

Depth Variation of Stress and Material Properties

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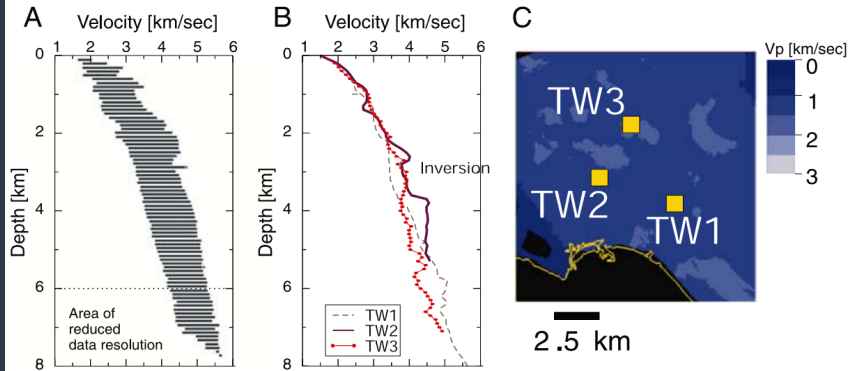
Depth Variation of Material Properties

Material properties vary with depth for several reasons

- Deposition of relatively softer sediments over more rigid bedrock
- Weathering of shallow bedrock
- Consolidation at depth due to pressure and temperature
- Damage due to deformation

Observed Variation in Vp with Depth

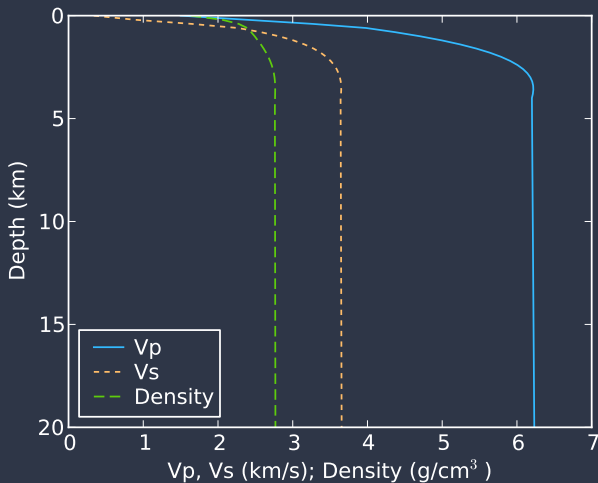
SÜSS AND SHAW: 3-D VELOCITY STRUCTURE IN LOS ANGELES BASIN



Süss and Shaw, *JGR*, 2003

Model of V_p , V_s , and Density with Depth

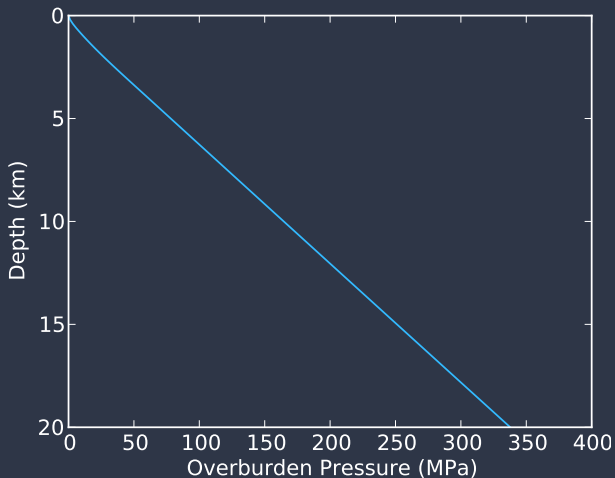
Material properties as a function of depth for granite



Brocher, *BSSA*, 2008

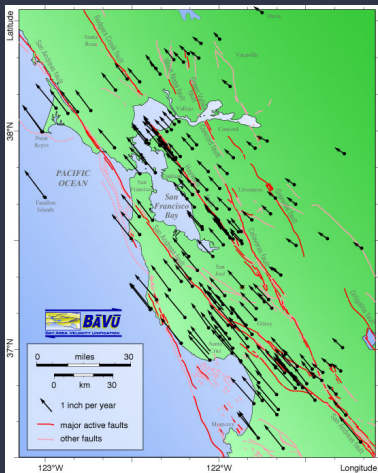
Variation in Overburden Pressure with Depth

Overburden pressure for granite assuming hydrostatic pore pressure



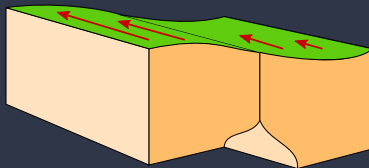
Fault Loading from Geodetic Observations

