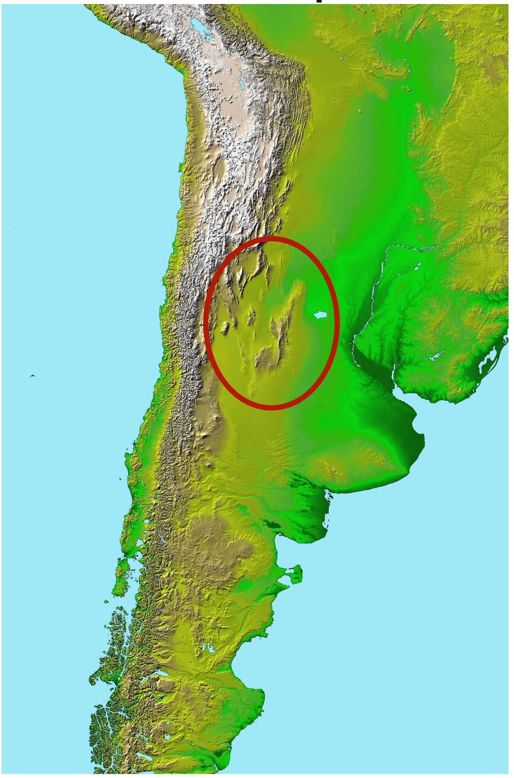
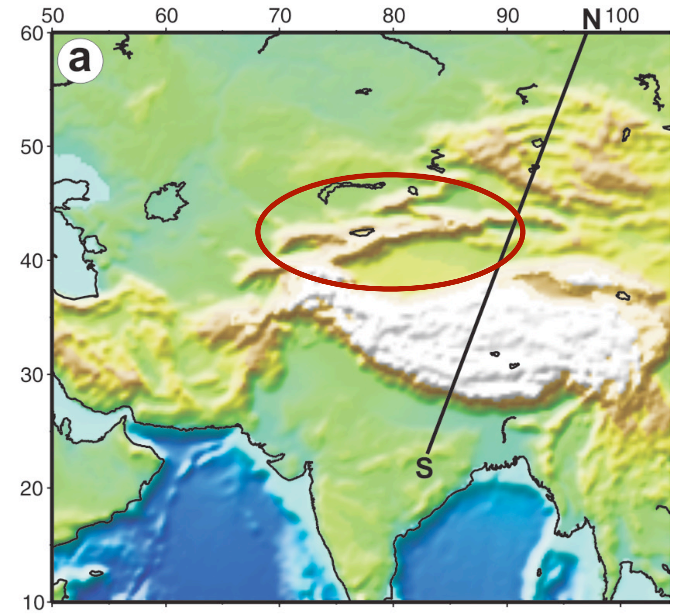
Laramide analogs

Sierras Pampeanas



"Flat slab" models

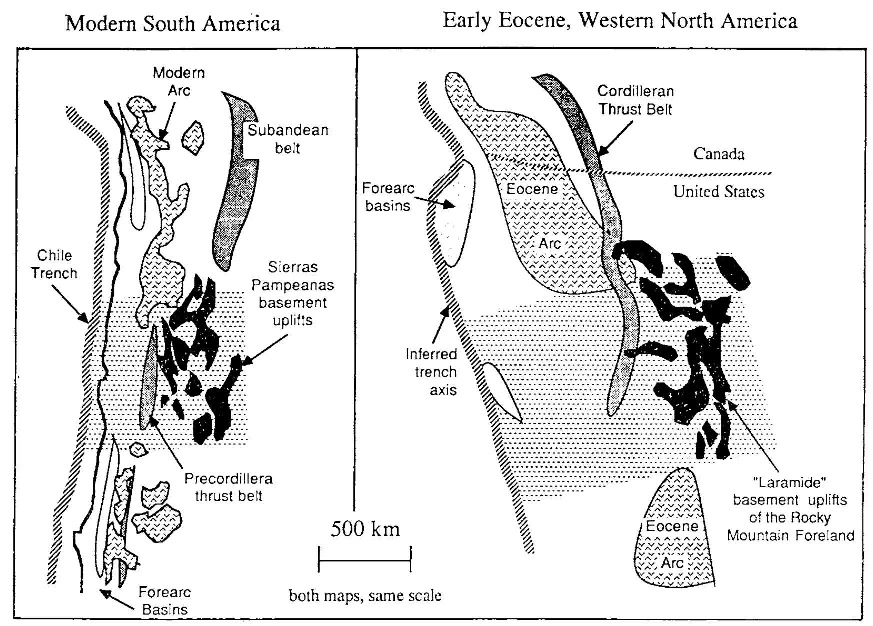
Tien Shan



Jiménez-Munt and Platt, Tectonics, 2006

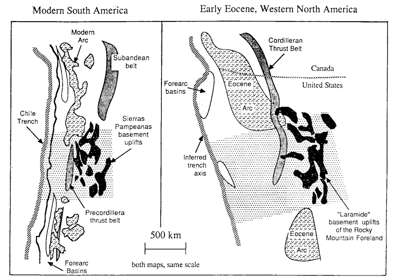
Collision and "orogenic collapse" models

Sierra Pampeanas as an analog
Behind missing arc



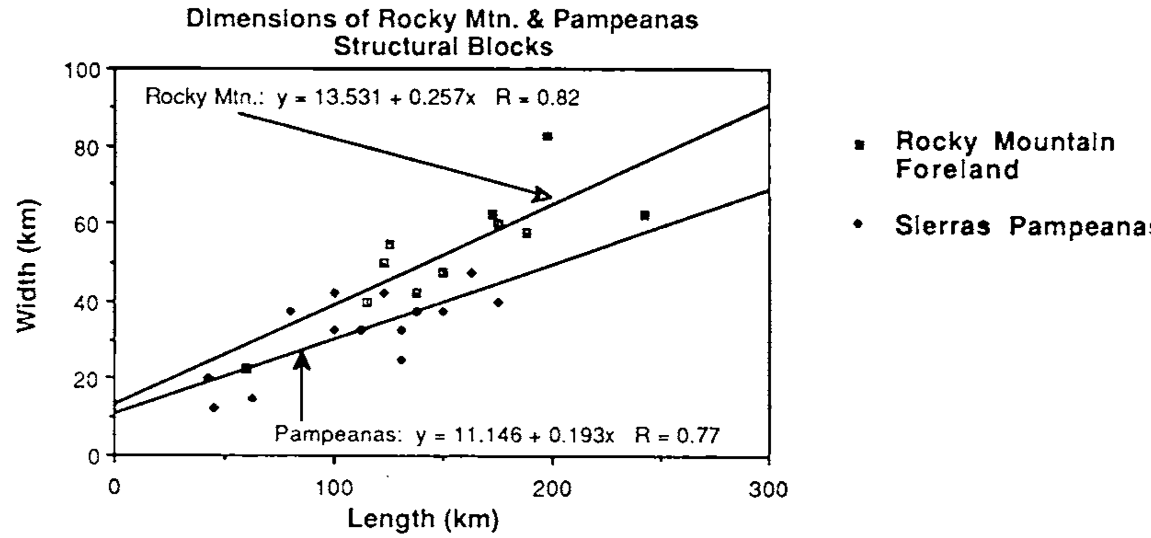
Jordan & Allmendinger, Am. J. Sci., 1986

So what of this analog? Style of deformation is similar, but is that reflective of driving force or simply the way that kind of crust shortens?



Sierra Pampeanas as an analog

Similar structural style

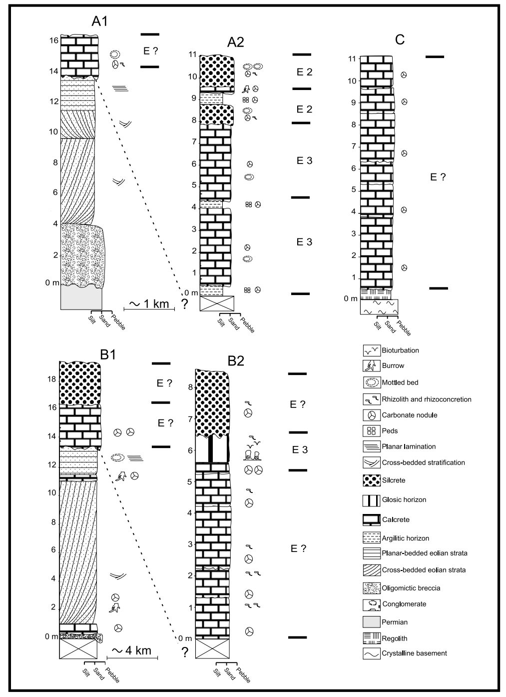


B.

