San Gorgonio Pass structure as modeled by potential-field data

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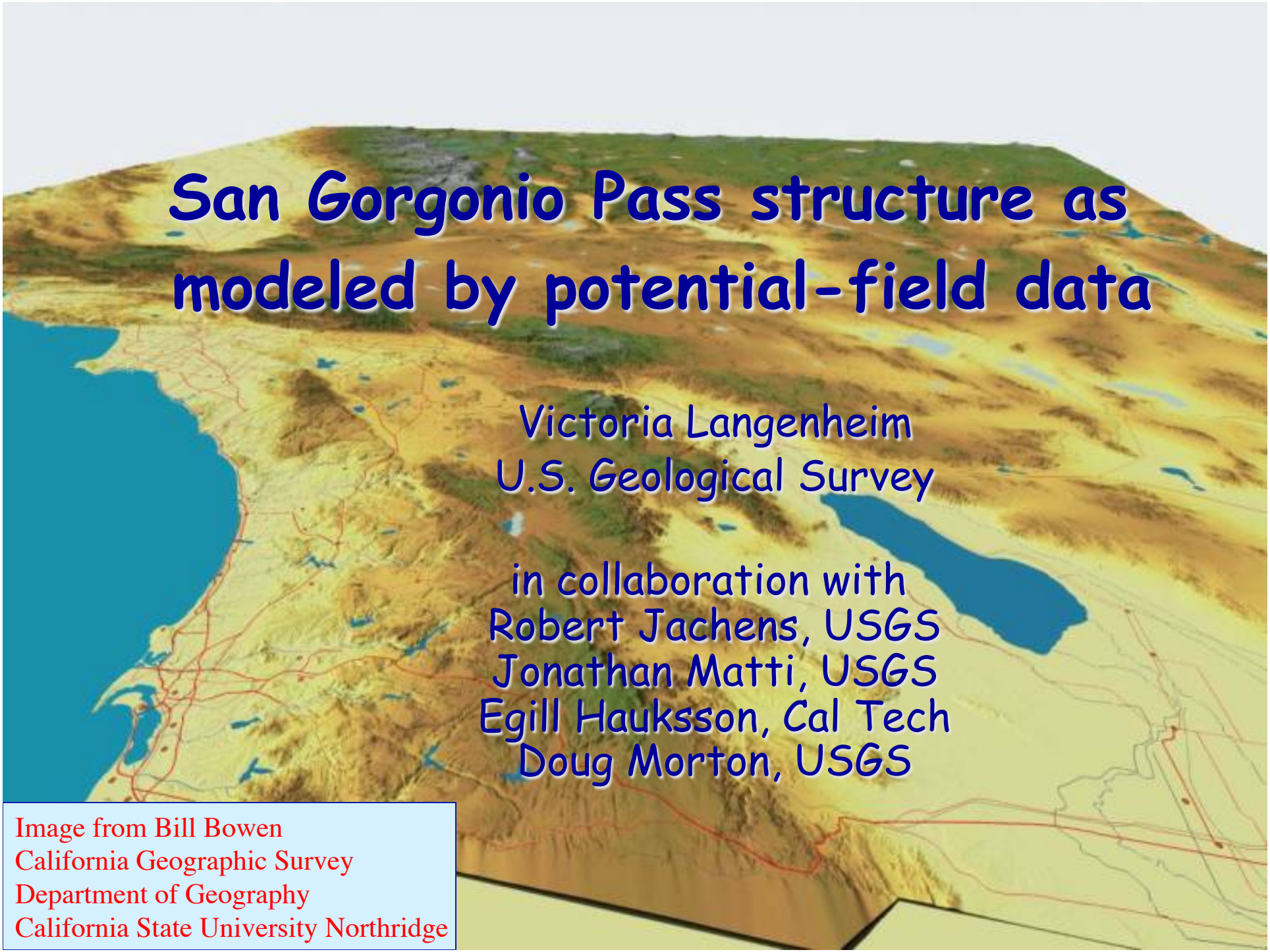
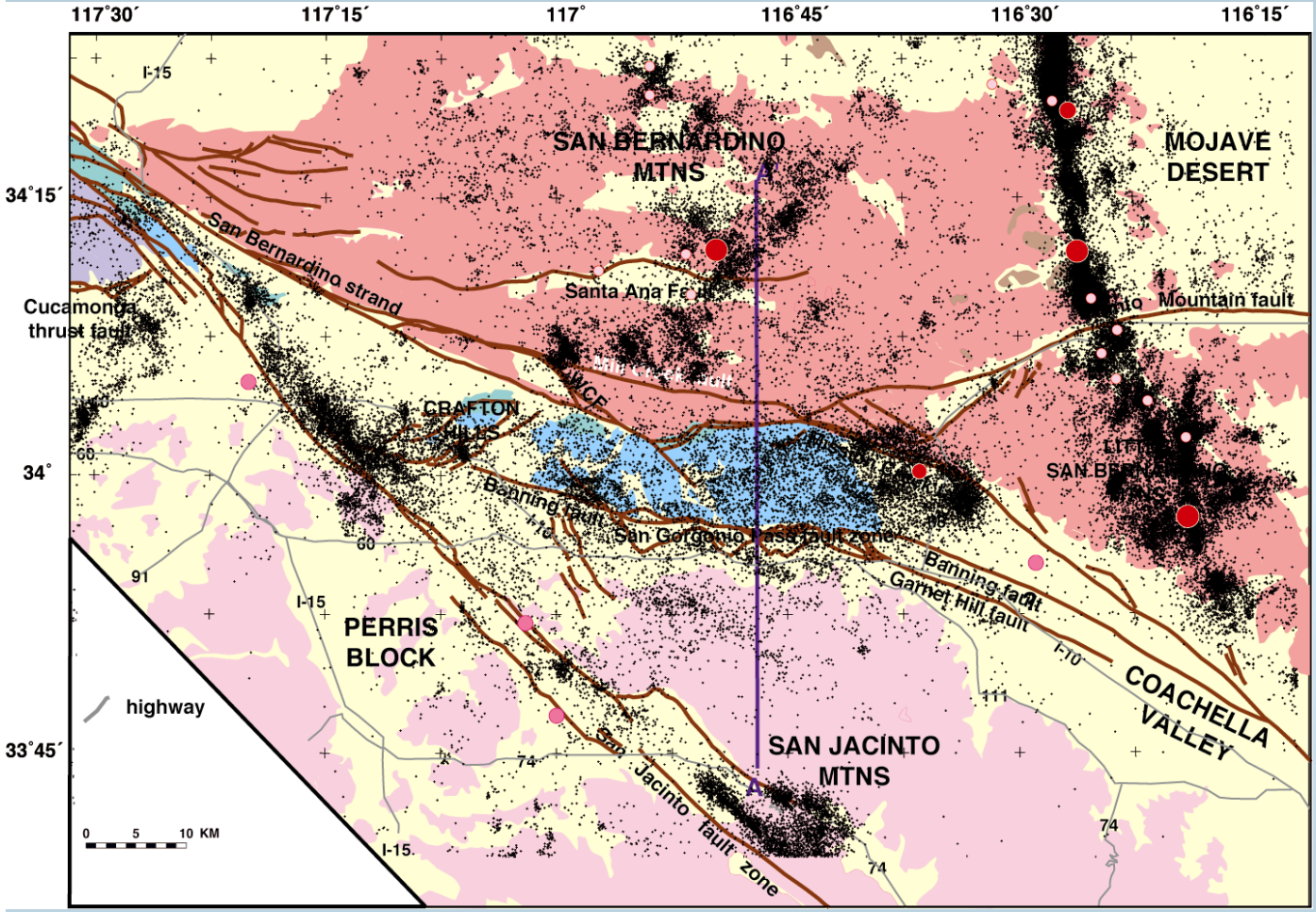


Image from Bill Bowen
California Geographic Survey
Department of Geography
California State University Northridge

Seismicity 1981-2000



Is the San Andreas fault throughgoing in San Gorgonio Pass?

