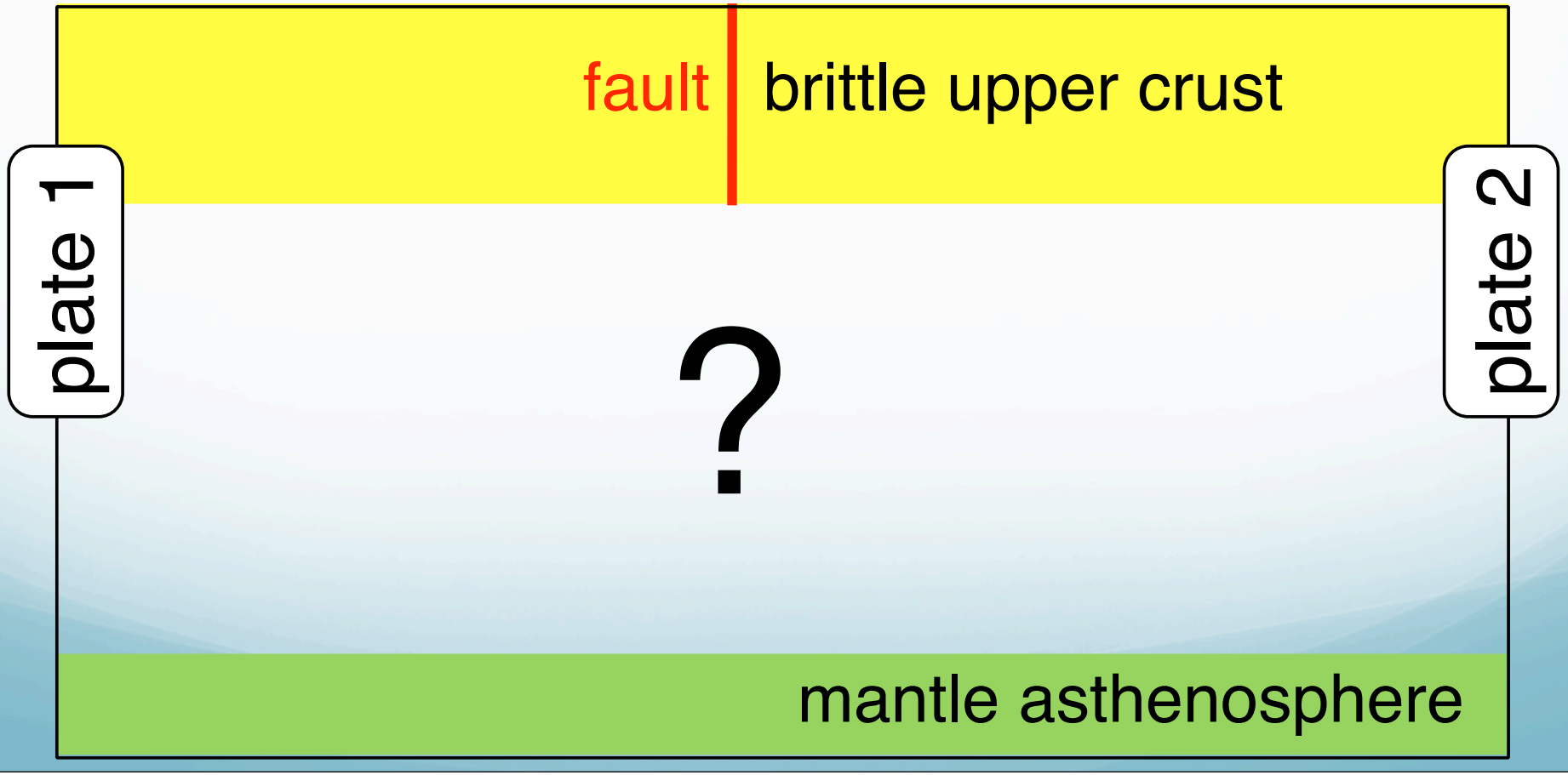
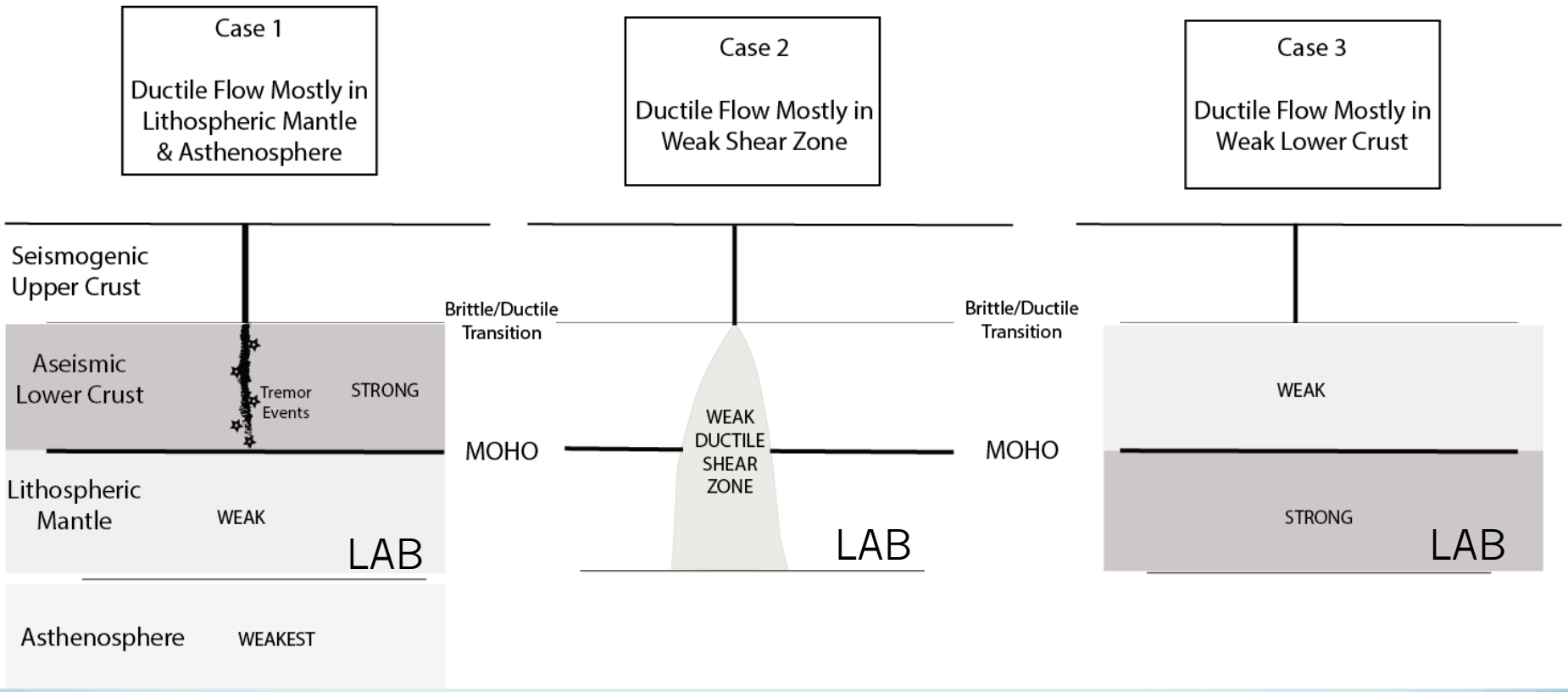
Workshop Summary: Ductile Rheology of the Southern California Lithosphere: Constraints from Deformation Modeling, Rock Mechanics and Field Observations