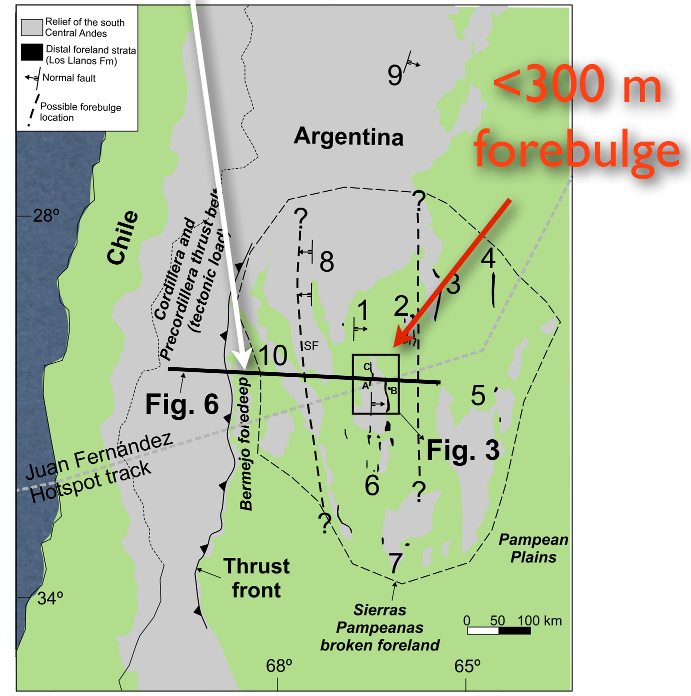
Jordan & Allmendinger, Am. J. Sci., 1986

Sierra Pampeanas differences

Miocene sediments



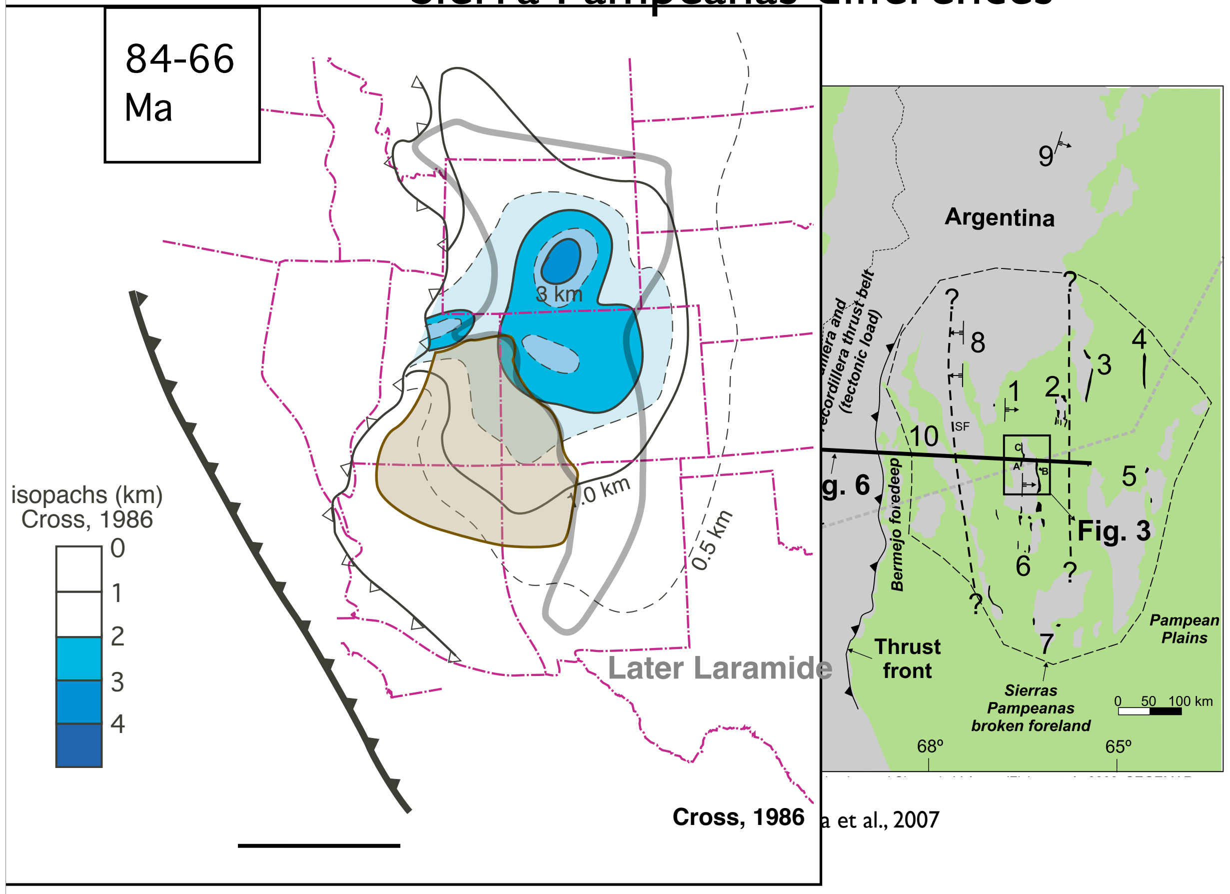
10 km foredeep



Dávila et al., Tectonics, 2007

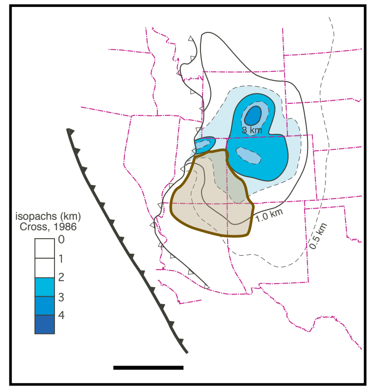
What of pre-shortening sedimentation? In Pampeanas, most sections only a few 10s of meters; up to maybe 300m in some wells. There is a ~10km deep foredeep to the west...

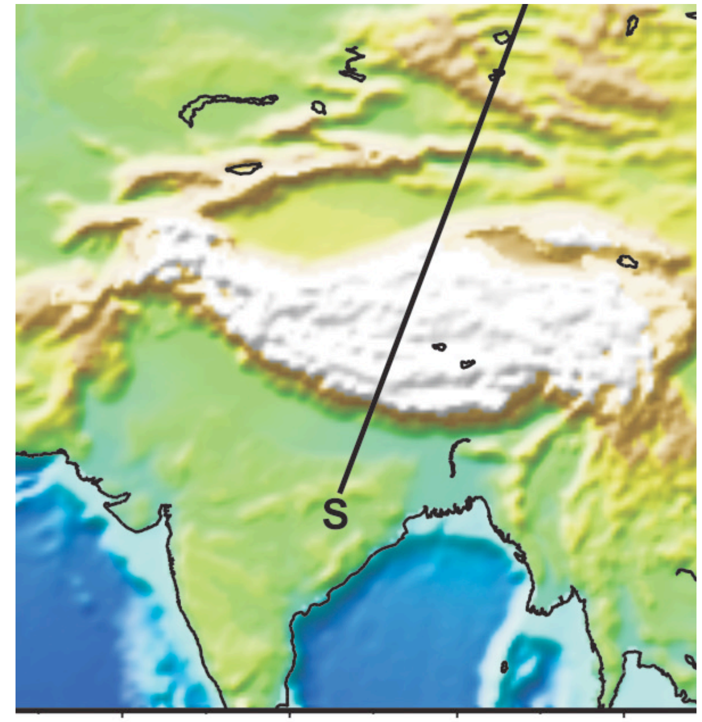
Sierra Pampeanas differences



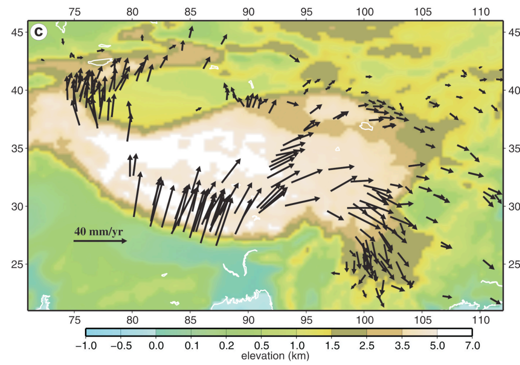
Rockies has kilometers of section. Also has undeformed Colorado Plateau between foreland and thin-skinned deformation--larger than entire Pampean orogen!

