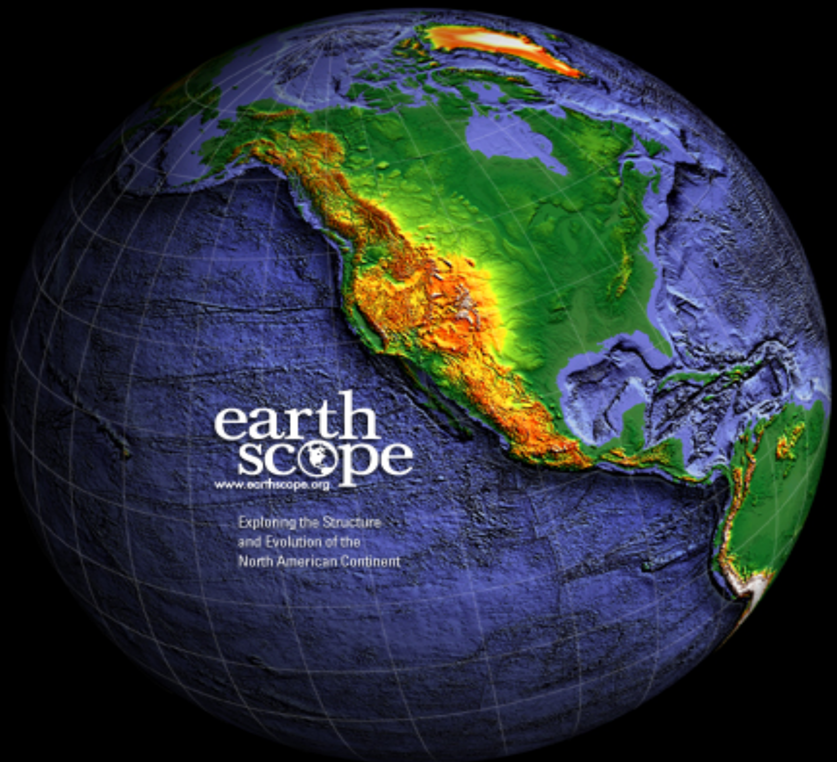
EarthScope Science Motivations

Ramon Arrowsmith
School of Earth and Space Exploration
Arizona State University

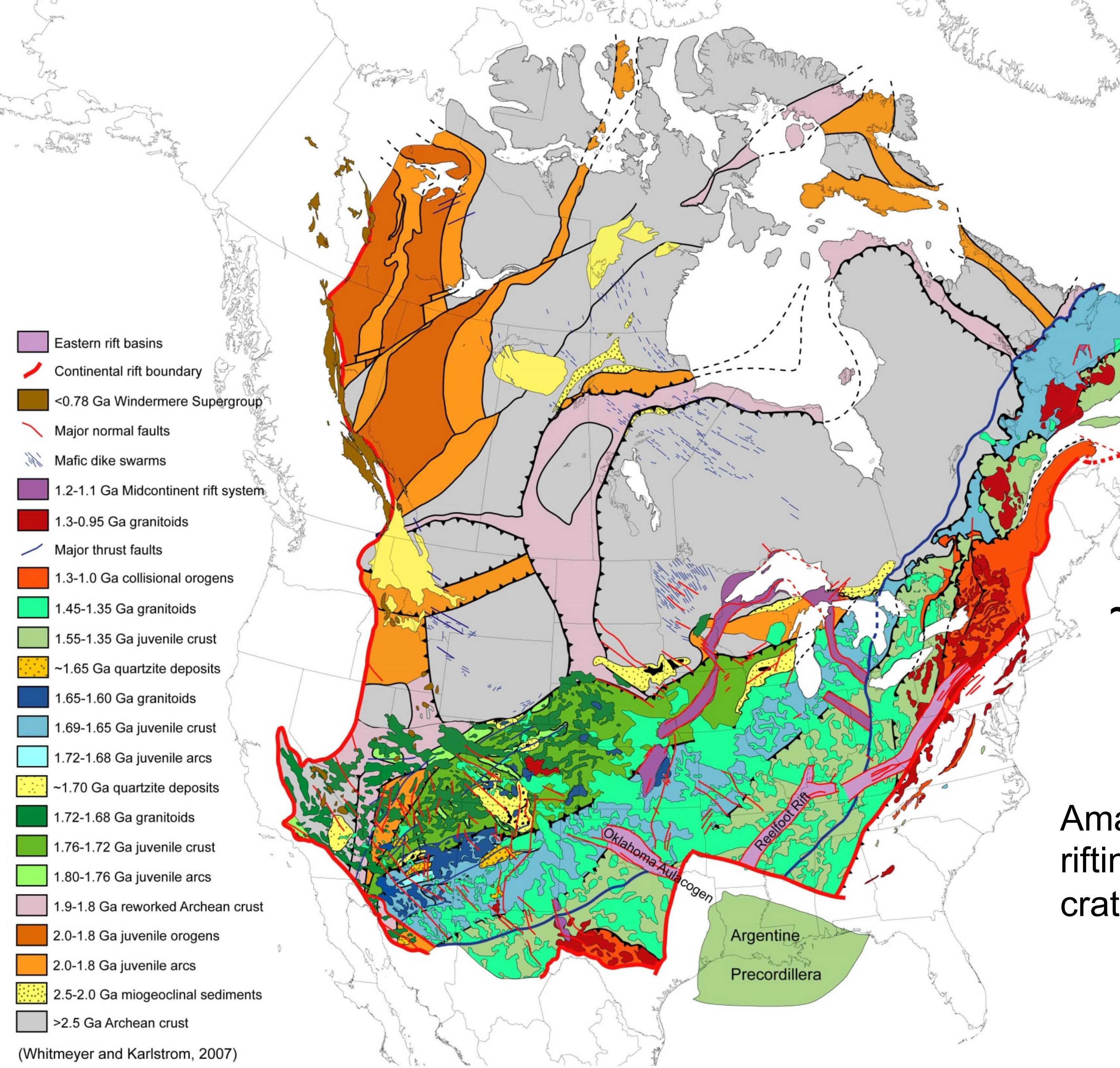


- Emphasize recent results and opportunities for geochronology
- There have been interesting papers published using geochronology related to EarthScope!

ramon.arrowsmith@asu.edu
www.earthscope.org

Exploring the Structure and Evolution of the North American Continent:

Measuring the motions and the properties that constrain the processes



~ 0.535 Ga

Amalgamation and rifting manifest in cratonic interior

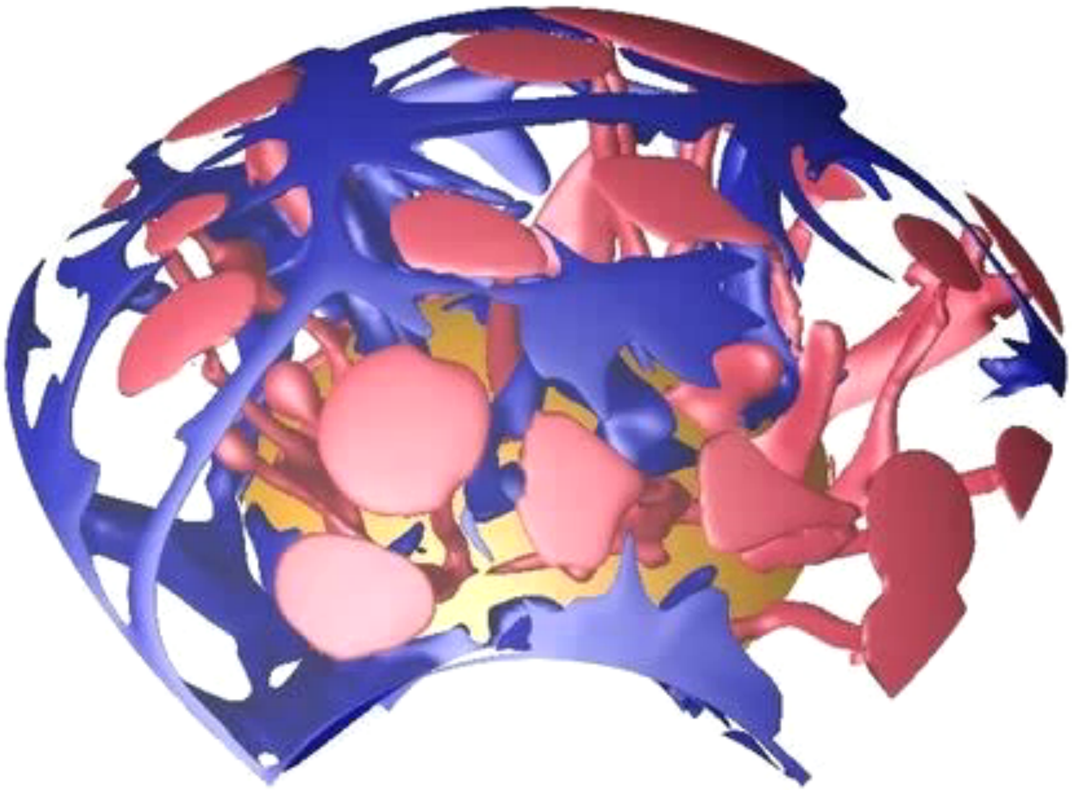
-Whitmeyer and Karlstrom, 2007

Exploring the Structure and Evolution of the North American Continent:

Measuring the motions and the properties that constrain the processes

Interactive Geology Project, CU Boulder http://igp.colorado.edu/animations.html
Professor Ron Blakey, Colorado Plateau Geosystems

