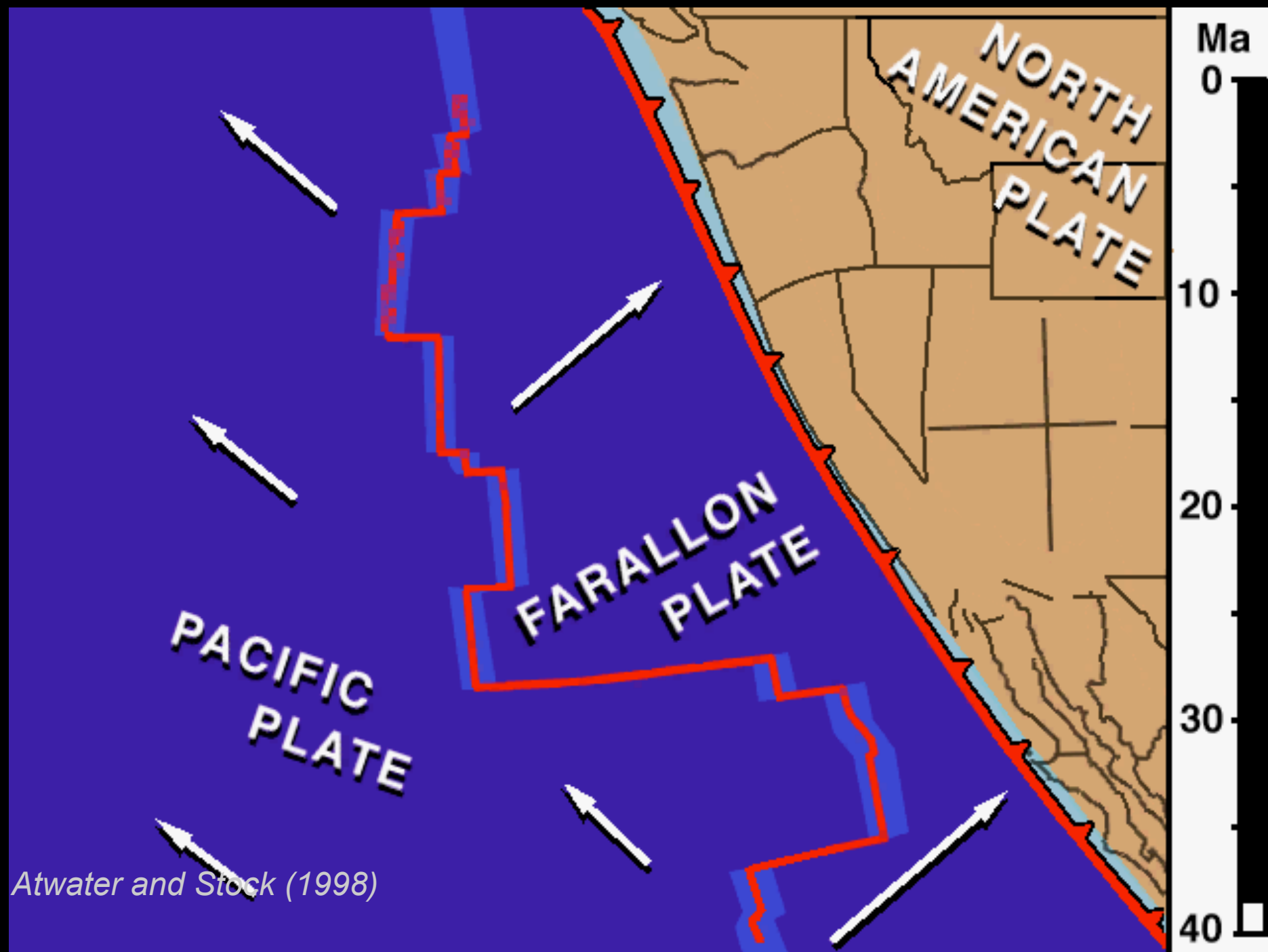




Adventure #14:

Tectonic, magmatic, and tomographic signals of the Farallon plate's influence on Western N. America

Plate kinematics of Western N. America

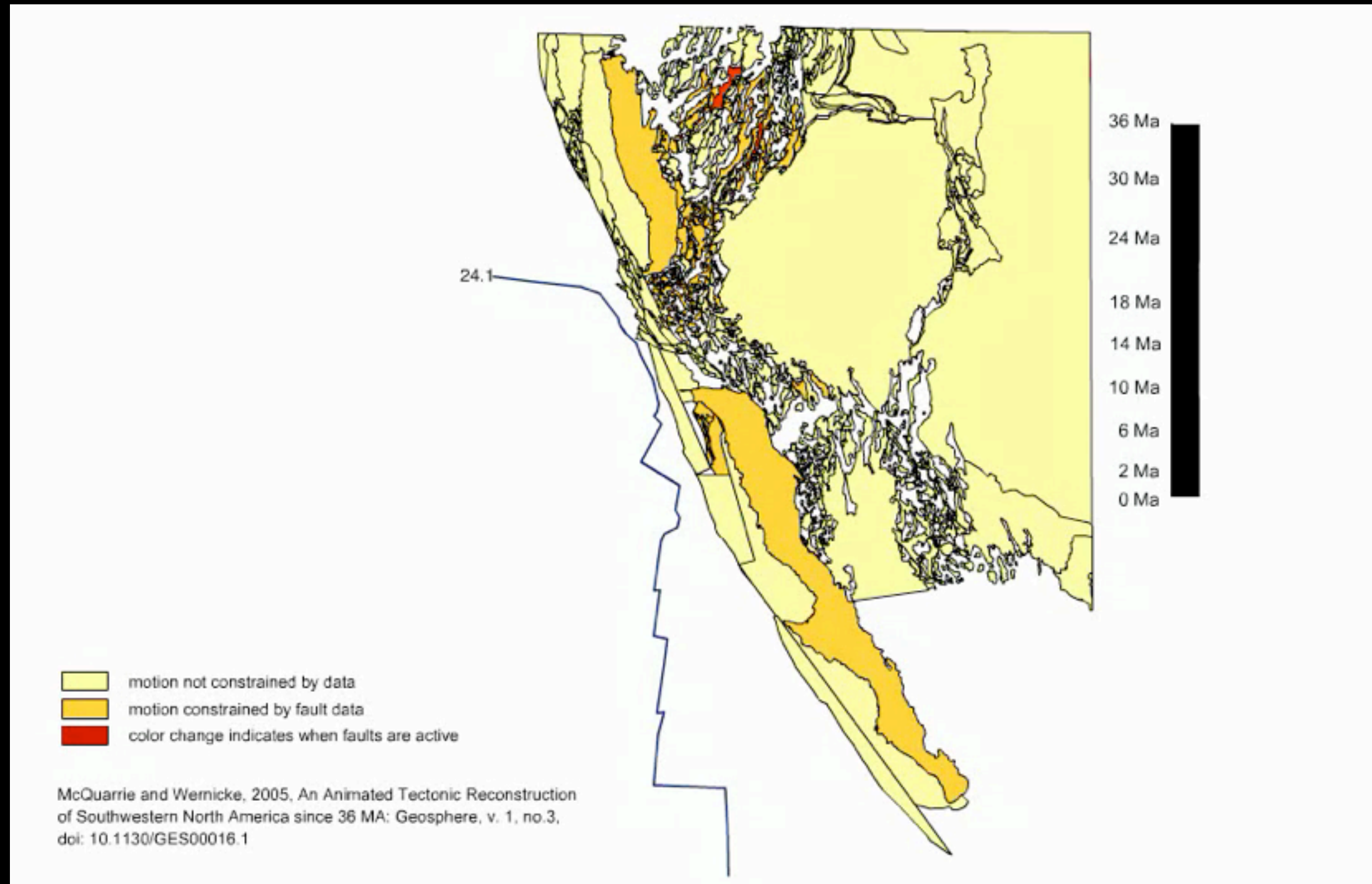


http://emvc.geol.ucsb.edu/3_downloads/M4WNACal/bNEPacWNoAmer/NEPacWNoAmer.zip



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The Basin and Range Province



http://geosphere.geoscienceworld.org/content/suppl/2009/02/13/1.3.147.DC1/10.1130_GES00016.1.s1.mov



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The Basin and Range Province