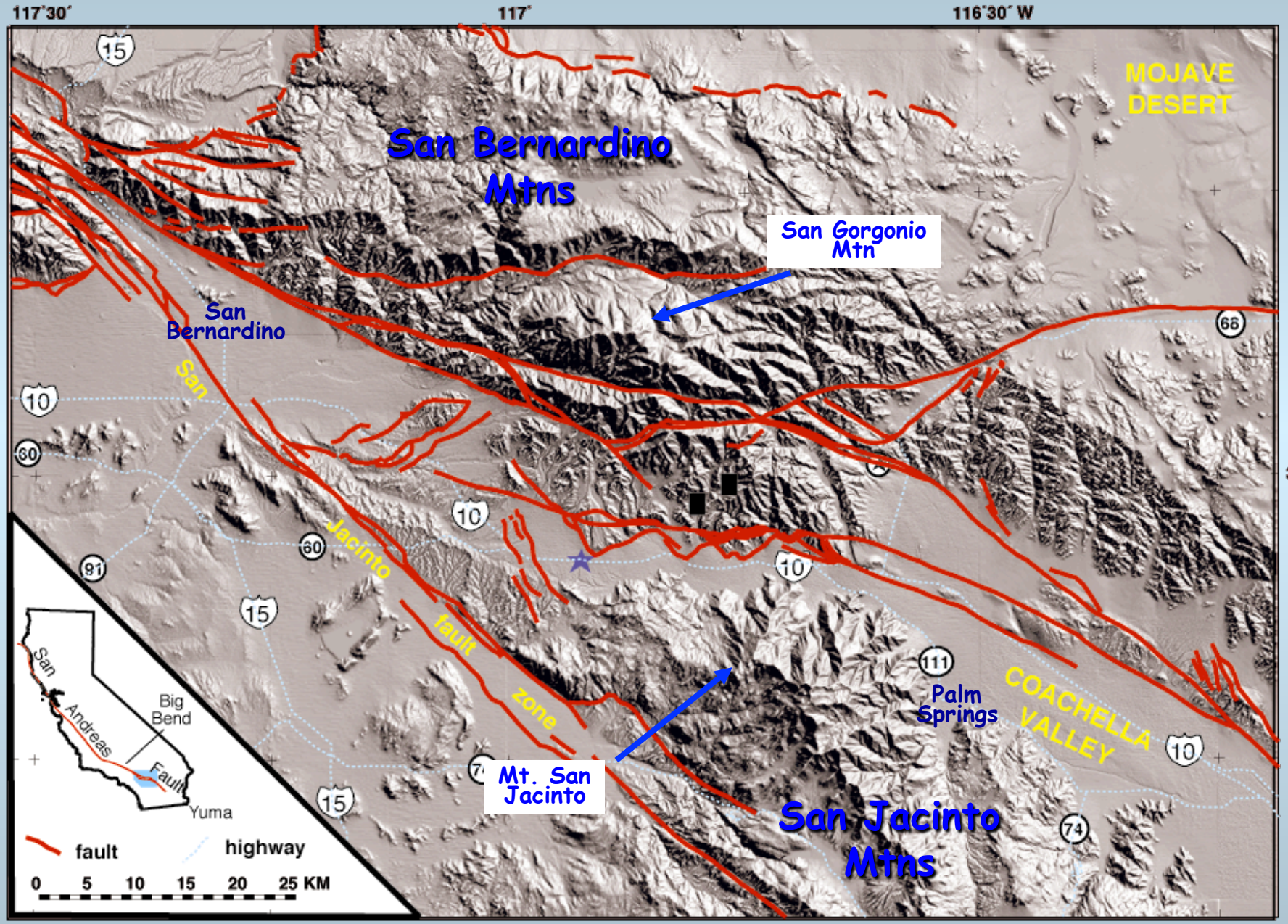
What happens at depth as these fault strands evolved?

Earthquake locations from Hauksson (2000)

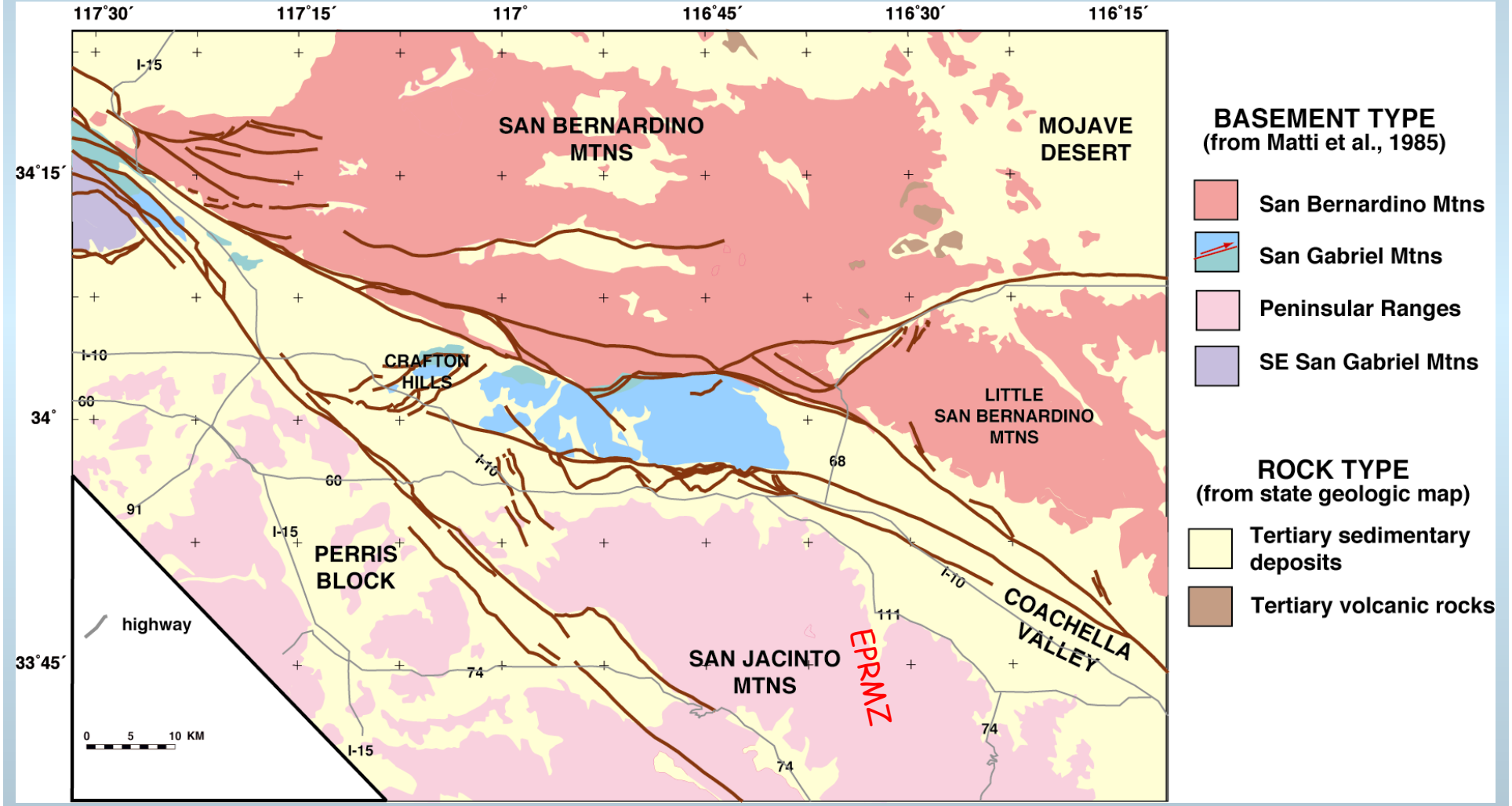
Seismicity Studies

Sykes and Seeber, 1985; Nicholson et al., 1986, 1996; Seeber and Armbruster, 1995; Carena and Suppe, 2004

