Geologic Observations and Structural Analysis of the East Bay

Implications for the Structural Fabric

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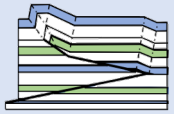

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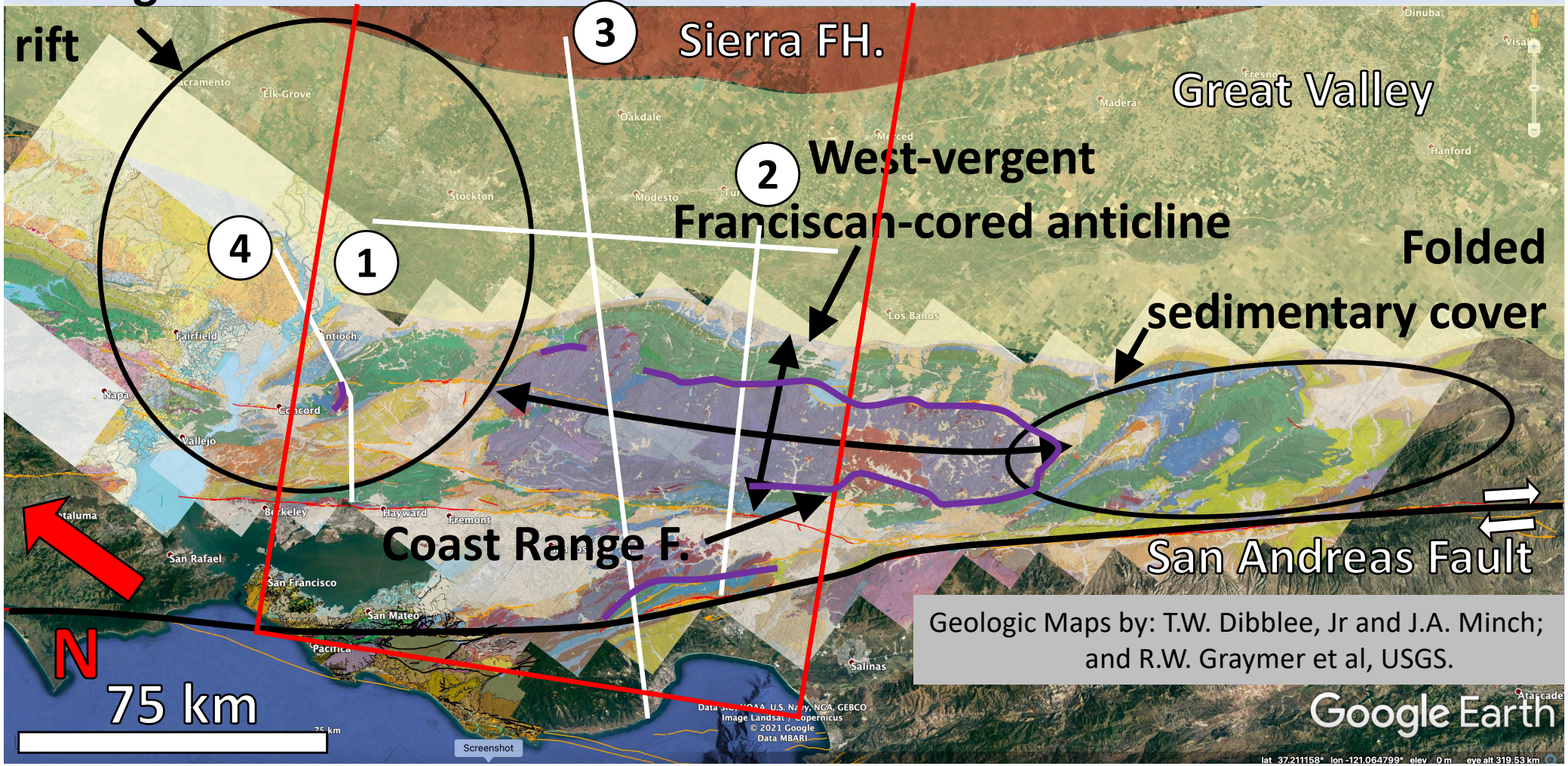
Key Points

- Despite apparent dominance of strike-slip motion in historic earthquakes, **the geologic fabric and velocity structure of the Bay Area is dominated by Late Cretaceous and Tertiary extensional and compressional structures.**

- Dip-slip motions are both larger (>78 vs <30 km) and more impactful as they directly effect velocity-depth functions.

- Integration of regional data and kinematic models provide critical constraints on the geologic and velocity structure.