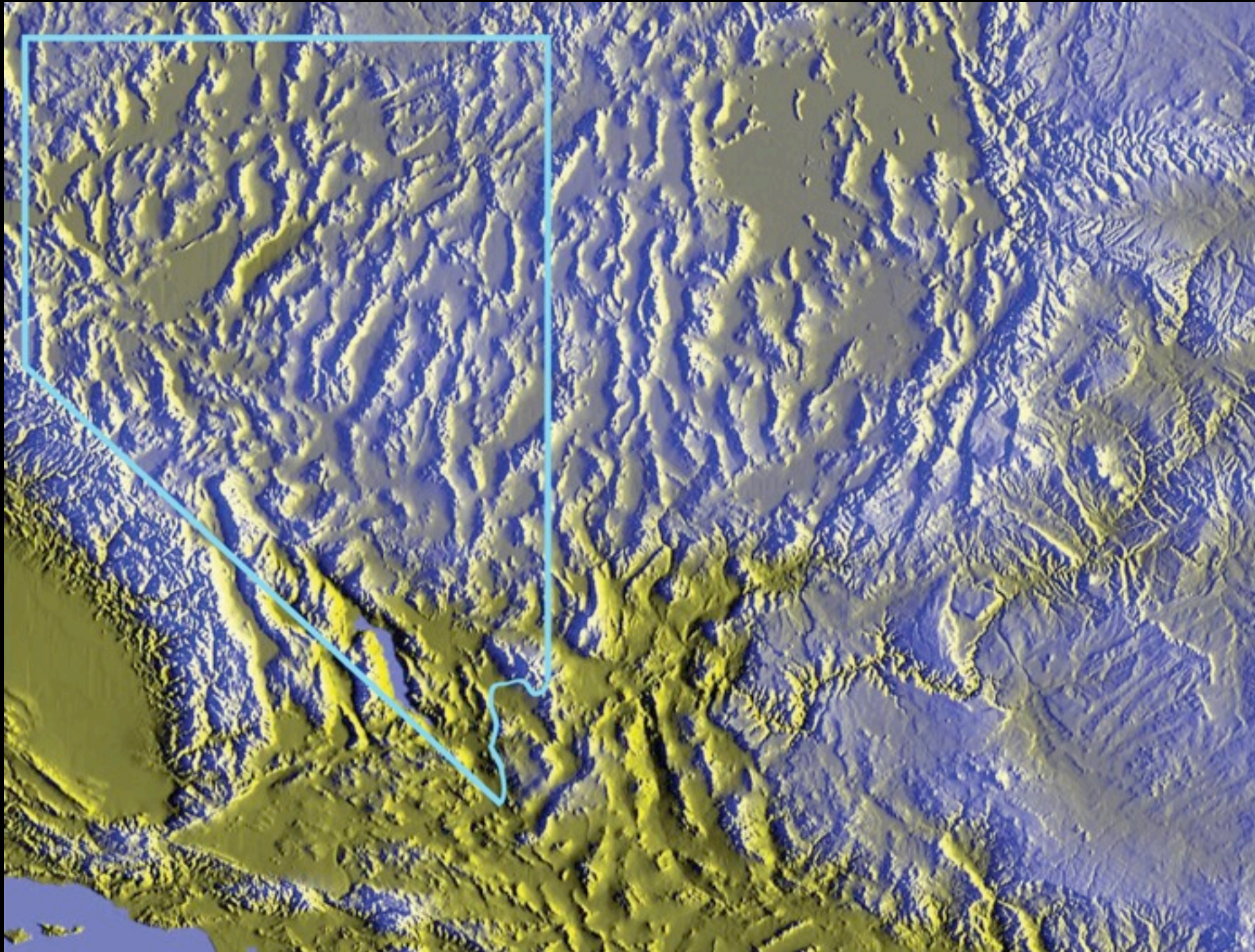
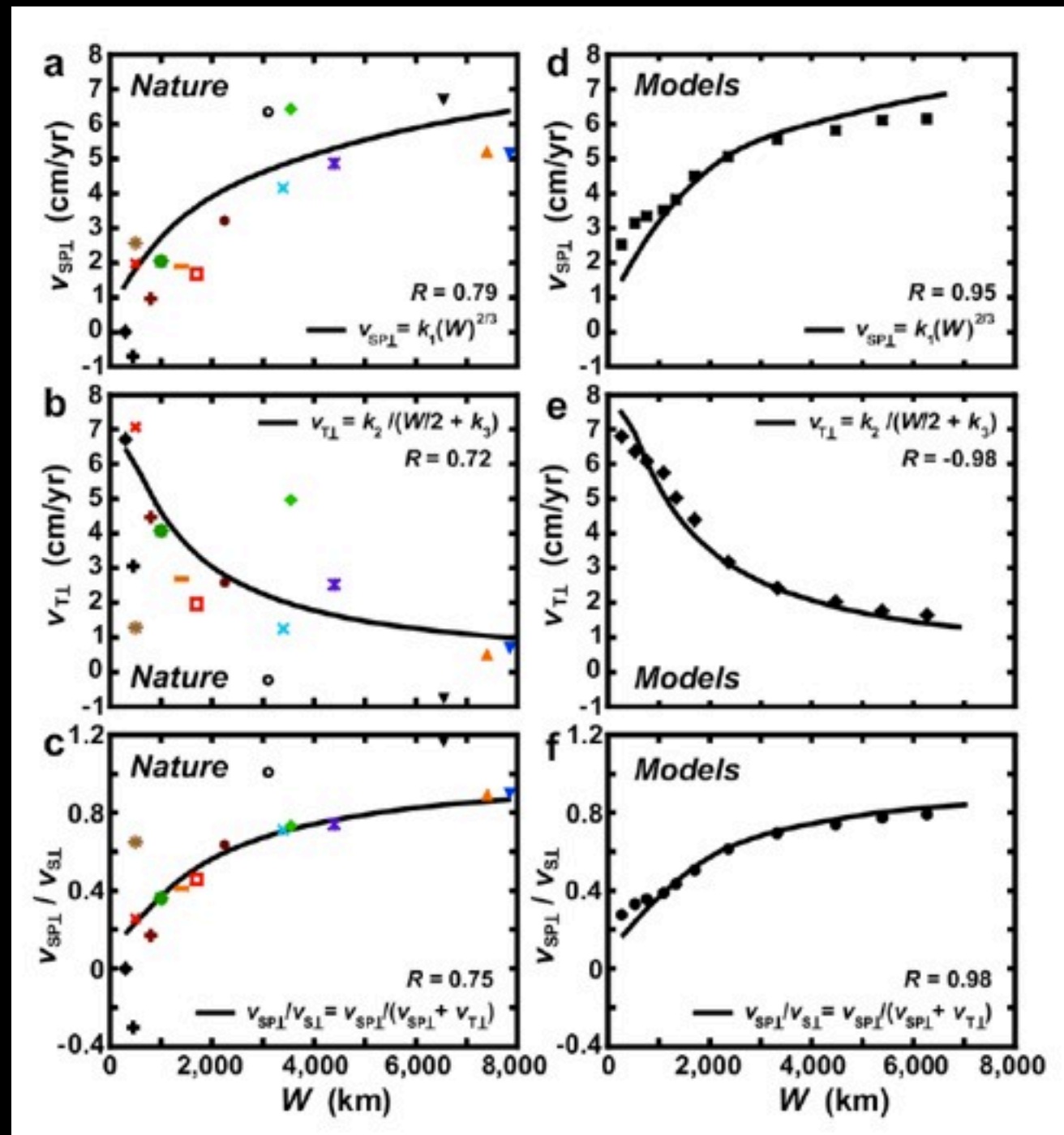


Image credit: Mike Sandiford (Univ. Melbourne)



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Slab pull alone explains plate motions

