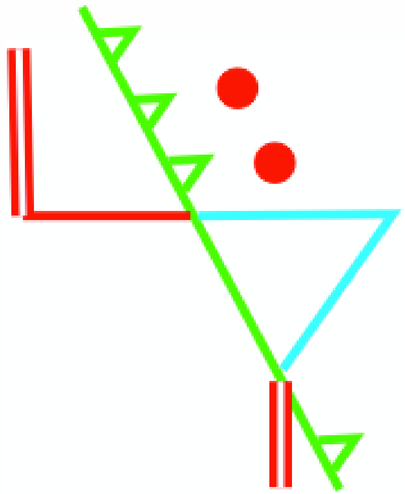
Department of Geological Science and Marine Science Institute, University of California, Santa Barbara, California, USA

Patricia A. McCrory and Richard G. Stanley

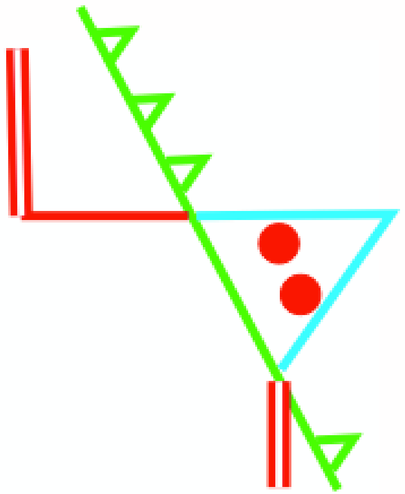
U.S. Geological Survey, Menlo Park, California, USA

Objective: Predict slab window geometry from offshore magnetic anomaly isochrons. Adjust continental reconstruction building on many previous studies so that mid-Cenozoic coastal volcanic units occur above slab windows, with emphasis on deformation west of San Andreas fault.

Strategy: Build quantitative reconstruction model for motion within western North America and Pacific-North America relative motion to predict positions of volcanic centers relative to slab windows. Refine reconstructions until positions match



Rejected Model:
Rift volcanics over
cold slab



Potentially Viable Model:
Rift volcanics over
slab window

Reconstructions

Plate Circuit:
Find Pacific-North America motion by adding:
Pacific -> West Antarctica -> East Antarctica -> West Africa -> North America

Most California pieces reconstructed to North America via Colorado Plateau

All plates & microplates treated as rigid plates on a sphere

Most figures plotted in the reference frame fixed to North America

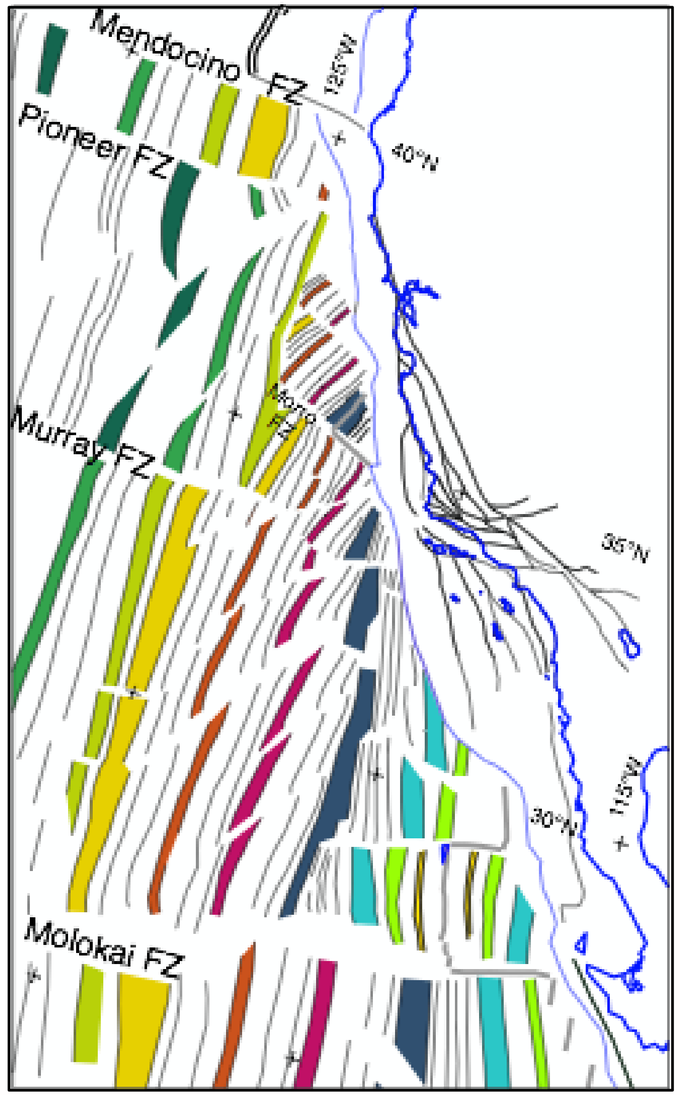
Time scale: Cande and Kent [1995] in 2005; GTS2012 current figures

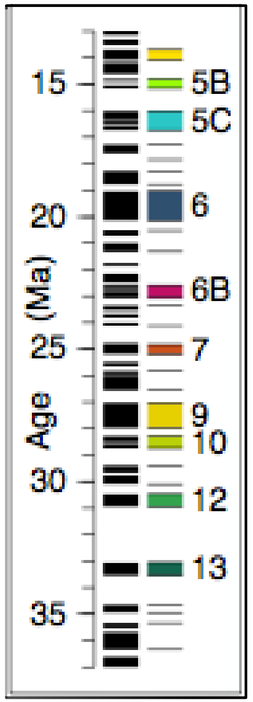
Offshore Magnetic Anomaly Record

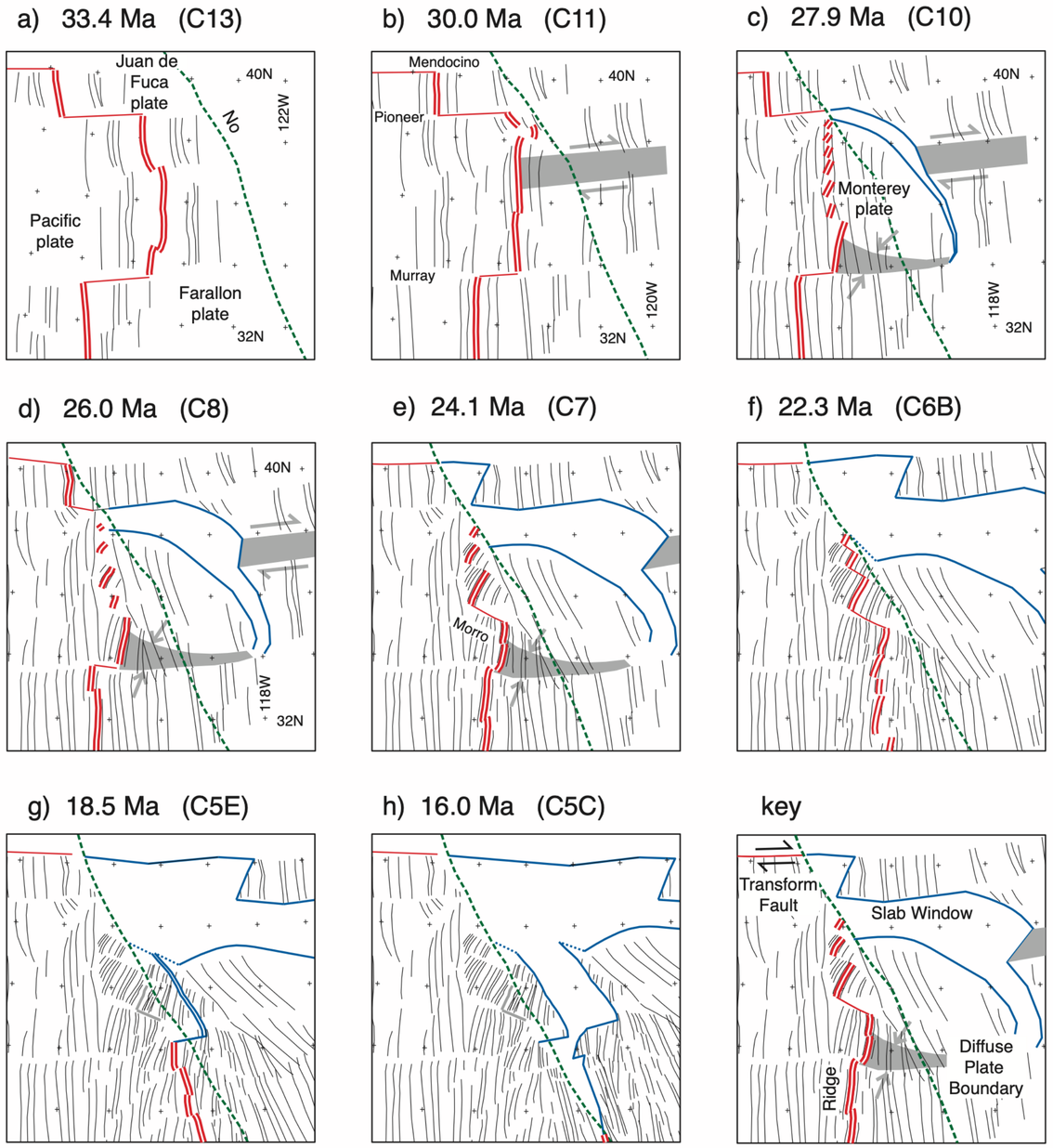
~28 Ma: Monterey microplate breaks from northern Farallon plate between Pioneer and Murray FZs at about time of initial Pac-NA contact