Tien Shan as analog



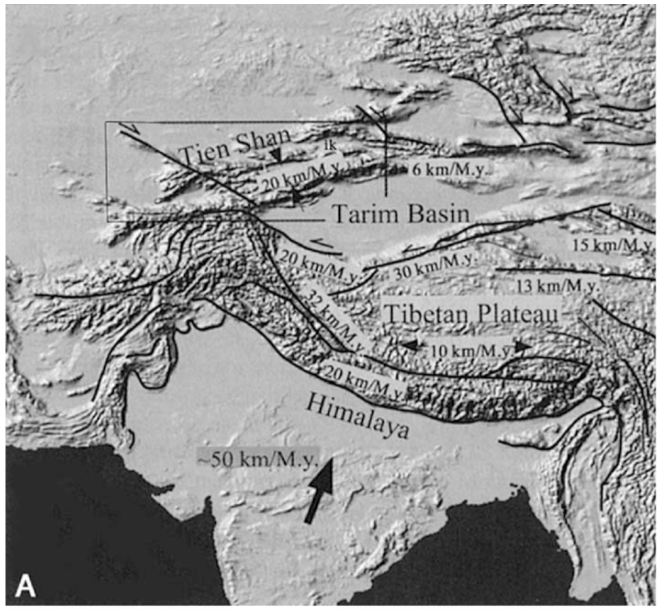


Tien Shan differences

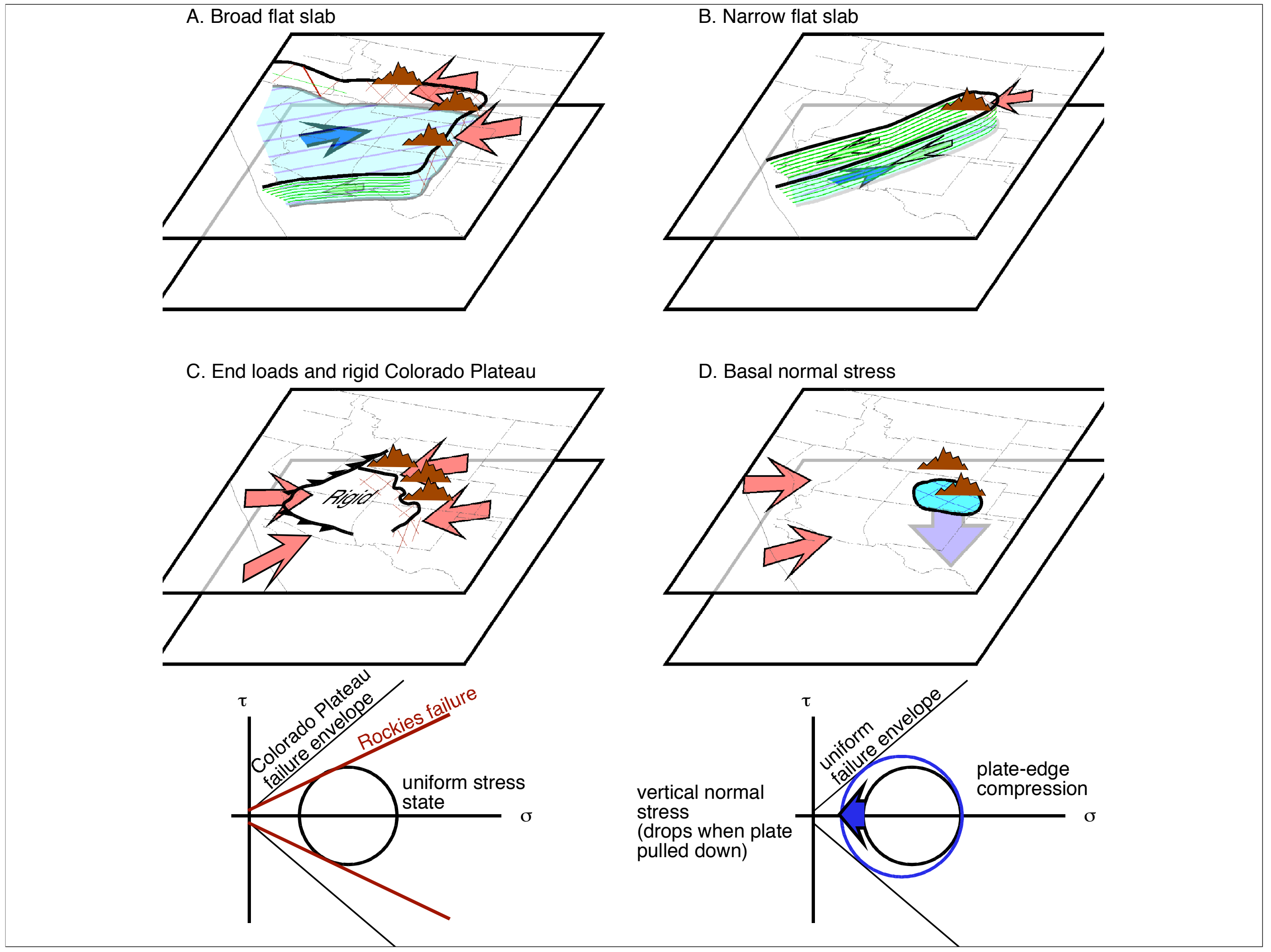


Jiménez-Munt and Platt, Tectonics, 2006

Is there an "India"?
Active shortening between collider and foreland mountains?
Colorado Plateau as rigid as Tarim Basin?
Subsidence pre-shortening?

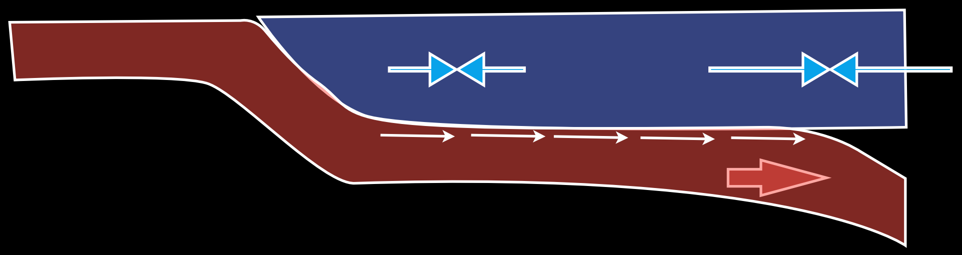


Dickerson, Tectonophysics, 2003



A. Broad flat slab
B. Narrow flat slab
C. End loads and rigid Colorado Plateau
Rigid
D. Basal normal stress
τ
Colorado Plateau
failure envelope
Rockies failure
uniform stress
state
σ
τ
uniform
failure envelope
plate-edge
compression
vertical normal
stress
(drops when plate
pulled down)
σ

Flat slab model

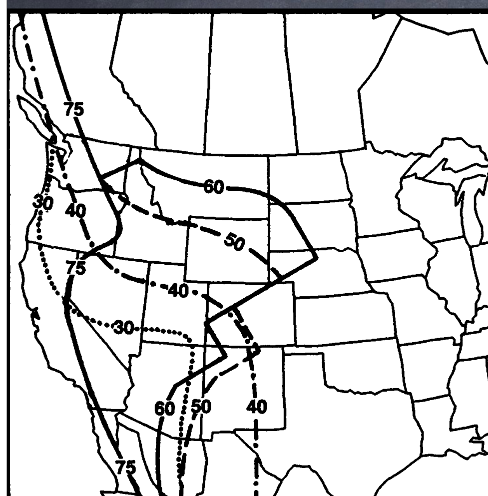


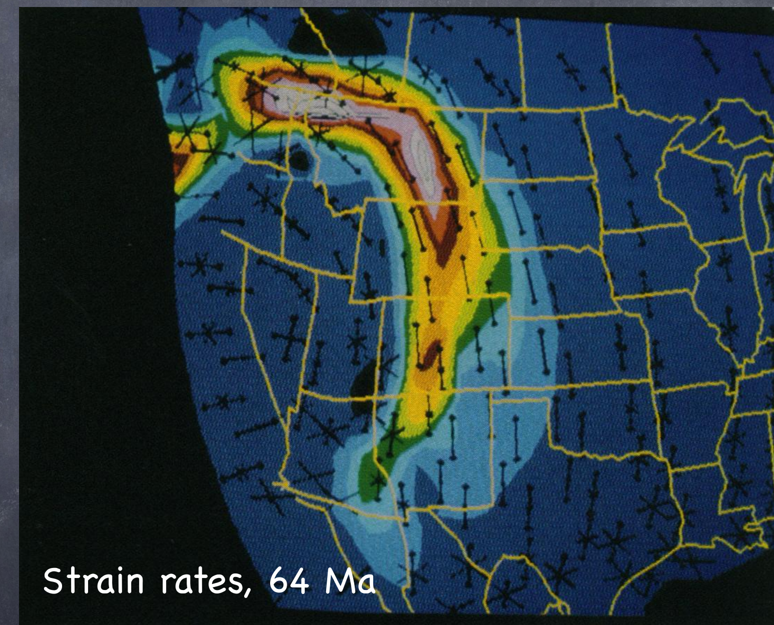
Basal shear produces maximum normal stress well inland

- Also connects magmatism with tectonism
- Sets up mid-Cz volcanism
- Analogs in South America

Although flat slab originally from volcanic variations, basic physics, goes back to Dickinson & Snyder (1978) and esp. Bird (1984, 1988).

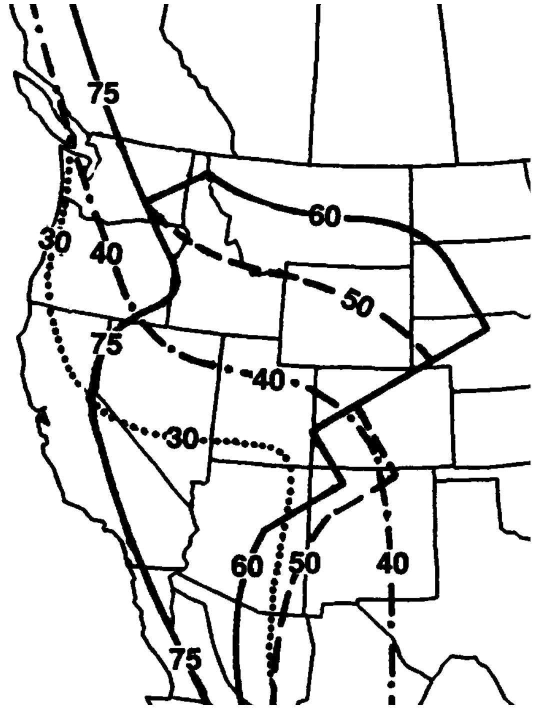
Can produce deformation in about the right places





Bird, 1988

…but has other issues



Bird, Science, 1988

1) Removal of lithosphere

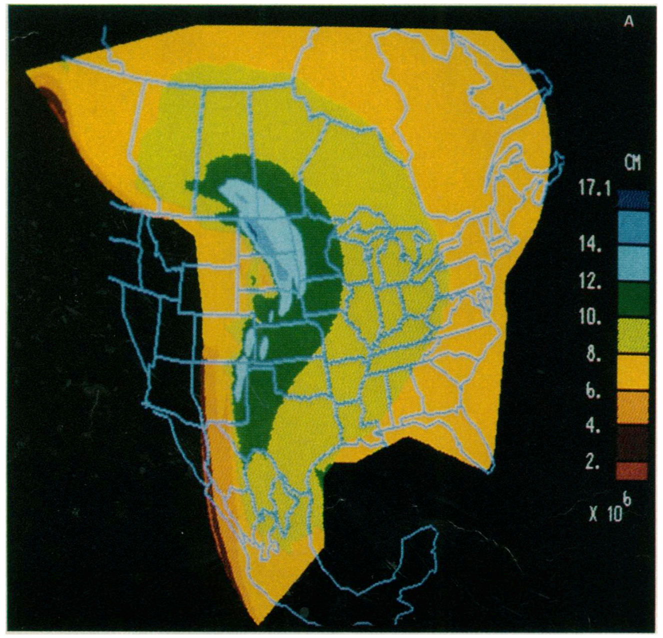


Fig. 3. (**A**) Final (middle Oligocene) displacement and thickness of the mantle layer of North America lithosphere. Thickness is contoured in 20-km intervals.