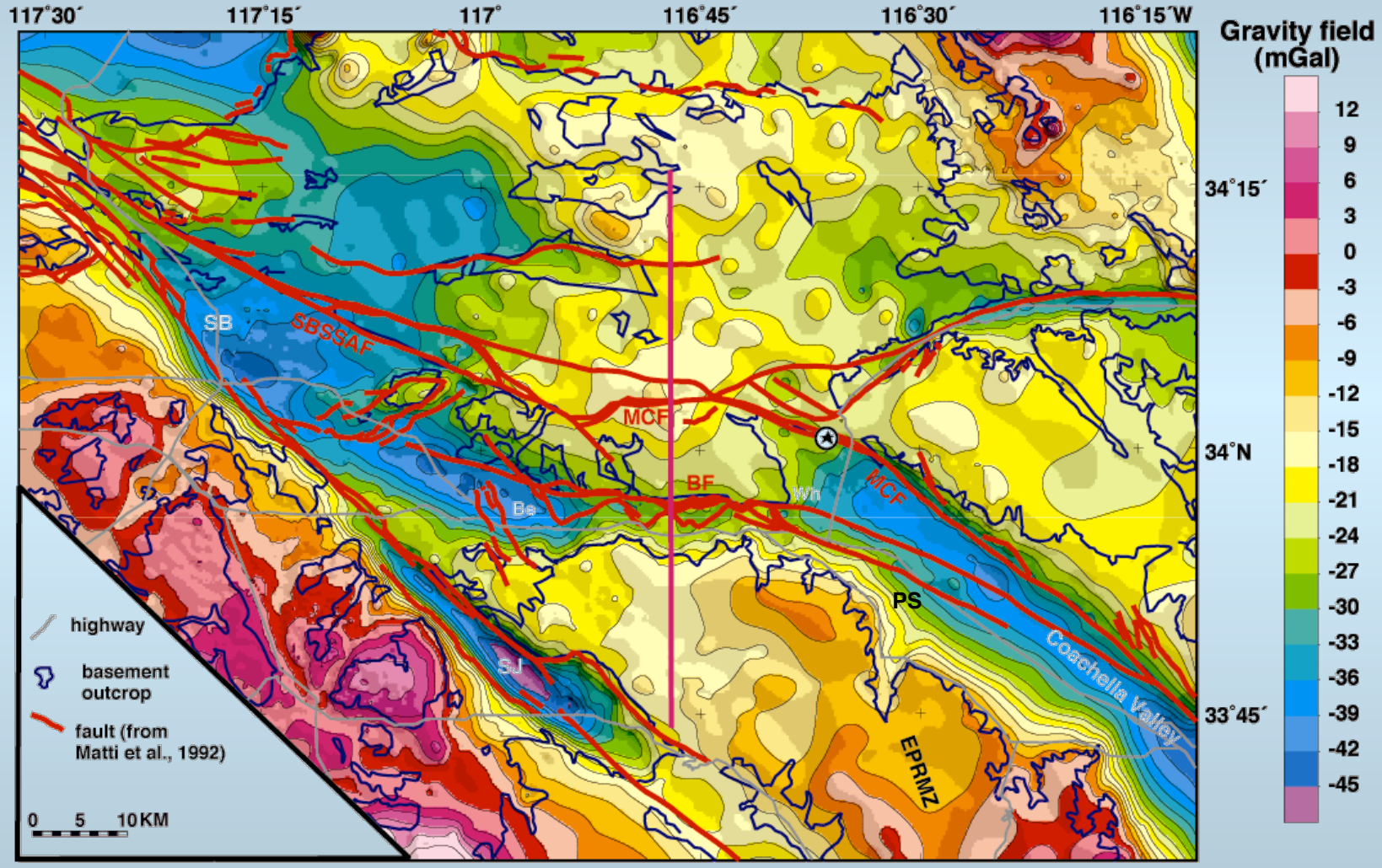
Shaded-relief Topography



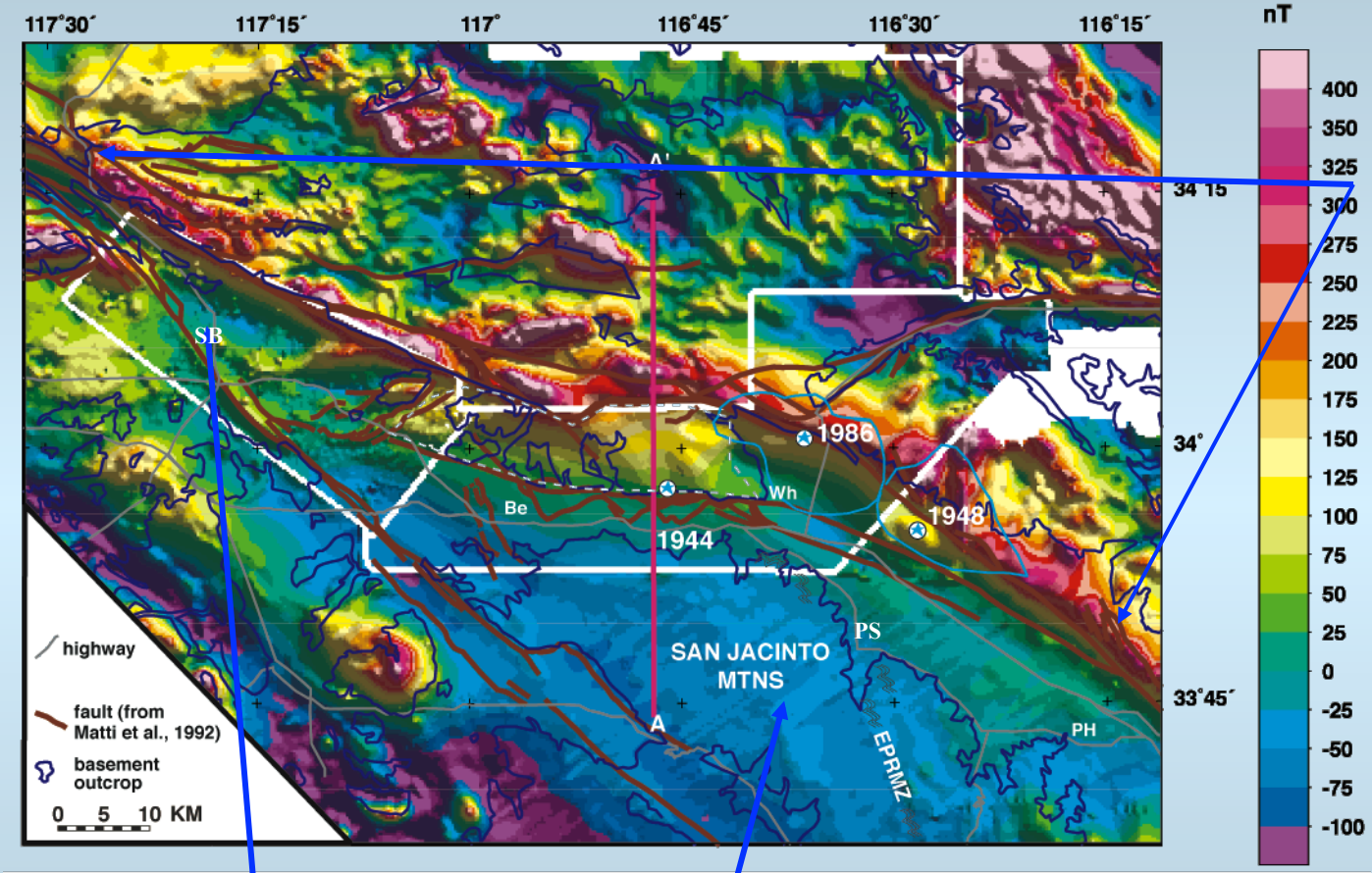
Geology indicates basement terranes juxtaposed by strike-slip faults of the San Andreas system