Geologic, geochronologic, and geophysical data are needed to test

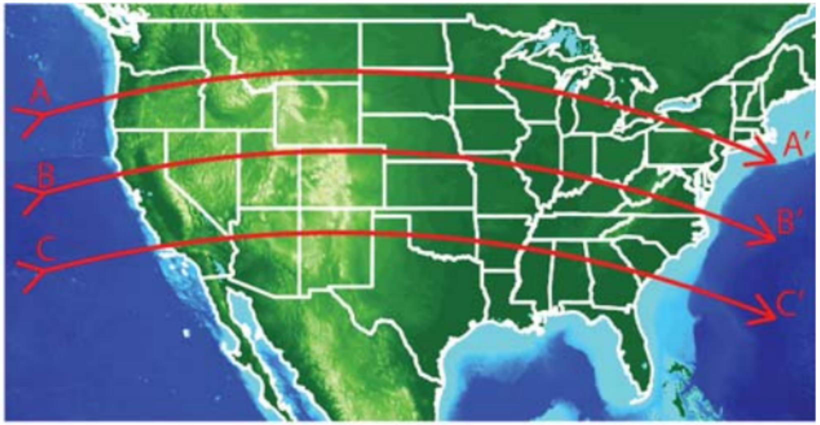


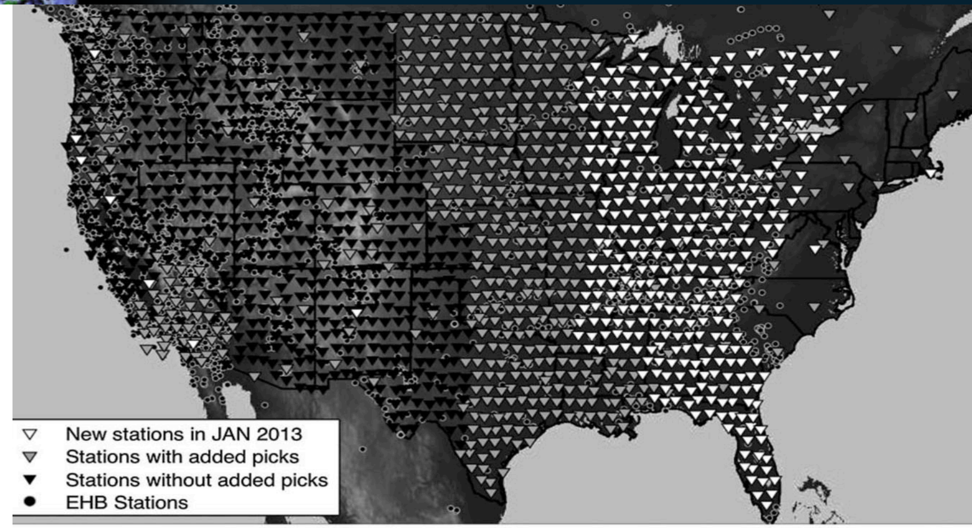
An EarthScope Science Sampler

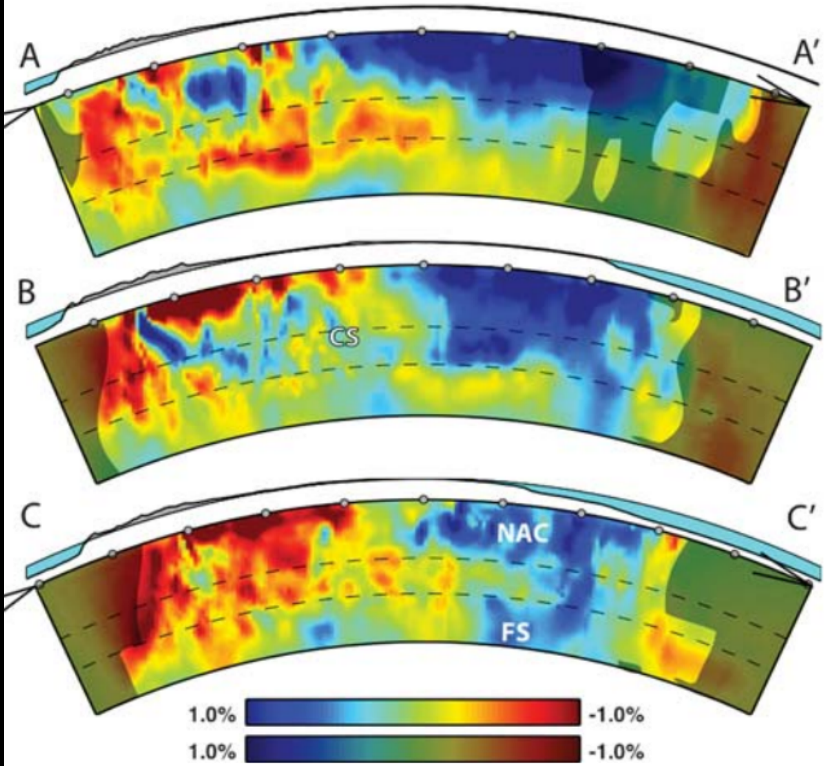
mage: http://www.formaggiokitchen.com

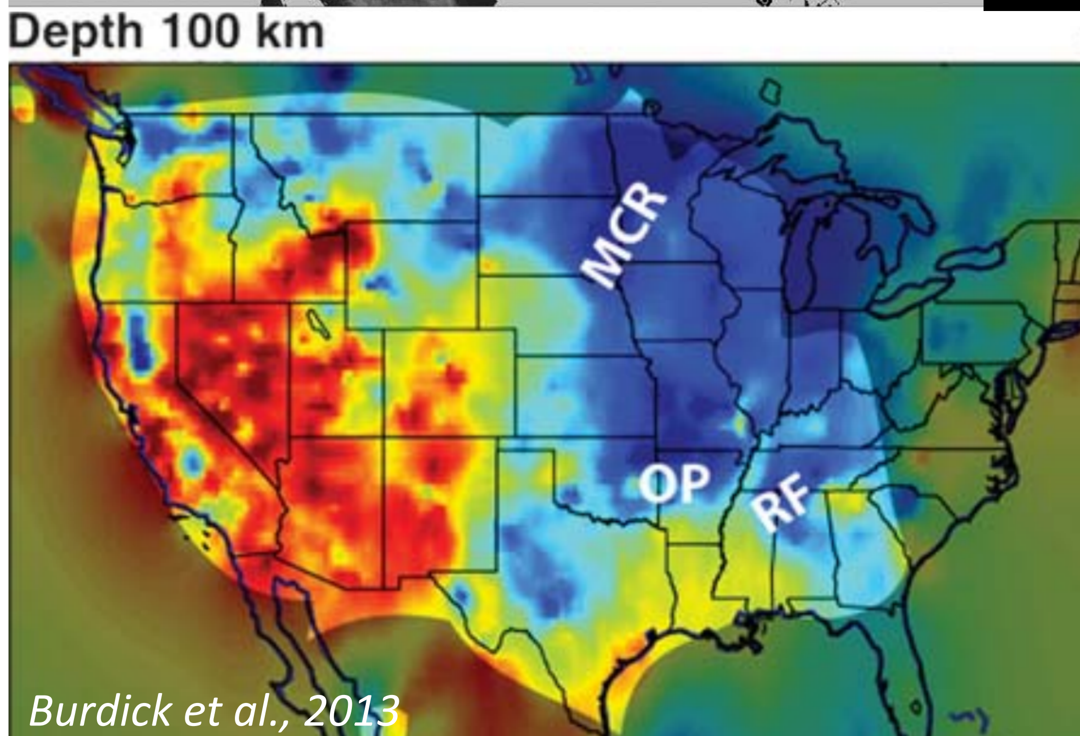
Joke: Jeff Freymueller

AMAZING IMAGES OF EARTH'S INTERIOR



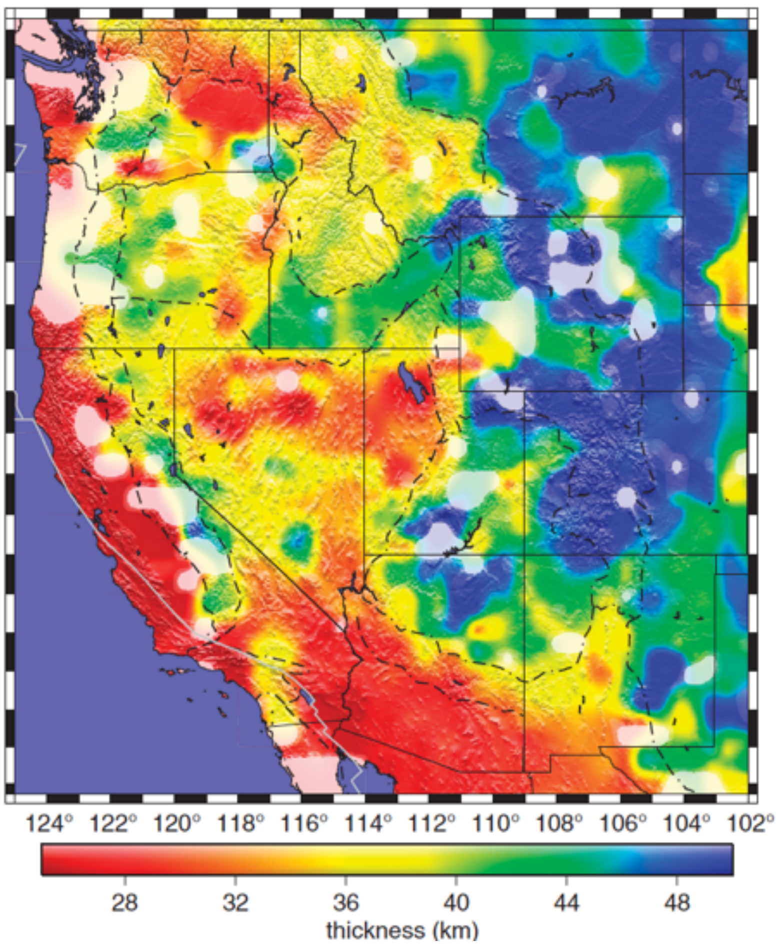




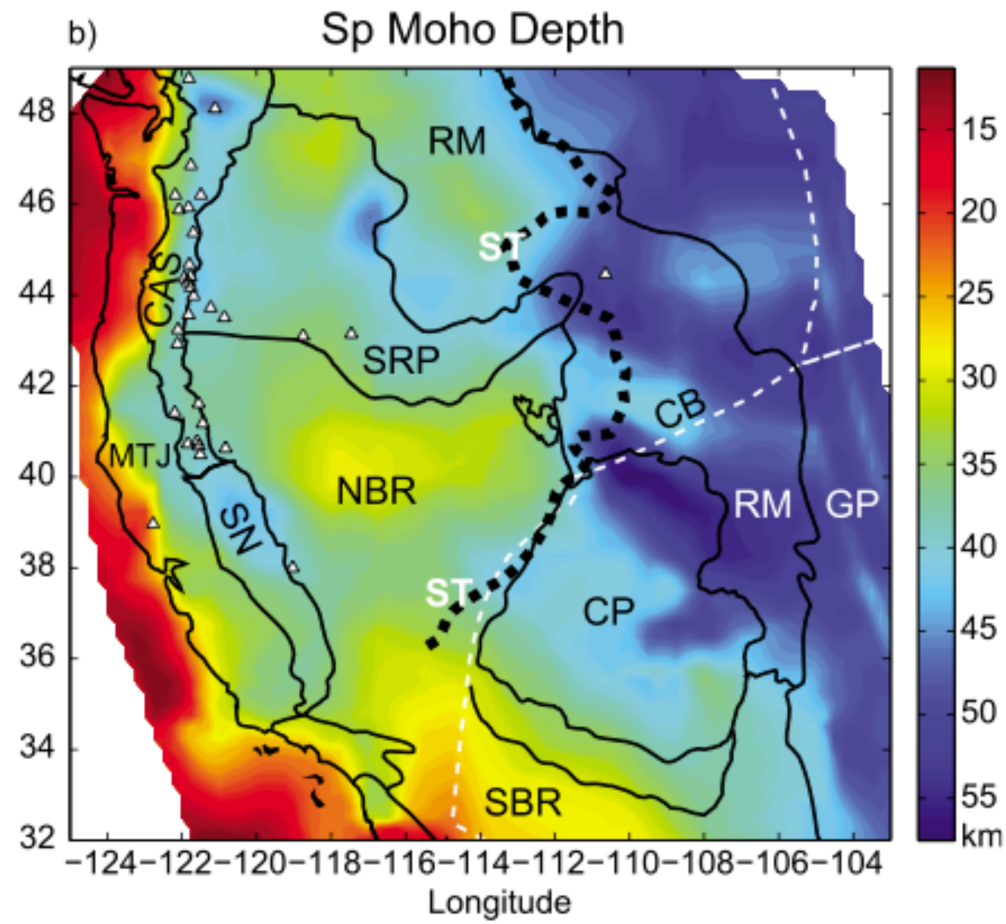


Burdick et al., 2013

CRUSTAL THICKNESS FROM RECEIVER FUNCTIONS