The question



Some Possible Geometries for Ductile Lithosphere



W Thatcher

Workshop Summary: Ductile Rheology of the Southern California Lithosphere: Constraints from Deformation Modeling, Rock Mechanics and Field Observations

- deformation modelers
- mineral physicists
- field geologists

Current areas of focus for participants' deformation modelers

1. rheology

Explore power law, transient, and power law + transient rheology combinations for models of postseismic and interseismic deformation.

2. shear zones

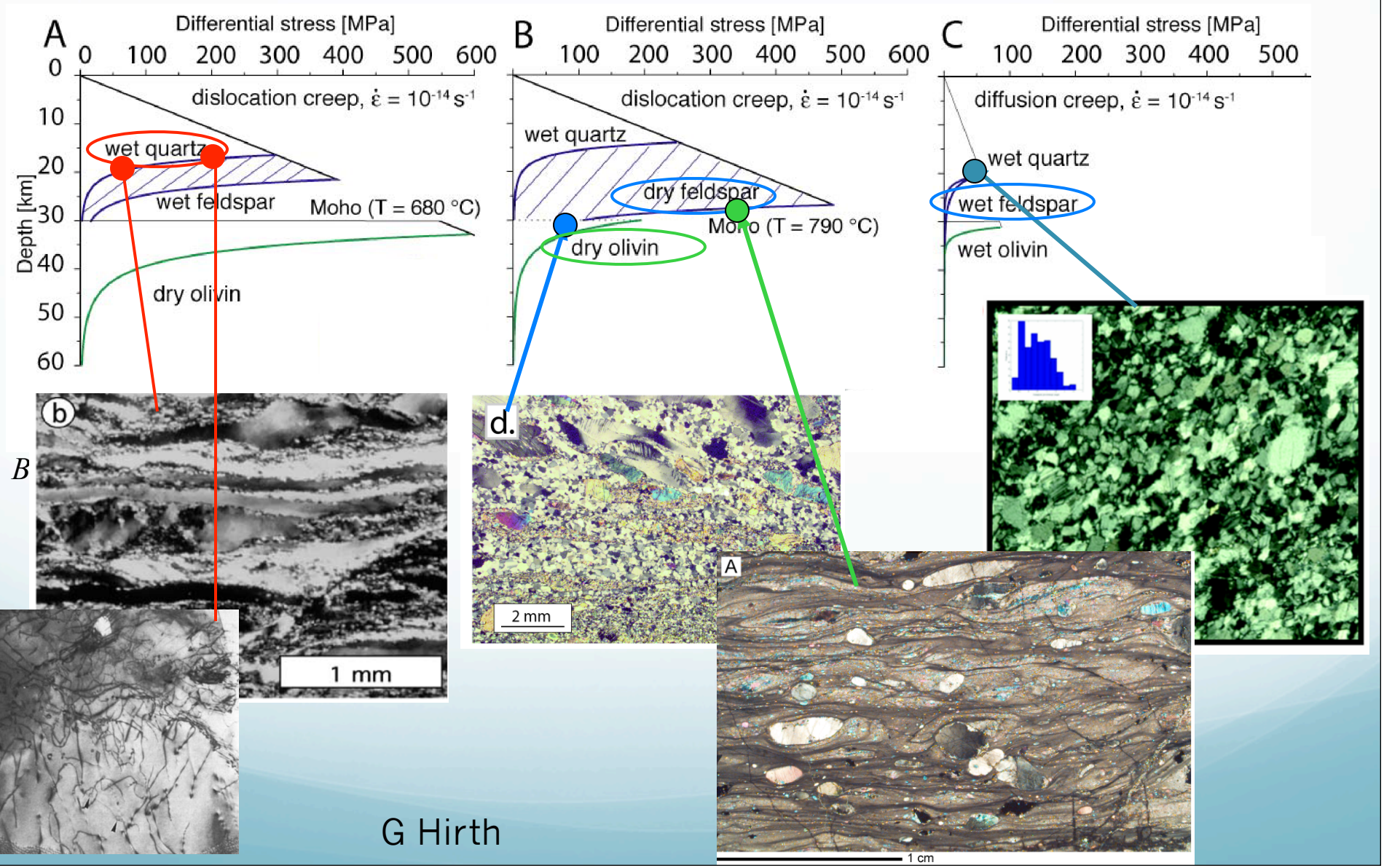
Tremor may argue that a deep SAF SZ is present and provide constraints on its rheology (e.g. D. Shelly). Physics plus flow laws also seem to require the development of shear zones (Takeuchi and Fialko, 2012; Montesi 2004). Earthquake cycle models with shear zones... (T and F 2012; Johnson et al. 2007; Hetland 2012; Hearn 2012).