Isostatic Residual Gravity Map of San Gorgonio Pass



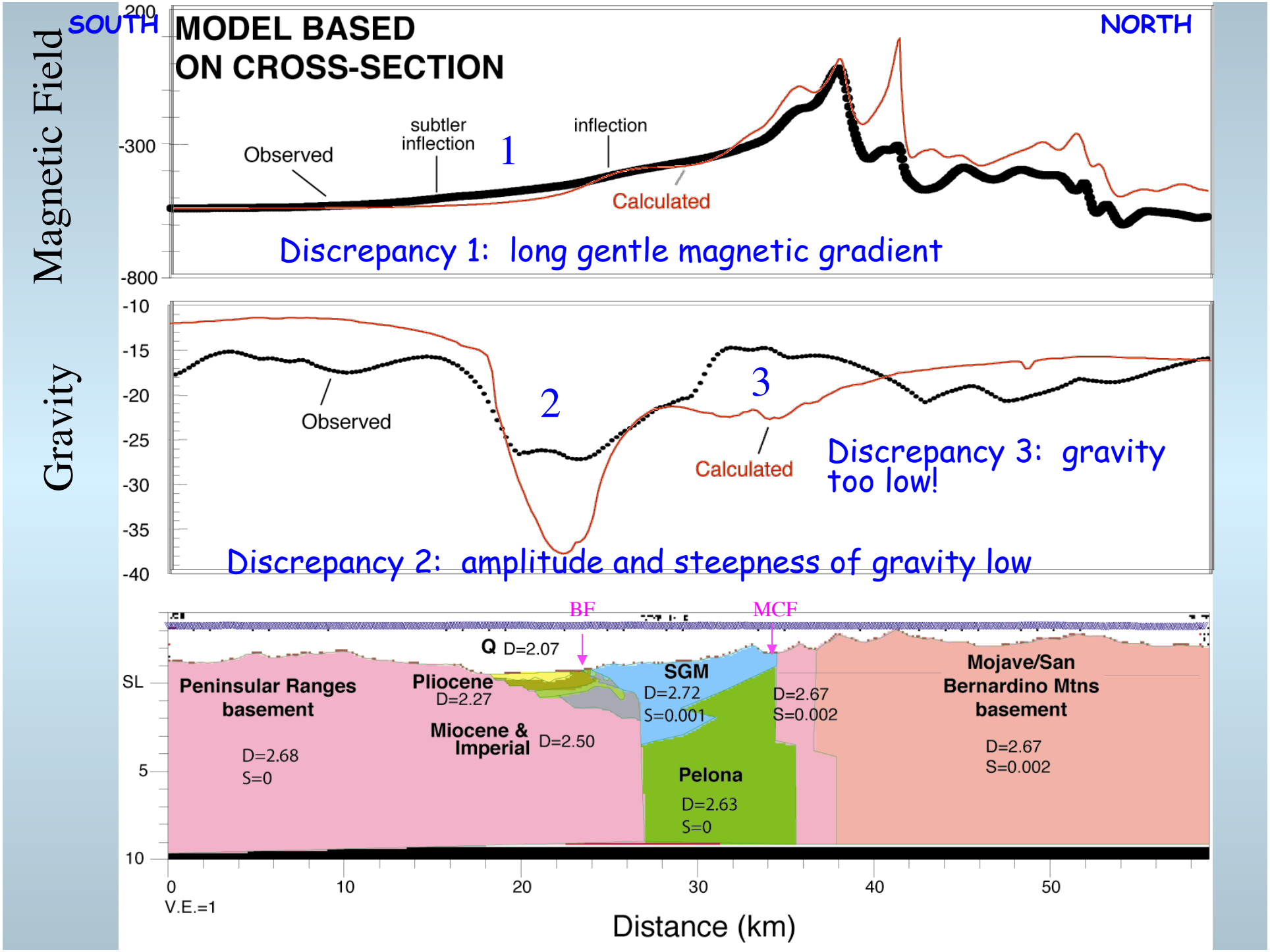
Aeromagnetic Map of San Gorgonio Pass



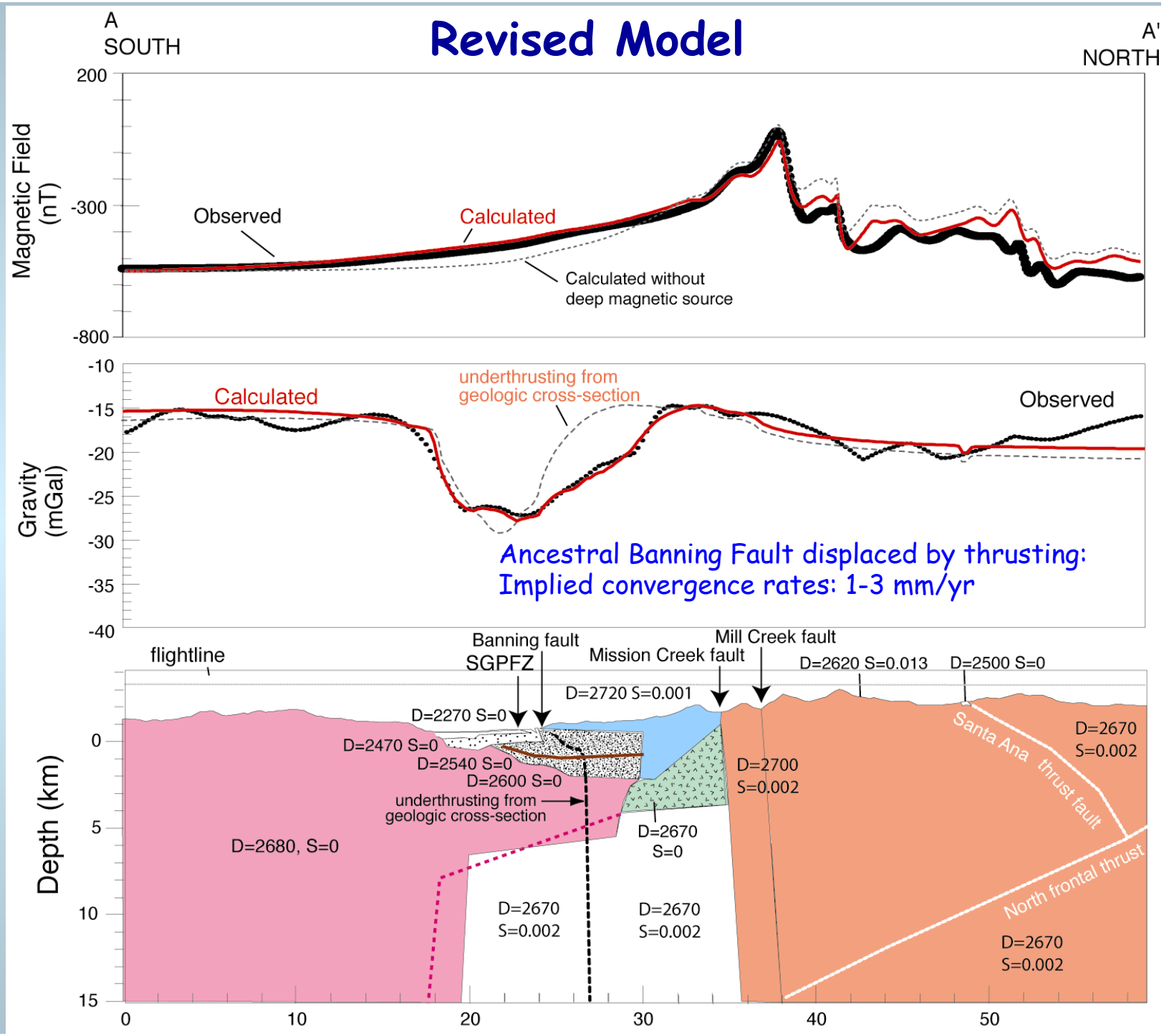
Long-term strand of SAF marked by prominent magnetic anomalies San Bernardino Mtns basement