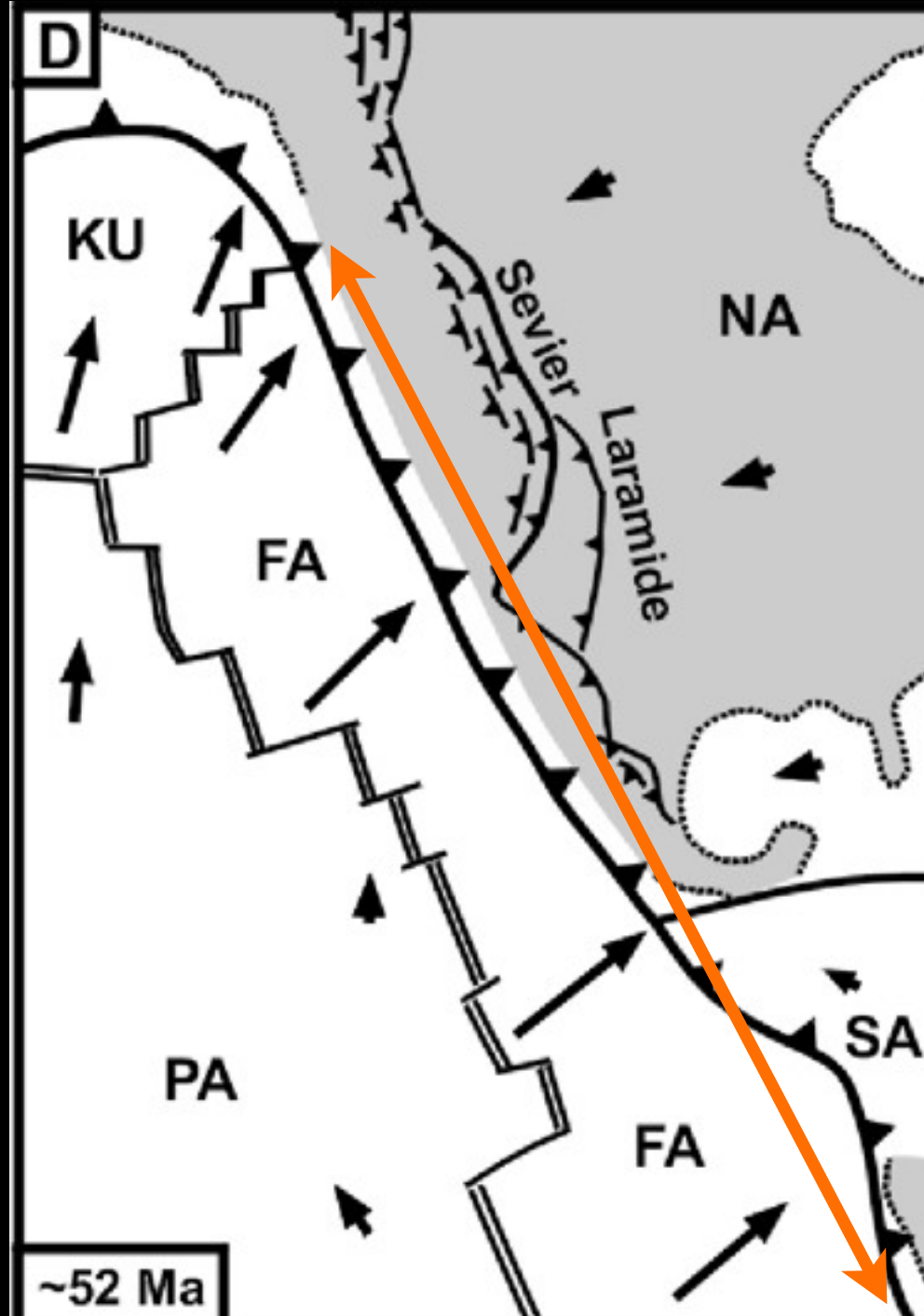


Schellart, Stegman, et al., Science, 2010

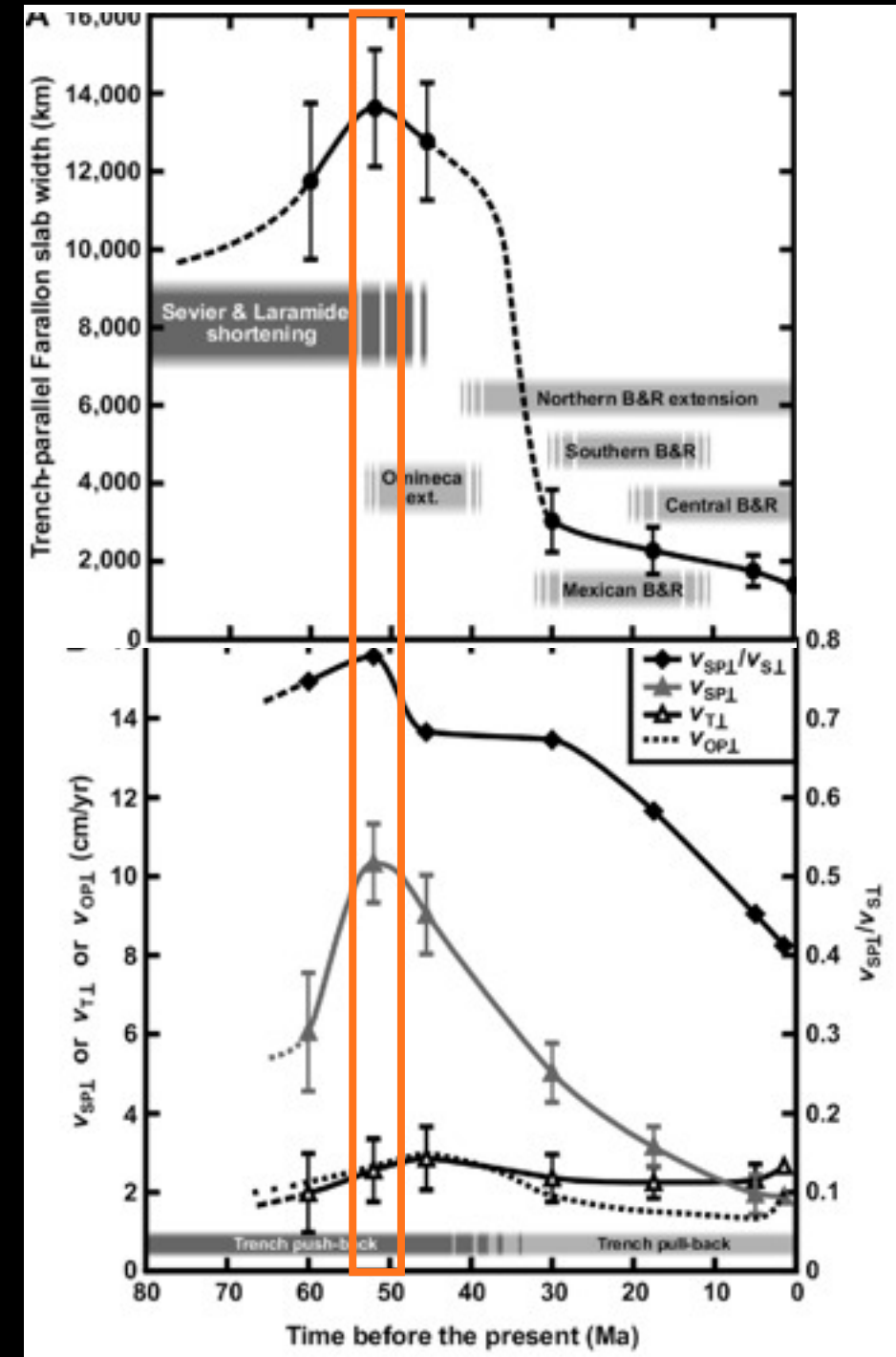


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