3. material heterogeneity

Geophysical studies suggest heterogeneous lithosphere thickness, asymmetric structure and/or dipping fault geometry. Including these may improve model fit to data and makes models more realistic (e.g. Pollitz et al. 2012; Ryder et al., 2011).

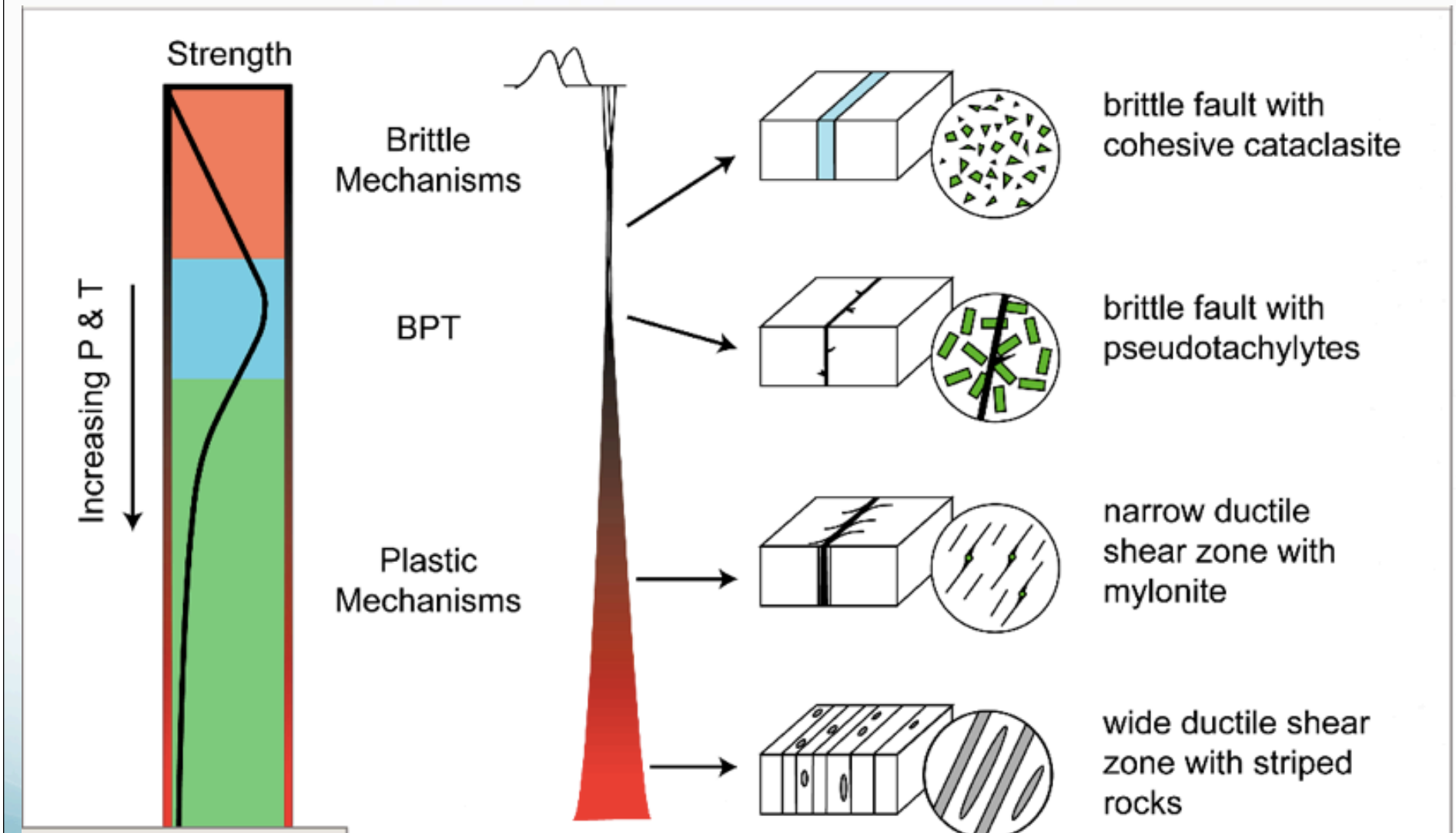
Rheology of the Crust and Mantle

(steady-state rheology)