Pelona Schist and Eastern Peninsular Ranges marked by low magnetic values

Western Peninsular Ranges, upper-plate San Gabriel Mtns moderate anomalies


Magnetic Field
SOUTH
MODEL BASED
ON CROSS-SECTION
NORTH
200
-300
-800
Observed
subtler
inflection
1
inflection
Calculated
Discrepancy 1: long gentle magnetic gradient
Gravity
-10
-15
-20
-25
-30
-35
-40
Observed
2
3
Calculated
Discrepancy 3: gravity
too low!
Discrepancy 2: amplitude and steepness of gravity low
BF
MCF
Q D=2.07
SGM
D=2.72
S=0.001
D=2.67
S=0.002
Peninsular Ranges
basement
D=2.68
S=0
Pliocene
D=2.27
Miocene &
Imperial
D=2.50
Pelona
D=2.63
S=0
Mojave/San
Bernardino Mtns
basement
D=2.67
S=0.002
SL
5
10
0
10
20
30
40
50
V.E.=1
Distance (km)

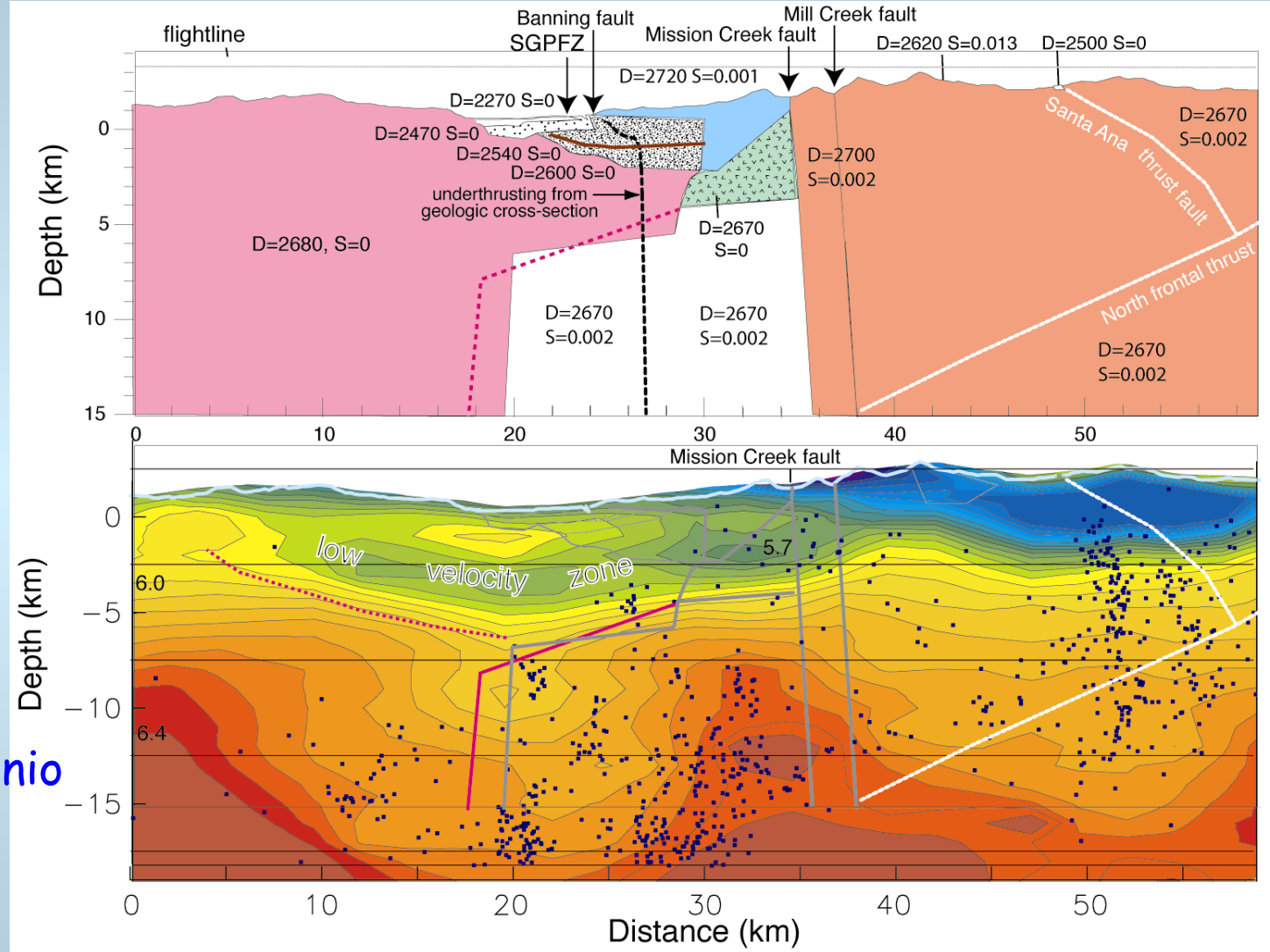
Revised Model



What are the deep magnetic rocks?--seismic velocity constraints?

No really exotic rocks beneath the Pass

Consistent with palinspastic reconstructions indicating same basement types as exposed in and around San Gorgonio Pass



Slice from seismic velocity model

What are the deep magnetic rocks?