~24 Ma: Juan de Fuca plate between Pioneer and Mendocino FZs entirely subducted

~19 Ma: Monterey plate captured by Pacific plate; Cocos-Pacific spreading ridge starts to retreat southward







Slab Window Evolution

1) ~28 Ma, slowly subducting Monterey plate separates south of Pioneer FZ

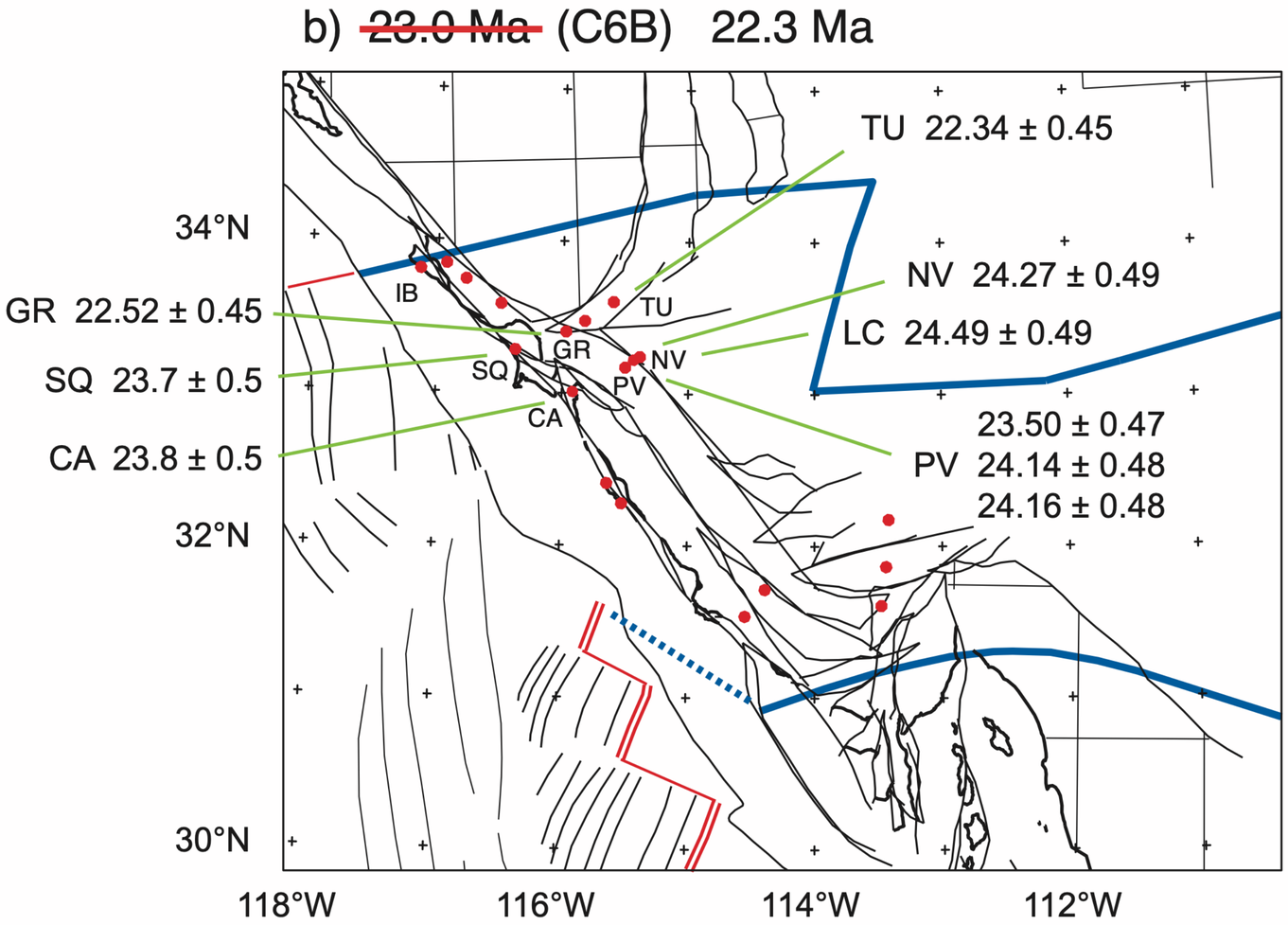
2) 26-24 Ma, Pacific plate grows to meet North America in Mendocino-Pioneer corridor

3) ~19 Ma, part of Monterey plate captured by Pacific plate, creating a new slab window beneath the continent

4) post-25 Ma, south edge of Juan de Fuca plate moves northward with Mendocino triple juction

[2005 figure, Pacific plate fixed, subducted isochrons predicted by symmetric spreading, revised magnetic reversal timescale]

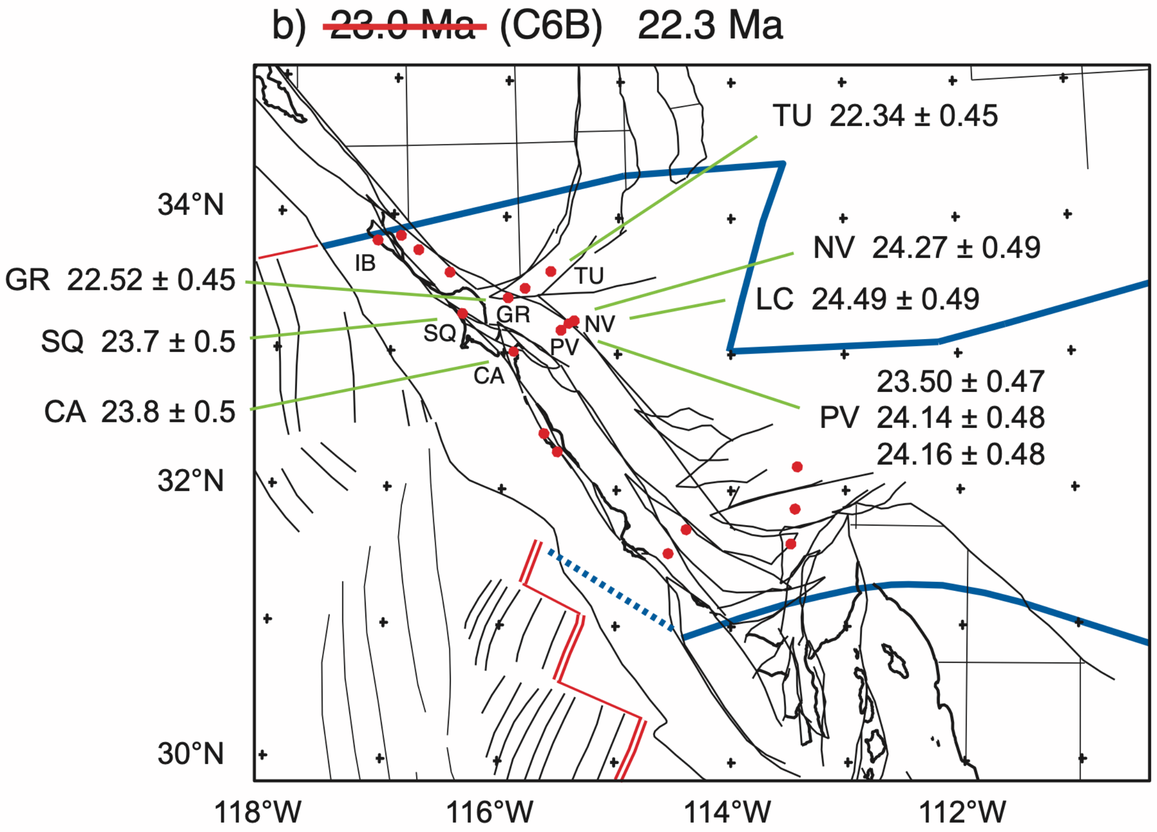
Reconstructed 25–22-Ma volcanic centers relative to C6B slab window