East Bay Geologic Setting



Principal Faults

1. Surface geology in the Coast Ranges.

2. Neogene subcrop in the Great Valley.

1. Great Valley section shows the Stockton Arch clearly as other deformation is limited.

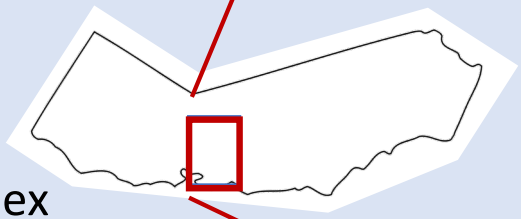
Neogene

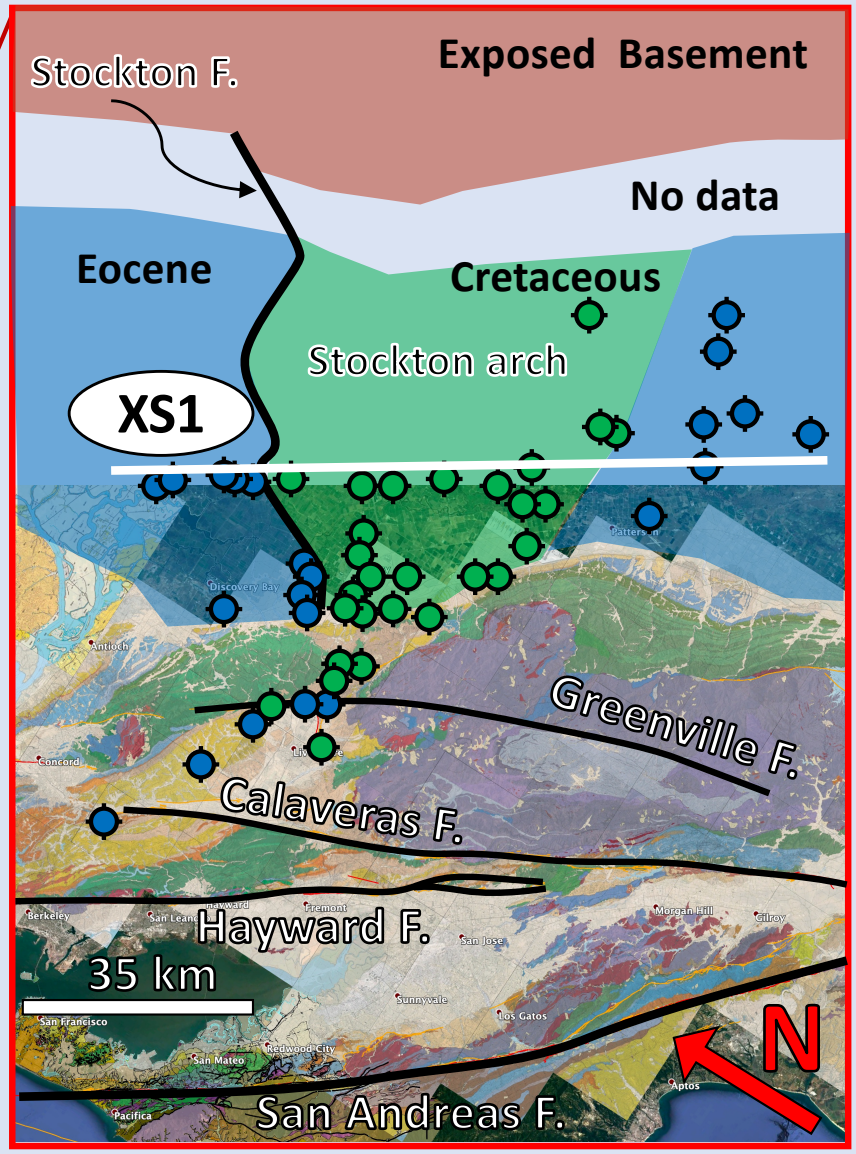
Paleogene (mostly Eocene)

Cretaceous

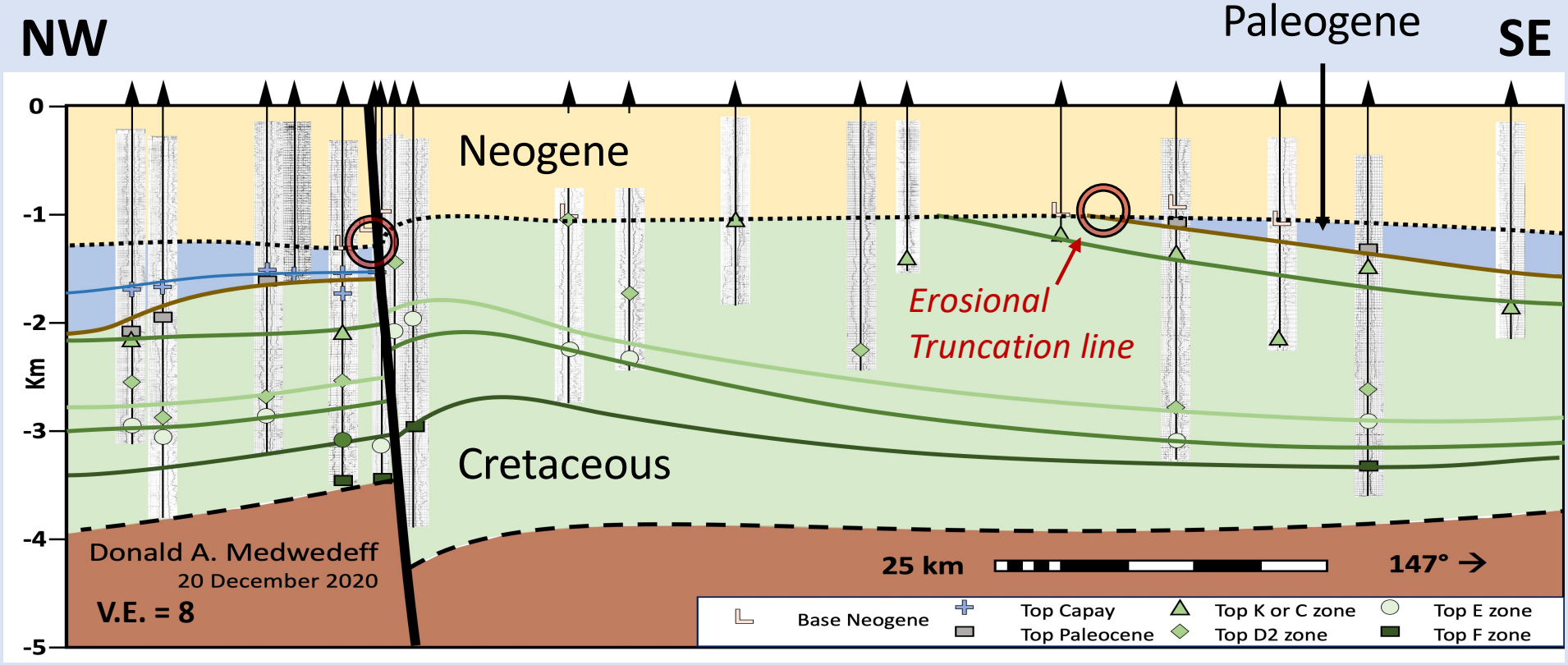
KJ Franciscan complex

Tr-J arc basement





XS1. Stockton Arch Structural Cross Section



- The Stockton Arch initiated as a Late Cretaceous, southeast dipping, basement-rooted normal fault.
- Erosion following post-Mid Eocene inversion stripped Paleogene and latest Cretaceous from the arch, producing a southwest-trending linear-erosional truncation that acts as a passive marker.

Modified and extended from Imperato, 1995
U.C. S.B. Ph. D.