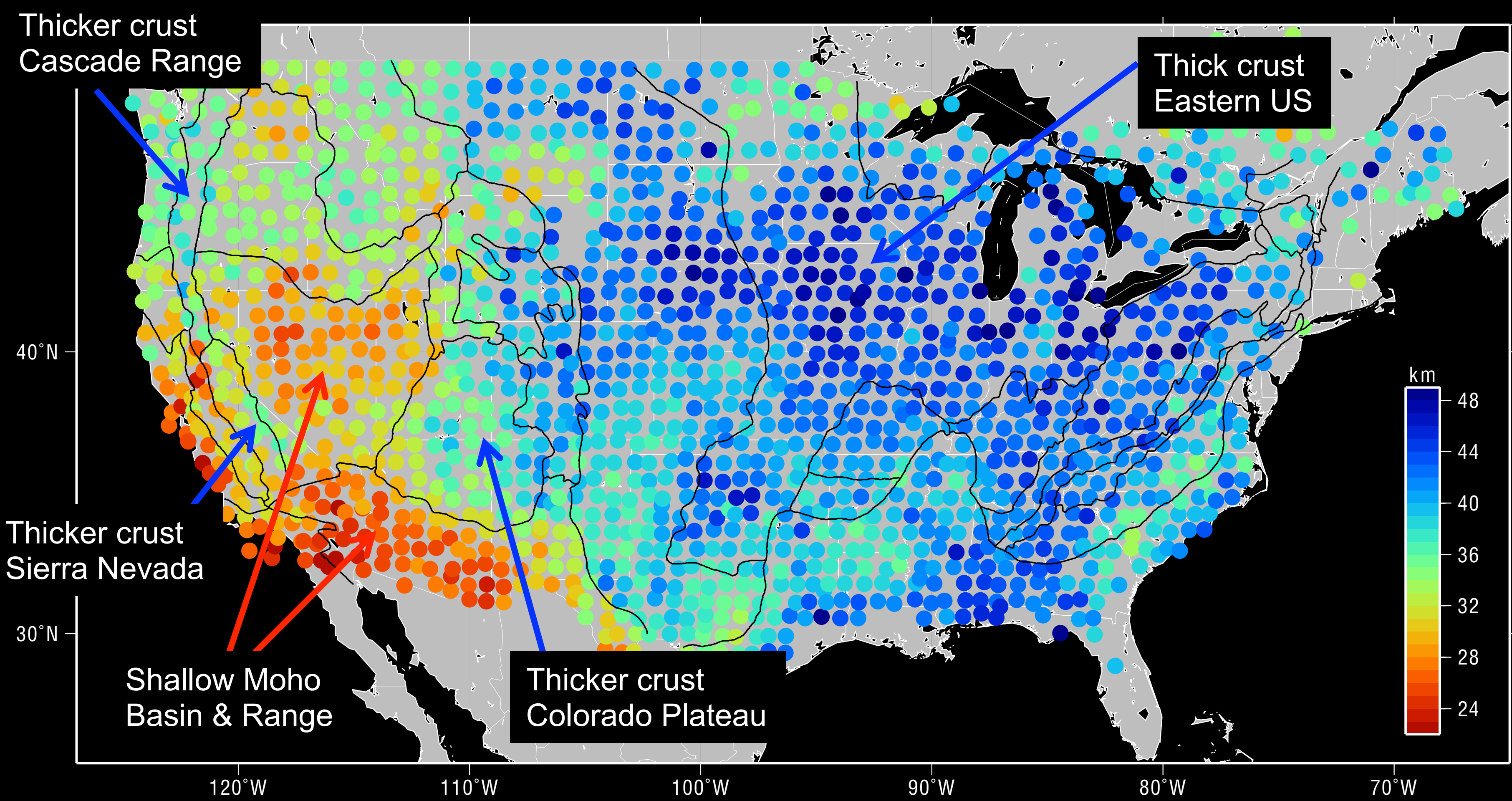


Gilbert, 2012

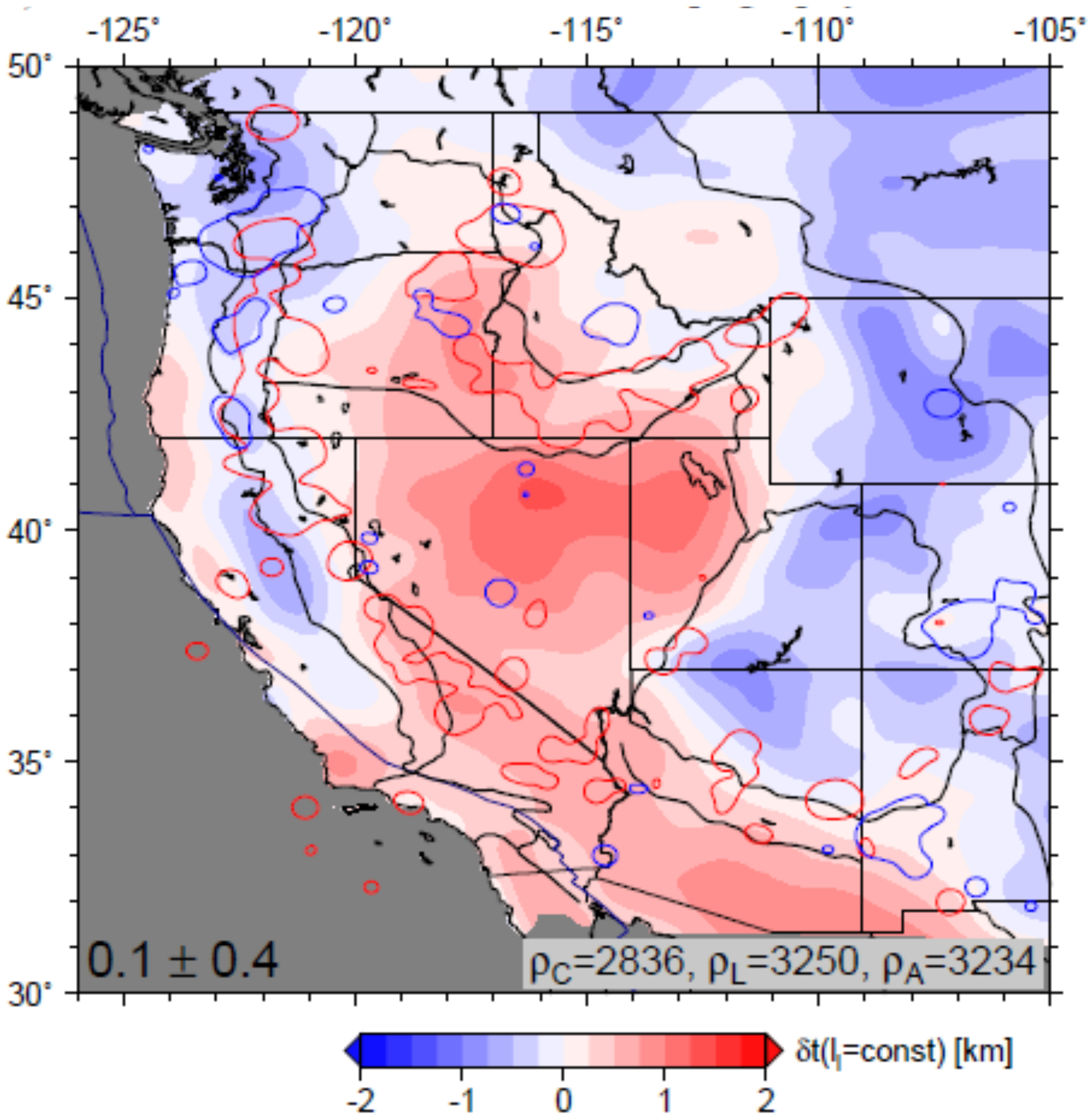


Levander & Miller, 2012

CRUSTAL THICKNESS FROM *Pn* STATION TIME TERMS



Buehler & Shearer, JGR 2014 and in prep



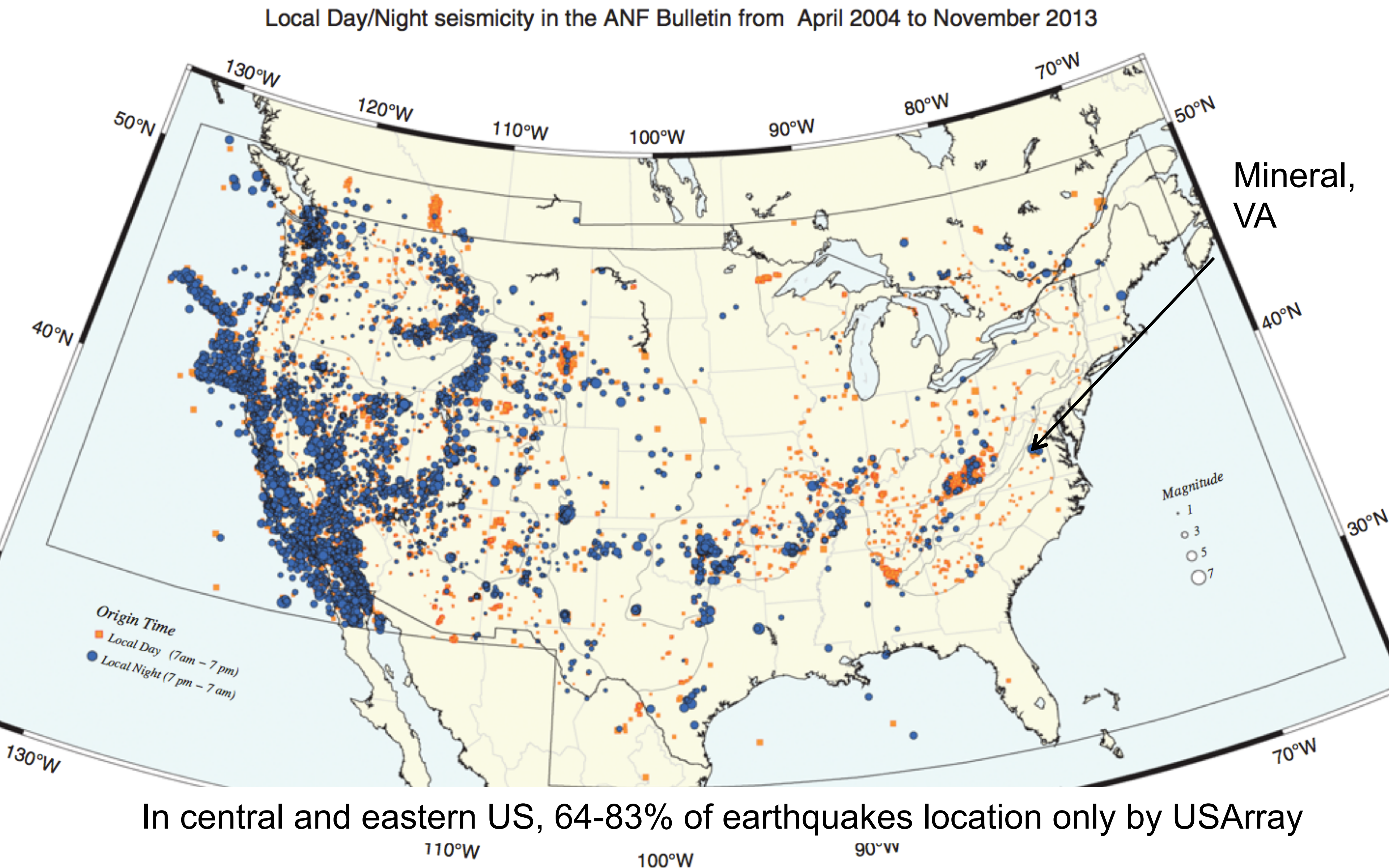
STATIC AND DYNAMIC SUPPORT OF TOPOGRAPHY

Topographic elevations not explained by variable crustal thickness. Lithospheric thickness variation hard to image and does not seem to explain either.
->important interactions between vigorous upper mantle convection and intraplate deformation