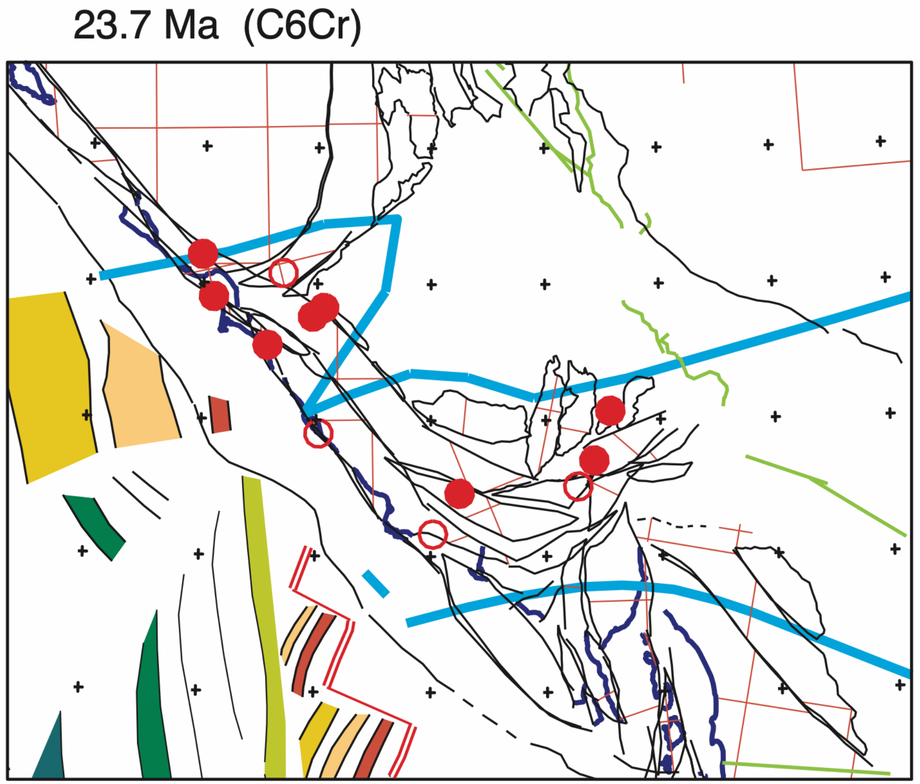
Ages from Stakes et al. (1999, SQ, Ar/Ar), Stanely et al. (2010, CA, Ar/Ar), and Anttila et al. (2025, U/Pb zircon)

2005 Figure, relabeled

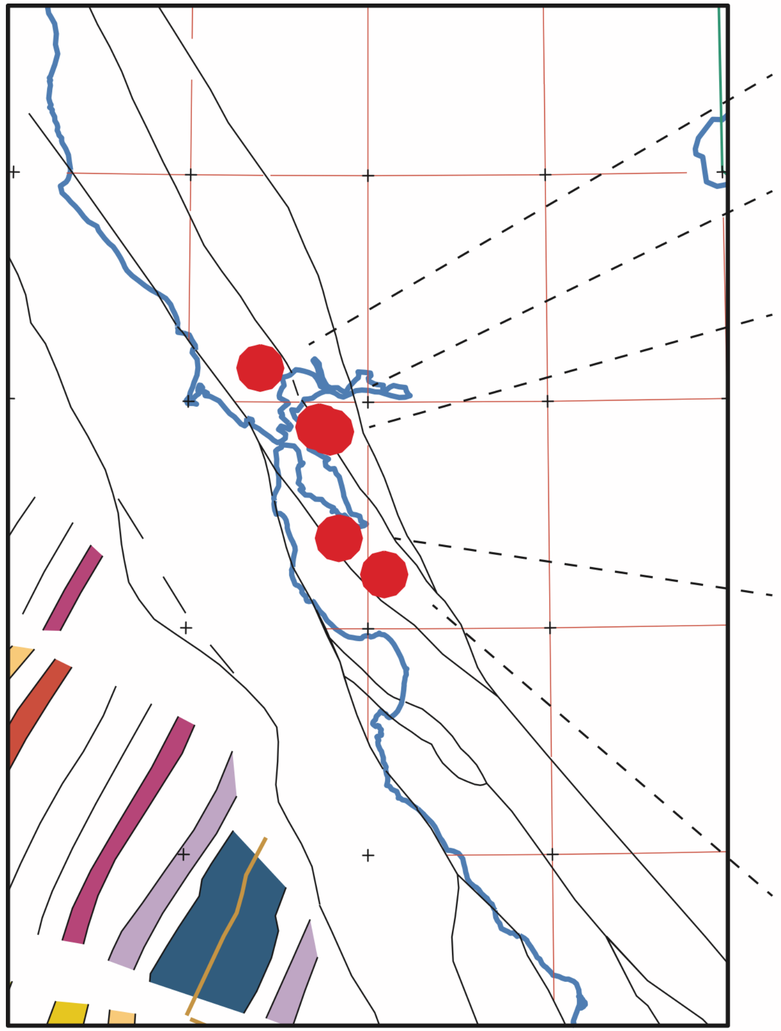
2005 Reconstruction
25–22 Ma volcanic centers



