Extensional Tectonics II

References:
Okaya and Thompson, 1986, GSA Special Paper 208
Dokka, 1986, GSA Special Paper 208
Rehrig, 1986, GSA Special Paper 208

Evidence for Deep Influx of Low Density Material

• Gravity data indicate that mass removed by extension is replaced by influx
• Upper crustal extension of 20% would produce an anomaly of 200 mgal with no deep flow
• Such large anomalies do not exist in the Basin and Range

Tertiary Extensional Events

• Dynamic horizontal translations >100%
• Eocene (55-40 Ma) north of SRP
• Oligocene-Miocene (35-16 Ma) further south

Associated Shallow Processes

• Listric or rotational faulting
• Decoupling along detachment faults
• Pervasive tensional fracturing
• Associated calc-alkaline magmatism

Deeper Processes

• Dikes
• Intrusions
• Mylonitic zones
  – Associated with metamorphic core complexes

Continental Rifts

• Brittle extension of upper crust by faulting
• Ductile extension of middle crust evidenced in core complexes
• Exposed igneous rocks are insufficient to account for the amount of spreading
• This leaves the addition of igneous materials deeper in the crust
Isostatic Rise of Crust?

- Requires inflow of dense mantle material below a crust thinned by extension
- This process would not allow the high elevations observed in the extended areas
- This implies an inflow of material of crustal density (basalt and andesite composition)

Evidence for Ductile Deeper Crust

- 20 km maximum depth of earthquakes
- Effect of temperature on crustal rocks
- Exposed sections of deep crust (metamorphic core complexes)
- Seismic reflection shows sub horizontal detachment faults

Rio Grande Rift Model

Comparison of primary and secondary faults

- Primary faults are planar and more deeply penetrating
- Secondary faults are listric and move into space afforded by primary breaks

Evidence for Igneous Additions

- Widespread basalts at the surface
- Basalt is likely trapped beneath lower density crust
- Rise of silicic magmas repressed by viscosity (only a small faction of these magmas erupt on the surface)
- This preserves the observed crustal thickness and maintains high isostatically supported elevations

Igneous vs. Isostatic Uplift

- Igneous additions to the crust (andesite or basalt) $\rho \approx 2.8-3.0$
- Mantle inflow $\rho \approx 3.3$
- Basalt extracted from mantle without changing the density of the peridotite
- The net volume of residual peridotite plus basalt increases and the net density decreases
- This produces uplift

Listric Faulting

Without areas of thrusting or compression, deeper crustal zones must also be involved
• Assume an equal extension of upper and lower crust
• Isostatic compensation would cause the general elevation to decrease

Thinned Crust Model
Assume:
A 42 km thick crust as in the Colorado Plateau
Density contrast of 0.4 g/cc

If extended and thinned to 50% (28 km) it would sink 1.7 km

Intrusion Model
• Basin and Range stands ~ 1 km asl
• Low density mass must have intruded
• Mantle derived products are the likely solution