Flat slab predictions

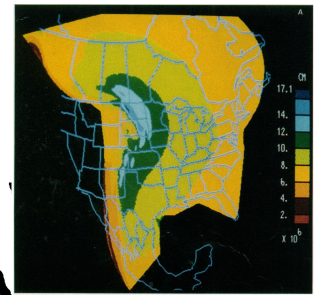
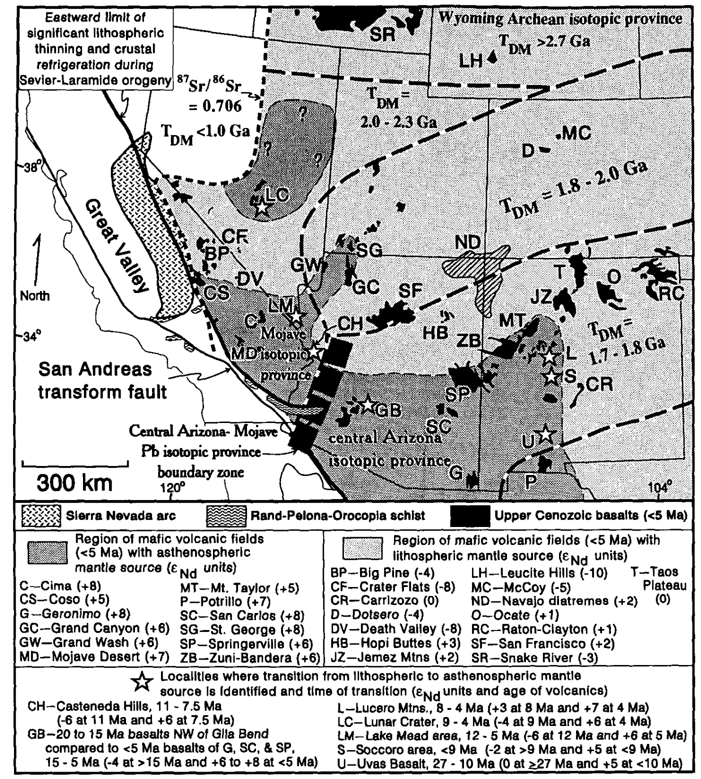


Fig. 3. (**A**) Final (middle Oligocene) displacement and thickness of the mantle layer of North America lithosphere. Thickness is contoured in 20-km intervals.

Bird, Science, 1988

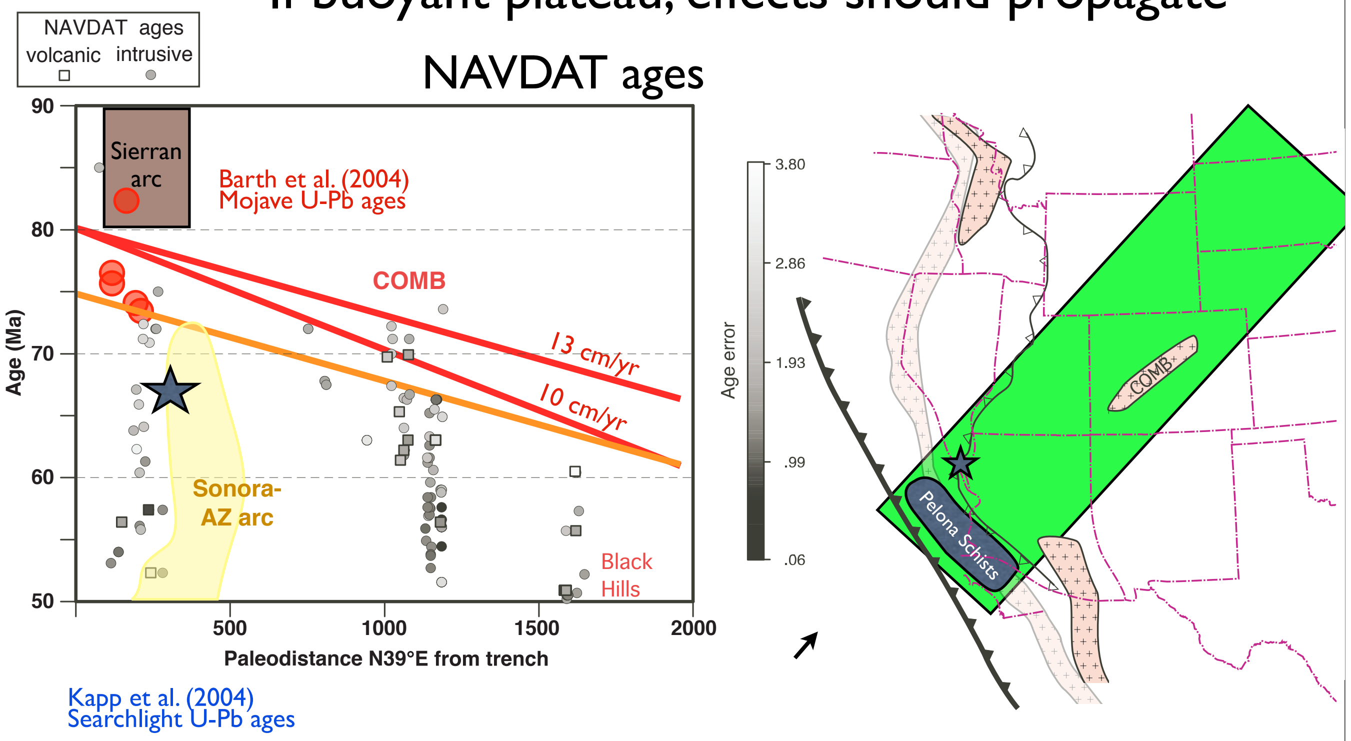
Livaccari and Perry, Geology, 1993

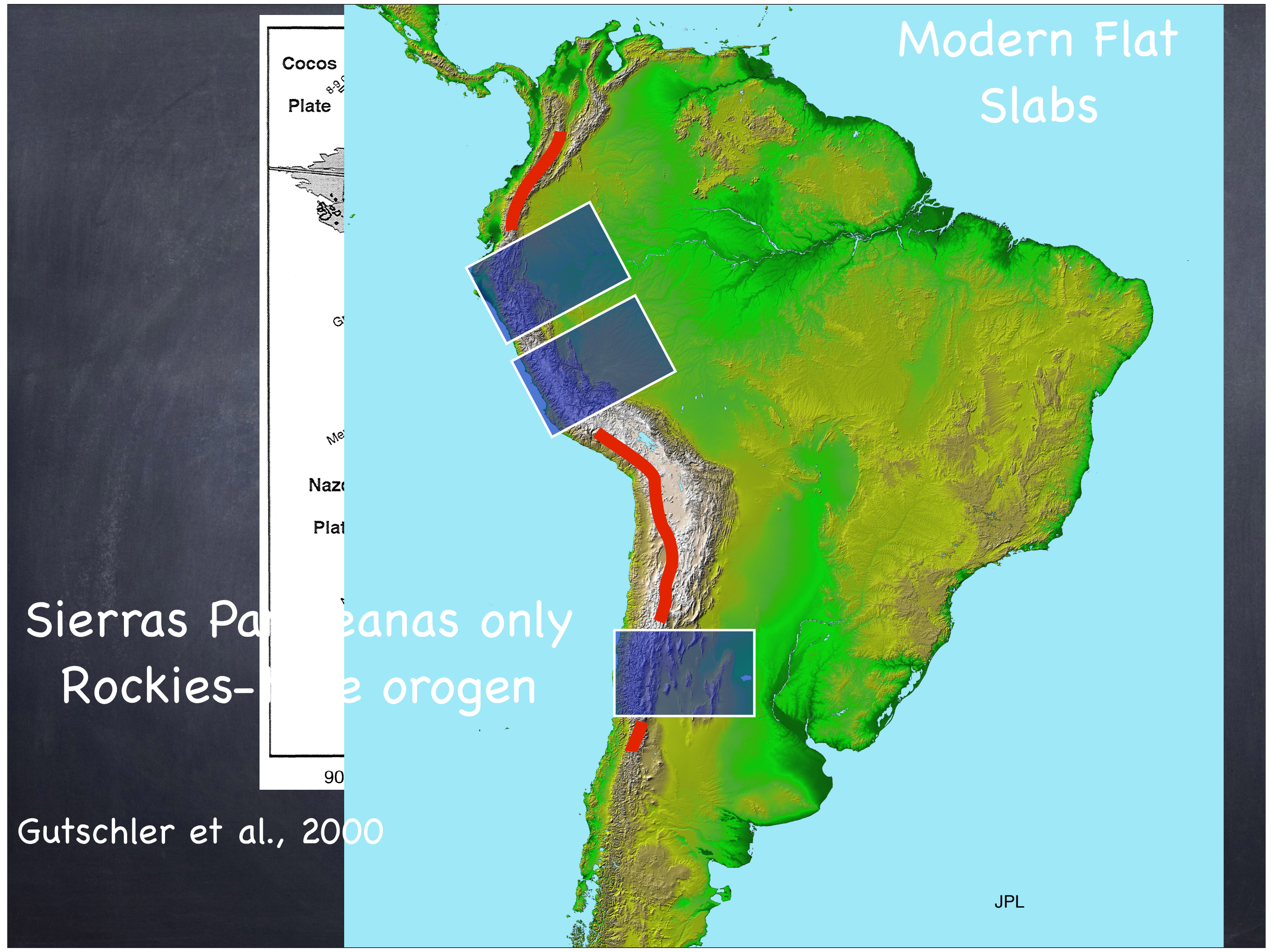


Flat slab predictions

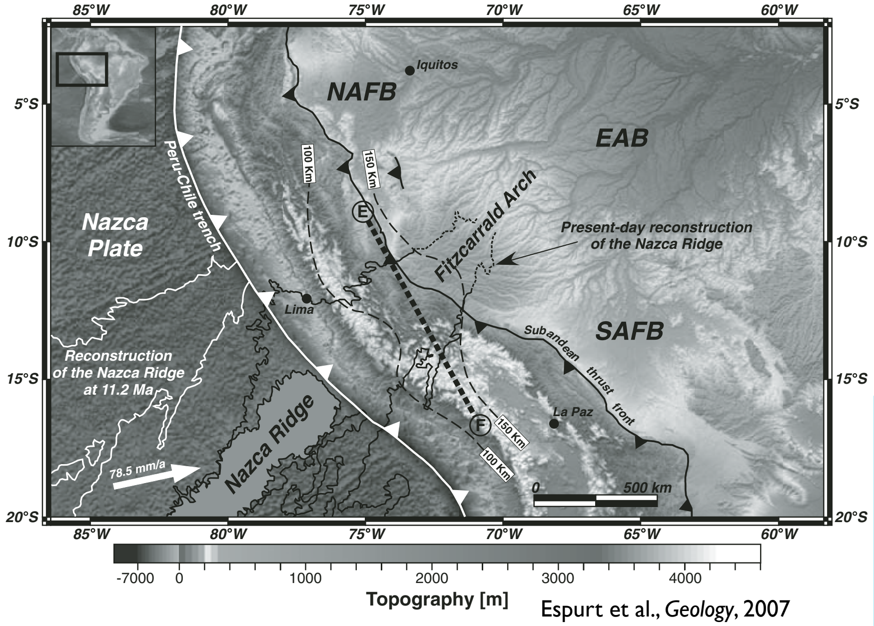
If buoyant plateau, effects should propagate