2026 Reconstruction
25–23.5 Ma volcanic centers



SF Bay Area volcanic centers, 16–10 Ma



11.11±0.22 Burdell Mtn Rhyolite

11.21±0.22 Northbrae Rhyolite

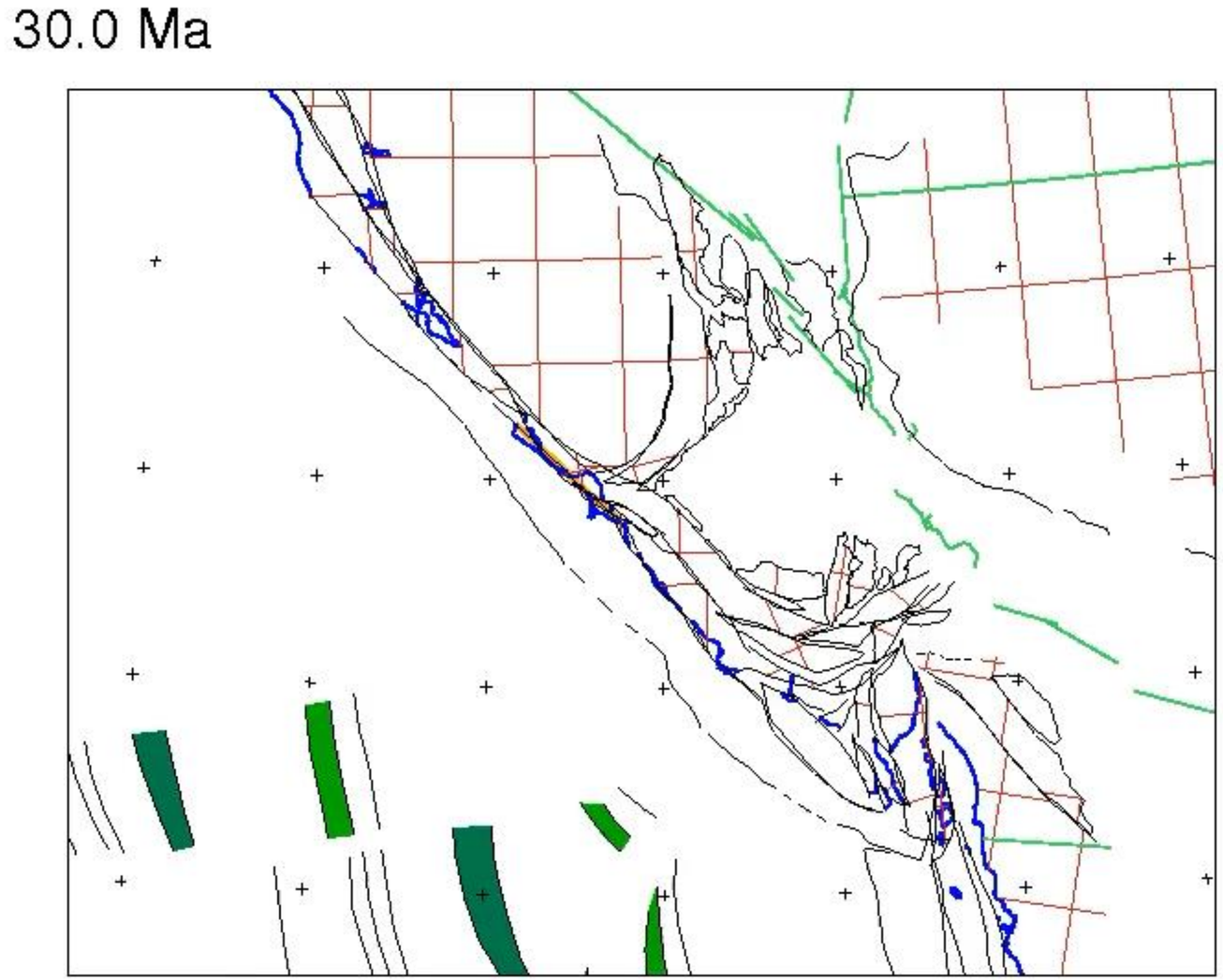
10.03±0.20 Orinda Fm lithic tuff

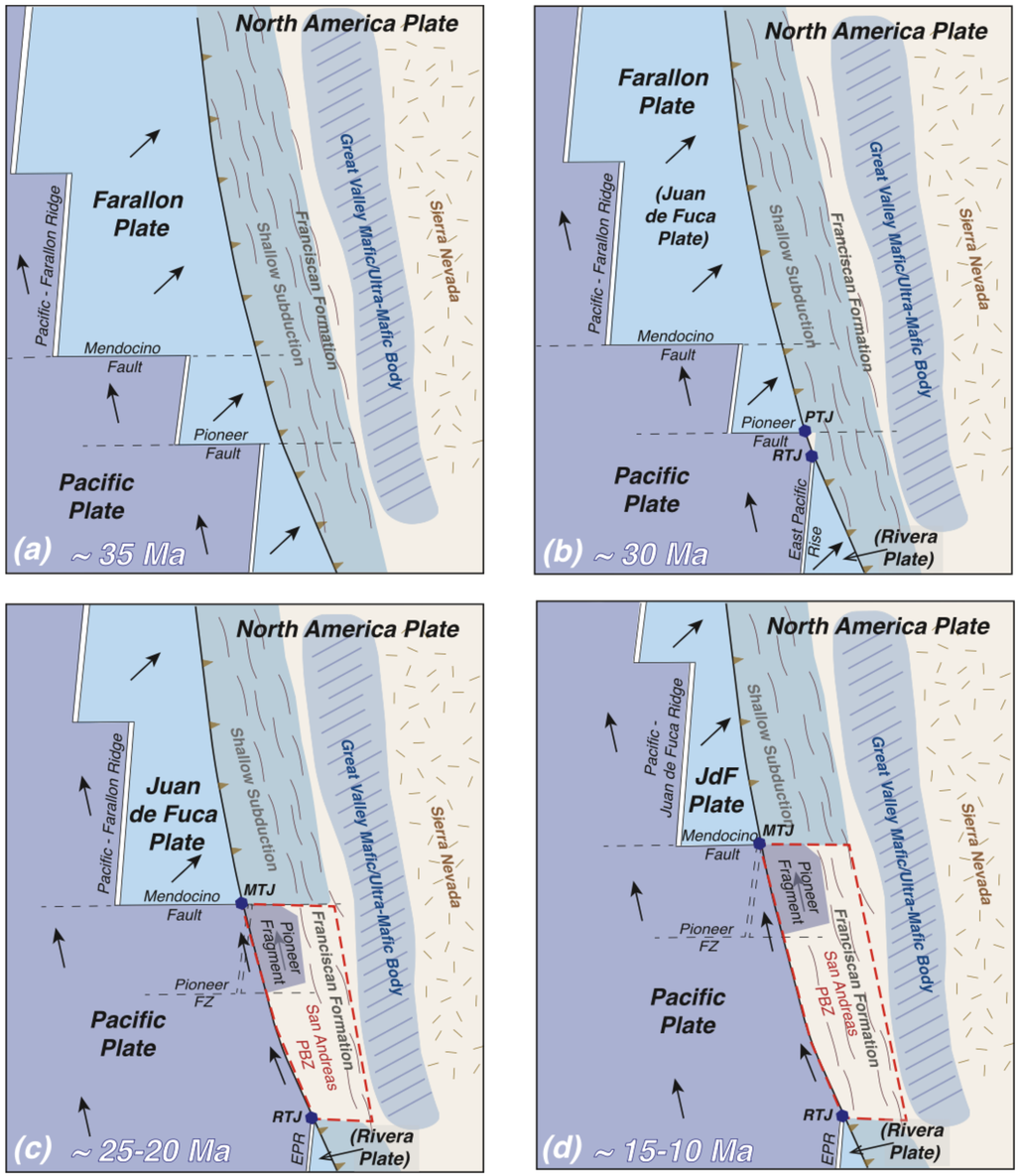
U/Pb zircon (Anttila et al., 2025)

15.61±0.04 Ar/Ar (Swisher unpub, via Wakabayashi, 1999)
Page Mill Basalt

15.6±0.4 K/Ar (Nakata et al., 1993)
lithic tuff, New Almaden

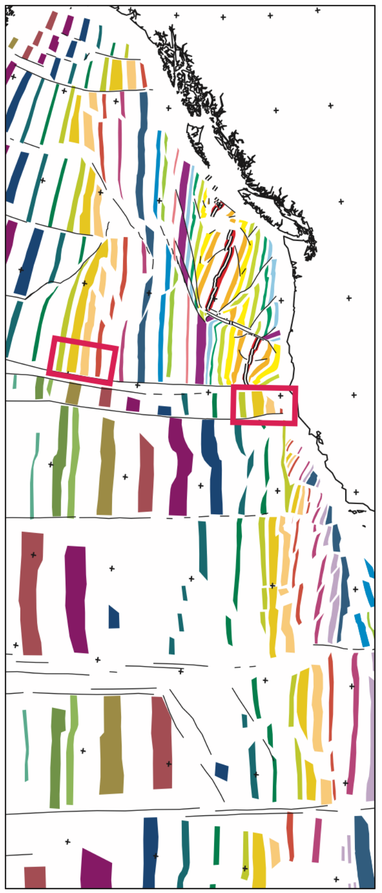
Volcanic center vs slab window reconstruction