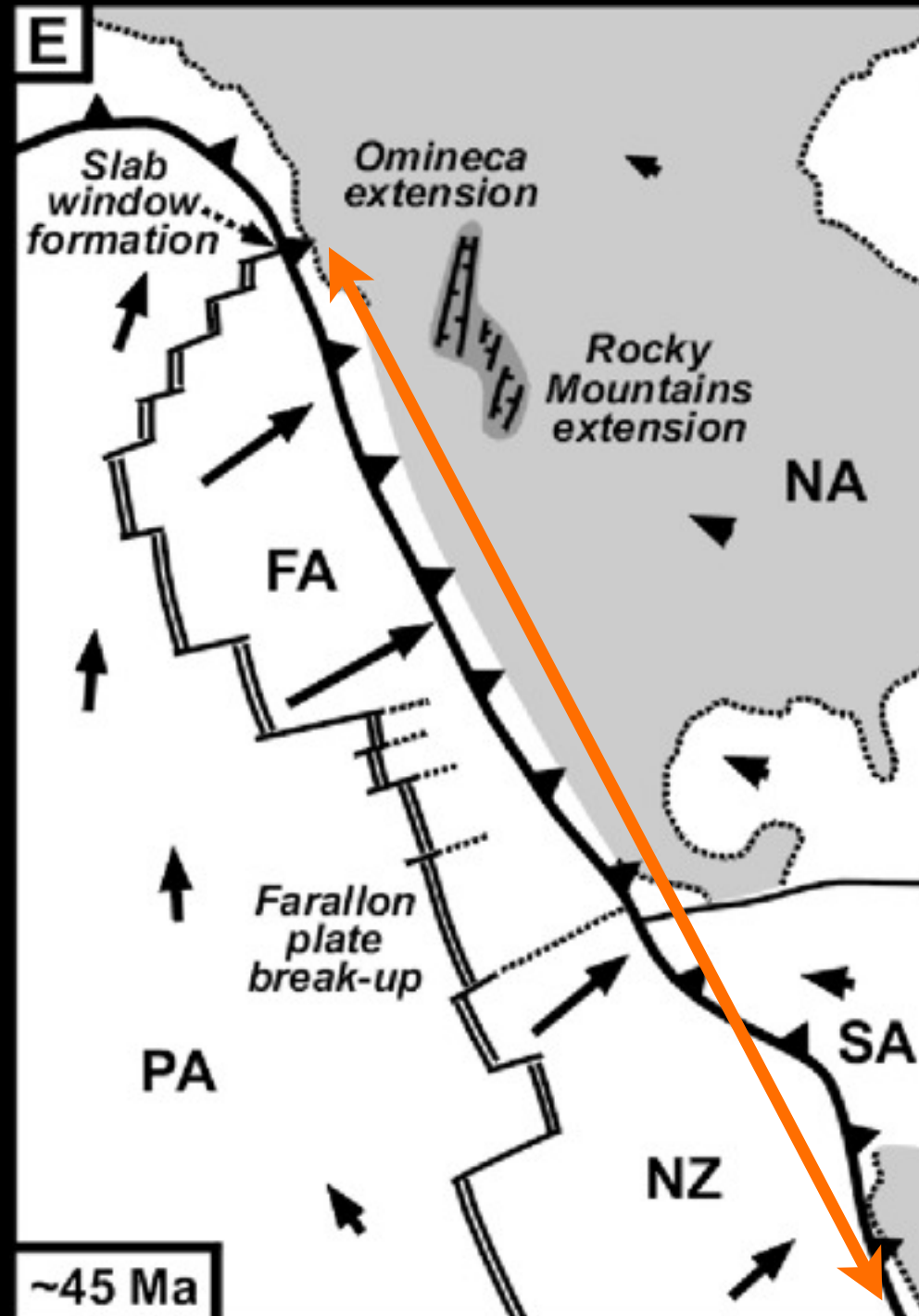
How the west was stretched



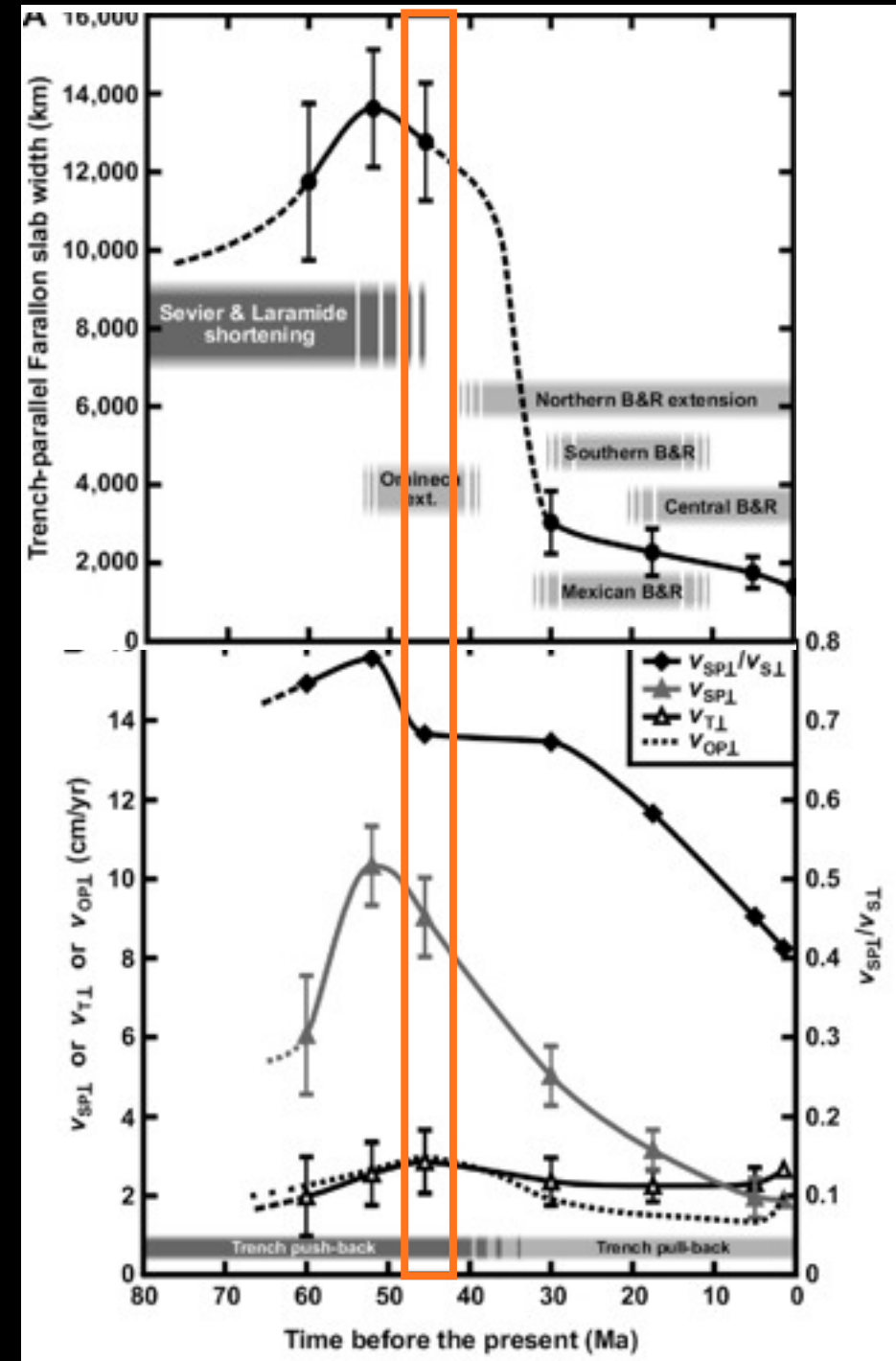
Schellart, Stegman, et al., Science, 2010