Possible candidates

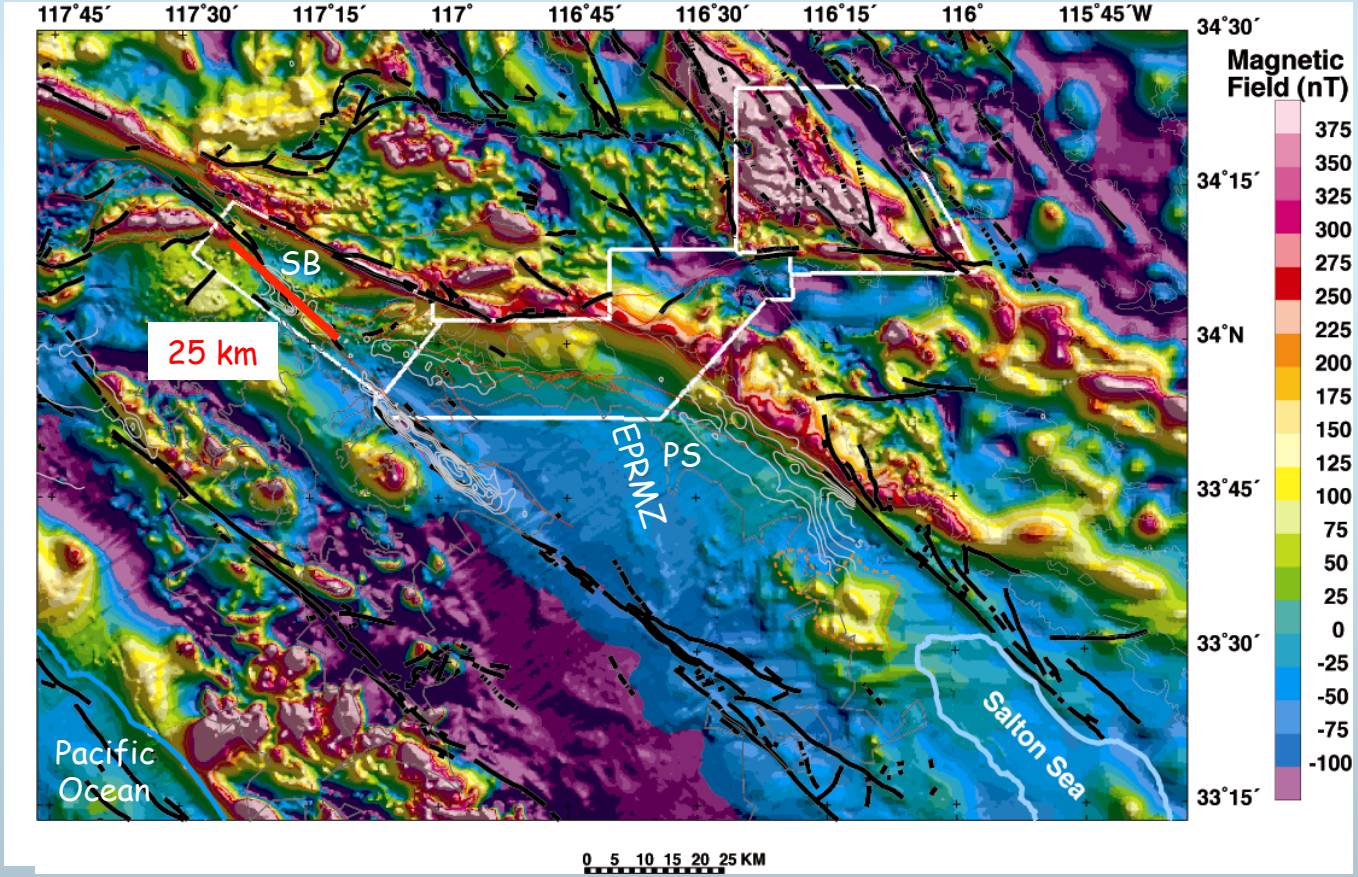
~~1) Peninsular Ranges~~

2) upper-plate San Gabriel Mts

3) San Bernardino Mtns

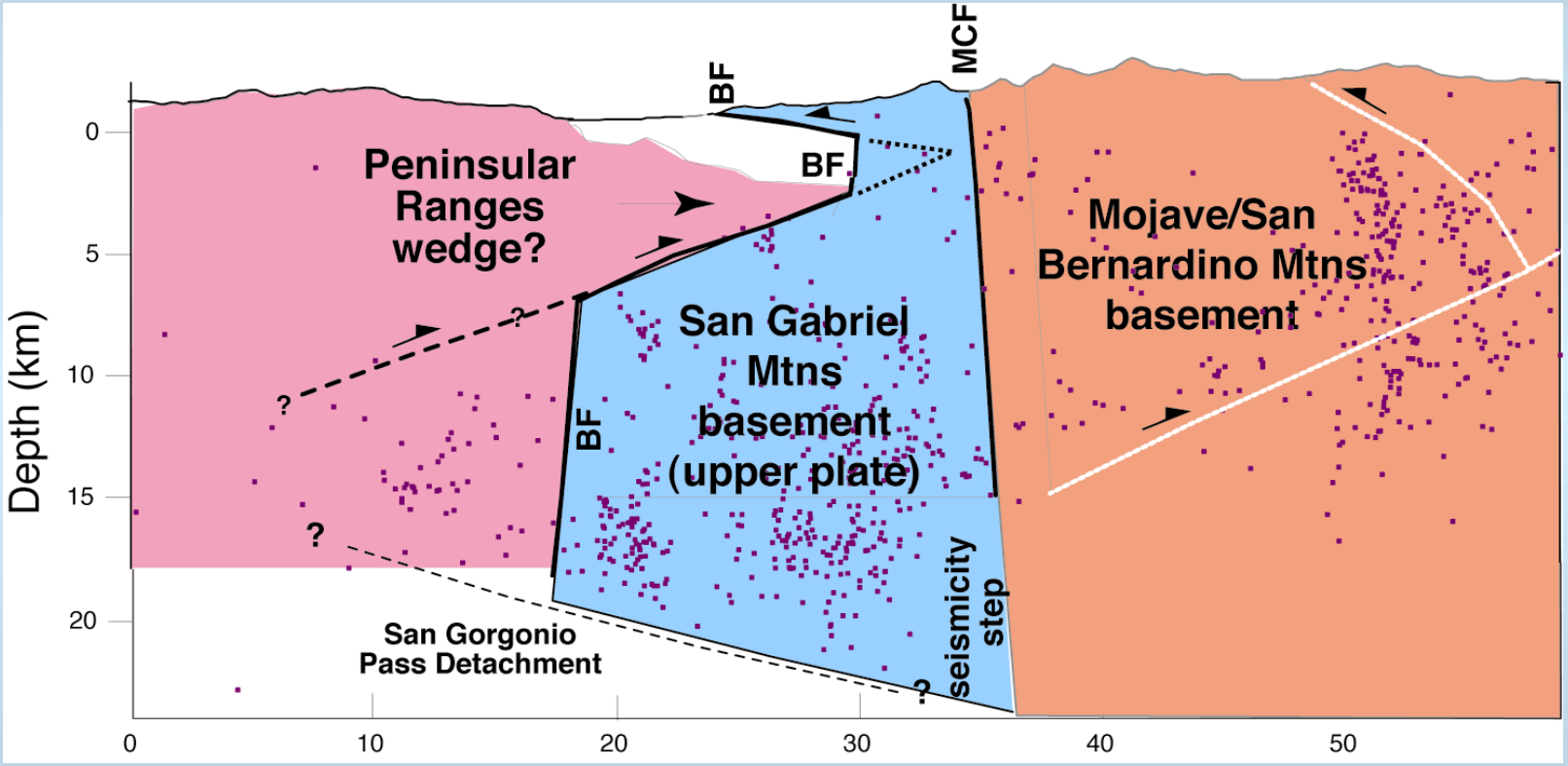
(1) Can't trace SE SGM magnetic anomaly across the San Jacinto Fault

(2) EPRMZ is not magnetic and dips north, not south



Deep Magnetic Rocks = wedging of Transverse Ranges basement beneath Peninsular Ranges basement!

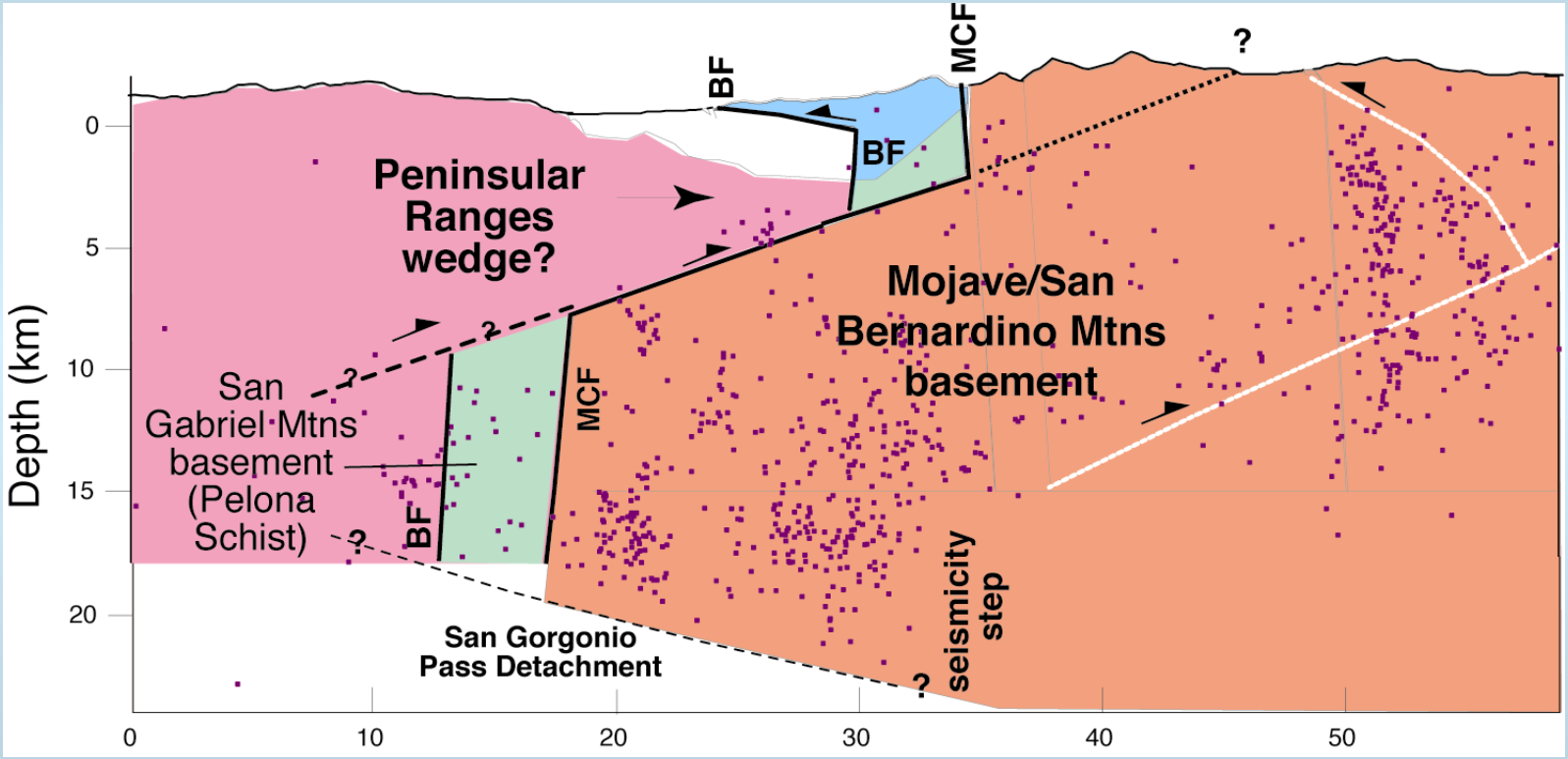
If deep magnetic rocks are San Gabriel Mtns---