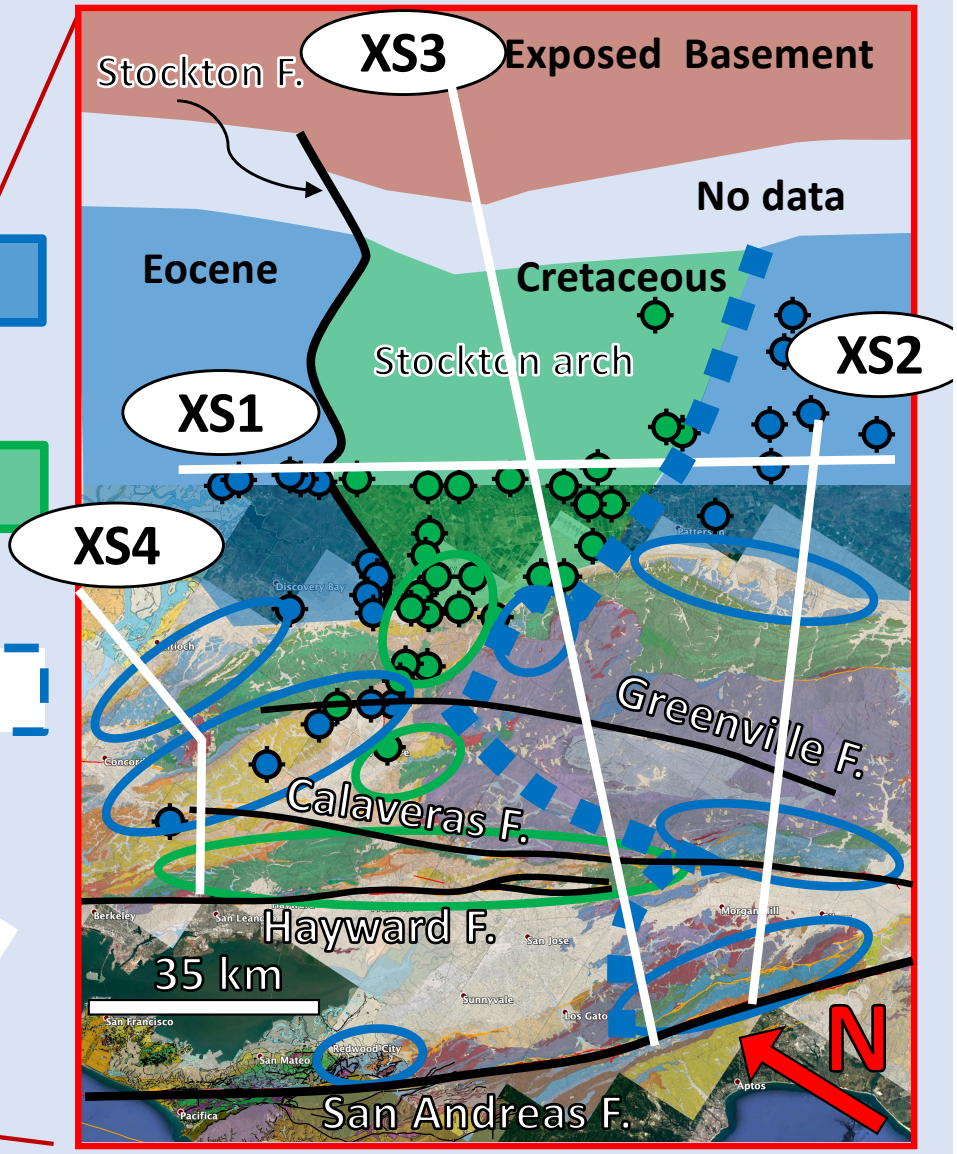
Westward Continuation of the Stockton arch

Eocene beneath Neogene

Cretaceous beneath Neogene

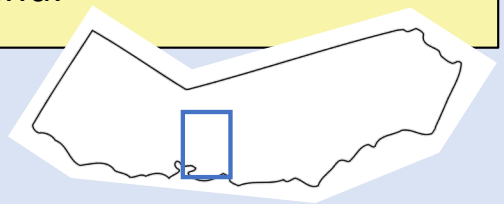
Estimated trace of Eocene erosional truncation

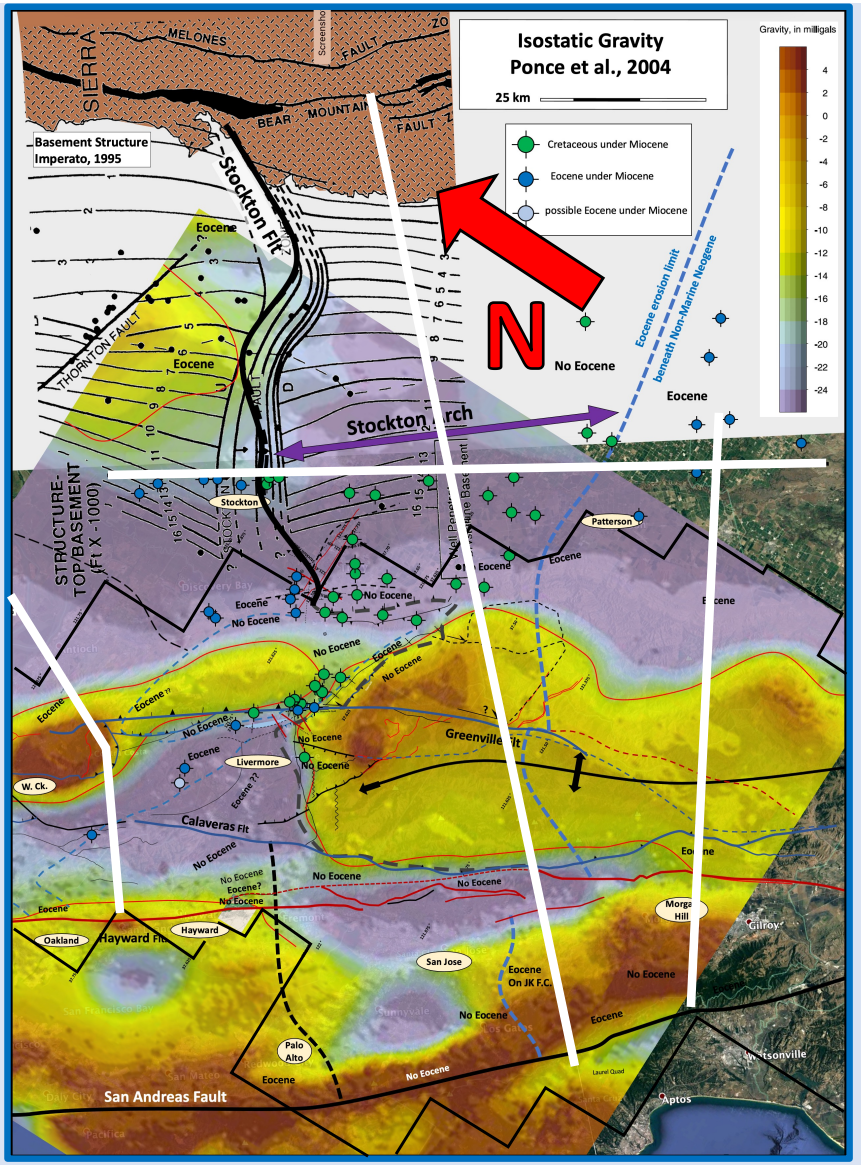
Fault	Total Offset	
	Graymer et al., 2002	*This Study*
Greenville	15	~4
Calaveras	160	<5
Miller Creek-Moraga	50	~0
Hayward	100	<25
Total	**175**	**<30**