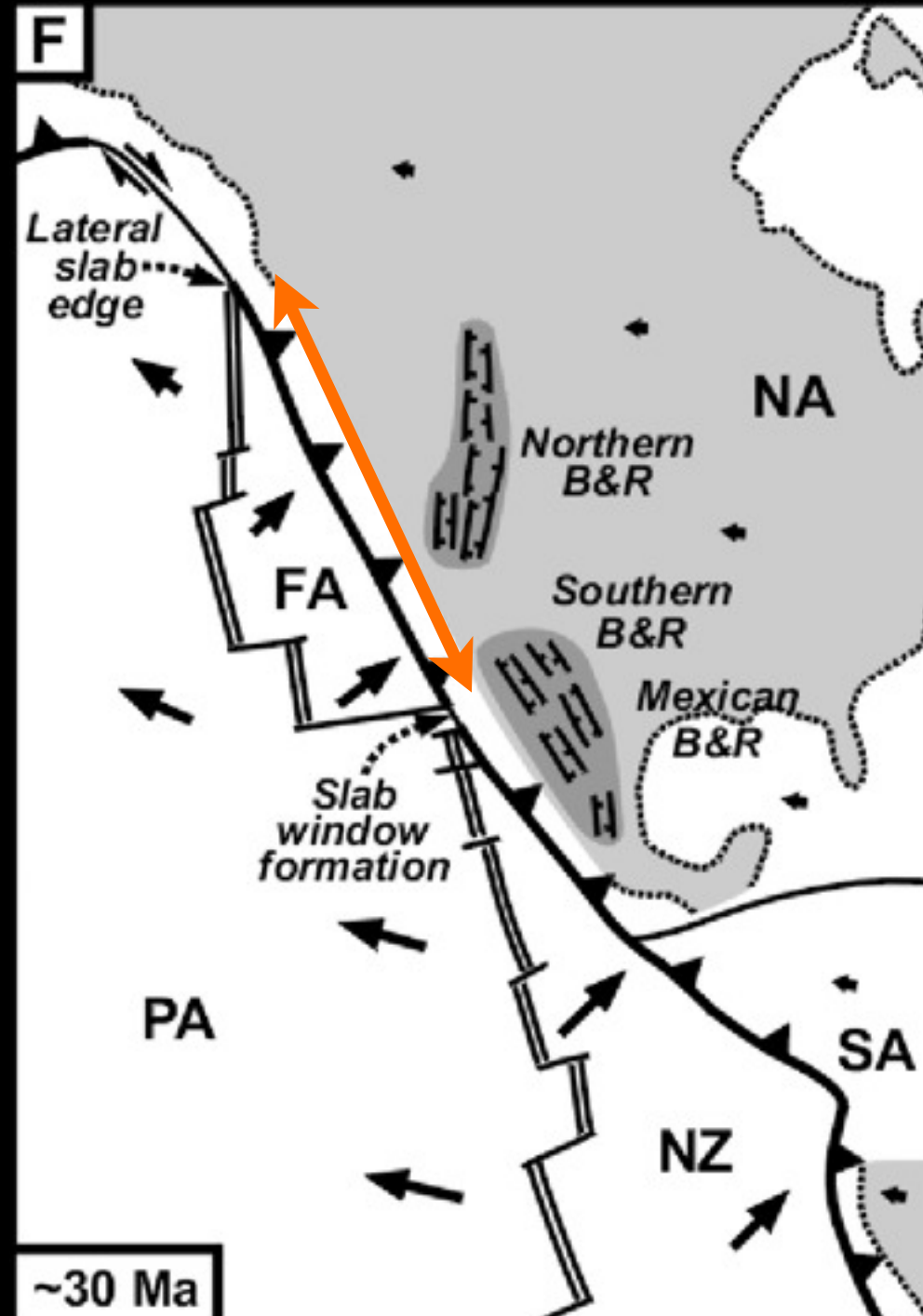
How the west was stretched



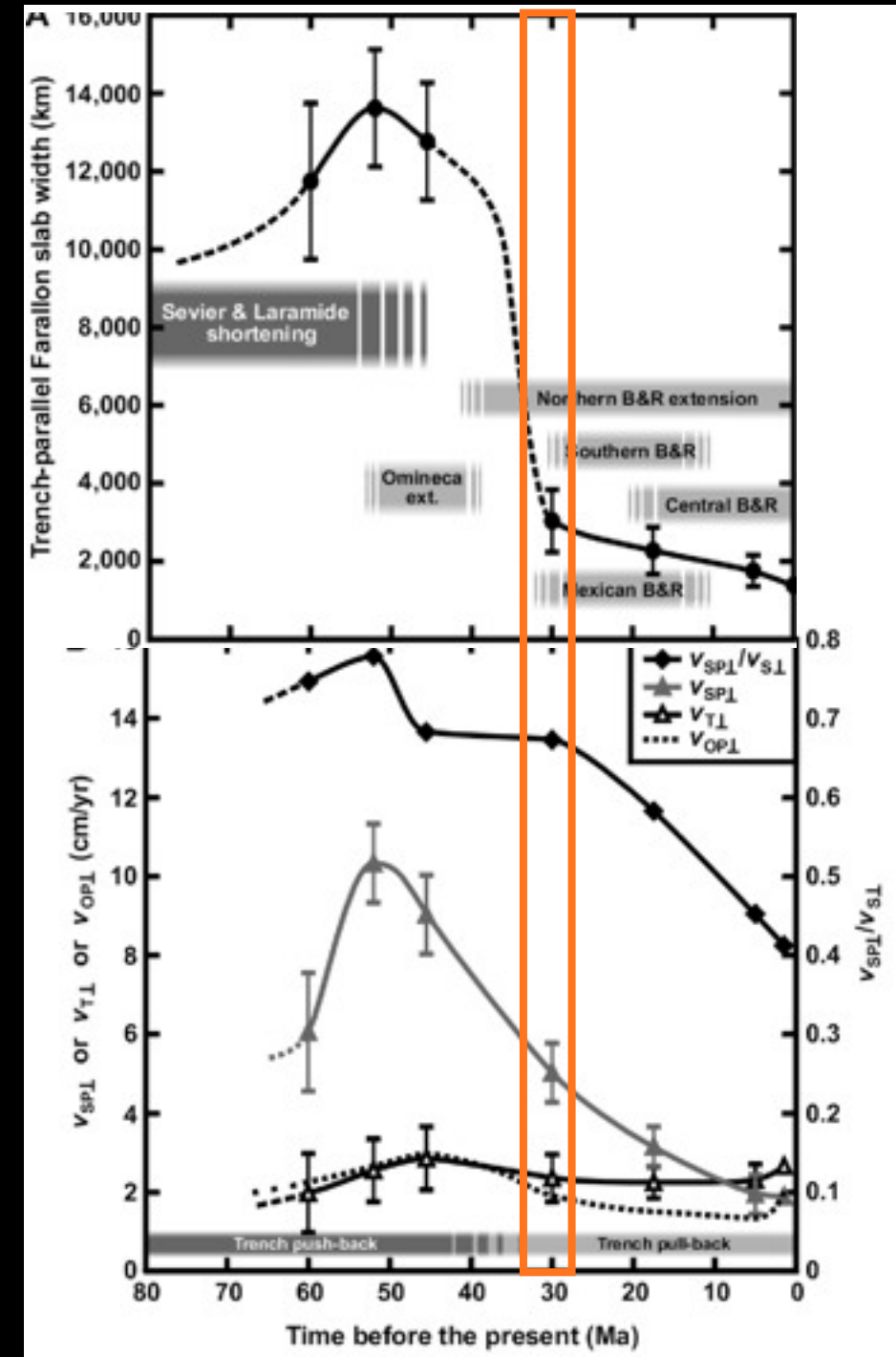
Schellart, Stegman, et al., Science, 2010