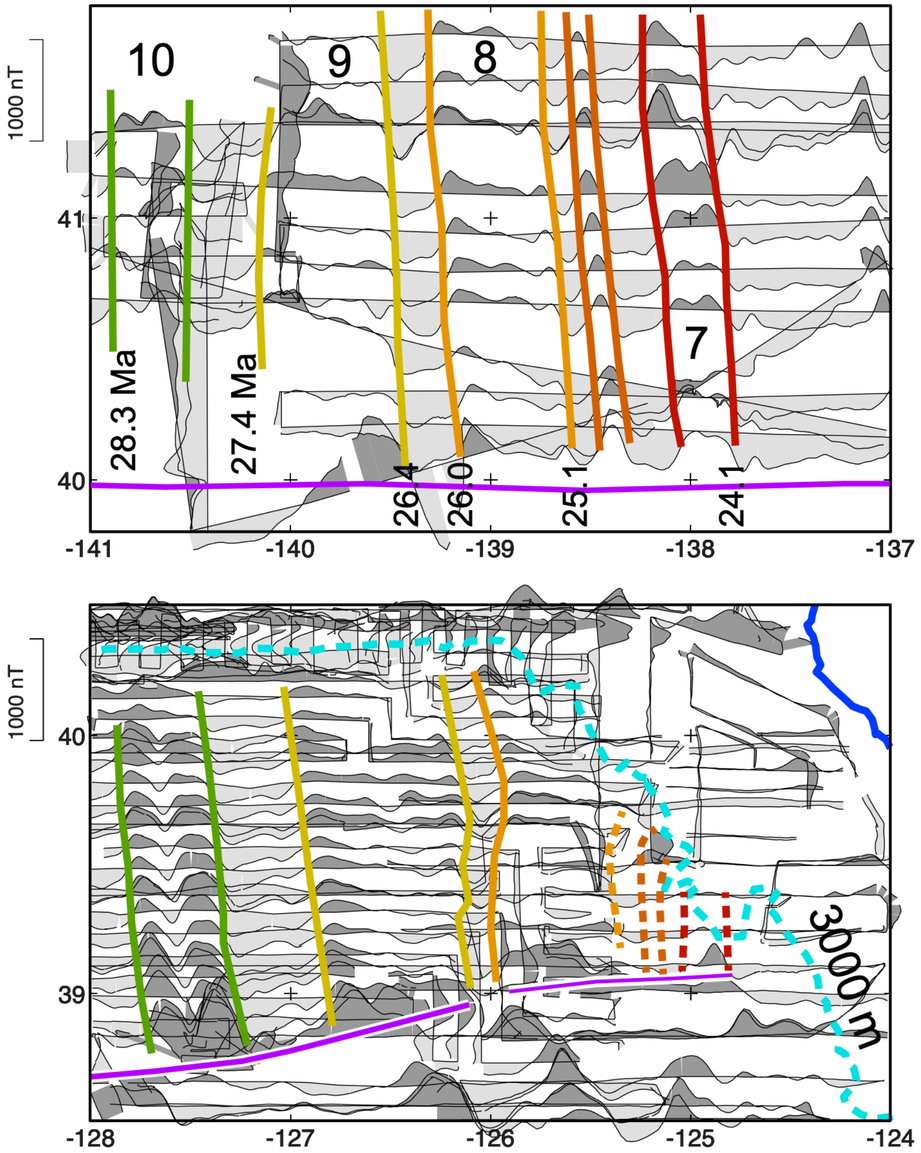


Pioneer Fragment Hypothesis

Fast seismic velocities under California ~39–40°N are explained by a captured fragment of subducted oceanic lithosphere formed between Mendocino and Pioneer FZs, moving northward with Pacific plate since capture. (Furlong et al., 2024, and prior papers to 2003)



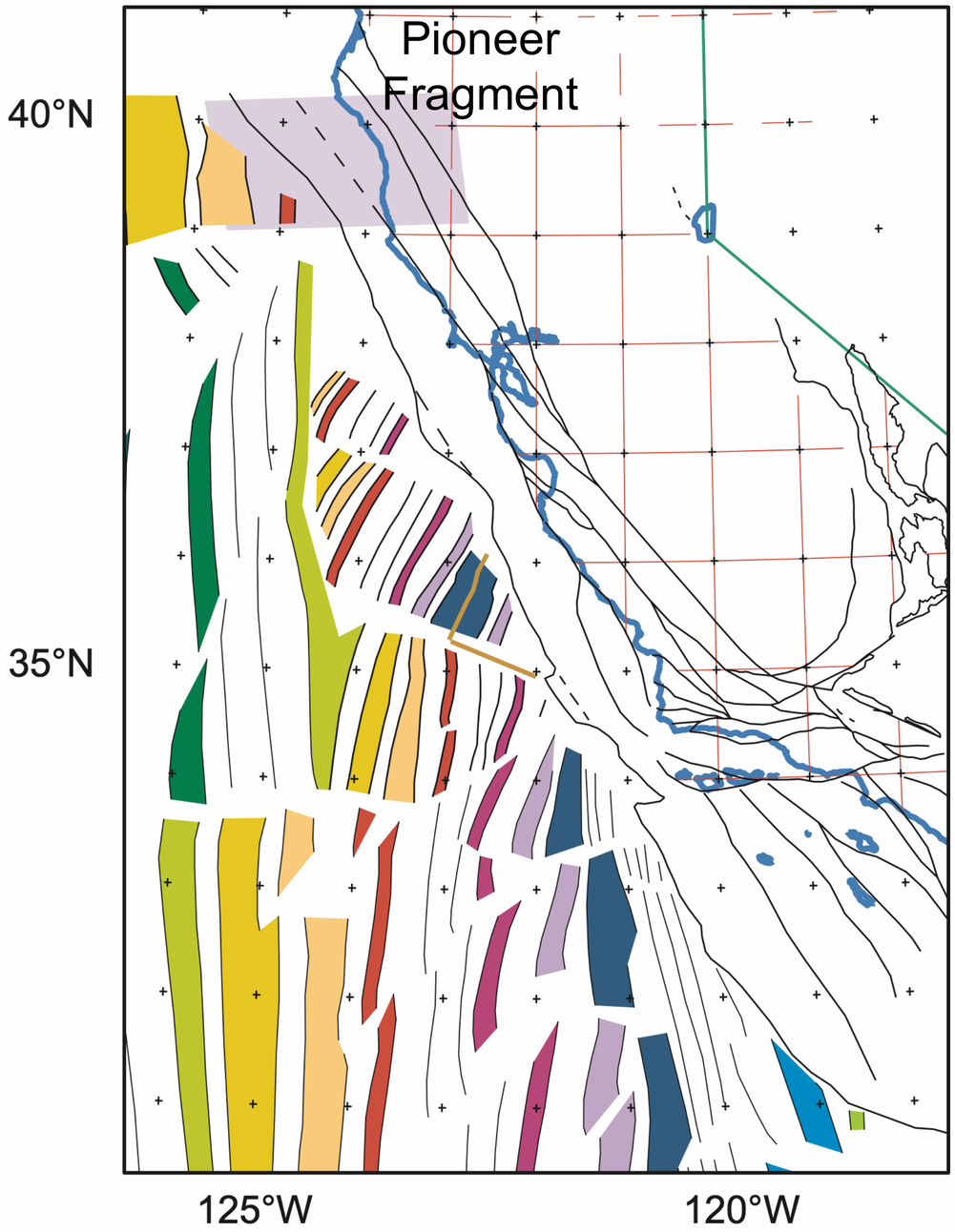
location map



28–24 Ma magnetic anomaly profiles adjacent to Mendocino FZ

Preferred interpretation: south side anomalies show the same eastward-younging progression as north side

