Laramide analogs
Sierras Pampeanas
Tien Shan

“Flat slab” models
Collision and “orogenic collapse” models

Jiménez-Munt and Platt, Tectonics, 2006
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
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...
Rockies has kilometers of section. Also has undeformed Colorado Plateau between foreland and thin-skinned deformation—larger than entire Pampean orogen!
As in the Ancestral Rocky Mountains, intraplate deformation began after subduction had ceased, the intervening ocean had been closed, and full collisional plate coupling (Ziegler et al., 1998) had been achieved. As much as 40% of the shortening that has occurred between the two continents.

Is there an “India”?
Active shortening between collider and foreland mountains?
Colorado Plateau as rigid as Tarim Basin?
Subsidence pre-shortening?
A. Broad flat slab

B. Narrow flat slab

C. End loads and rigid Colorado Plateau

D. Basal normal stress

σ_{plate-edge compression}

σ_{vertical normal stress (drops when plate pulled down)}

σ_{uniform stress state}
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

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

Livaccari and Perry, Geology, 1993

Bird, Science, 1988

Downloaded from [source](http://example.com) on March 2, 2007
Flat slab predictions
If buoyant plateau, effects should propagate

NAVDAT ages

Barth et al. (2004) Mojave U-Pb ages
Kapp et al. (2004) Searchlight U-Pb ages
Sierras Pampeanas only
Rockies-type orogen

Gutschler et al., 2000
What do flat slabs do?

Make things go up?
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

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

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van Hunen et al., PEPI, 2004
Observed effect of subducting a plateau?

Map of slab dip for subduction zones around the Pacific Ocean. The map shows color-coded slab dips with blue indicating steep dips and purple indicating shallow dips. The map includes numbered circles representing specific locations of interest. The text notes that the observed effect of subducting a plateau can be analyzed by examining the dip of subducting slabs and correlating it with observable bathymetric features. The text also mentions the importance of considering spatial and temporal metrics to accurately predict the location of observable features. References to specific studies and models are included, such as Pardo-Casas and Molnar (1987), Gutscher et al. (1999), and Pilger (1981). The map provides evidence in support of the buoyancy hypothesis, which suggests that the presence of buoyant features like plateaus can influence the geometry of subducting slabs. The agreement of the location of observed magnetic isochrons with the predictions of the rotation model is highlighted as an improvement over past studies. The text discusses the ability of the reconstruction method used to predict the location of observable features and the importance of considering subduction processes in the interpretation of plate tectonic reconstructions.
Observed effect of subducting a plateau?

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 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.
“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?

![Diagram](image-url)
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

Rigidity of Colorado Plateau

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Cather (2003) estimates 1/2 to 3/4 of structural throw on Hogback Monocline could be during deposition of Kirtland Fm, 74-67 Ma.
Collision and collapse difficulties

Where is collisional deformation near margin?

Why would Sevier belt shutdown?

Why was igneous activity temporally tied to Laramide?

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REFERENCES CITED

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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
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.