Wedging occurred after cessation of slip on ancestral Banning Fault 5 Ma
Average convergence rate = 2-3 mm/yr

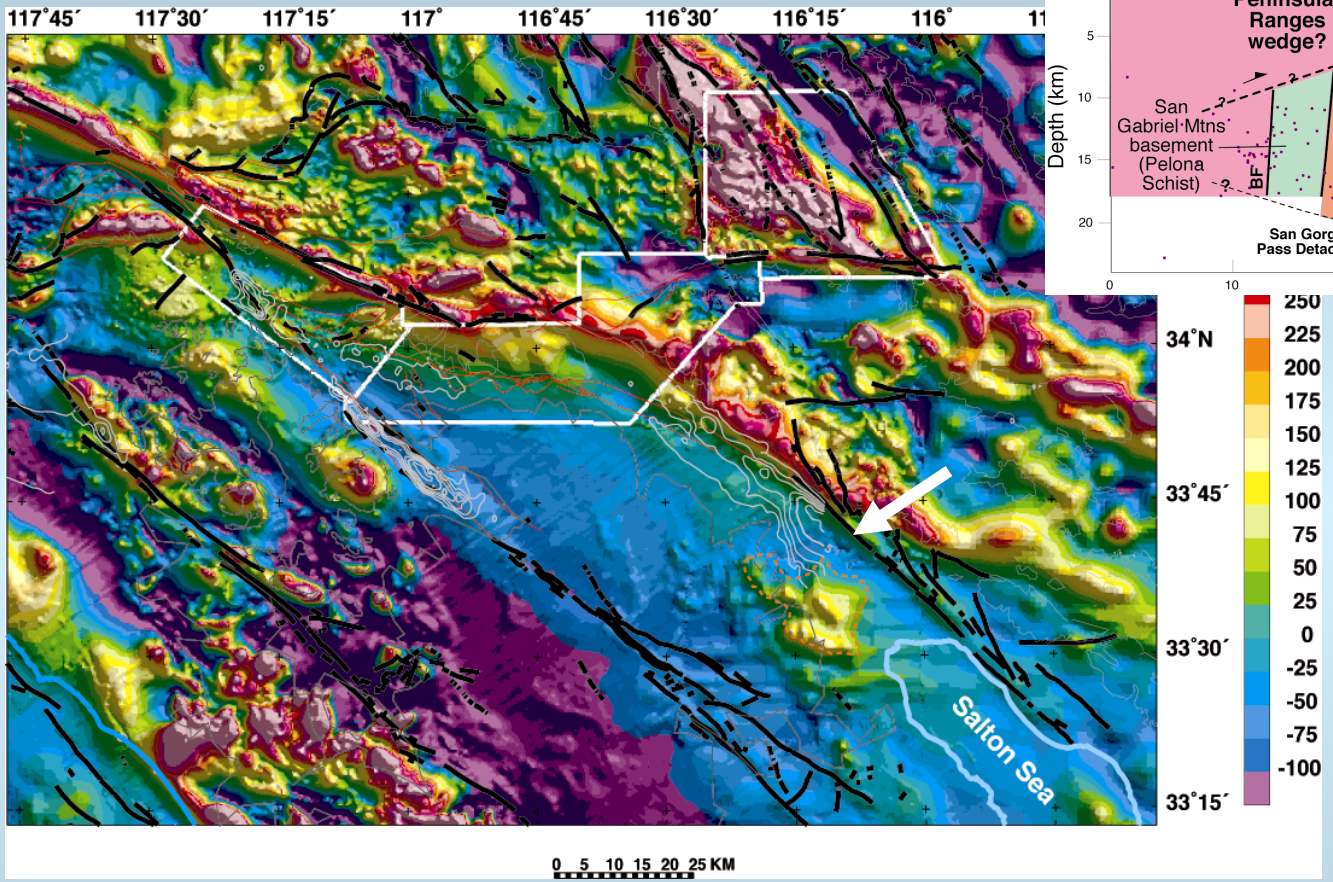
Deep Magnetic Rocks = wedging of Transverse Ranges basement beneath Peninsular Ranges basement!

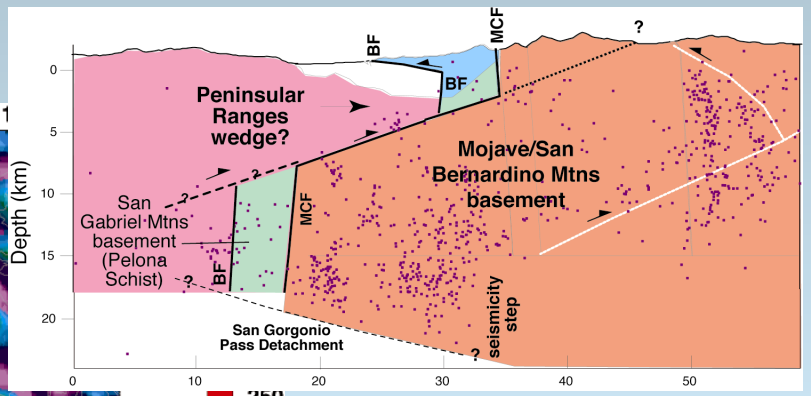
If deep magnetic rocks are San Bernardino Mtns---



Wedging occurred after cessation of slip of Mission Creek Fault 1.5 Ma
Average convergence rate = 11-12 mm/yr OR