Becker, Faccenna, Humphreys, Lowry, & Miller, EPSL 2013

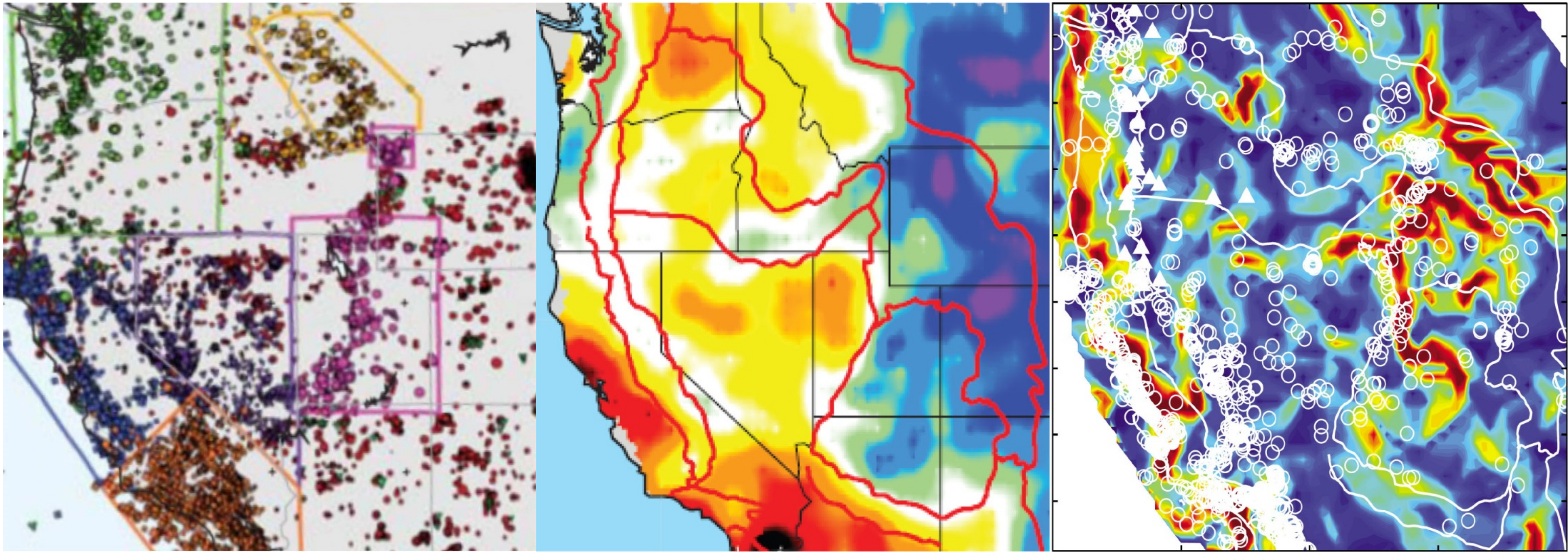
Earthquakes located by USArray

Luciana Astiz
University of California, San Diego

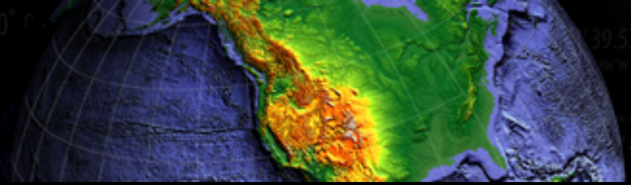


In central and eastern US, 64-83% of earthquakes location only by USArray

SEISMICITY CORRELATES WITH GRADIENTS IN CRUSTAL STRUCTURE

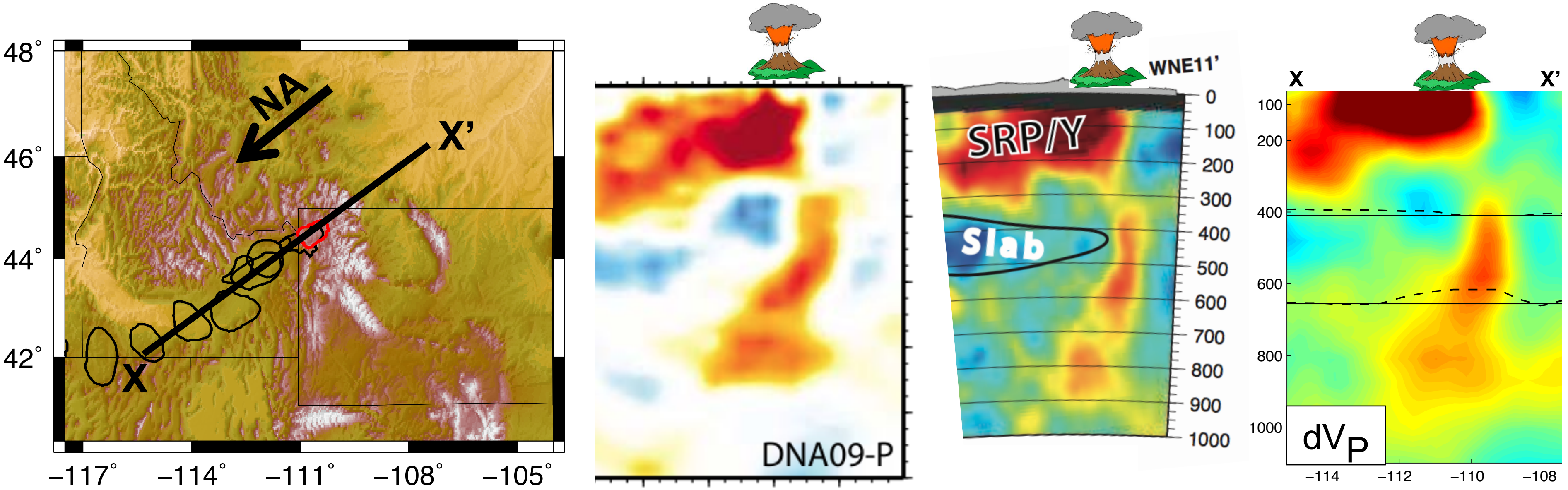


Astiz et al., 2014 | Shen & Ritzwoller, 2014 | Levander & Miller, 2012



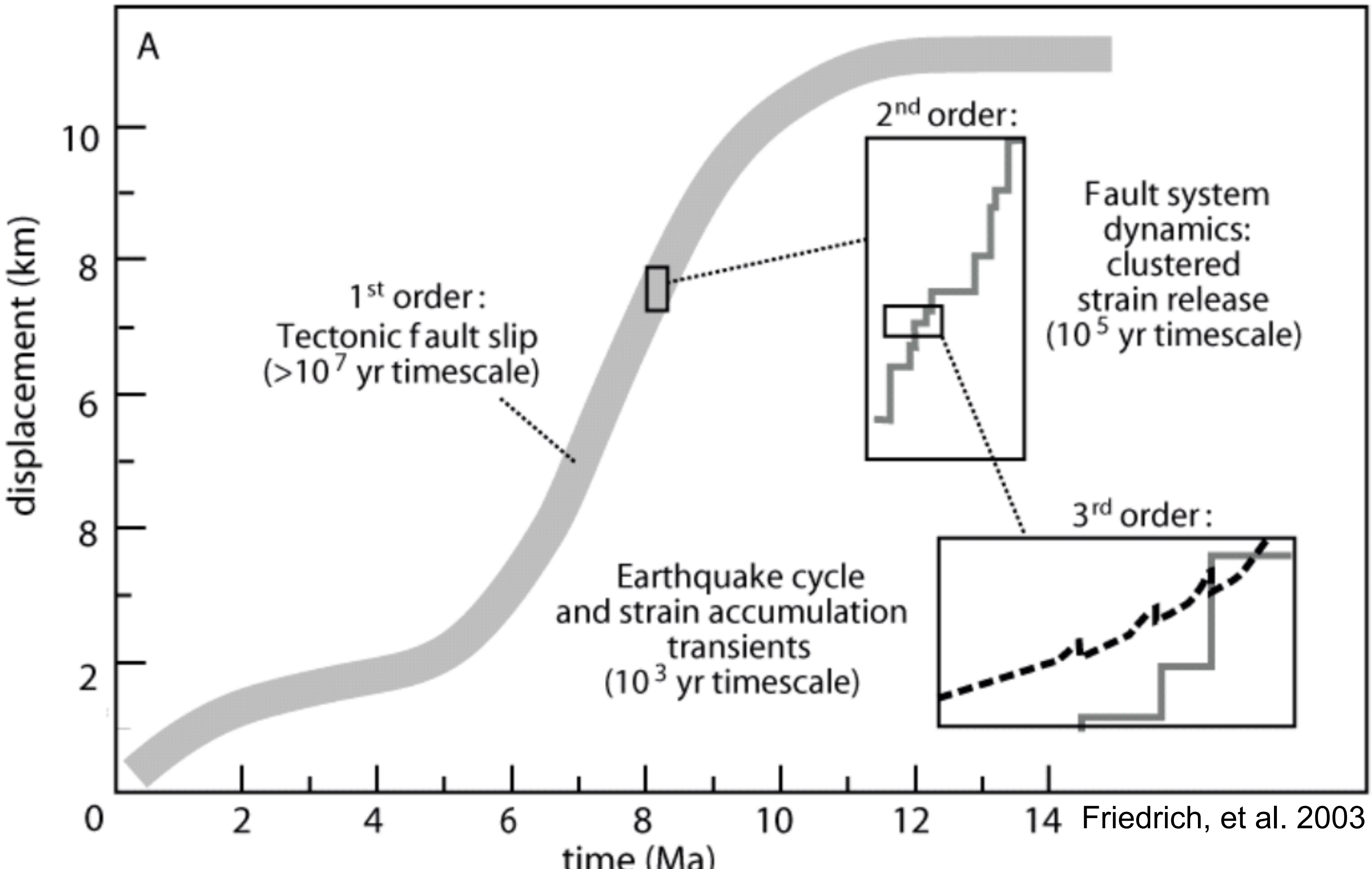
USARRAY TOMOGRAPHY BENEATH YELLOWSTONE

A vertically heterogeneous low-velocity anomaly extending into the lower mantle in the USArray tomography models.



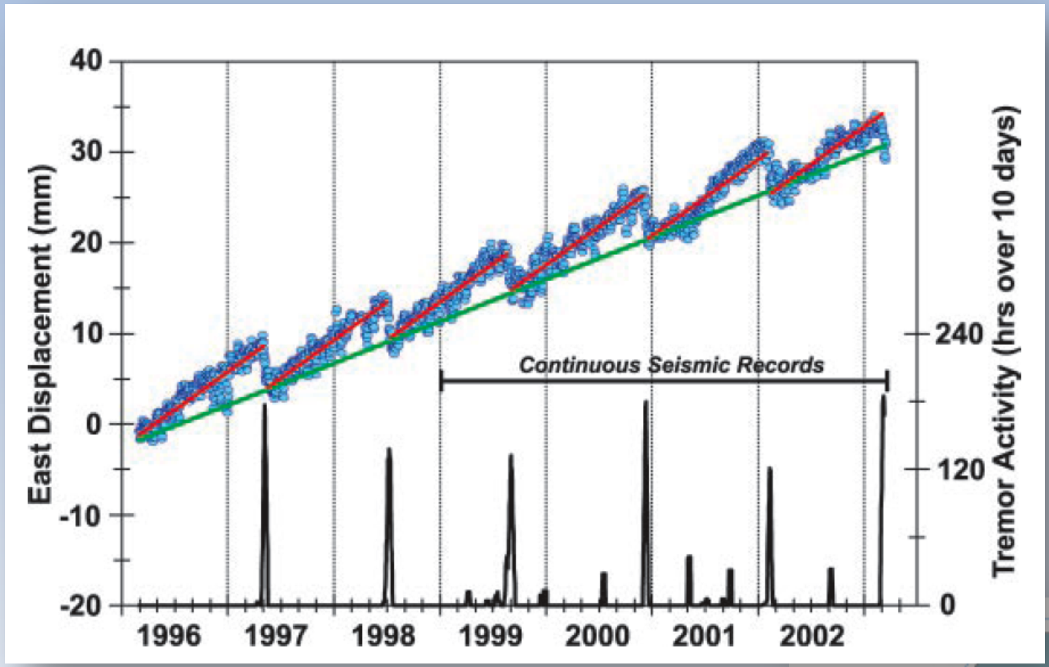
Obrebski et al. (2010) James et al. (2011)Schmandt et al. (2012)