Plausible alternative: south side anomalies are mirrored about C8r, 26.2 Ma

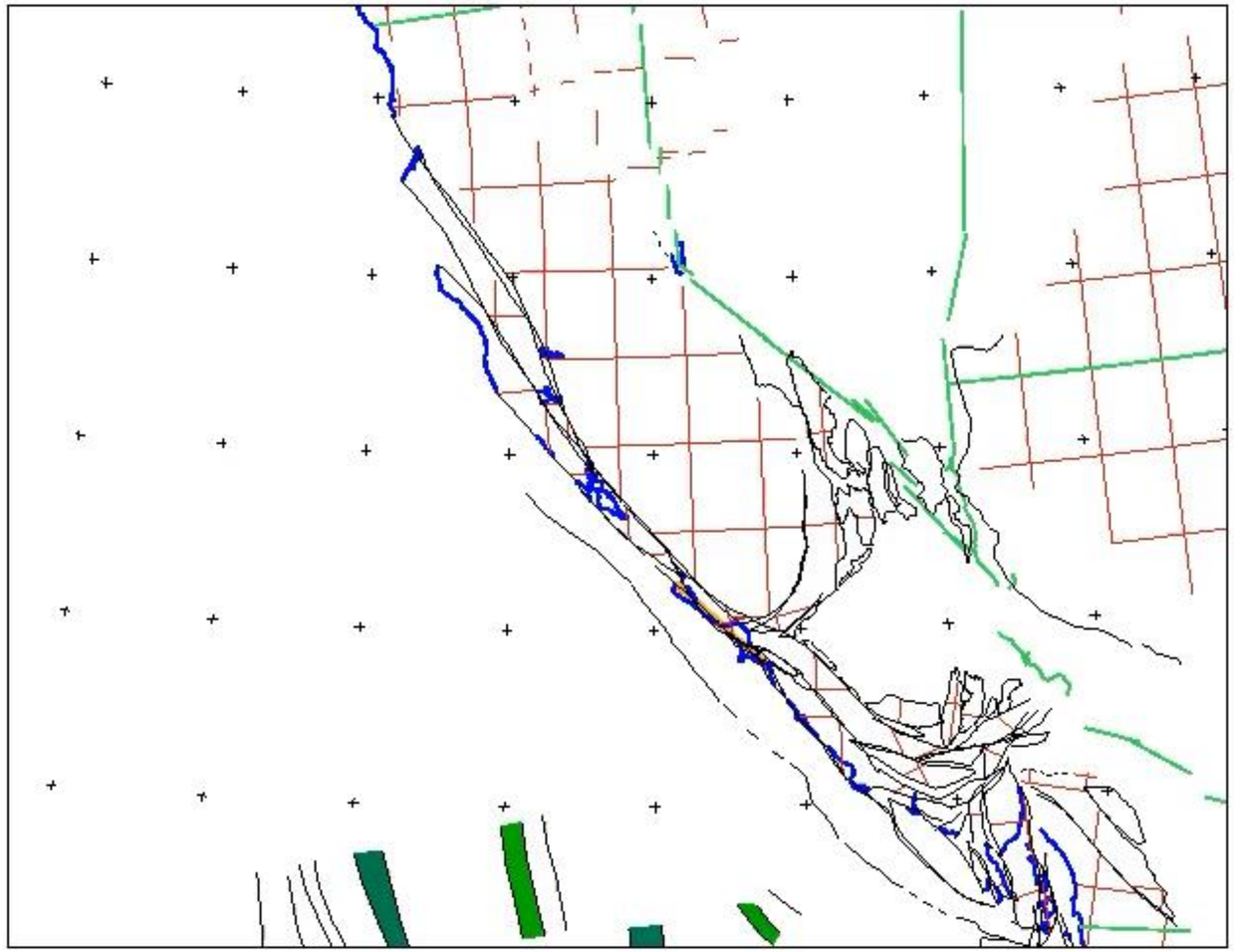


Present location of Pioneer Fragment in subsequent reconstruction

Eastern limit of fragment follows Furlong et al. (2024): “a relatively high-seismic-velocity layer … extending to approximately 100 km east of the coastline.”

Volcanic center vs slab window reconstruction

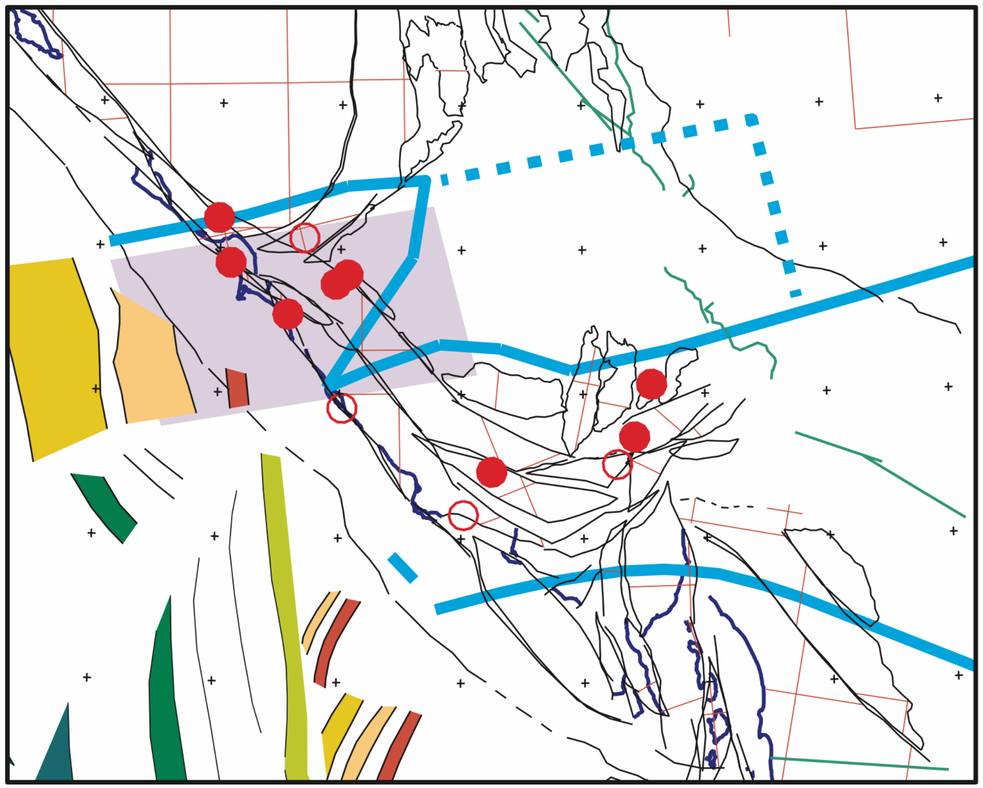
30.0 Ma



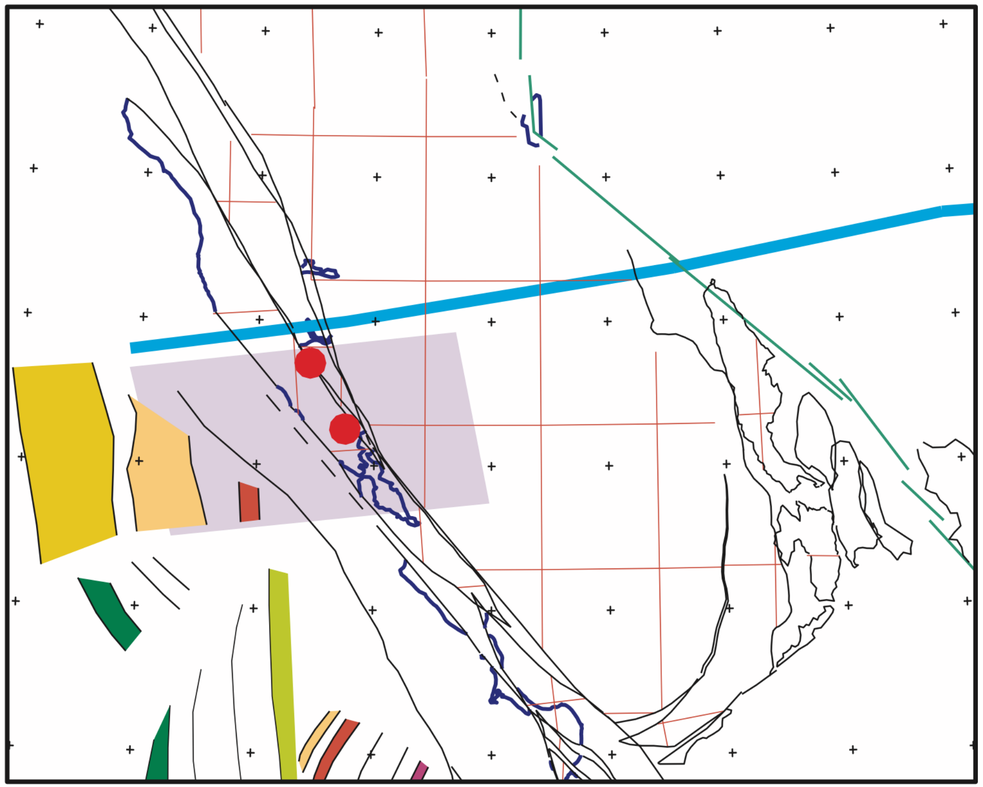
Pioneer fragment included

Hypothesized Pioneer Fragment reconstructs under most post-25-Ma coastal volcanic centers in central and northern California