NAVDAT ages



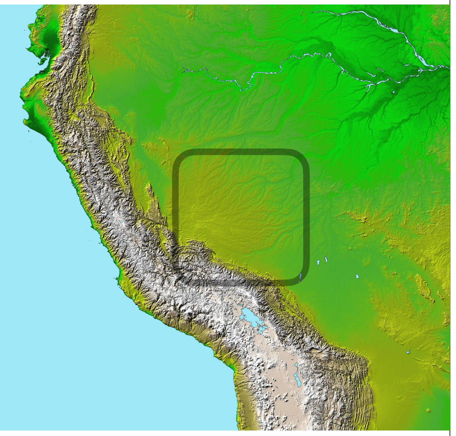

Modern Flat
Slabs
Cocos
Plate
Nazc
Plat
90
Sierras Pa eanas only
Rockies- e orogen
Gutschler et al., 2000
JPL

What do flat slabs do?

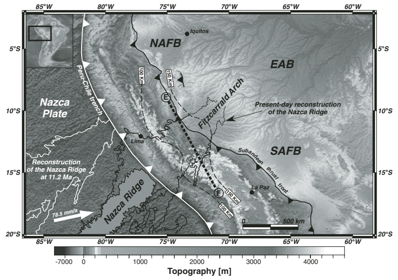


Espurt et al., *Geology*, 2007

Make things go up?

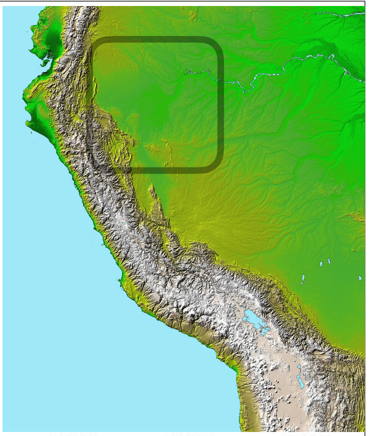


What do flat slabs do?

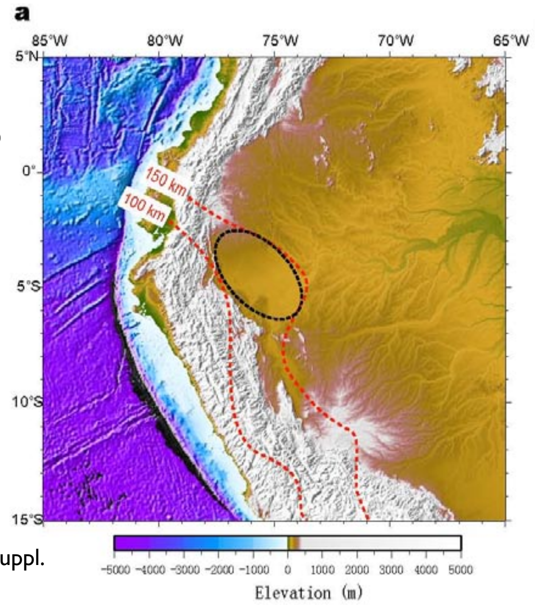


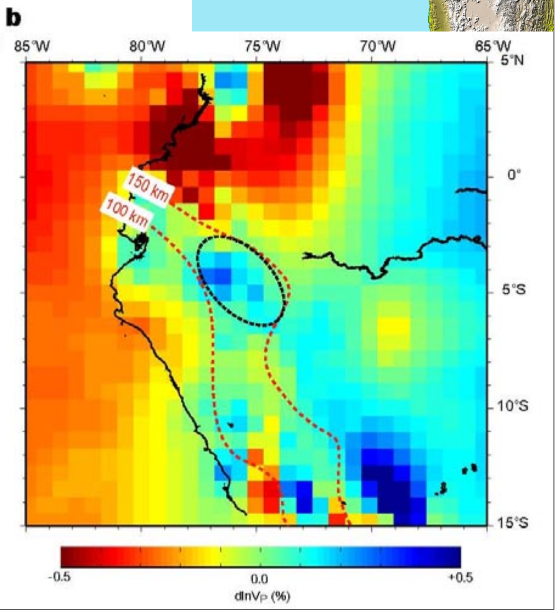
Make things go up?

Espurt et al., *Geology*, 2007



Make things go down?





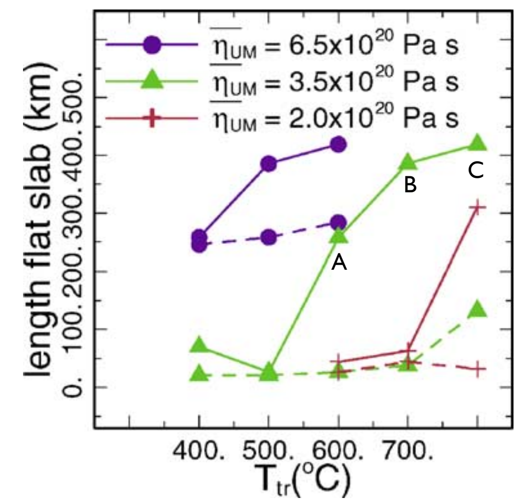
Liu et al., *Nature Geosci*, Suppl. Mat., 2010

As an aside, the Skinner et al. 2013 paper argues that due to asymmetry in spreading in Pacific, Inca Plateau is 600 km farther east than shown here

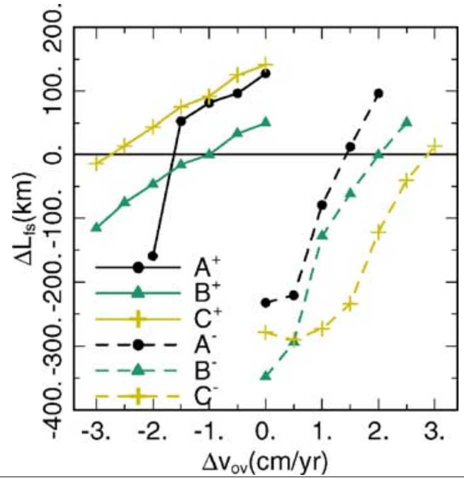
What makes slabs go flat?