Stockton Arch Gravity Structure

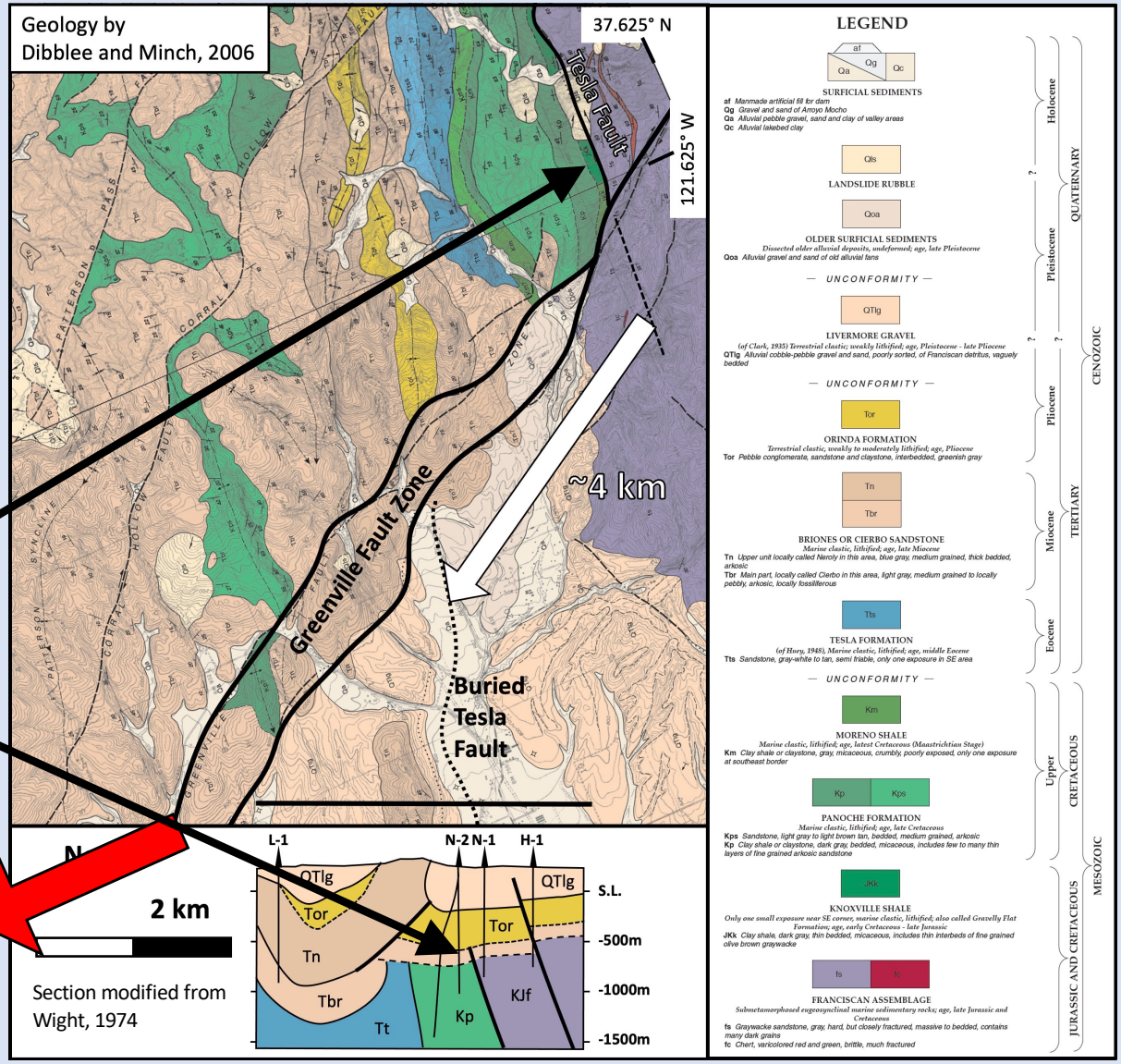
- Though high at the base Tertiary unconformity, the Stockton Arch is a gravity low.
- This indicates that
  - crystalline basement is structurally low and
  - *shallow structure is not a reliable indicator of basement structure*.
- Surface and well data indicate that Paleogene uplift extends at least to the Hayward fault trend.





Greenville Fault Offset

- Matching surface and subsurface Neogene structure indicate about 4 km slip on the Greenville fault.
- Tesla fault separates Franciscan complex and Great Valley sequence
- Equivalent relationship in the subsurface is offset ~4km



Hayward Fault Offset

Occurrence of Blueschist-rich/Chert-Poor and Chert-rich/Blueschist-Poor clasts in Orinda conglomerate and source terranes west of the Hayward Fault indicate 7 – 27 km right-lateral offset on the Hayward Fault.

Basin Evolution During Change from Convergent to Transform Continental Margin in Central California[1]