How the west was stretched



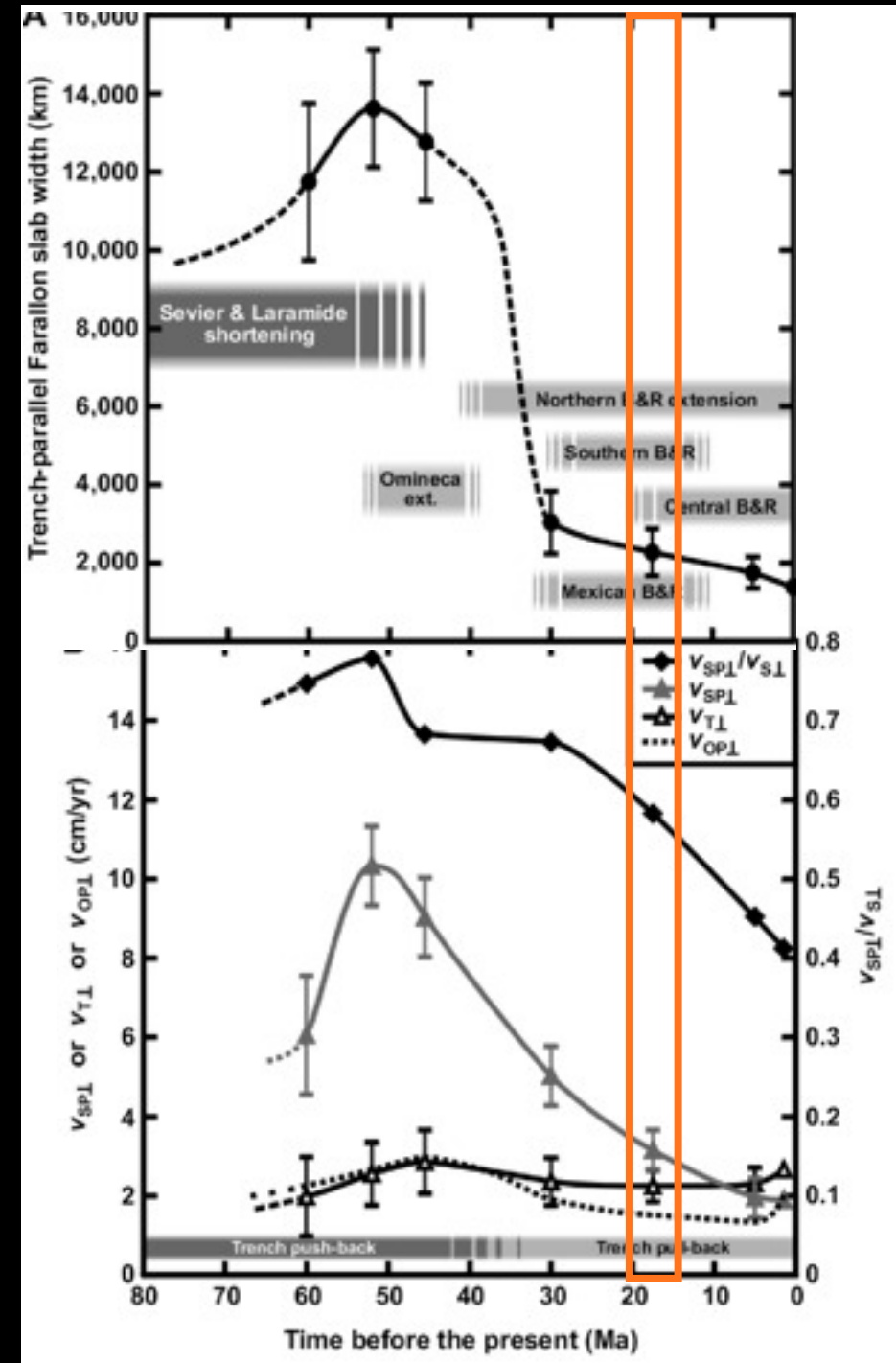
Schellart, Stegman, et al., Science, 2010



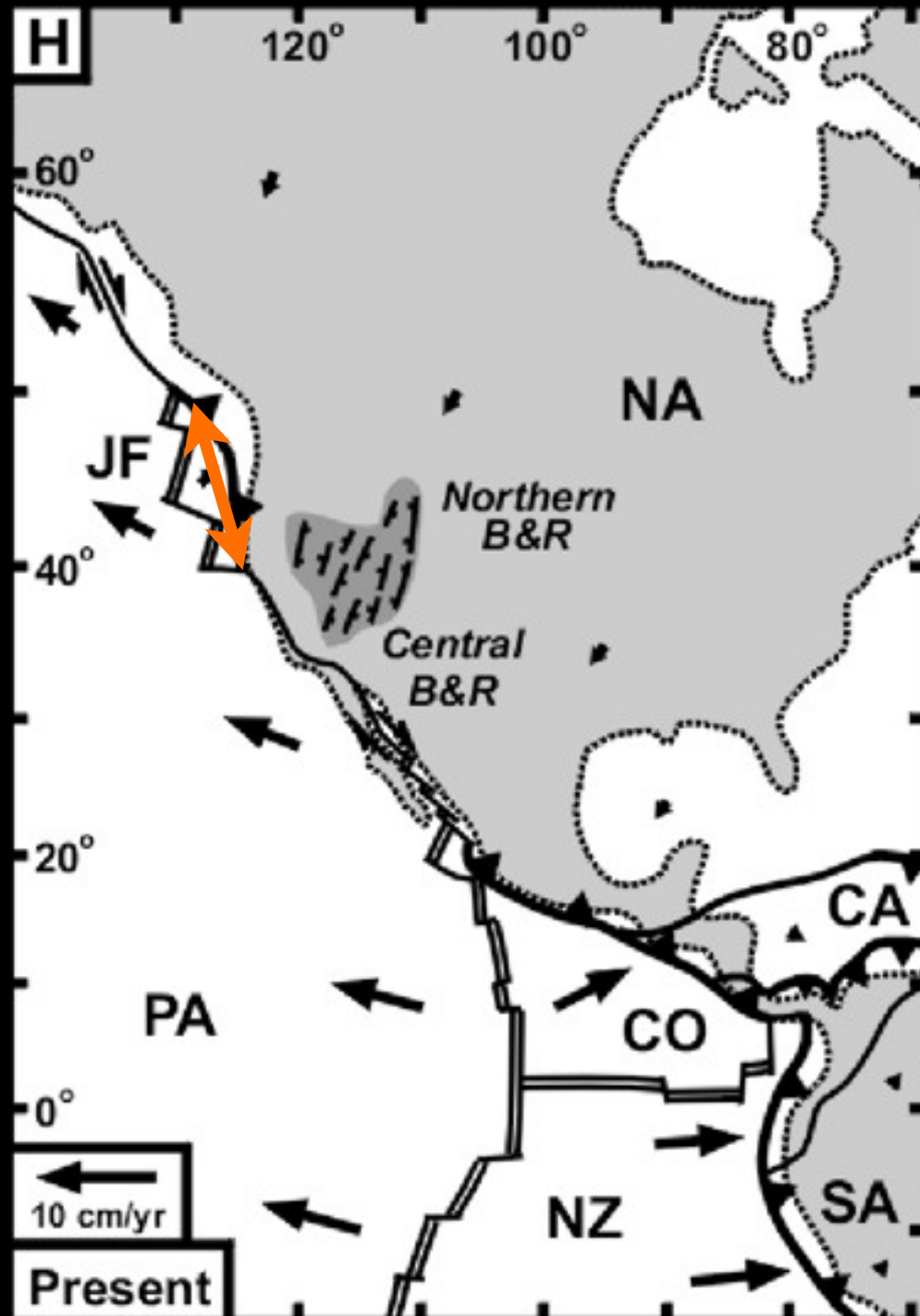
How the west was stretched



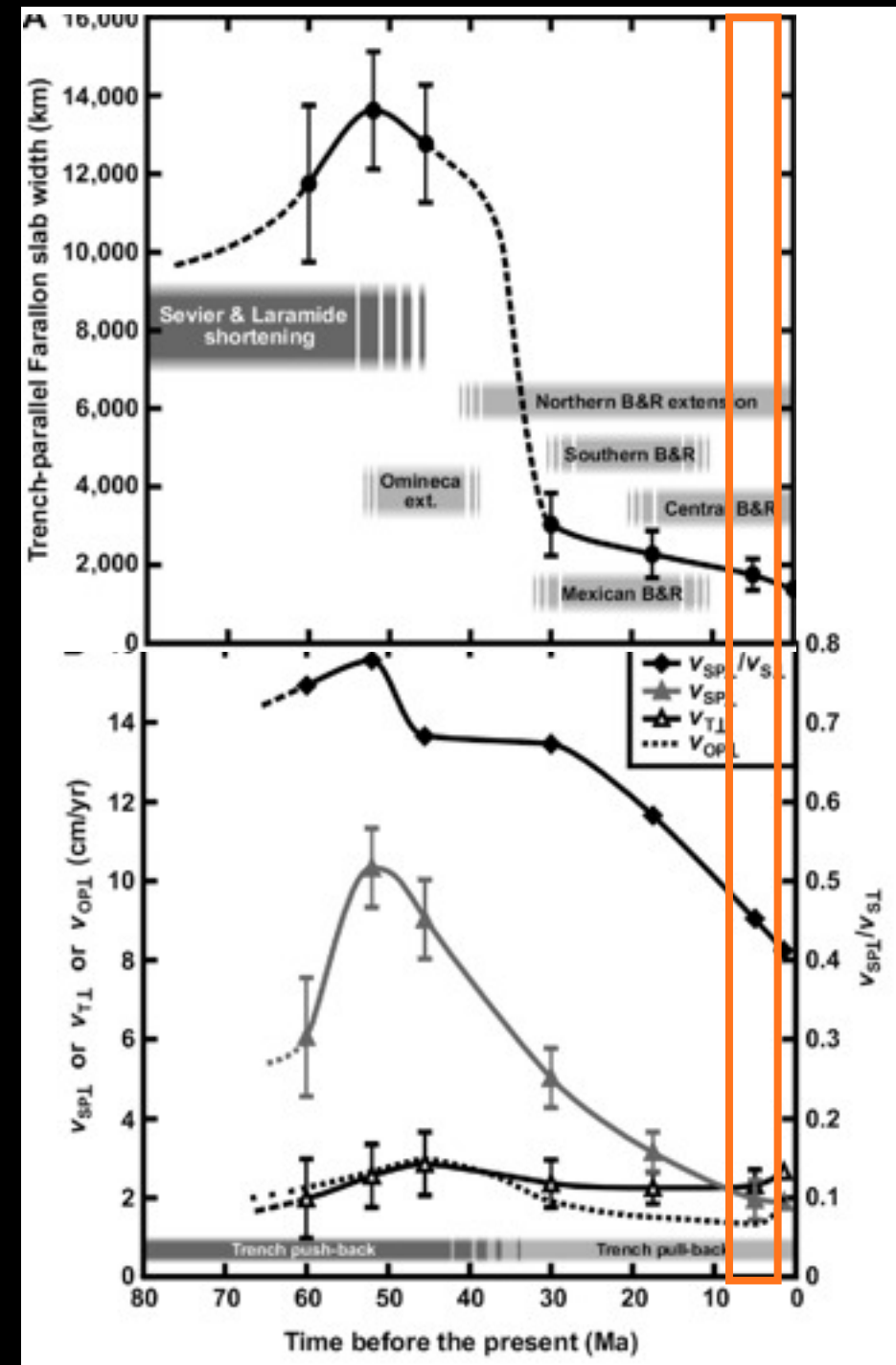
~15 Ma
Schellart, Stegman, et al., Science, 2010