23.7 Ma



11.0 Ma



Conclusions

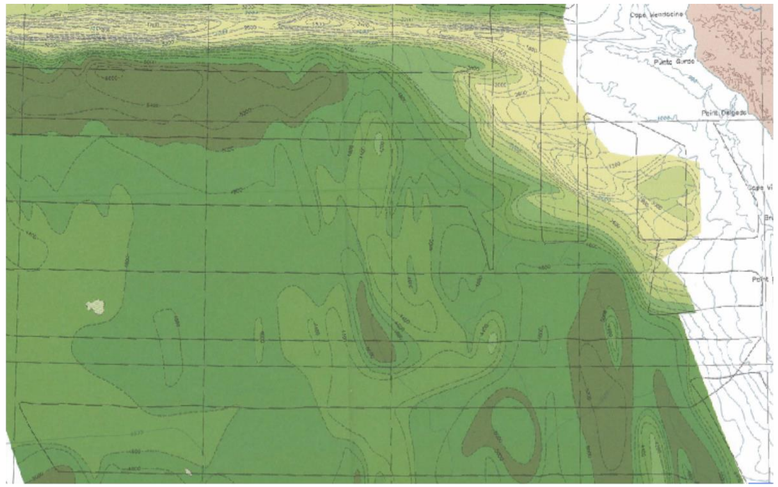
Hypothesized Pioneer Fragment of former Juan de Fuca slab, if moving with the Pacific plate since 26 Ma, reconstructs under many volcanic centers younger than 25 Ma long interpreted as forming over slab windows.

Option 1: Find a new explanation for volcanic centers that reconstruct north of Pioneer FZ.

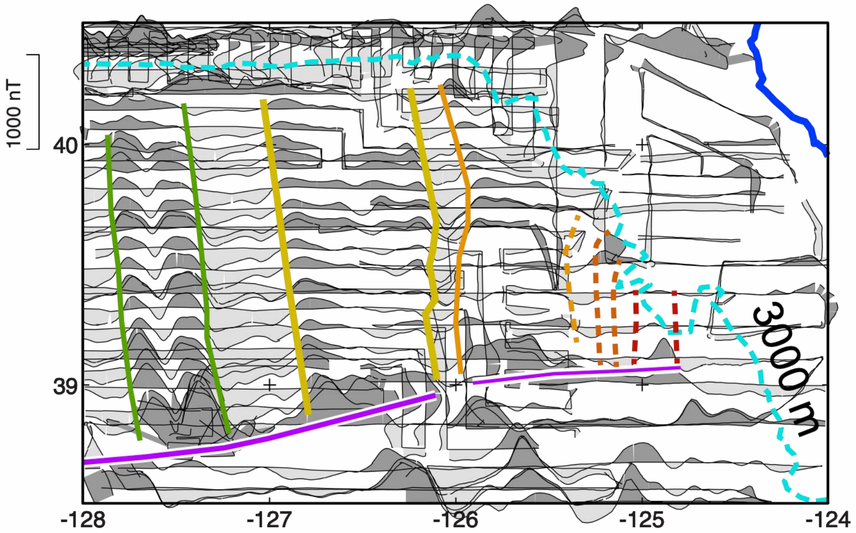
Option 2: Find a new explanation for fast seismic velocities under Klamath Mountains, inland from Pioneer-Mendocino corridor.

Discussion slides

Offshore Pioneer Fragment Fossil Rift?

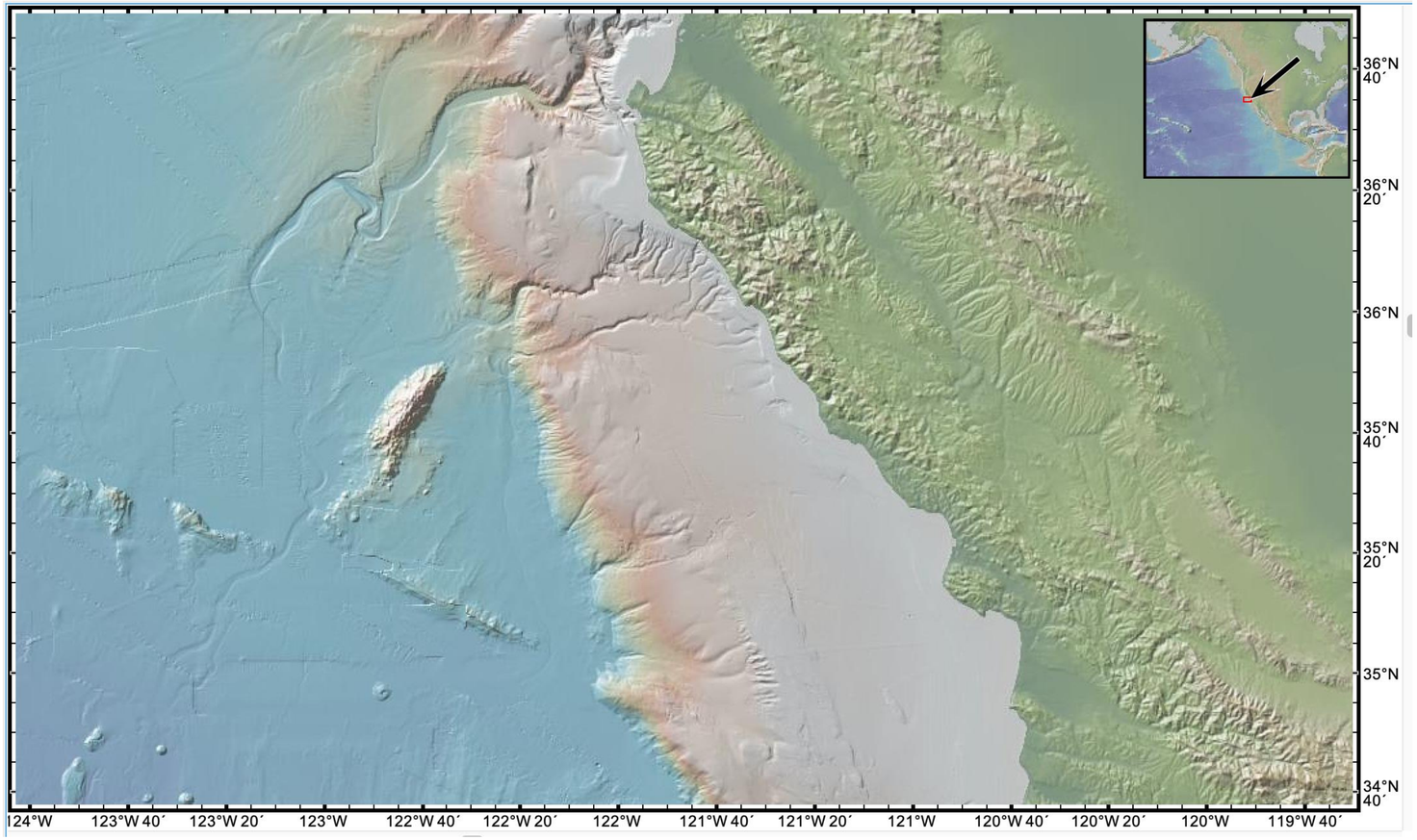


Depth to acoustic basement
Gardner et al. (1993)