S. A. GRAHAM, C. MCCLOY, M. HITZMAN, R. WARD, and R. TURNER[2]

AAPG Bulletin, 1984

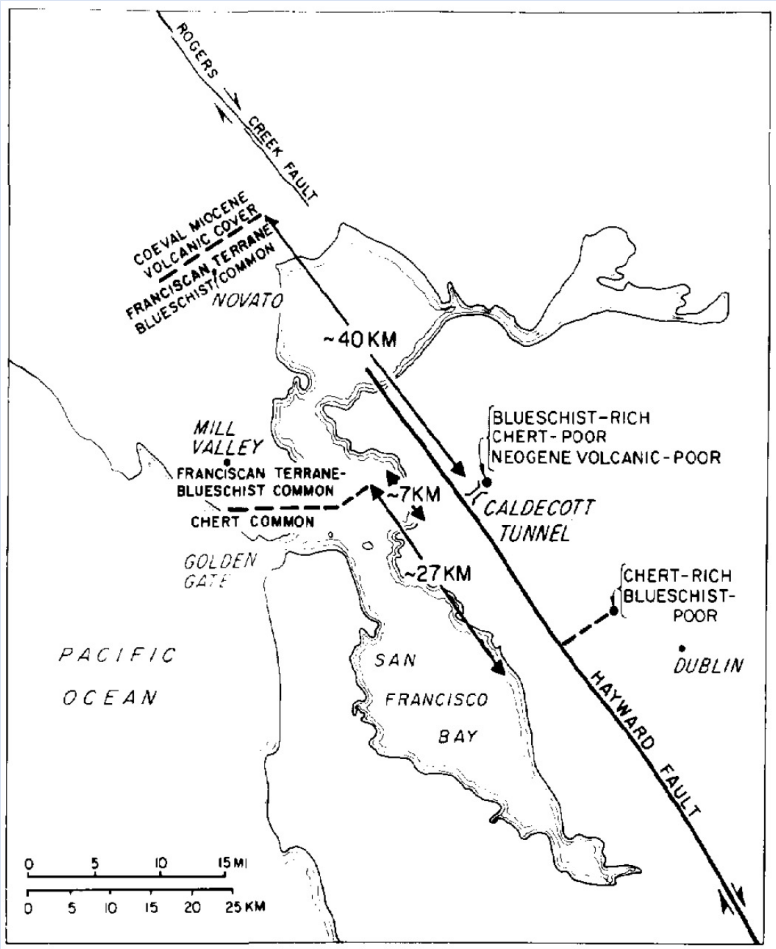
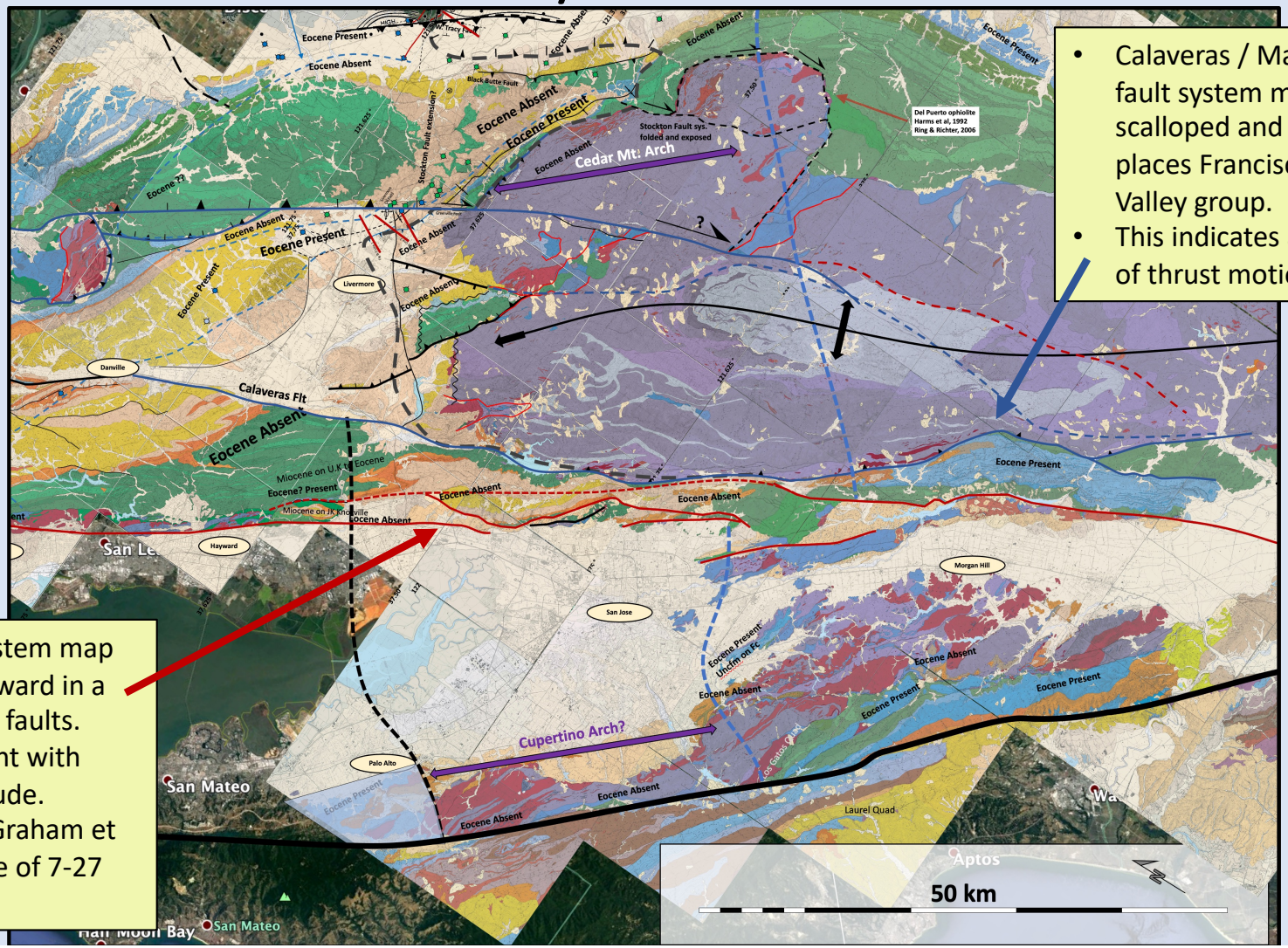


Figure 11—Orinda conglomerate compositions, source terrane relations, and constraints on right slip on Hayward fault. Simplified from Figure 2.