How the west was stretched

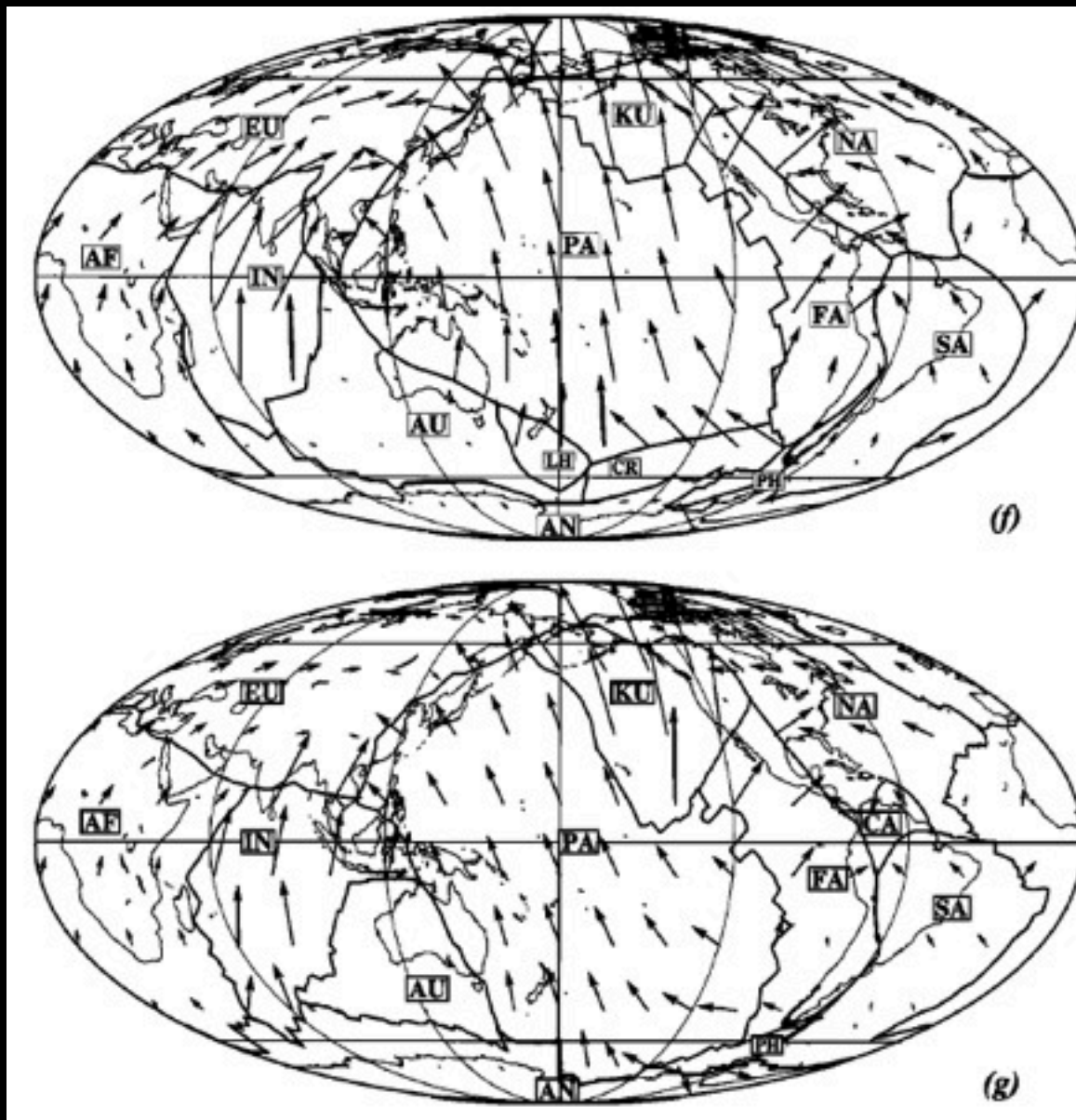


Schellart, Stegman, et al., Science, 2010



Data Assimilation

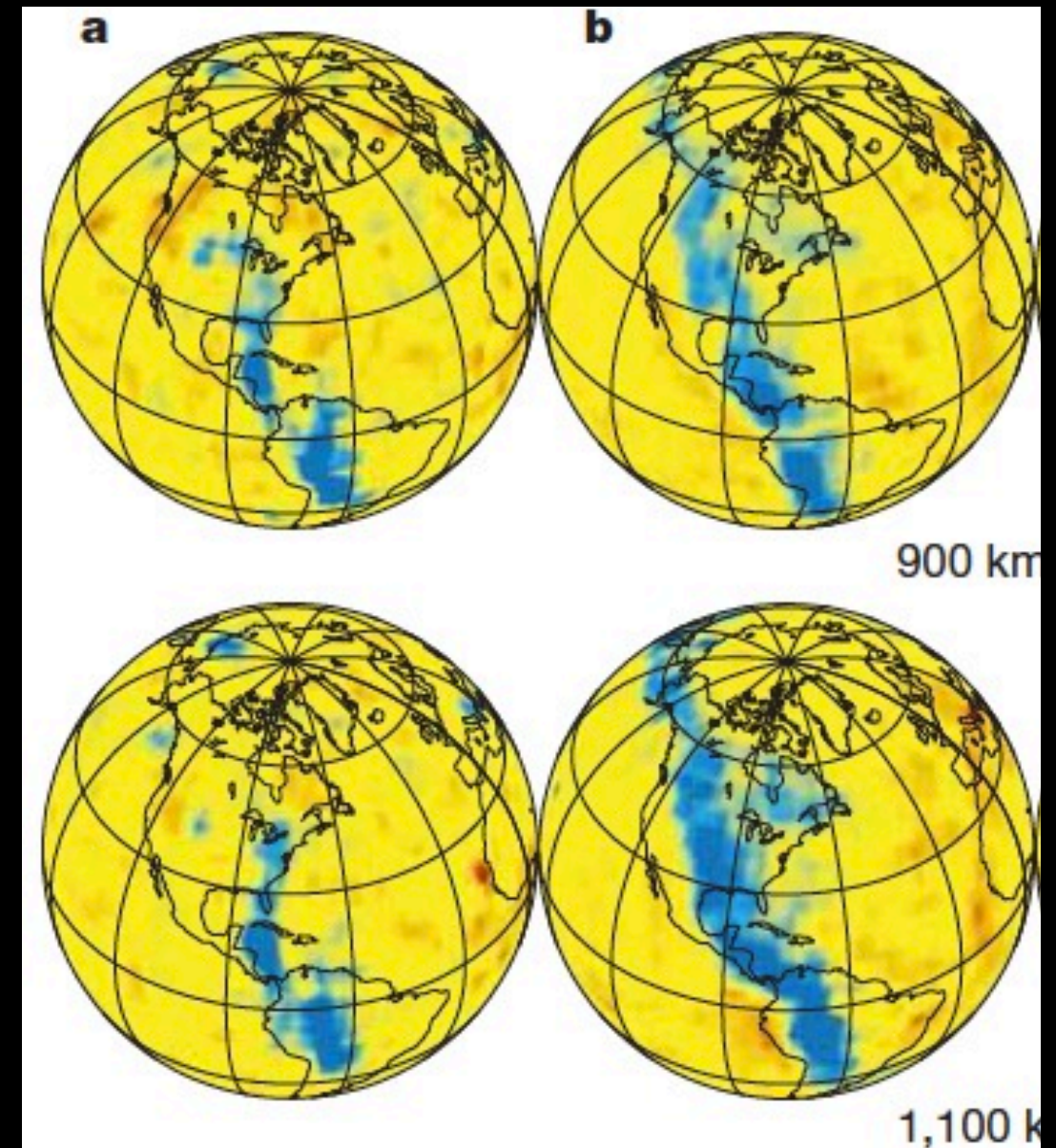
Plate reconstructions (~10 Myr stages)