Oceanic plateau under some circumstances

(Models with plateau solid lines, without dashed)
van Hunen et al., PEPI, 2004



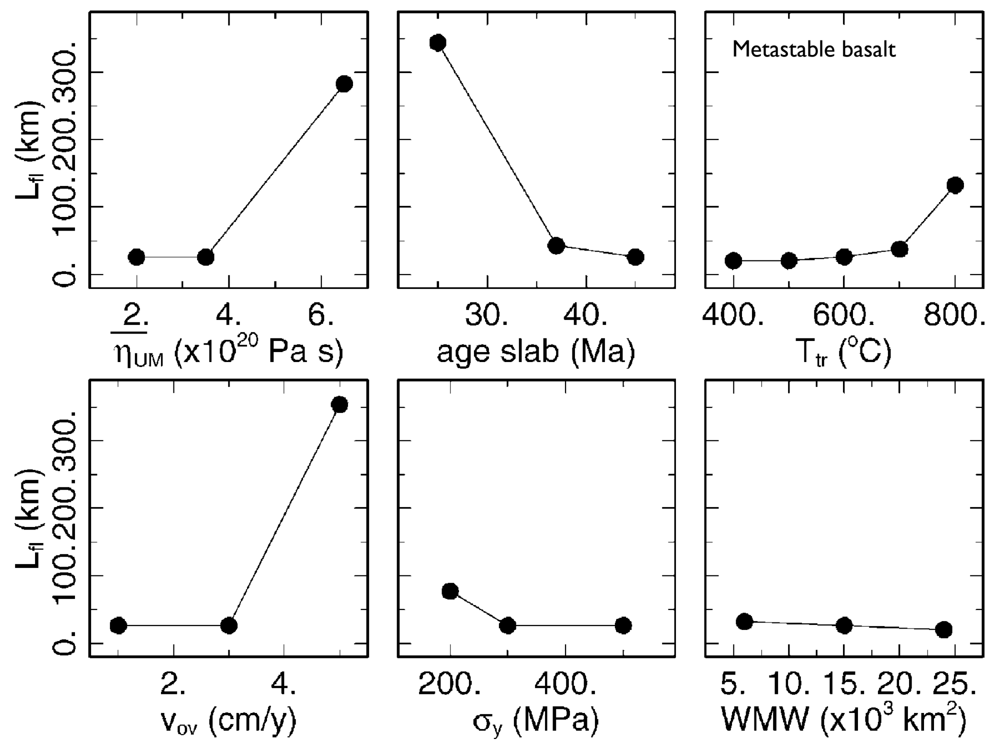
Metastable basalt



Rapidly moving upper plate under some circumstances

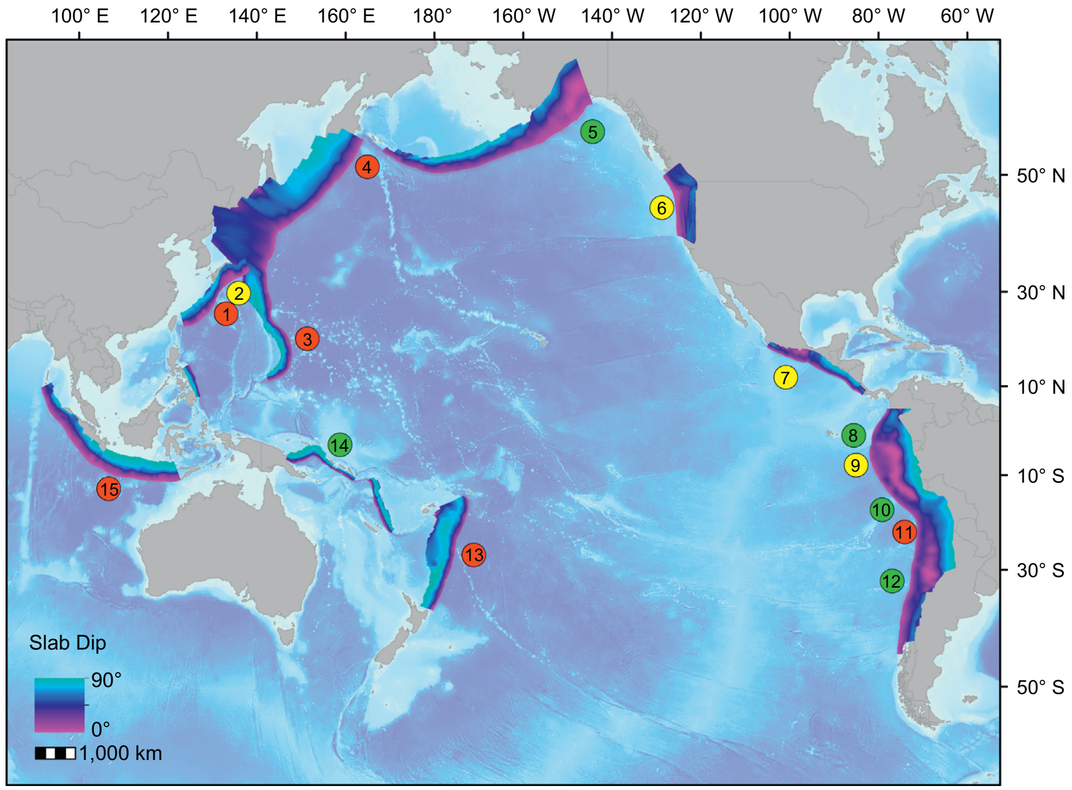
(Models with doubly thick plateau solid lines, no plateau dashed)
van Hunen et al., PEPI, 2004

Some other effects that can shallow subduction



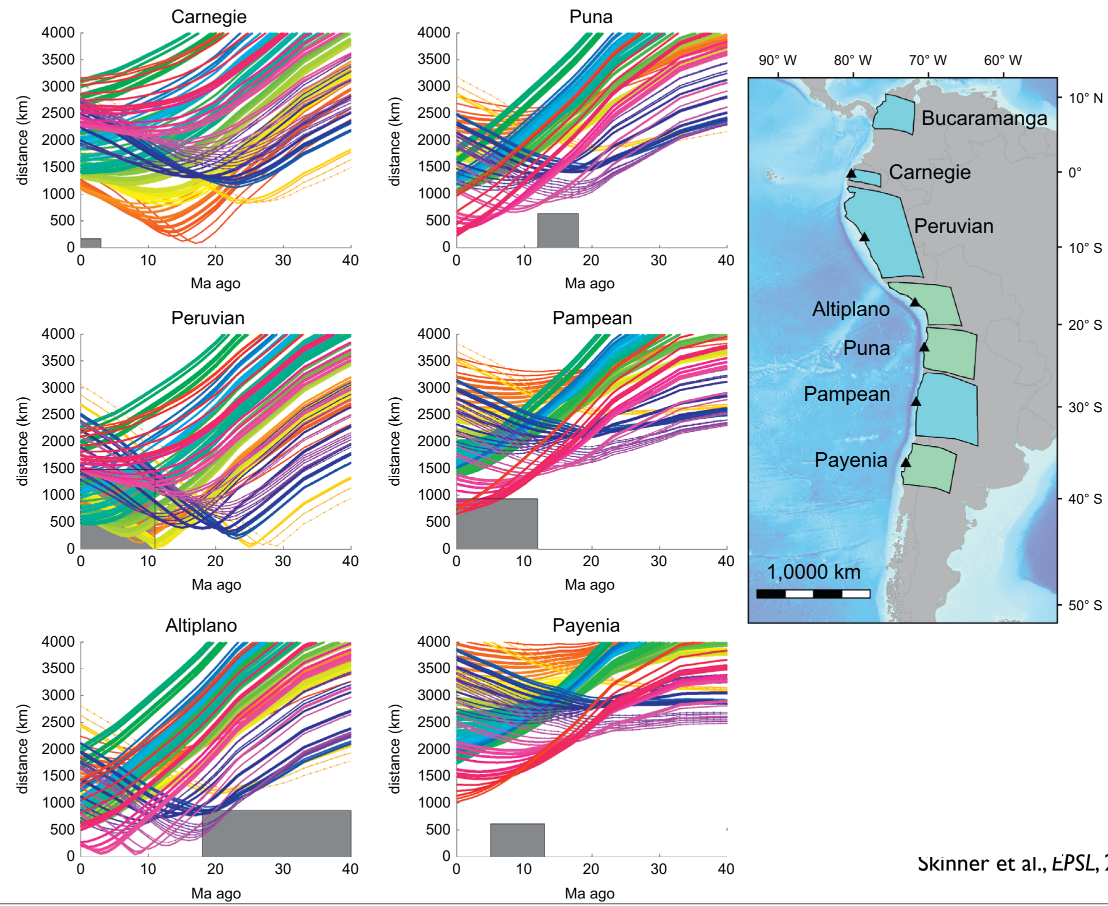
van Hunen et al., PEPI, 2004

Observed effect of subducting a plateau?



Skinner et al., *EPSL*, 2013

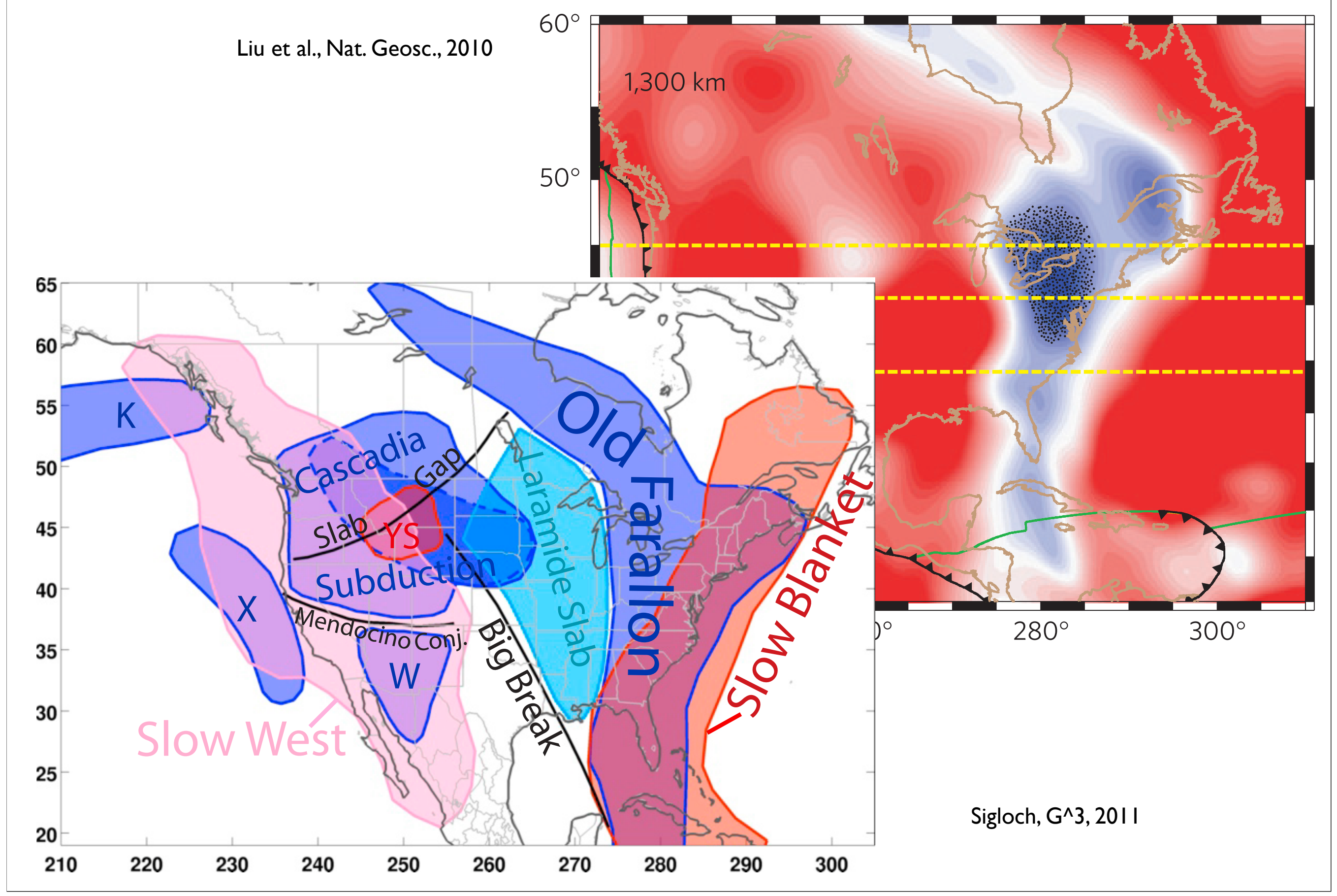
Observed effect of subducting a plateau?