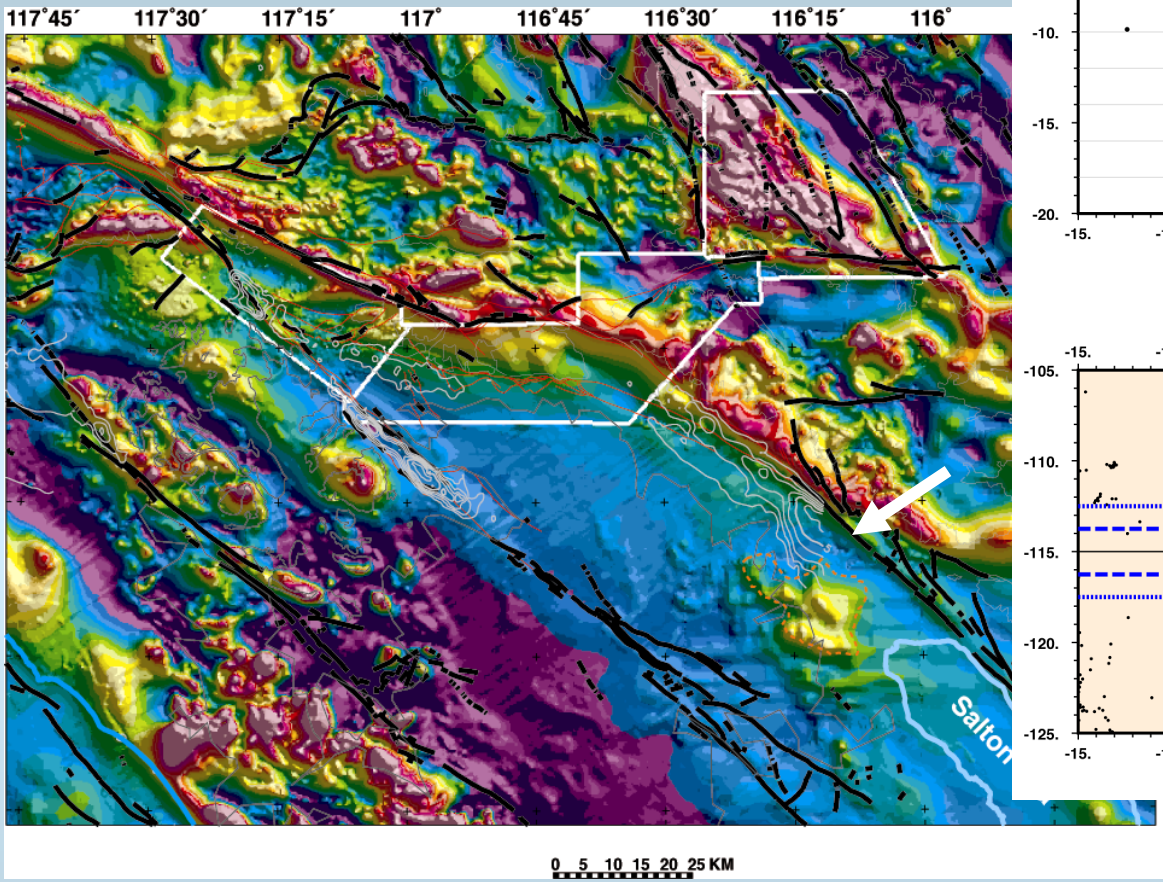
If deep magnetic rocks are San Bernardino Mtns---

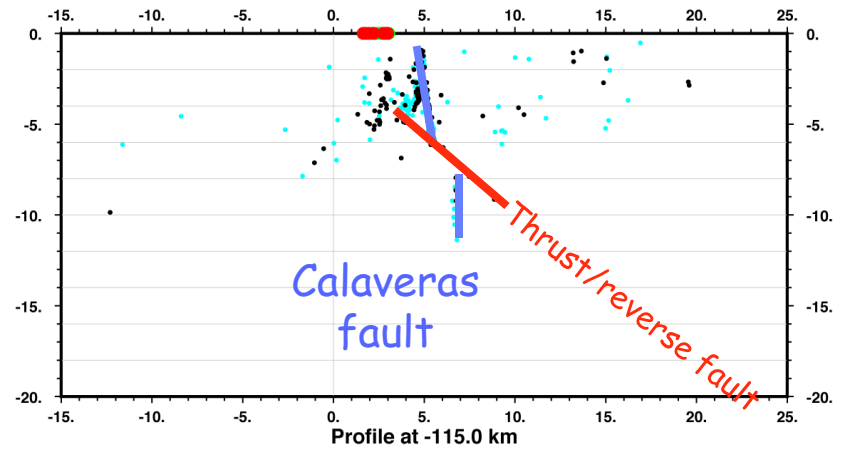




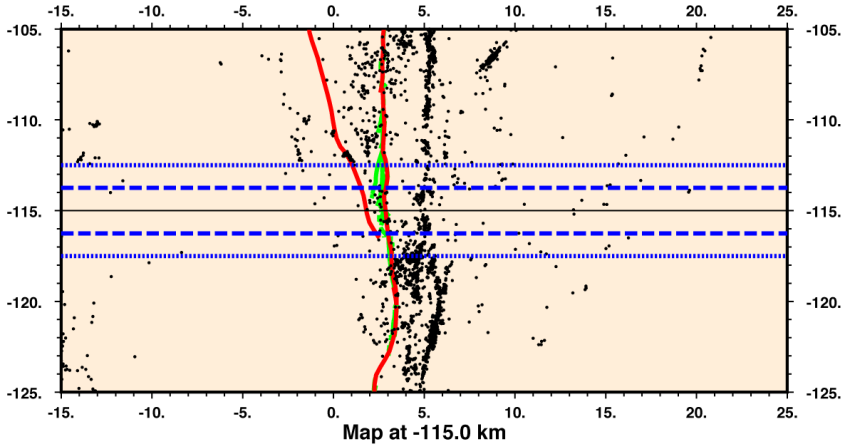
Wedging occurred after 2.5 to 3 Ma otherwise no magnetic rocks available on NE side of fault

If deep magnetic rocks are San Bernardino Mtns---





From Simpson et al. 2004

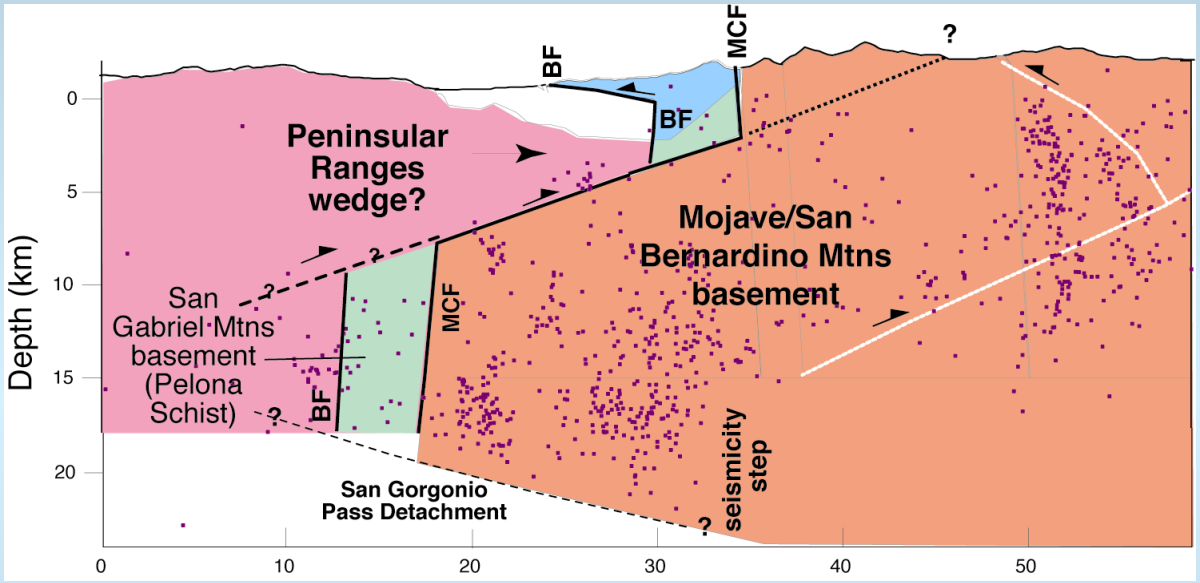


Wedging occurred after 2.5 to 3 Ma otherwise no magnetic rocks available on NE side of fault

Average convergence rate = 5-7 mm/yr

We've ignored isostasy and thus may overestimate uplift rate by a factor of 7!

Shallow marine Imperial Formation exposed in SGP at 700 m elevation



Depression of base of seismicity = thickness of Peninsular Ranges wedge

The amount of SURFACE UPLIFT is 800 m if Peninsular Ranges wedge (6 km thick) is isostatically compensated

Conclusions from San Gorgonio Pass gravity & magnetic modeling:

Magnetic rocks beneath the Pass are out of place and imply wedging of Transverse Ranges rocks beneath Peninsular Ranges rocks—is this occurring today?

Unraveling the structural knot means vertical as well as horizontal displacement—can GPS/landscape tell us rates?

Complicated structure suggests that a rupture of the San Andreas Fault through SGP will be complex—can we account for all the slip via trench studies across one or two strands?

3-D complicated structure implies fault reorganization not only within restraining bend but also OUTSIDE bend…
Do we need to look beyond the knot?