Earth Deformation at periods of 10^1 to 10^7 yr



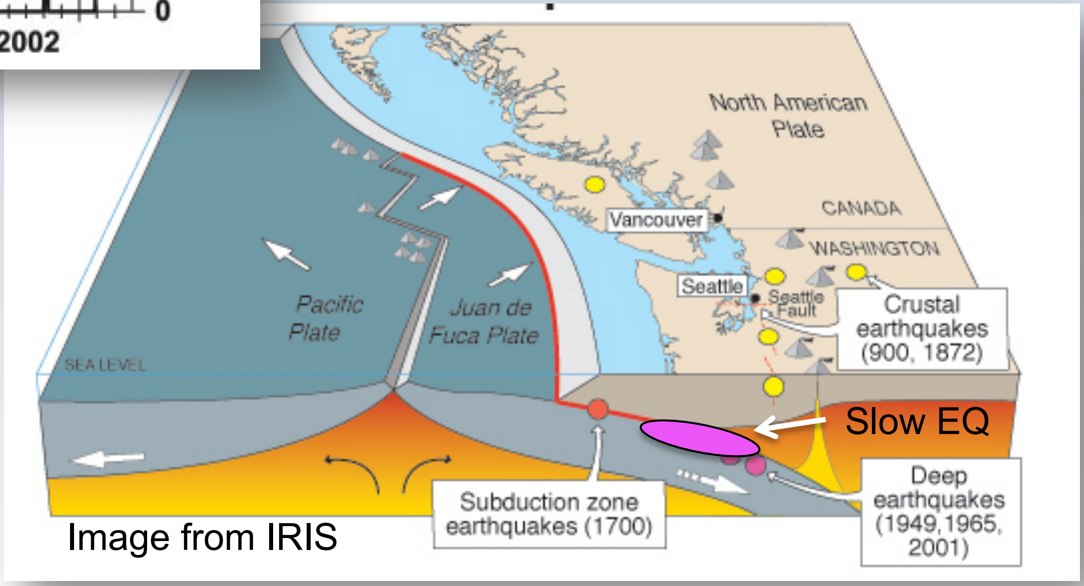
Friedrich, et al. 2003

Earthquakes, tremor and aseismic slip in Cascadia



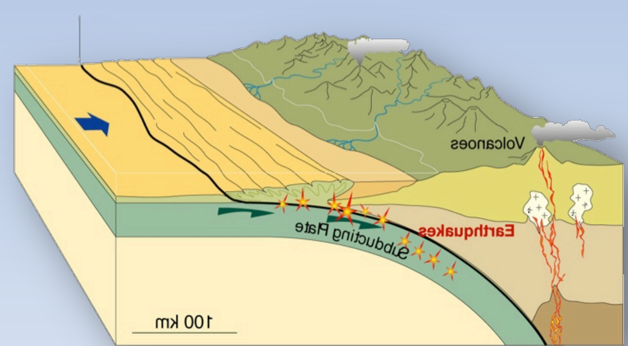
Rogers and Dragert, 2003

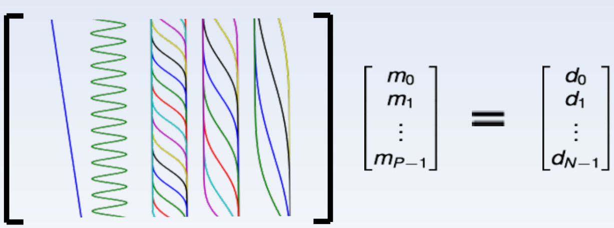
What
Where
When
Why



Cascadia: Aseismic Fault Slip Transients & Tremor

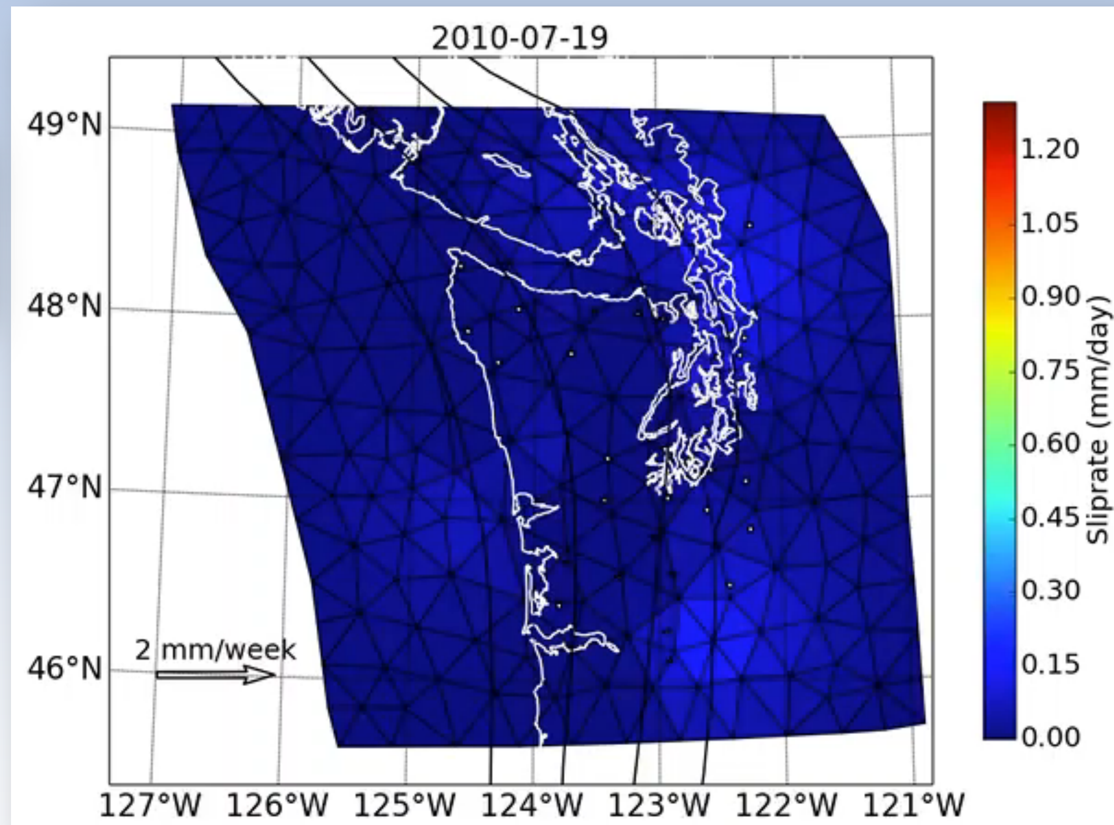
New Algorithms: Automated transient detection using sparsity based approaches





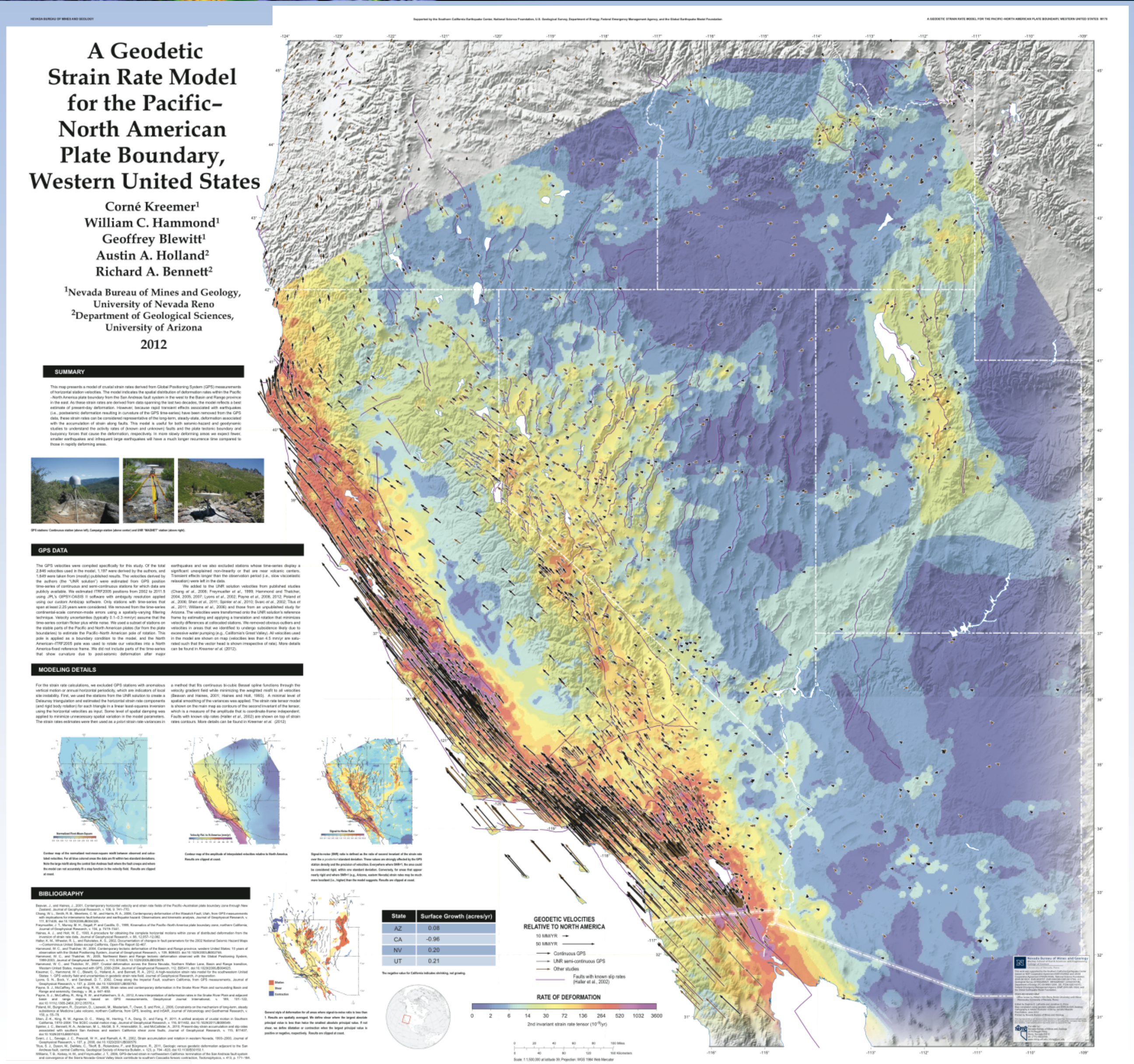
$$\mathbf{m} = \underset{\mathbf{m}}{\operatorname{argmin}} \|\mathbf{d} - \mathbf{G}\mathbf{m}\|_2^2 + \lambda \|\mathbf{m}\|_0$$

Transient slip rate and tremor vs time



Riel et al., 2014

Pacific - North American Plate Motions



Kinematics, dynamics & structure of the San Andreas Fault

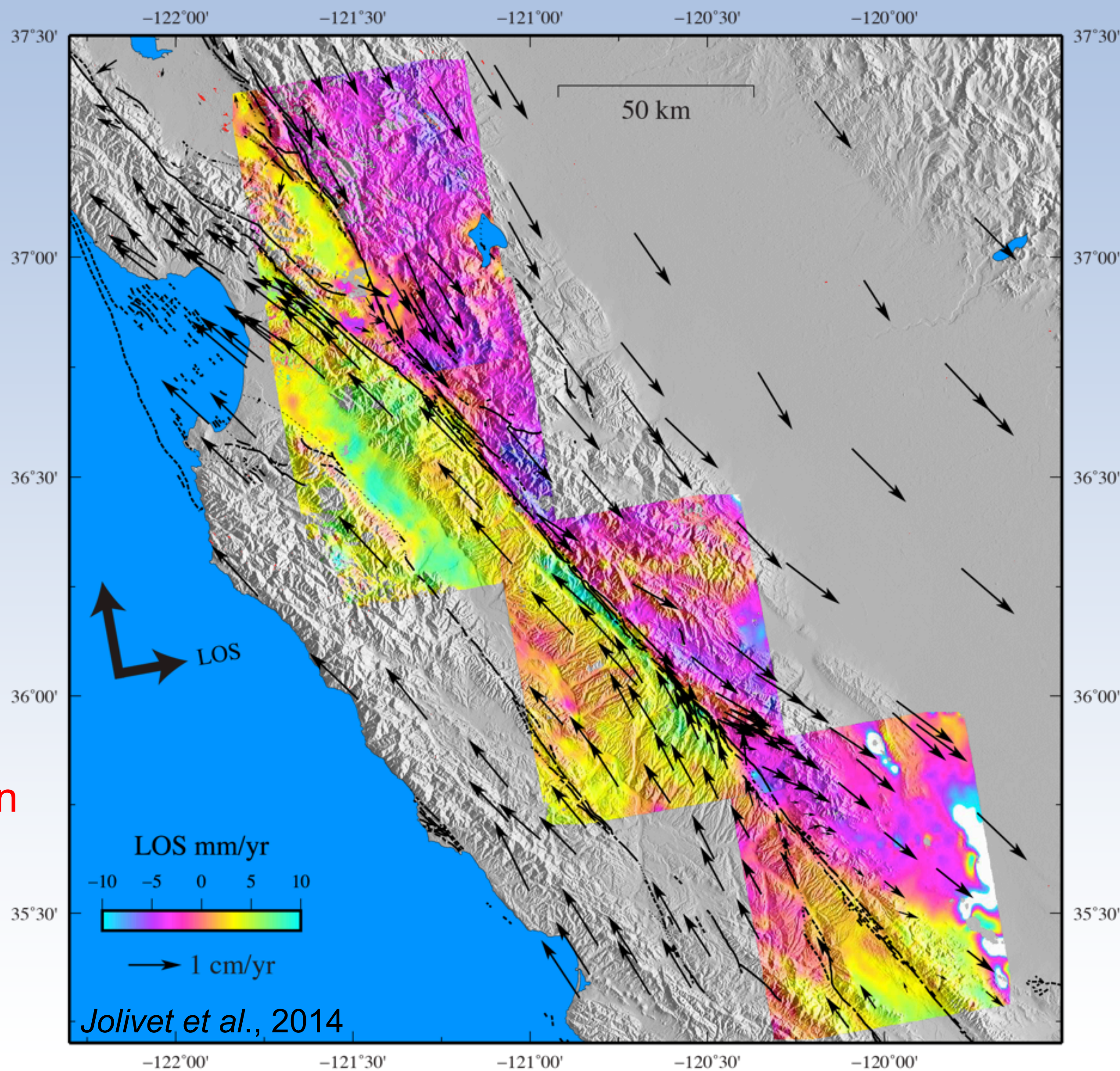
- Low strain accumulation across the Central SAF
- Previous ruptures don't overlap with creeping regions.
- Transition from creeping to locked is smooth in the north but abrupt in the south.