Uniform strain w/depth + creep/flow below locked region



d'Alessio *et al.*, *JGR*, 2005

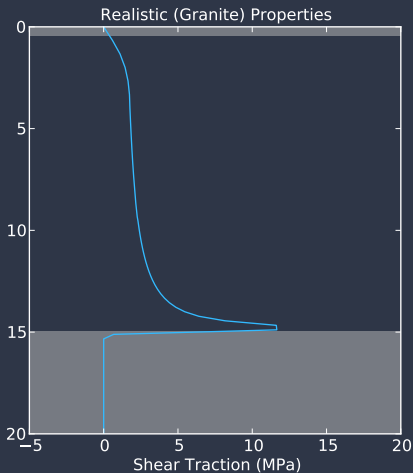
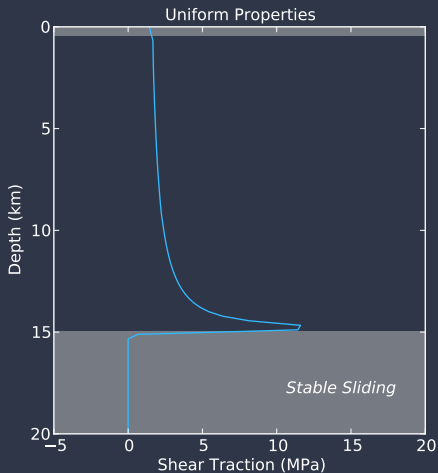
Back-slip Model



Savage, *JGR*, 1983

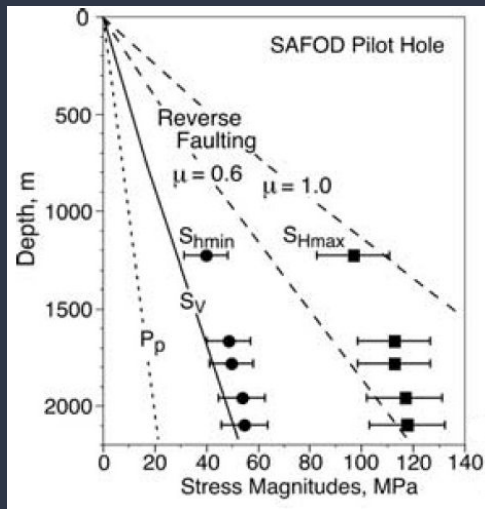
Loading Stress Variation with Depth

Loading from back-slip model combines uniform strain with stress concentration



Observed Variation in Stress with Depth

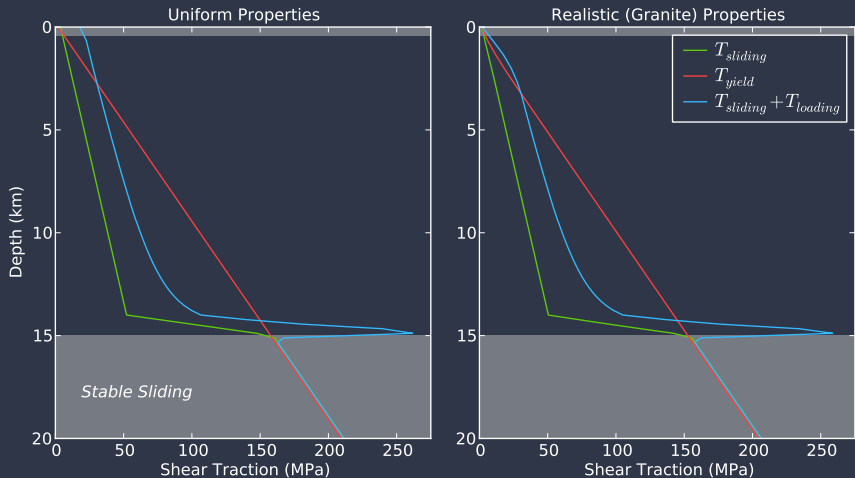
Horizontal principal stresses increase with depth



Hickman and Zoback, *GRL*, 2004

Stress Conditions assuming Uniform Friction

Incompatibility between depth variation in friction and loading



Summary

- V_p and V_s have much stronger variations with depth than density
 - Overburden pressure has small deviations from a linear slope
 - Shear modulus has strong variation with depth
- Geodetic observations suggest back-slip loading model
 - Loading is not proportional to overburden pressure
 - Loading creates some “issues” at the top and bottom of the unstable regions
 - Realistic variations in properties reduces magnitude of shallow “issues”