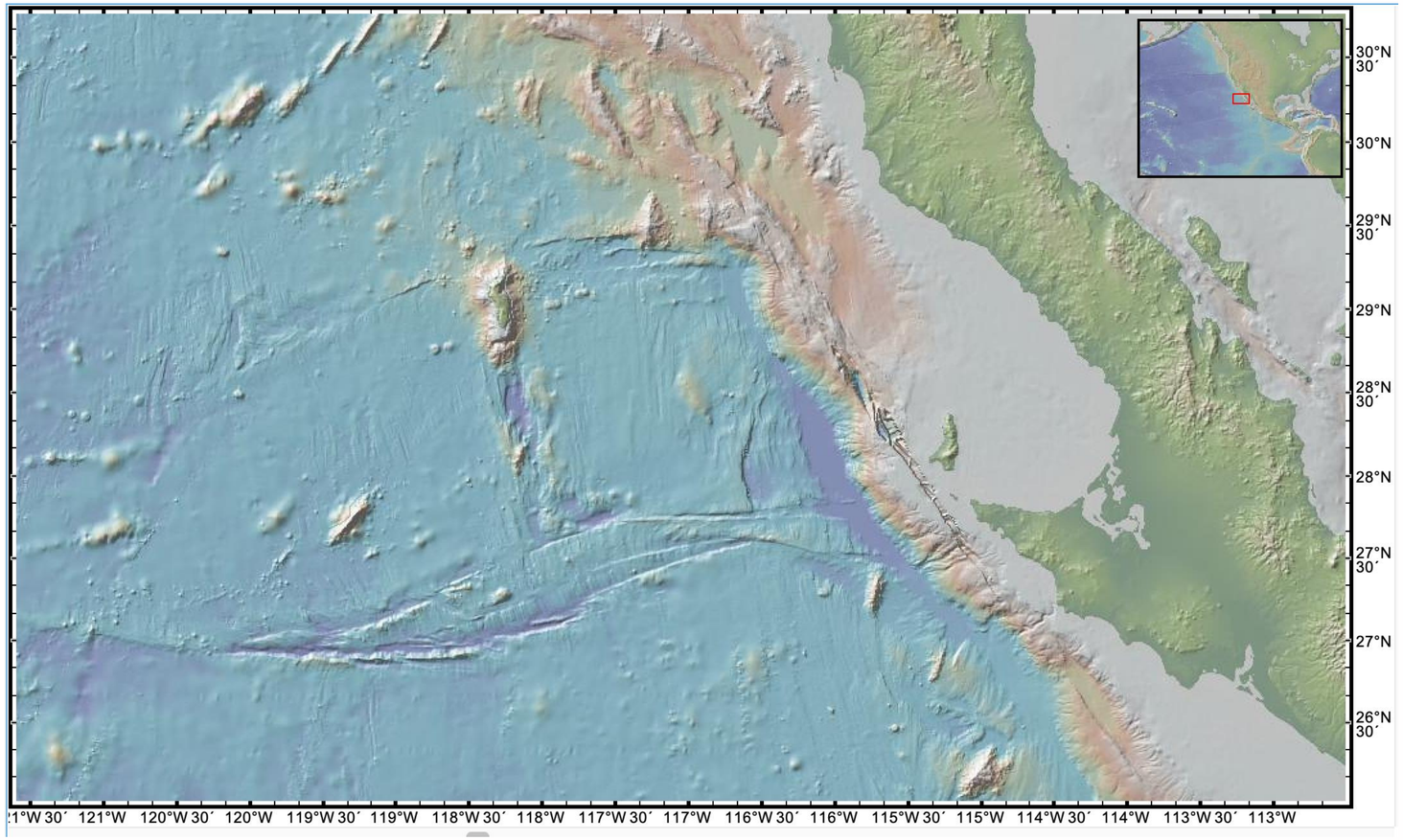


Magnetic anomaly profiles

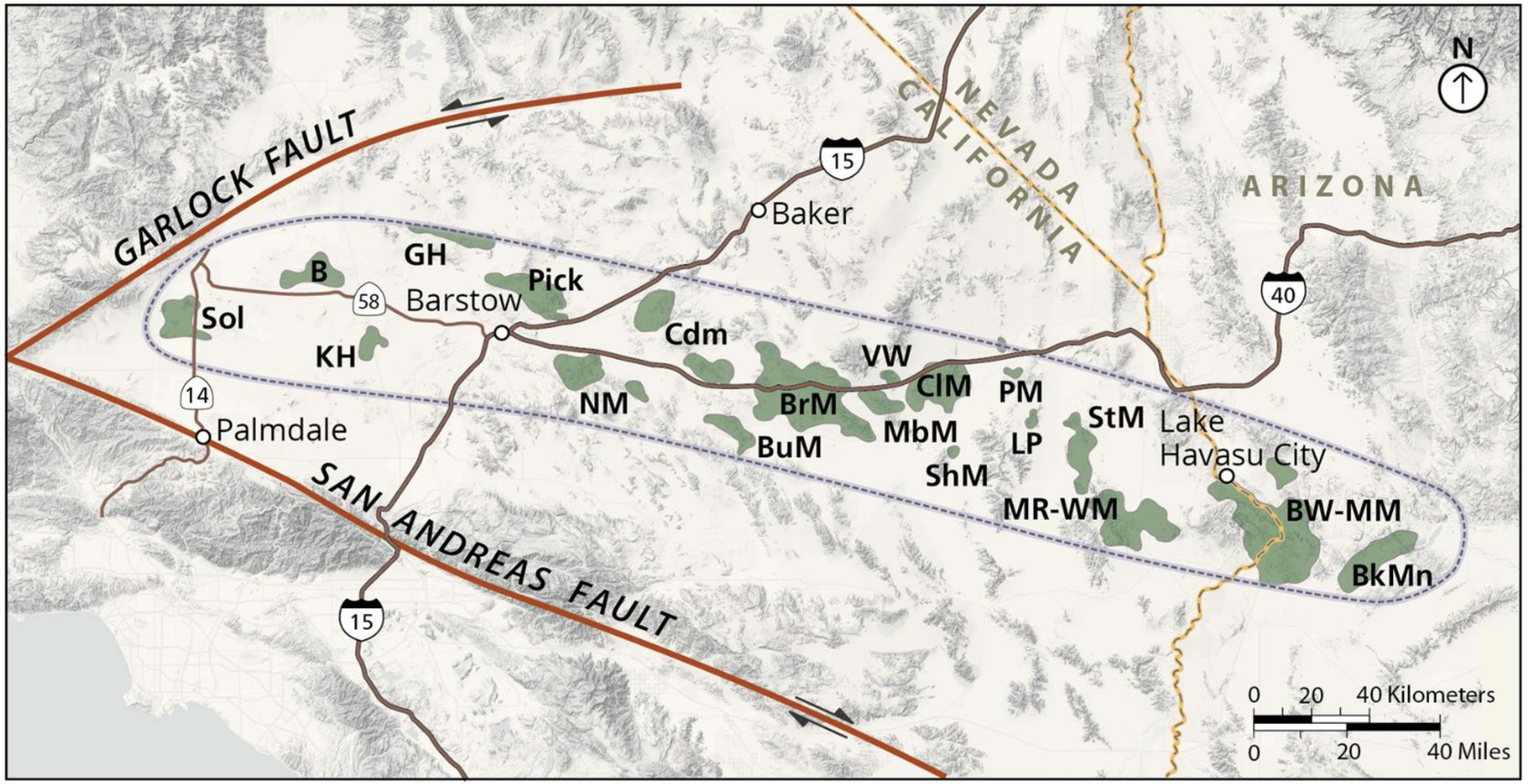
Captured Monterey Plate Fragment



Captured Guadalupe Plate Fragment



Early Miocene Mojave magmatic belt, mostly 22-19 Ma



Why a narrow band? Why 22-19 Ma?