Skinner et al., *EPSL*, 2013

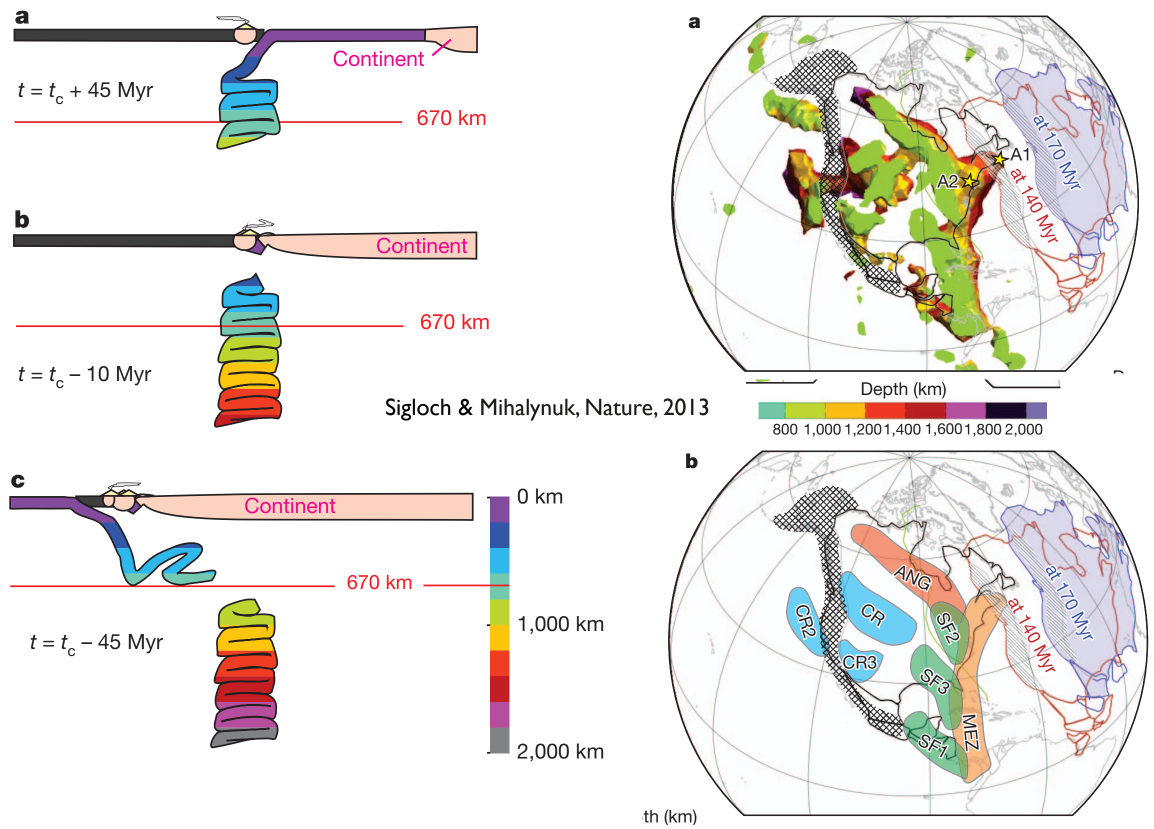
Fig. 3. Location of Pacific–Farallon/Nazca conjugate features relative to a given flat slab. We have placed points along Pacific plate bathymetric highs, and created conjugate features using standard plate reconstruction techniques and the rotation model of Müller et al. (2008). A plot for each flat slab shows the proximity of a reconstructed point on the bathymetric anomaly to that flat slab, plotted as a function of time. The thickness of the line scales with the crustal volume in a 100 km 200 km box around the Pacific plate conjugate point. The grey box represents the spatial and temporal extent of the flat slab from Ramos and Folguera (2009). We expect impactors to pass through this target zone if the buoyancy hypothesis is the cause of the flat slab. The map shows the location of the flat slabs along the South American margin (Ramos and Folguera, 2009). The black triangles are the point from which our distances are calculated. See Supplementary Table 3 for information about the conjugate points.

Where is flat slab today?



“Old Farallon” is basically ~1300km depth shown as pre-Laramide Farallon plate in this image (it is Mescalara in later papers , which is Jurassic). Black dots in Liu image are “tracers" in their mantle flow model tracking the Shatsky conjugate [but there is some circularity here]

...or is it even Farallon?



Sigloch & Mihalynuk, Nature, 2013

Collision predictions

South-to-north movement of igneous gap
(and emplacement of schists)

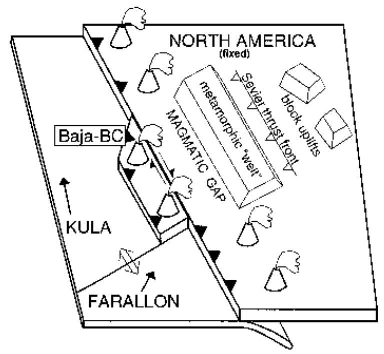
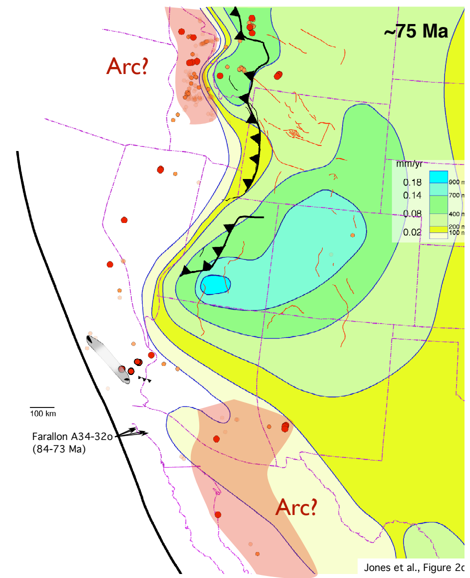
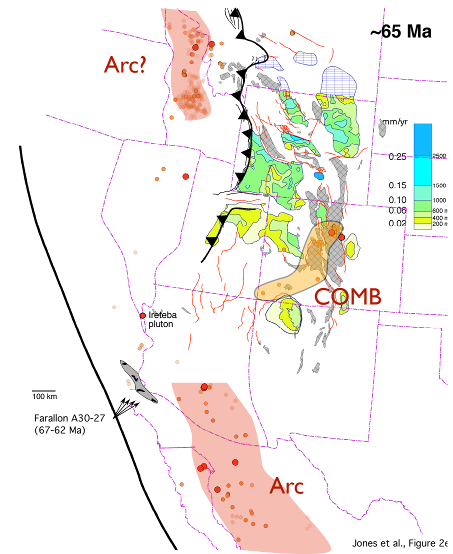


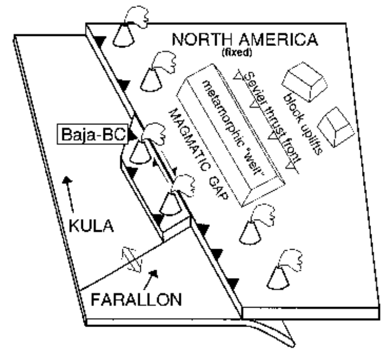
Figure 2. Paleogeographic configuration of dextral transpressional collision ("run") of Baja BC microplate and North America, resulting in the Laramide orogeny. Baja BC is inferred to have had an east-dipping subduction zone beneath its western edge and dextral, transpressional fault system on its eastern edge, which shut off subduction-related arc magmatism on adjacent North America during its northward movement.

Maxson & Tikoff, Geology 1996





Collision and collapse predictions



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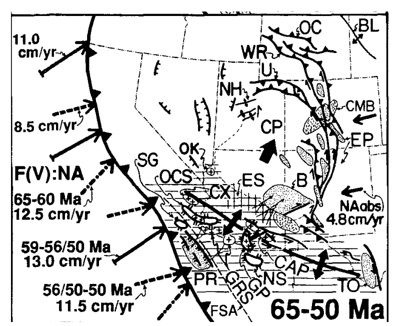
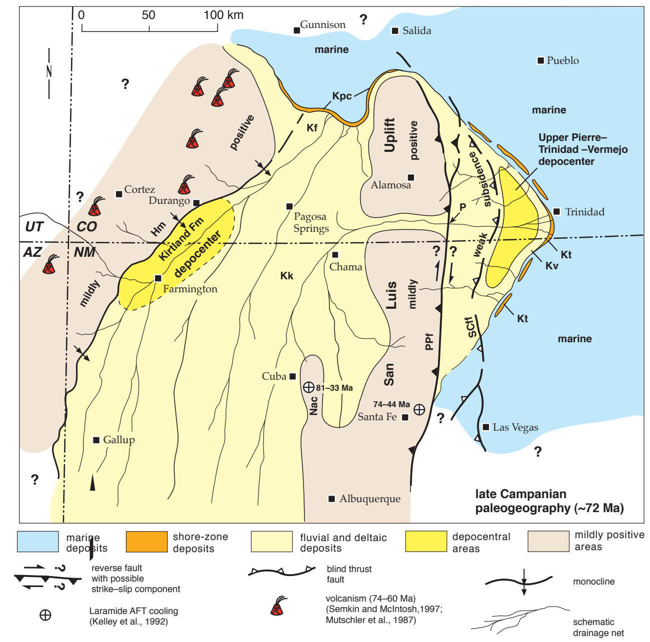


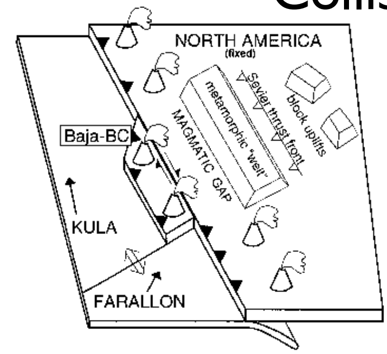
Rigidity of Colorado Plateau



Cather, 2003

Cather (2003) estimates 1/2 to 3/4 of structural throw on Hogback Monocline could be during deposition of Kirtland Frm, 74-67 Ma

Collision and collapse difficulties



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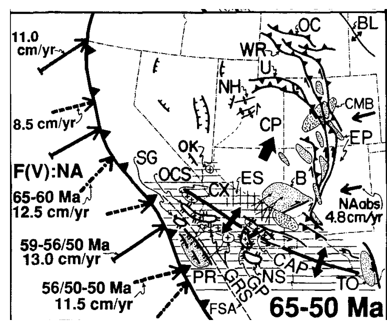


Where is collisional deformation near margin?