Data

Satellite radar: ALOS

GPS: PBO, BARD

Mapping interseismic strain accumulation by merging GPS and repeat satellite radar imaging



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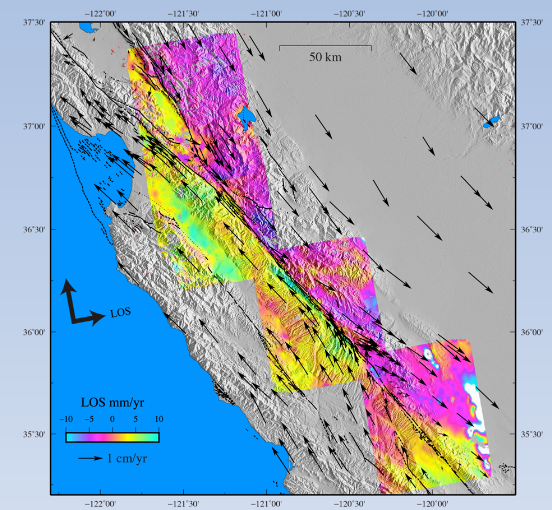
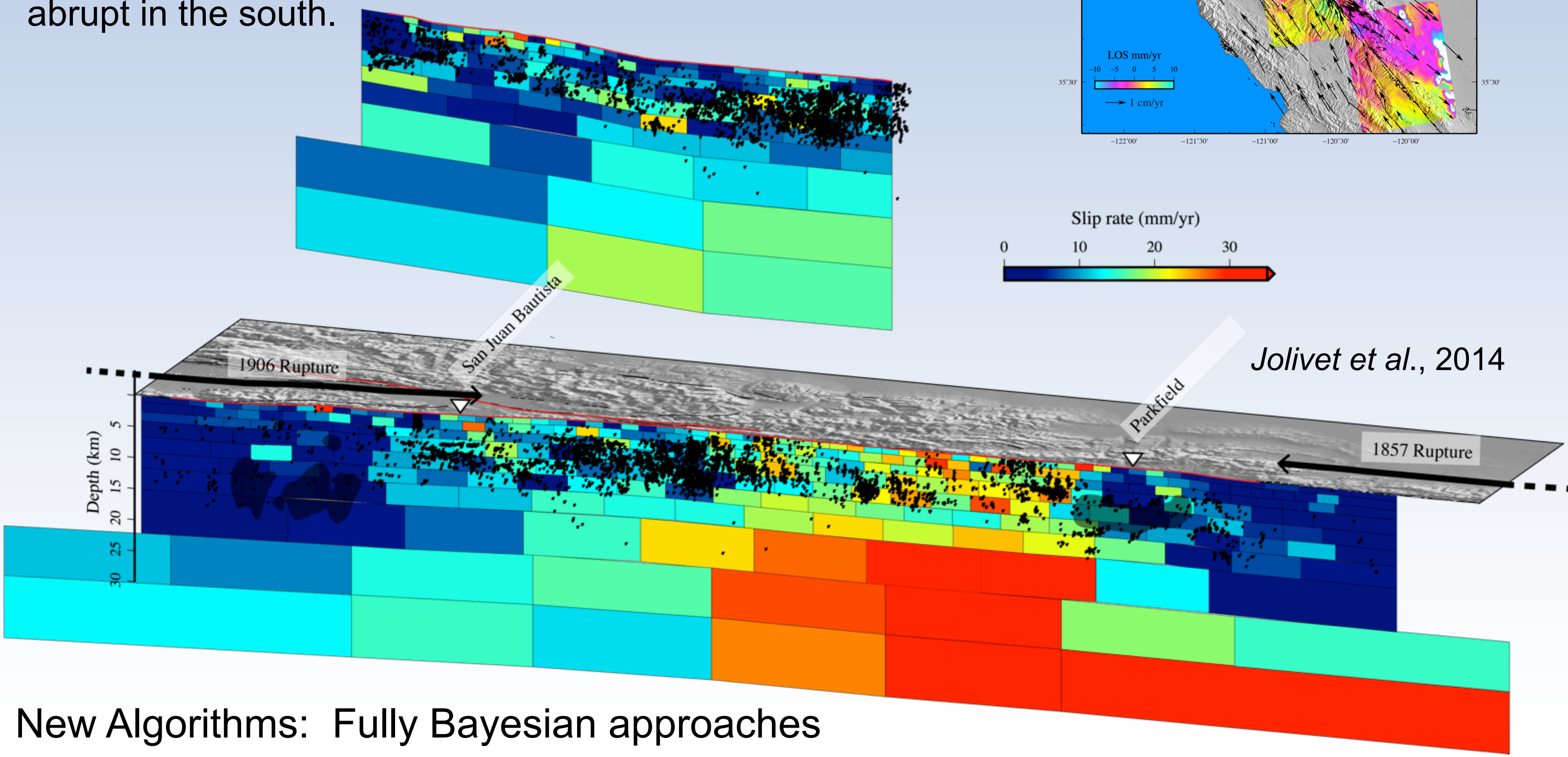
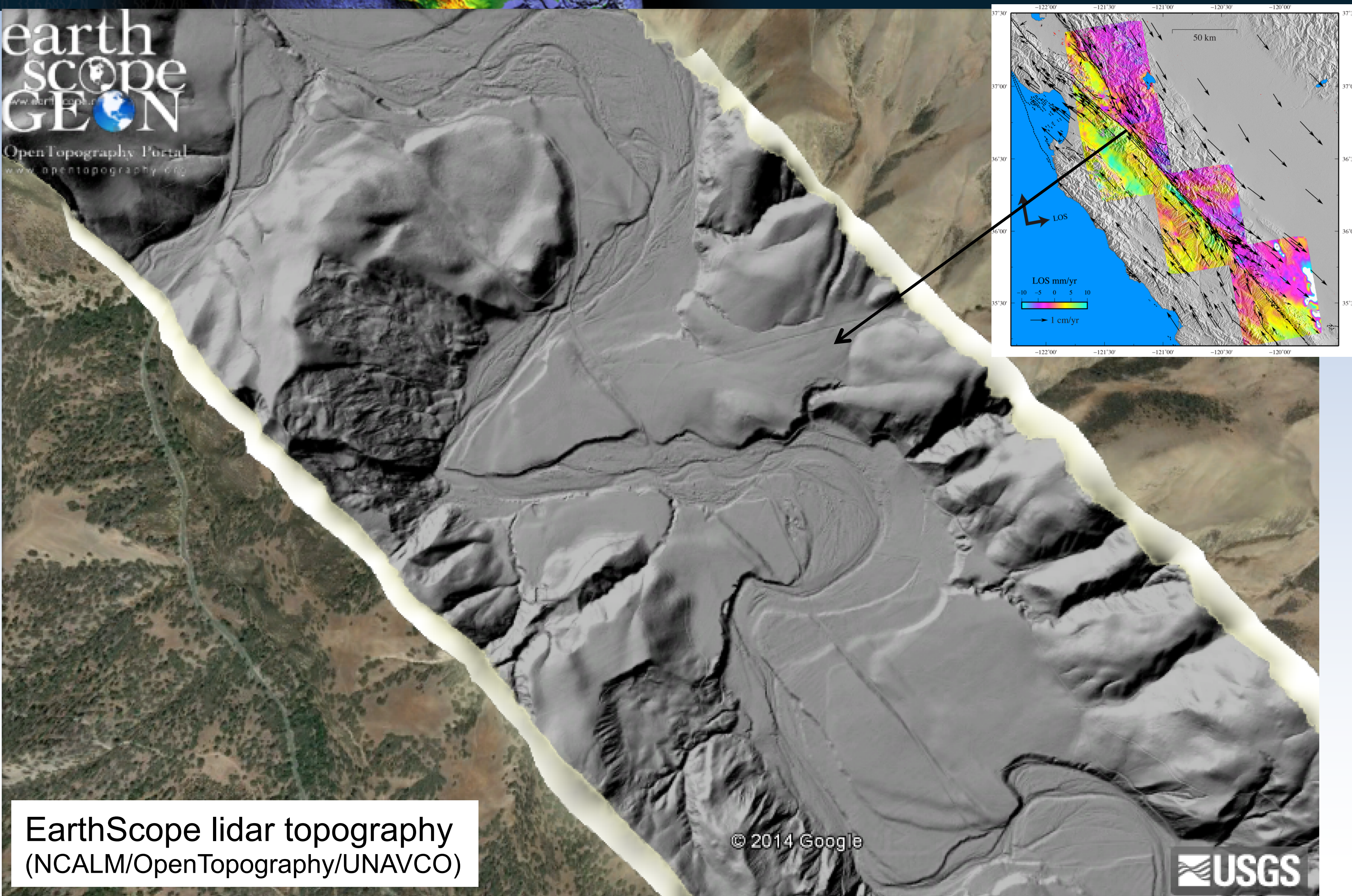




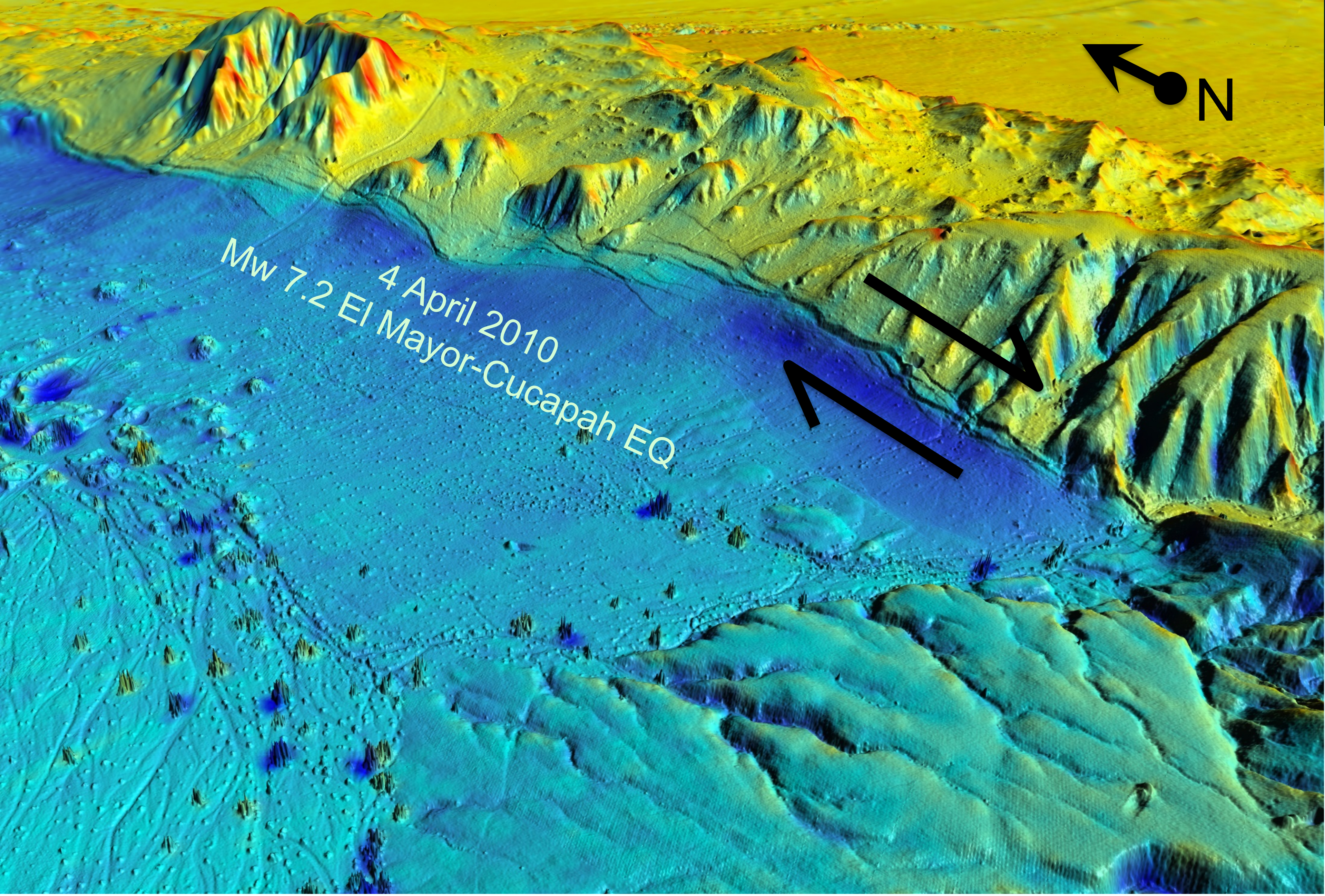
Jolivet et al., 2014

New Algorithms: Fully Bayesian approaches

Kinematics, dynamics & structure of the San Andreas Fault



EarthScope lidar topography
(NCALM/OpenTopography/UNAVCO)