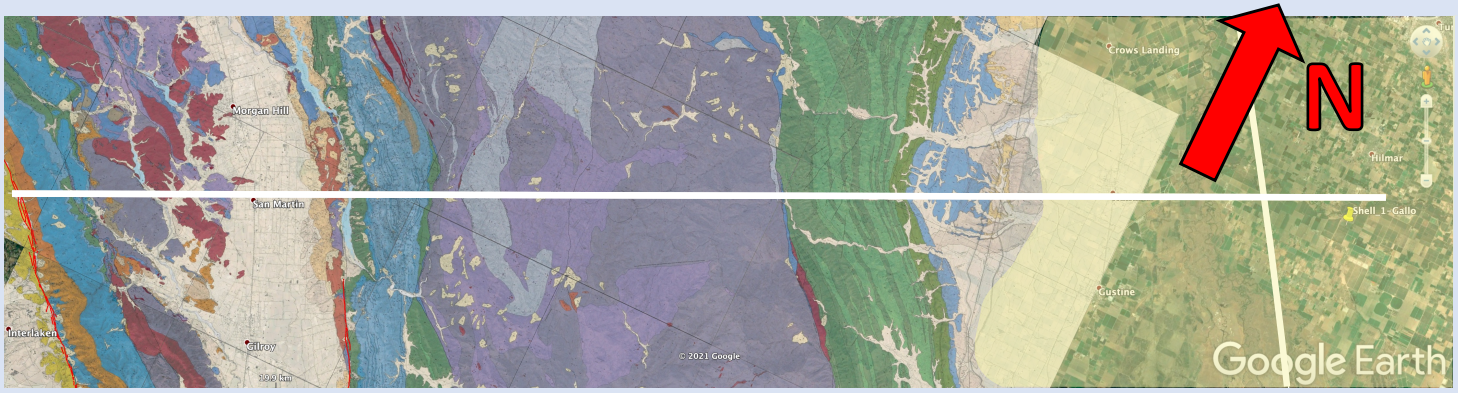
Calaveras and Hayward Fault Offsets

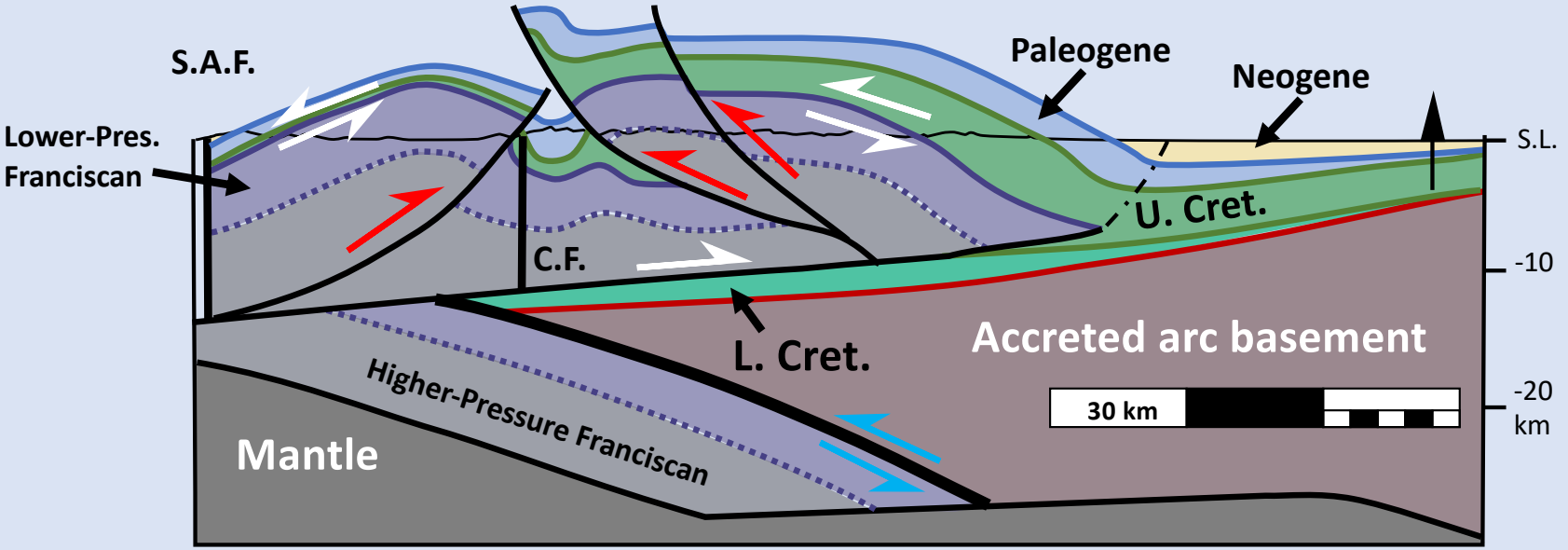


- Calaveras / Madrone Springs fault system map trace is scalloped and consistently places Franciscan against Great Valley group.
- This indicates a predominance of thrust motion.

- Hayward fault system map trace ends southward in a series of stepped faults.
- This is inconsistent with large slip magnitude.
- Consistent with Graham et al., 1984 estimate of 7-27 km

XS2. Newman San Martin Cross Section





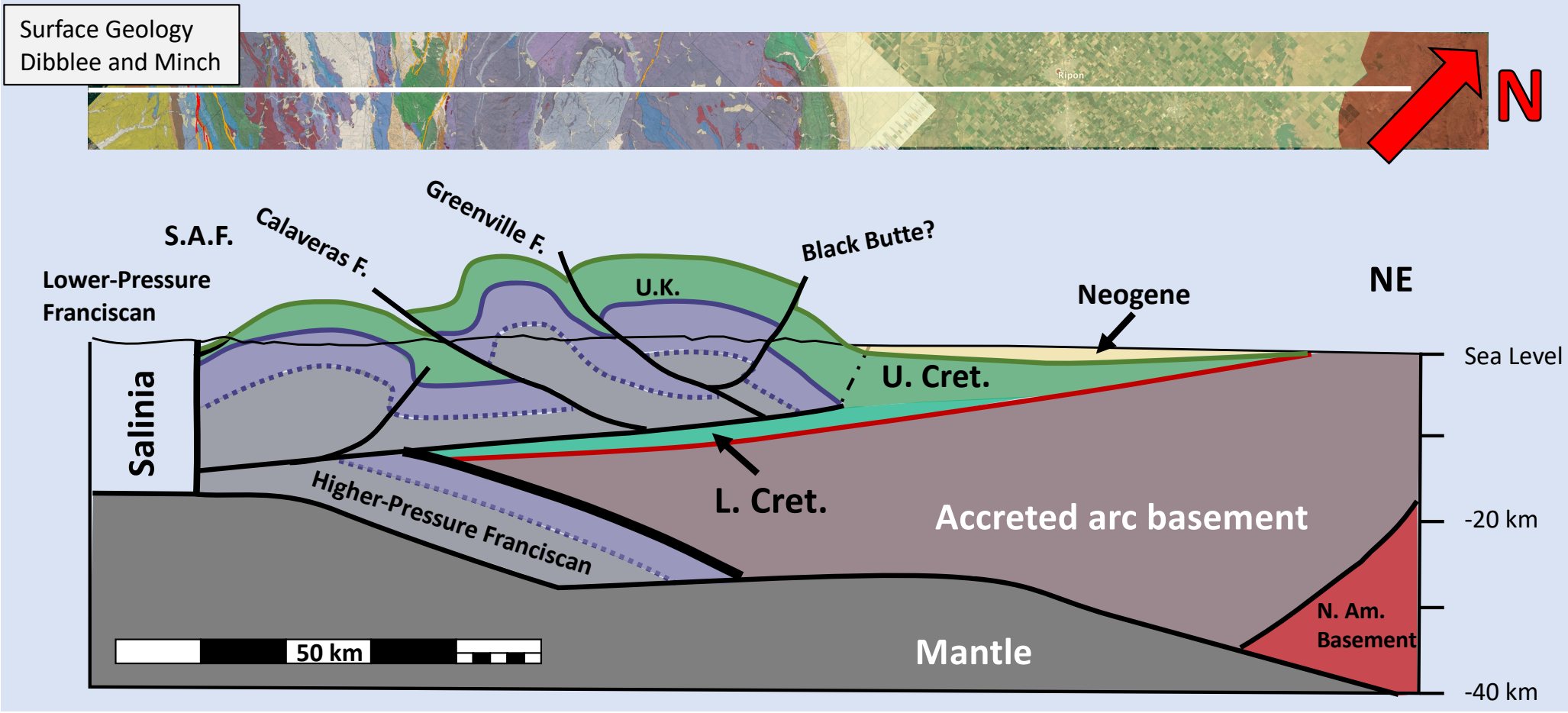
Principal tectonic association of thrust faults