G Hirth

Shear Zones



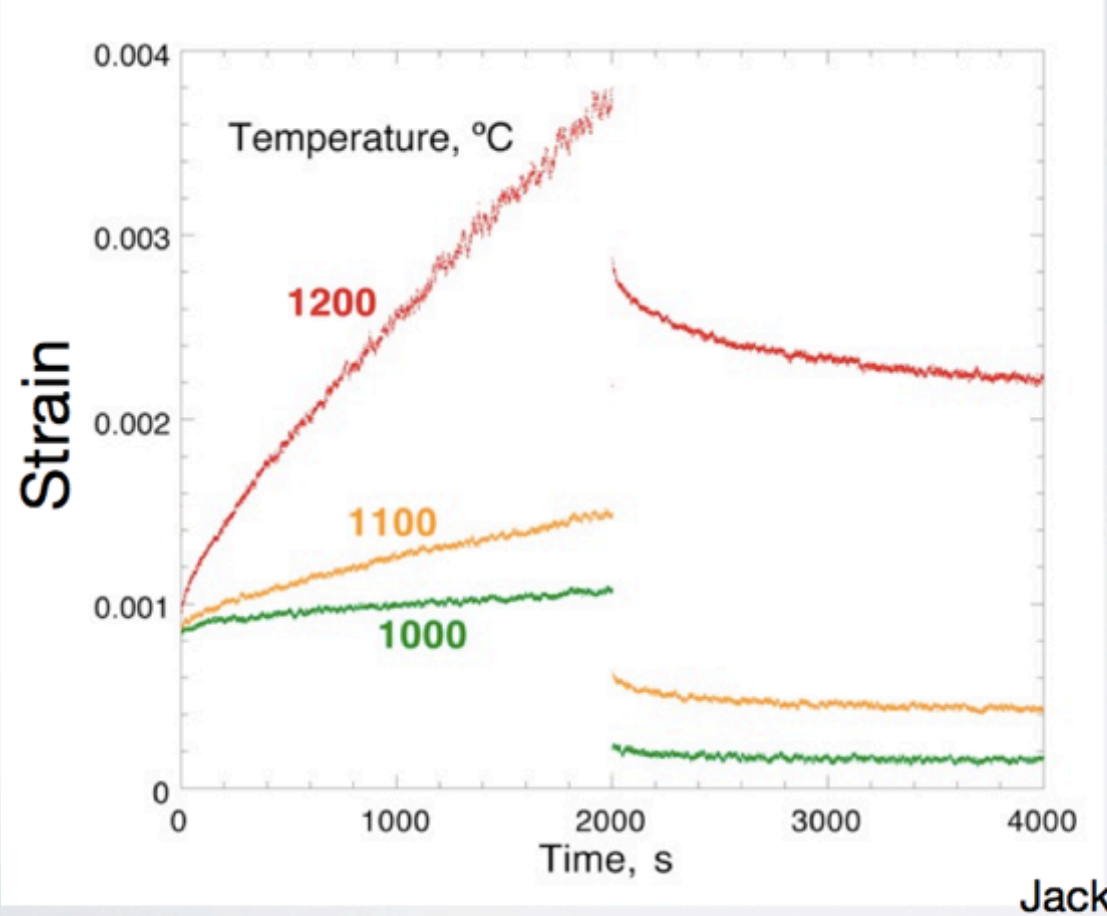
Sibson 1977, 1983
Scholz 1988,1990

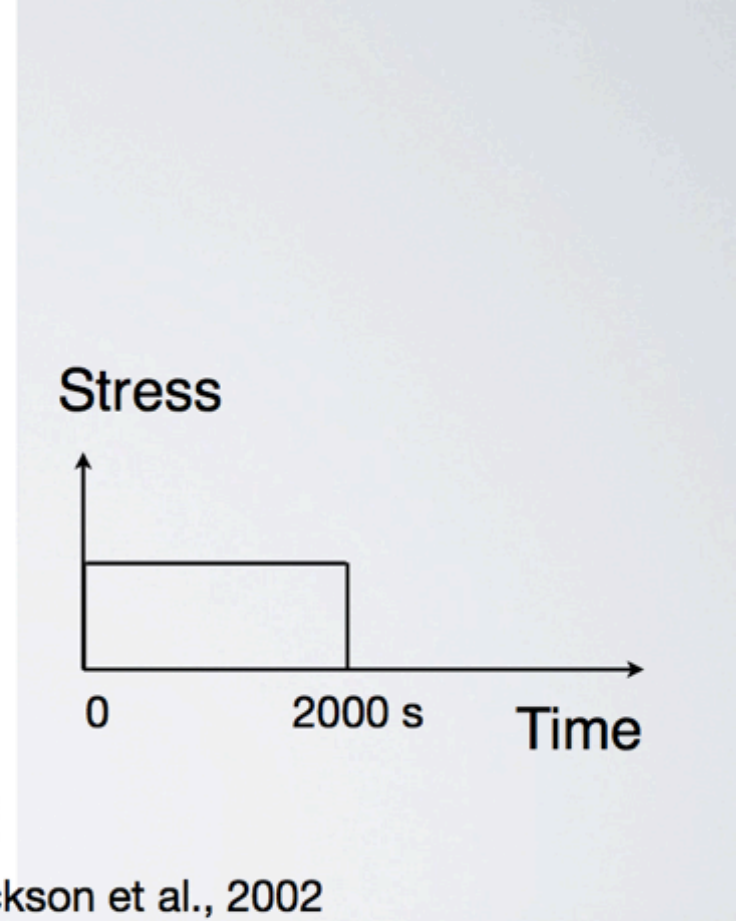
3

Diagram from Passchier and Trouw

L Montesi

Transient viscoelastic rheology





Jackson et al., 2002

response: elastic + transient + viscous

Workshop Consensus Conclusions

- Lab based steady-state ductile flow laws are supported by field based observations at same P, T, state.
- We should use these laws in modeling seismic cycle, along with candidate transient flow laws.
- Relatively narrow ductile shear zones exist beneath seismogenic faults with large displacements.
- "Ghost transients" from past, large earthquakes could be important contaminants of presumed steady-state surface deformation field.
- SCEC4 goal: Map 3D structure of S. California ductile lithosphere via seismic imaging, infer P-T-state, rock type, define range of possible ductile rheologies
- Need to explain postseismic, interseismic and long-term (e.g. lake unloading) deformation in the same region with the same Earth. More sophisticated models and inversions, transient rheology?

Relevance to CDM (modelers' perspective)

- Constrain rheology with postseismic deformation models: spatially and temporally dense postseismic velocities. Dense, high-precision 3D pre-earthquake velocity field and coseismic displacements.
- Bracket rheology with interseismic deformation: spatially dense 3D surface deformation field. Will we ever see curvature (Japan)?
- Be able to remove seasonal signal and apparent signals due to non-tectonic activity.
- Slow slip events: identify and characterize
- (CSM): use aforementioned rheologies into deformation models calibrated to surface velocity field (and other constraints)