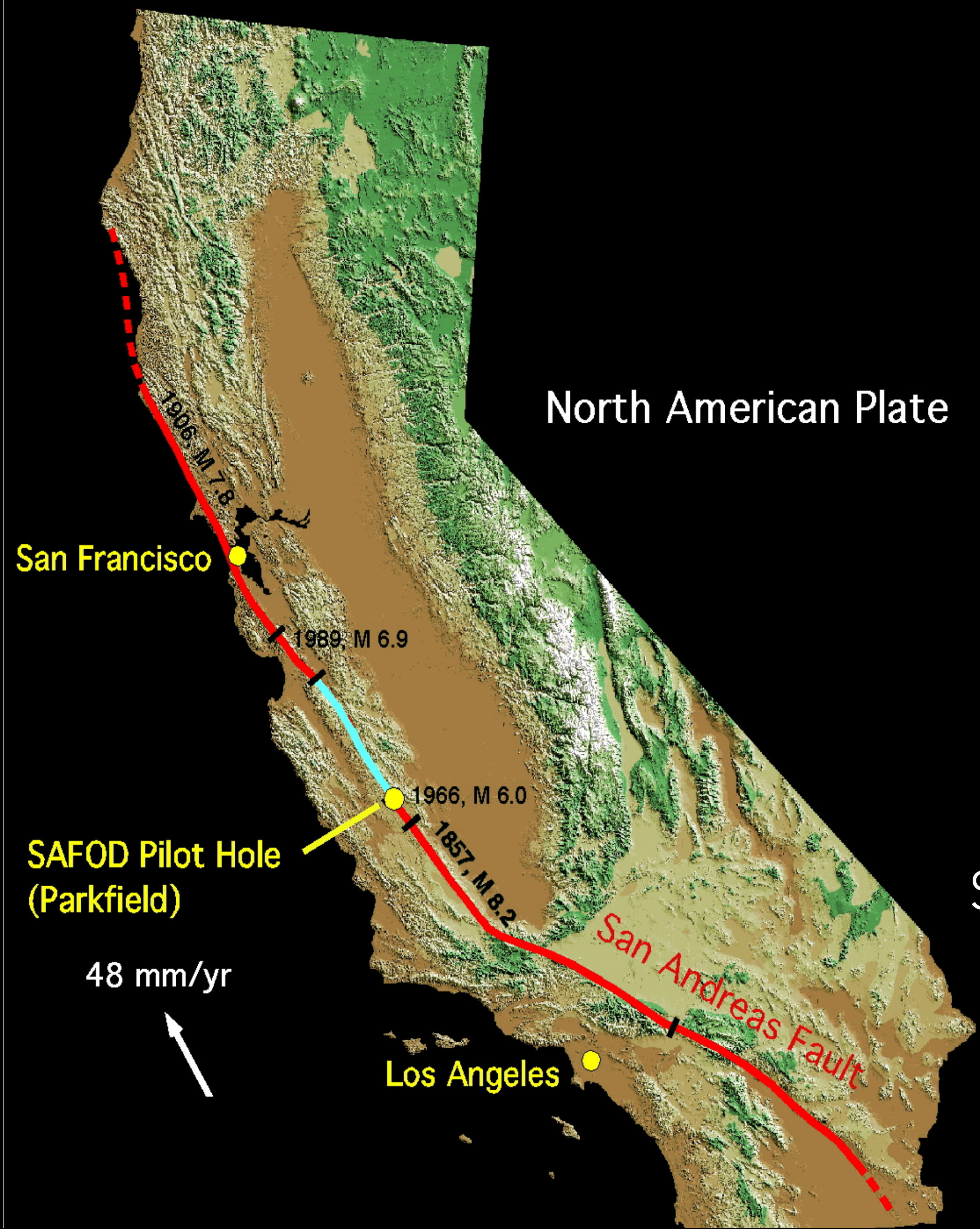


Using LIDAR to detect detailed fault offsets

Oskin, et al., 2012

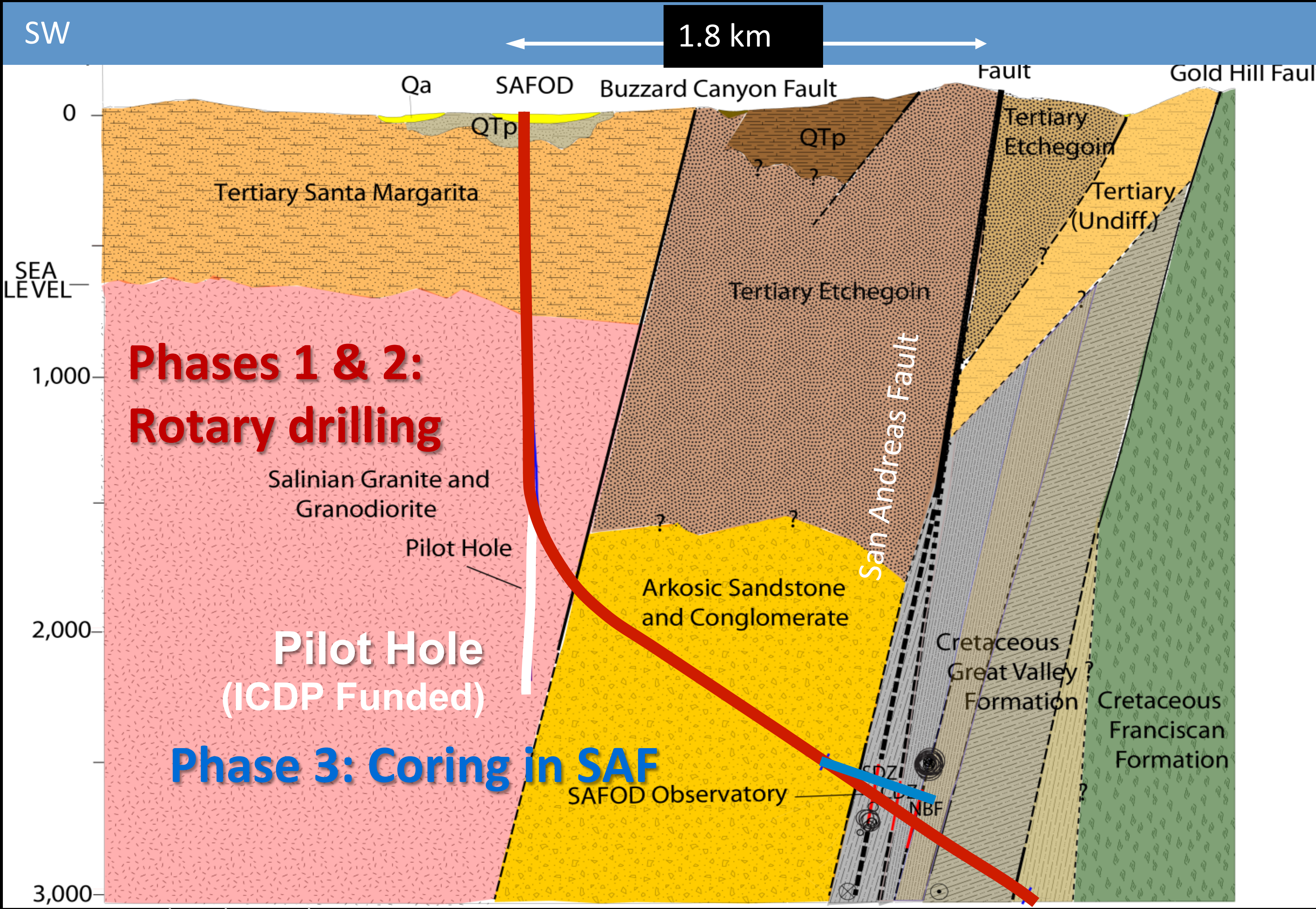
What is the strength of a plate boundary fault at seismogenic depth?

Is it 100-200 MPa, $\mu \approx 0.6$, or 10-20 MPa, $\mu \leq 0.2$?



SAFOD: Determine physical and chemical processes controlling deformation and earthquake generation within an active plate-bounding fault zone