Subduction

Franciscan emplacement

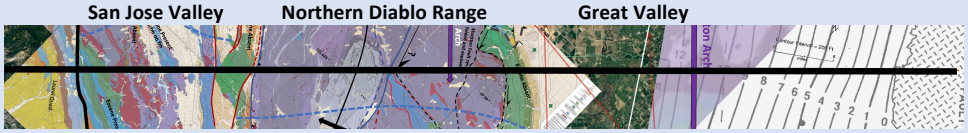
Late imbrication

XS3. Structural Transect of the Eastern Coast Ranges and adjacent Great Valley



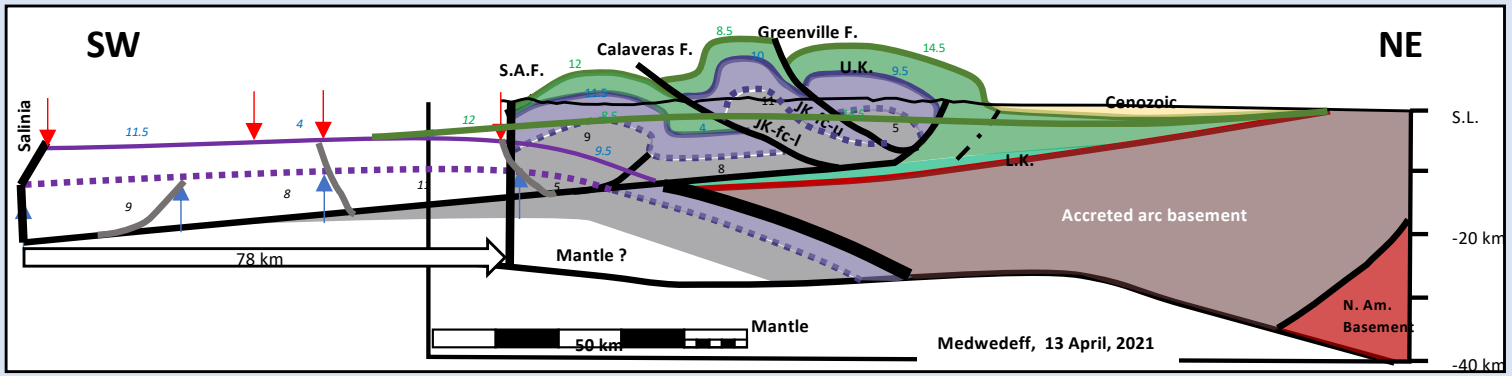
Geometric Restoration of the Structural Transect XS3

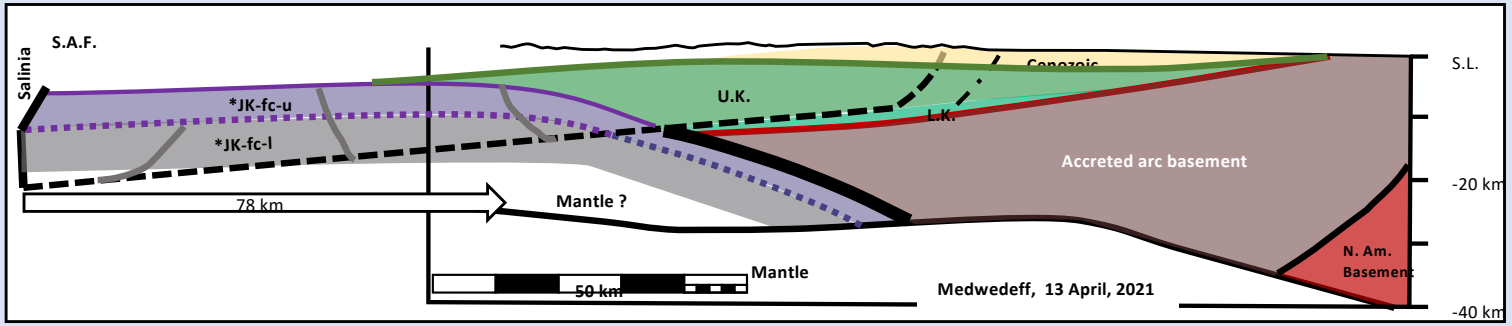
***Division of the Franciscan in to upper and lower units is intended only to illustrate late-stage sheet emplacement. It does not represent stratigraphic units.**