Why would Sevier belt shutdown?

Why was igneous activity temporally tied to Laramide?

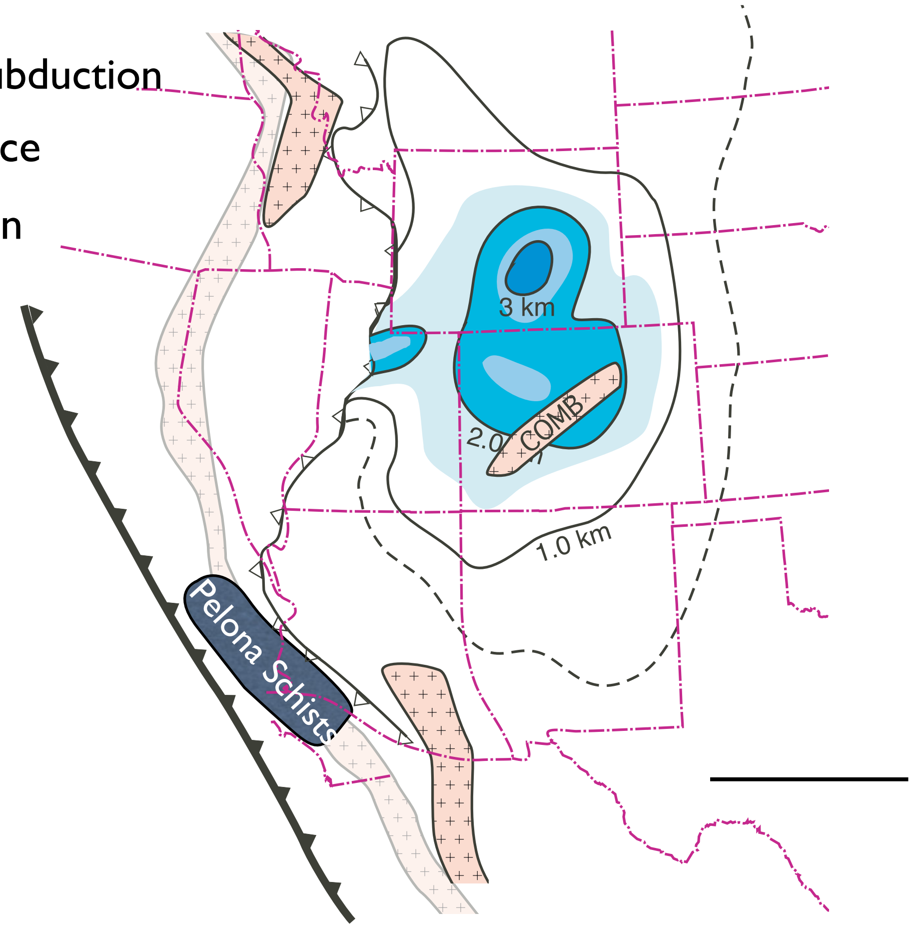
Underexplained Laramide elements

Limited shallow subduction

Latest K subsidence

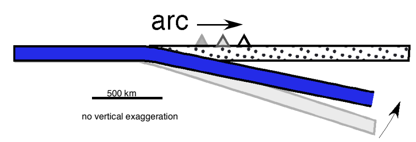
COMB orientation
and timing

Duration

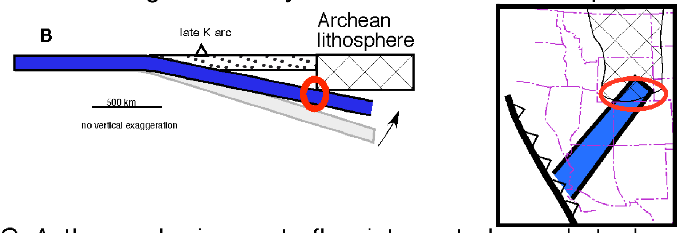


So we have some contradictions. Also note Colorado Plateau, extent of arc shutdown. UNclear if schists record true flat slab

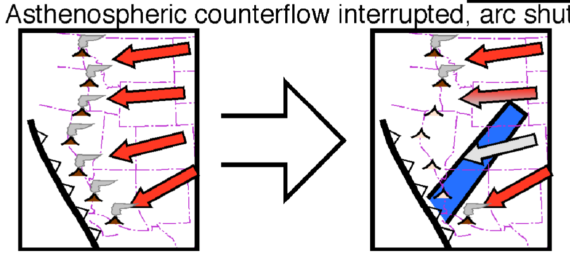
A. Shallowing subduction as North America moves westward



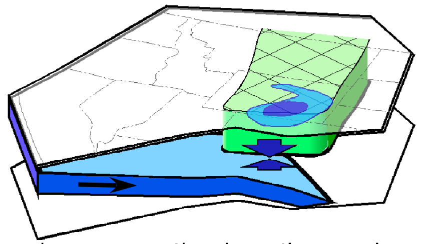
B. Shallowing slab locally interacts with thick lithosphere



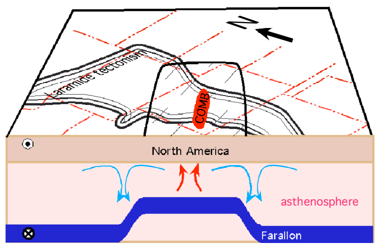
C. Asthenospheric counterflow interrupted, arc shuts down



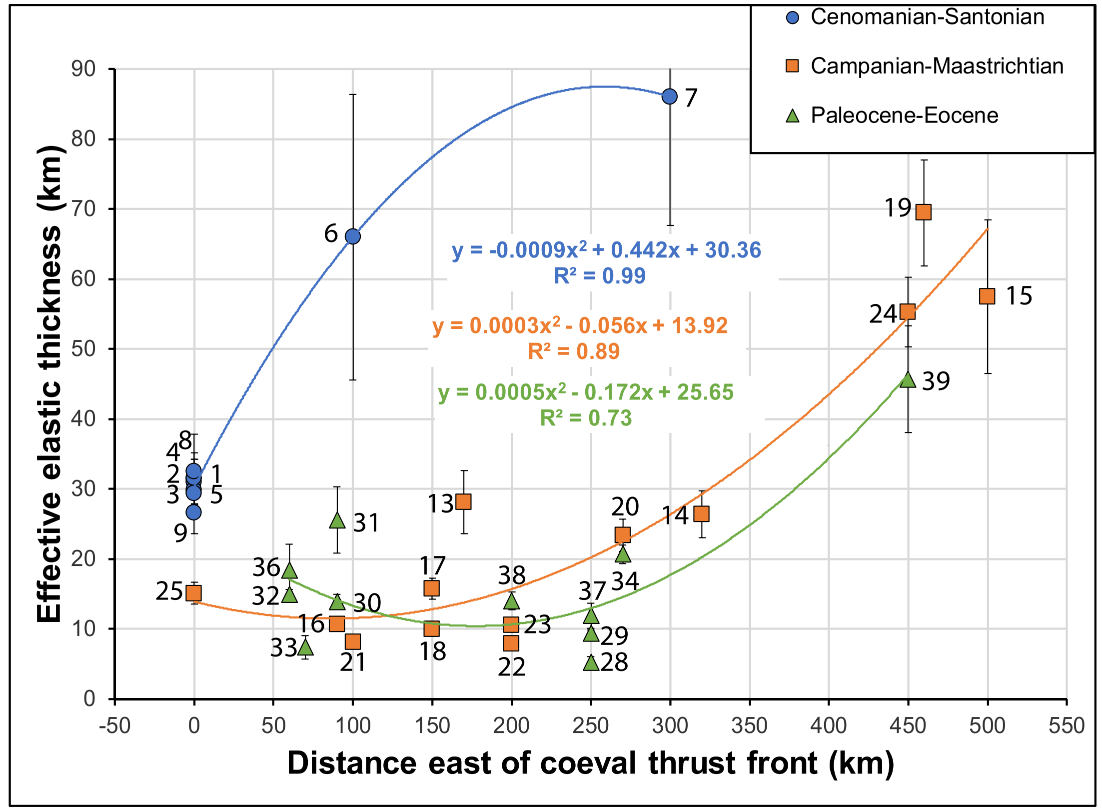
D. Suction on lithosphere drives subsidence, stresses



E. Secondary convection in asthenosphere
localizes Colorado Mineral Belt



Flexural estimate of lithospheric strength



Saylor et al., JGR, 2020

Attempts to measure flexural rigidity at different times—often in different places at different times. Argues that the change from Cenomanian to Campanian is due to a change in lithospheric strength. Clearly points 6 & 7—with huge error bars—are crucial to this—eastern Green River Basin and Wind River Basin.