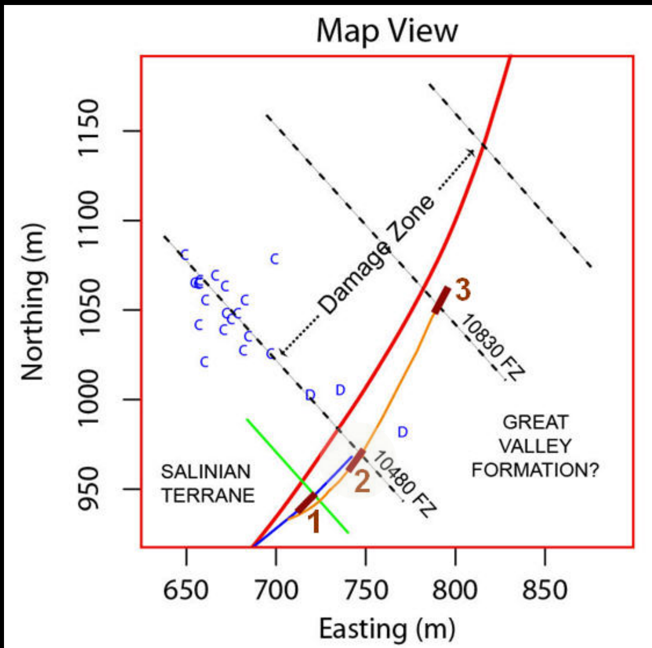
SAFOD Geology and Drilling Plan

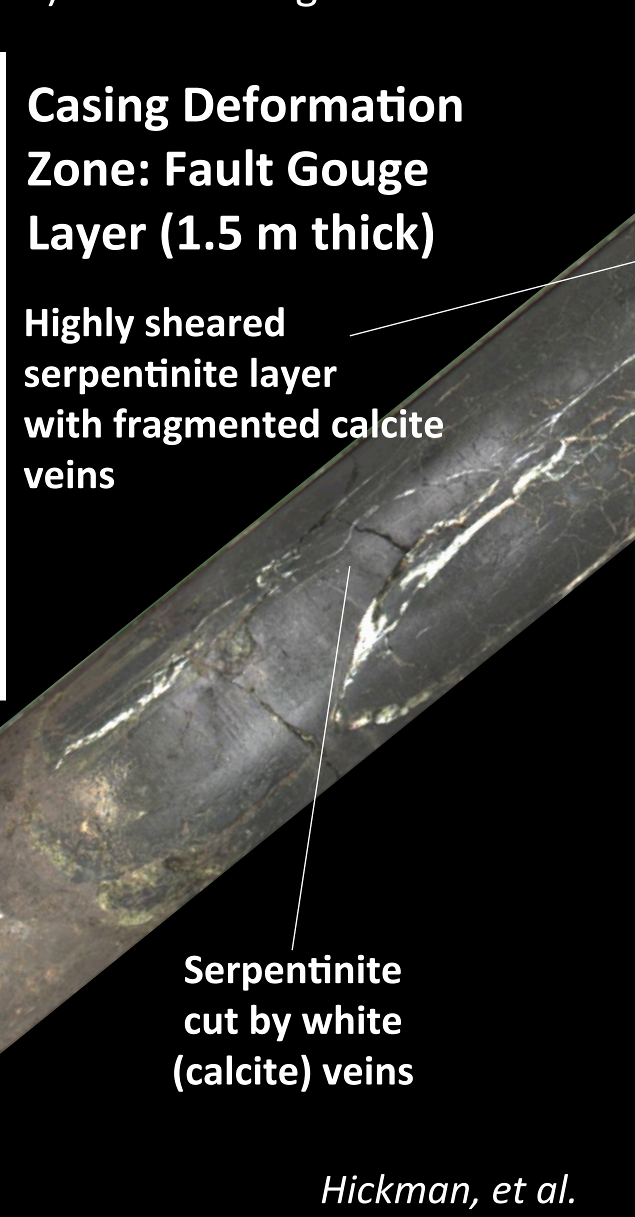


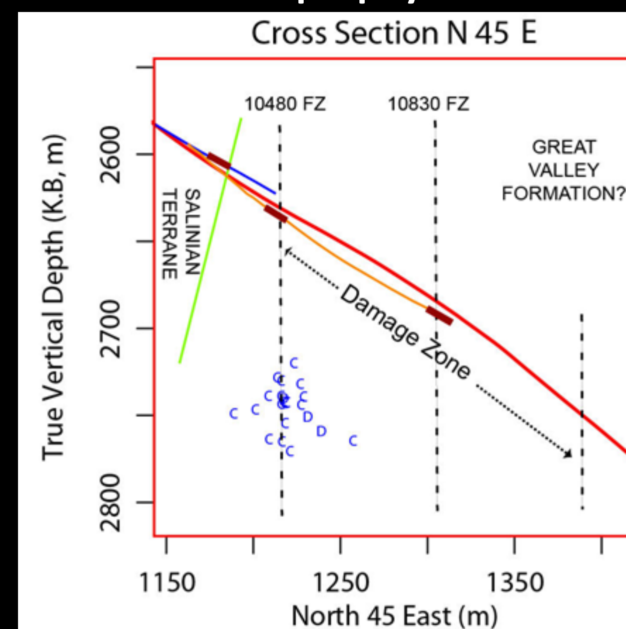
Zoback et al., EOS 2010

Phase 3 Coring: Interval 2 - Across 10,480′ Fault

Talc + Serpentine Found in Cuttings from 10,480 and 10,830 faults (see Solum et al, 2006; *Moore and Rymer, 2007*) →Mineralogical control on fault strength?

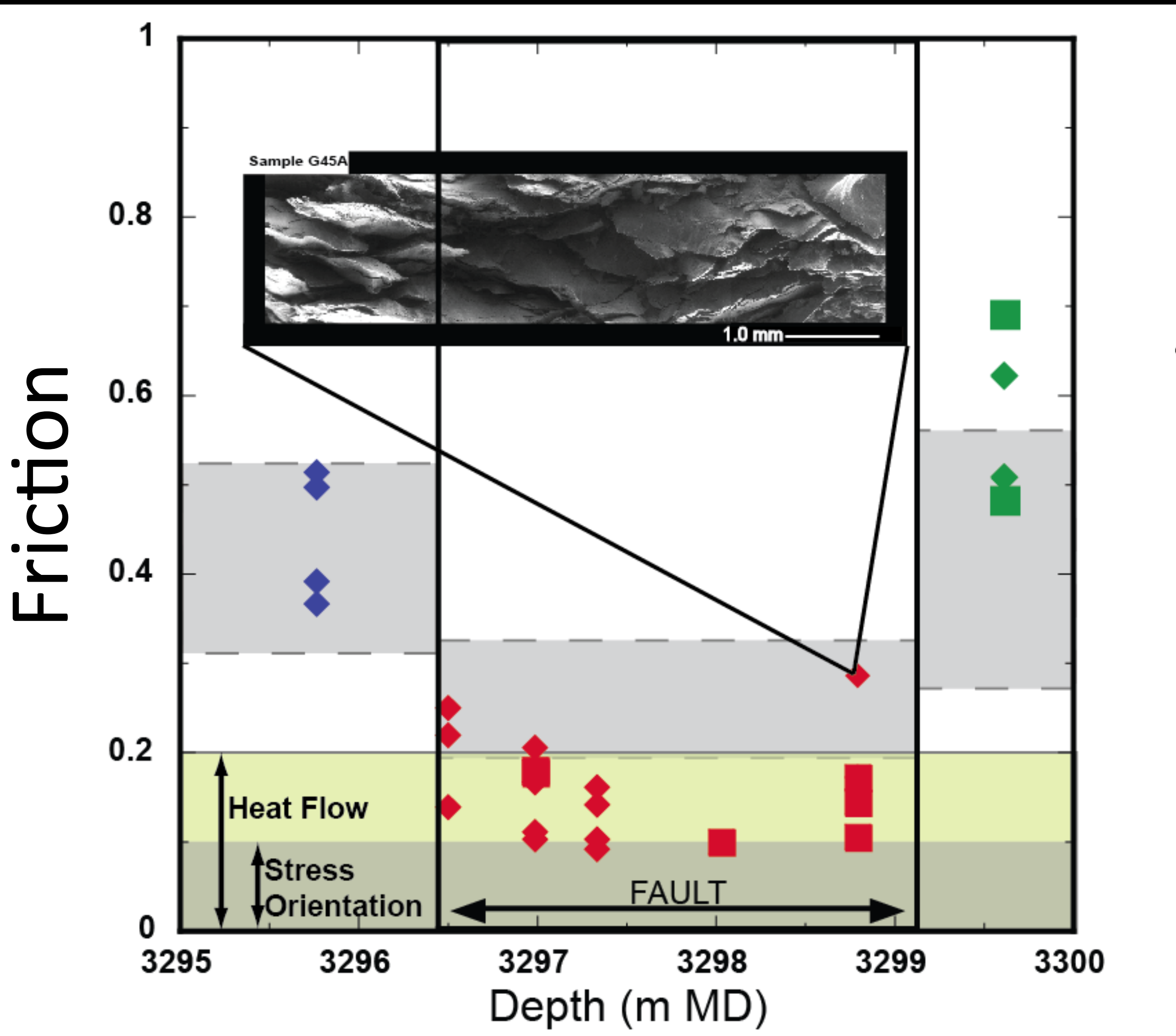


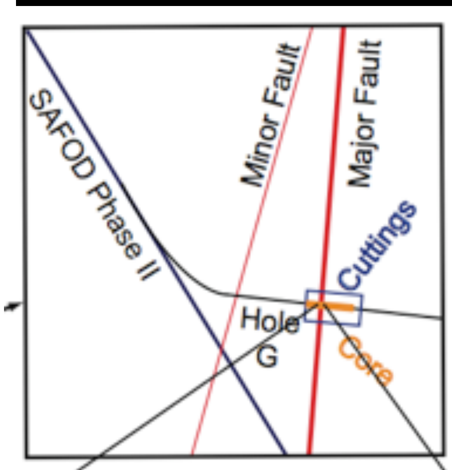




Hickman, et al.

Frictional Strength, SAFOD Phase III Core





Carpenter, Marone, and Saffer, 2011

Carpenter, Saffer and Marone, 2012

David Lockner
US Geological Survey, California

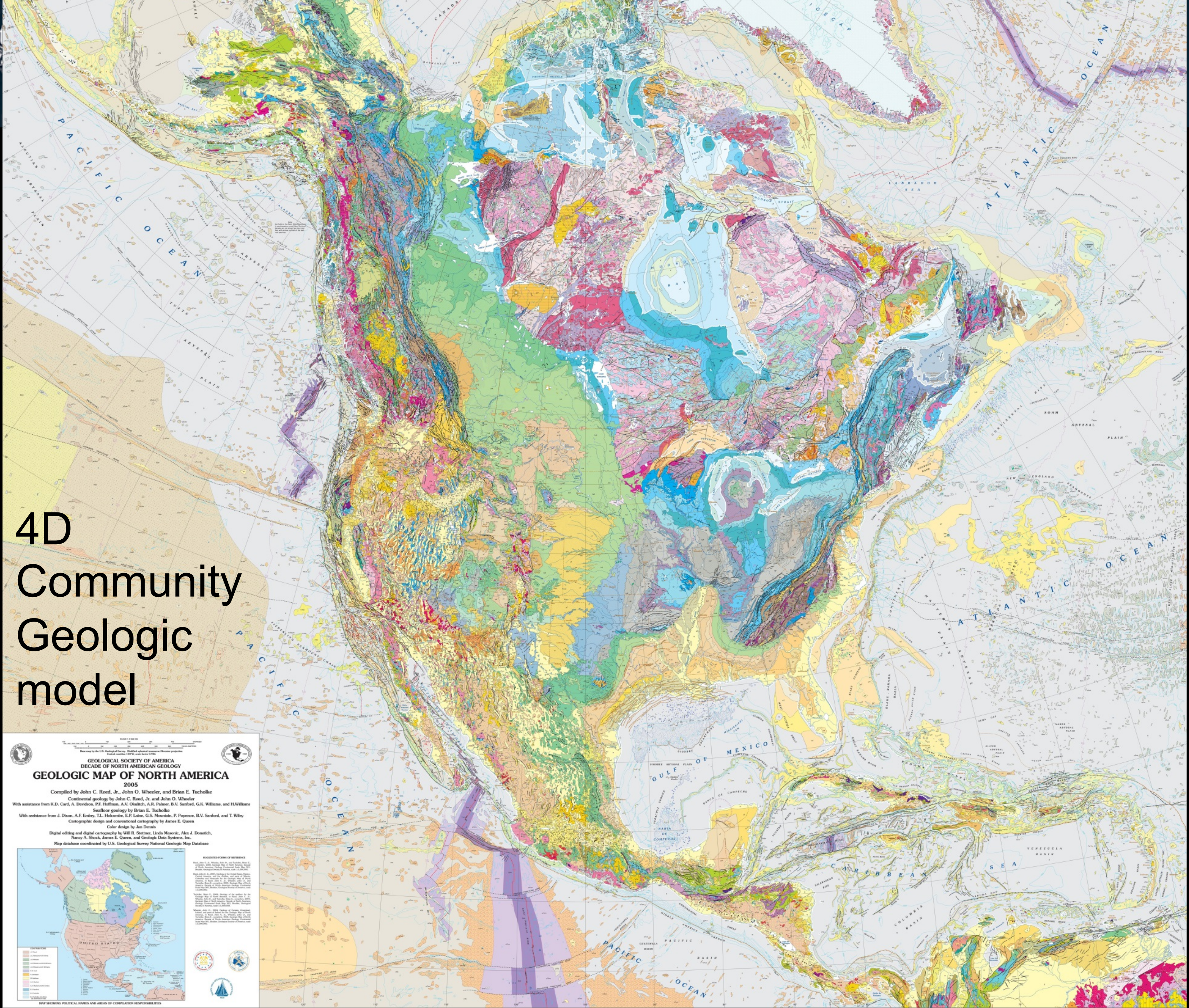
San Andreas Fault is Profoundly Weak

- Weakness is due to properties of fault gouge, not fluid pressure.
- Fault zone is narrow.
- Drilling laid to rest decades of debate about weakness and structure of fault zone.

What is next?

- What do we want to be doing in 2020?
- Build on the scientific, technical, and broader impact successes of EarthScope
- New partnerships

http://www.trainerscity.com/startrek/ships.php



4D Community Geologic model

A Big Idea: Subduction Zone Observatory

Facilitate – Collaborate – Educate

Understanding Subduction Zones

- Subduction Zone Observatories
  - IRIS-UNAVCO collaboration to spearhead an international effort
- Leverages a history of technical interchange and collaboration: GSN, Polar, GLISN, Polenet, TA, PBO, Reference Network, COCONet, TlalocNet
- Builds from the existing backbone and engagement of regional partners
- Basic research and societal relevance and impact
- Multidisciplinary
  - Seismology, geodesy, volcanology, atmospheric . . .
- A legacy of EarthScope beyond 2018?

-SAGE and GAGE proposals; community meetings