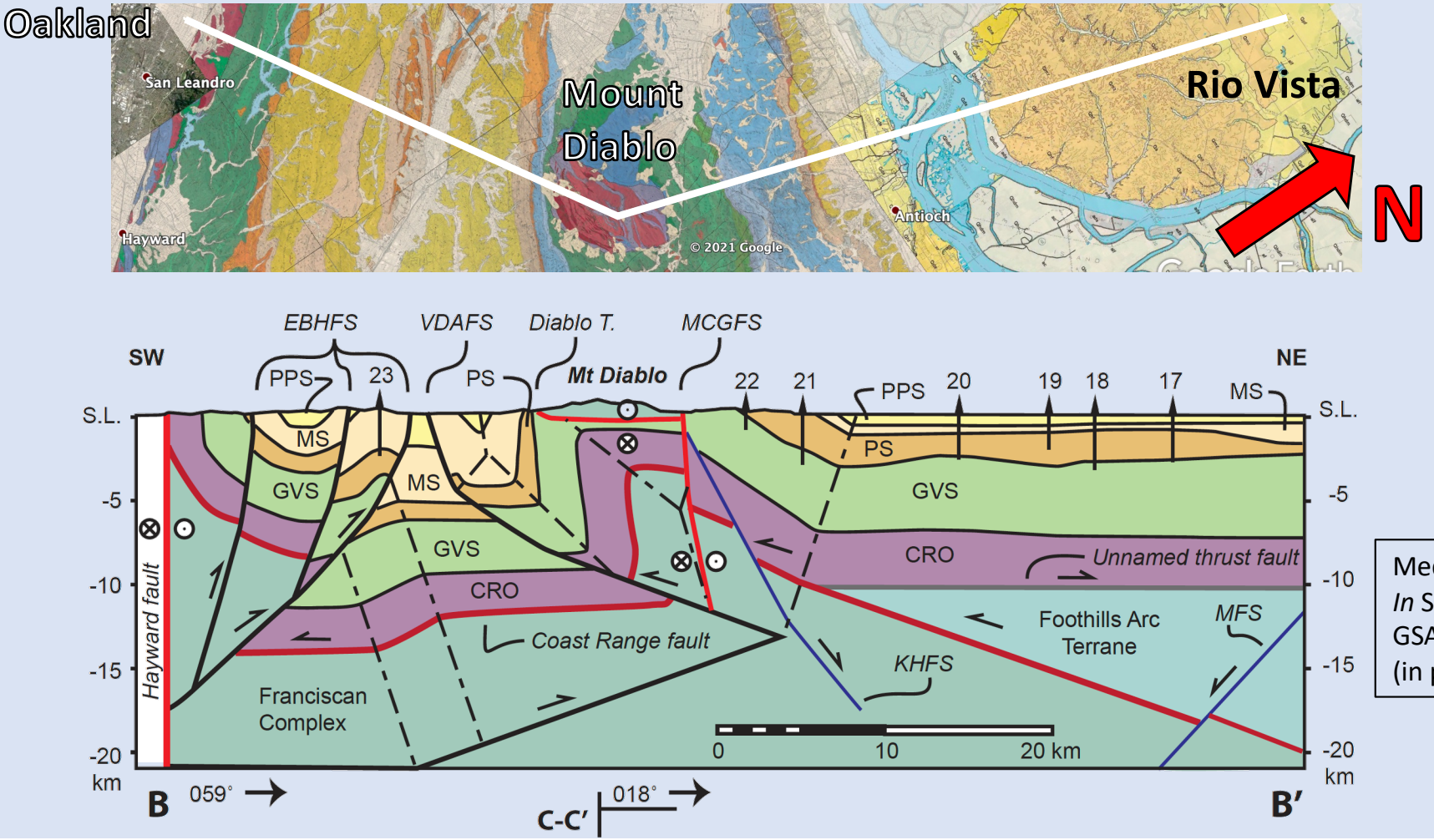
Surface Geology Maps, Dibblee and Minch, various dates

Basement Structure Map, Imperato, 1995





XS4. Structural Section from Oakland to Rio Vista



Medwedeff, 2021,
In Sullivan et al. (eds.),
GSA Memoir 217
(in press)

Summary

- Despite apparent dominance of strike-slip motion in historic earthquakes, **the geologic fabric and velocity structure of the East Bay Area is dominated by late Cretaceous and Tertiary extensional and compressional structures.**

- Thrust shortening is >75 km and thus greater than the <30 km of strike-slip motion.

- Vertical motions related to extension and shortening directly effects velocity-depth functions.

- Integration of regional data and kinematic models provide critical constraints on the geologic and velocity structure.

References

Dibblee, T.W., jr., and Minch, J.A., various pub dates, Geologic quadrangle maps of the California Coast Ranges, Dibblee, T.W., Jr., Dibblee Geological Foundation, Santa Barbara, California, Santa Barbara Museum of Natural History, scale 1:24,000.

Graham, S. A., C. McCloy, M. Hitzman, R. Ward, and R. Turner. "Basin evolution during change from convergent to transform continental margin in central California." AAPG bulletin 68, no. 3 (1984): 233-249.

Graymer, R.W., Sarna-Wojcicki, A.M., Walker, J.P., McLaughlin, R.J., and Fleck, R.J., 2002, Controls on timing and amount of right-lateral offset on the East Bay fault system, San Francisco Bay region, California: Geological Society of America Bulletin, v. 114, no. 12, p. 1471–1479, https://doi.org/10.1130/0016-7606(2002)114<1471:COTAAO>2.0.CO;2.

Graymer, R.W., Moring, B.C., Saucedo, G.J., Wentworth, C.M., Brabb, E.E., and Knudsen, K.L., 2006, Geologic Map of the San Francisco Bay Region: U.S. Geological Survey Scientific Investigations Map 2918, scale 1:275,000, https://doi.org/10.3133/sim2918.

Imperato, D.P., 1995. Studies of the stratigraphy and structure of the Great Valley of California and implications for plate tectonics: Volume One. Subduction-related deformation of the central Great Valley forearc basin. Volume Two. Neogene shortening of the remnant Great Valley forearc basin, southwestern San Joaquin Valley (Doctoral dissertation, University of California, Santa Barbara).

Medwedeff, D.A., 2021, Interaction of extensional, contractional, and strike-slip elements at Mount Diablo and the surrounding eastern Coast Ranges, San Francisco Bay area, California: A model-based analysis, in Sullivan, R., Sloan, D., Unruh, J.R., and Schwartz, D.P., eds., Regional Geology of Mount Diablo, California: Its Tectonic Evolution on the North America Plate Boundary: Geological Society of America Memoir 217, p. 1–22, https://doi.org/10.1130/2021.1217(08).

Ponce, D.A., Simpson, R.W., Graymer, R.W. and Jachens, R.C., 2004. Gravity, magnetic, and high-precision relocated seismicity profiles suggest a connection between the Hayward and Calaveras faults, northern California. Geochemistry, Geophysics, Geosystems, 5(7).

Wight, L. G., 1974, A Geological and Seismological Investigation of the Lawrence Livermore Laboratory Site, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-51592.