Lithgow-Bertelloni and Richards, 1998

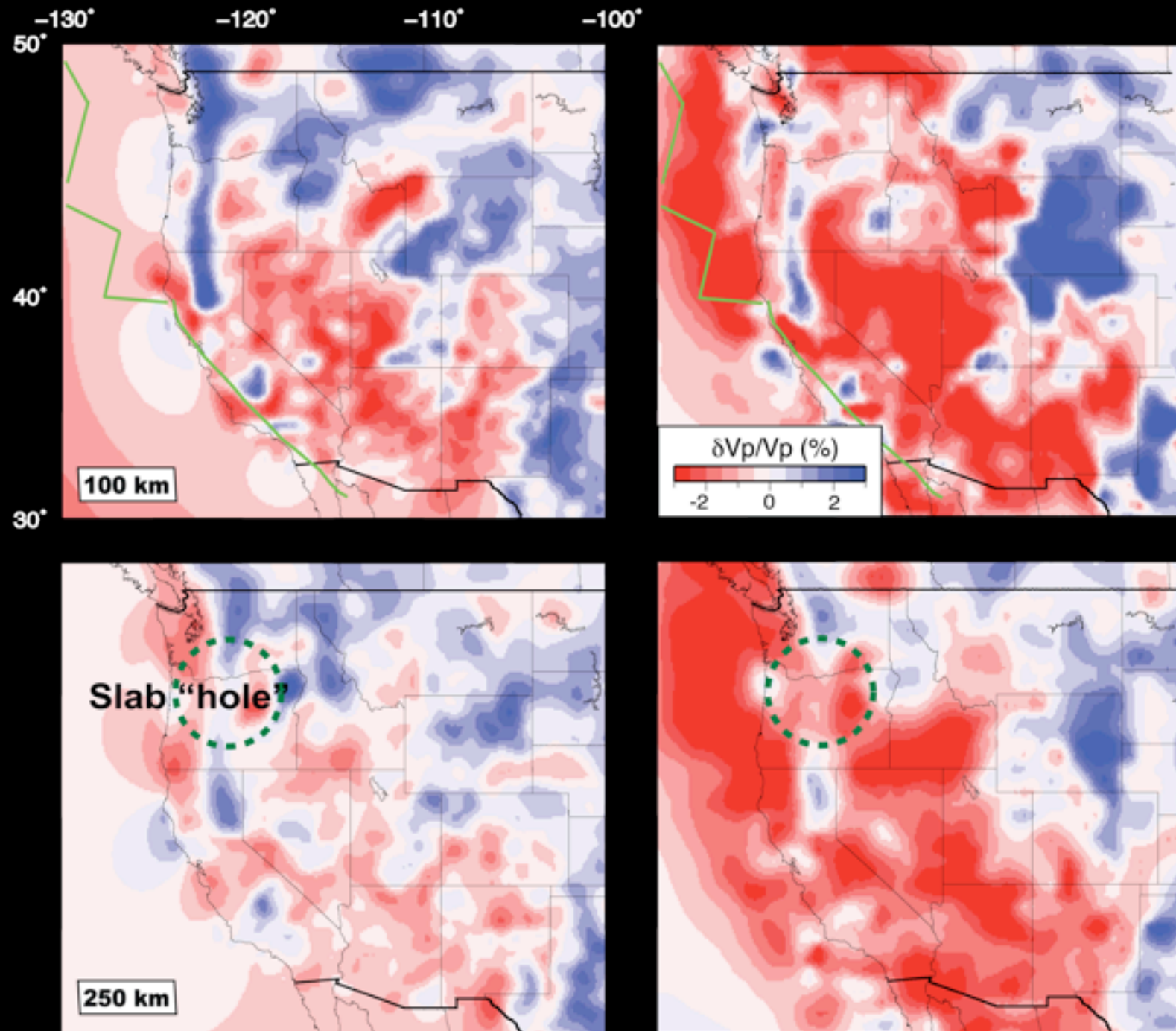
Tomographic Model

Geodynamic Model



Bunge and Grand, 2000

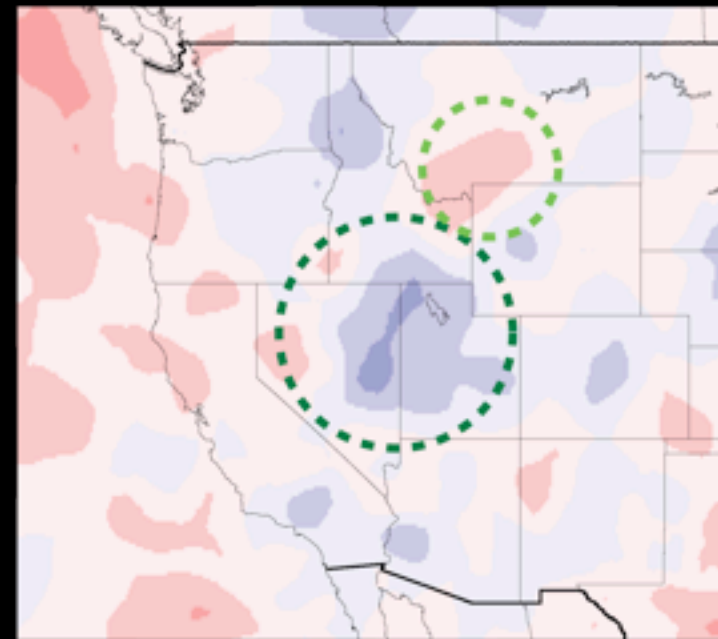
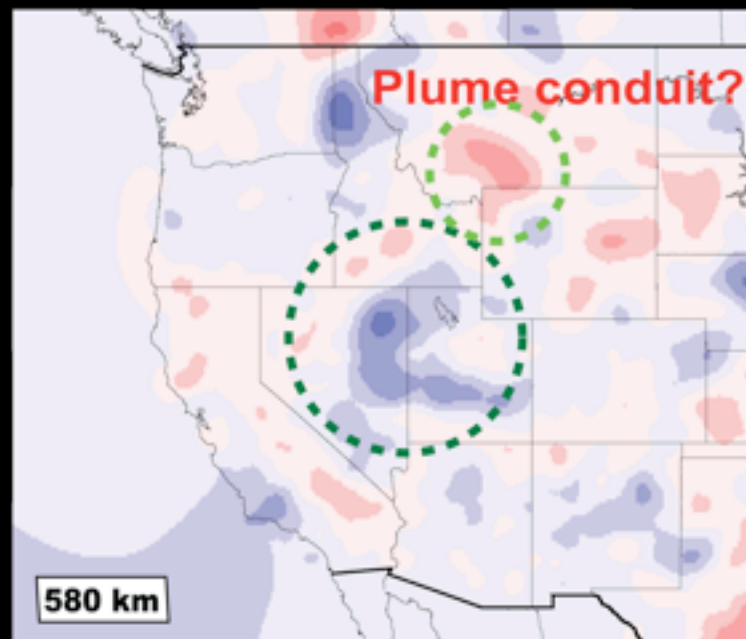
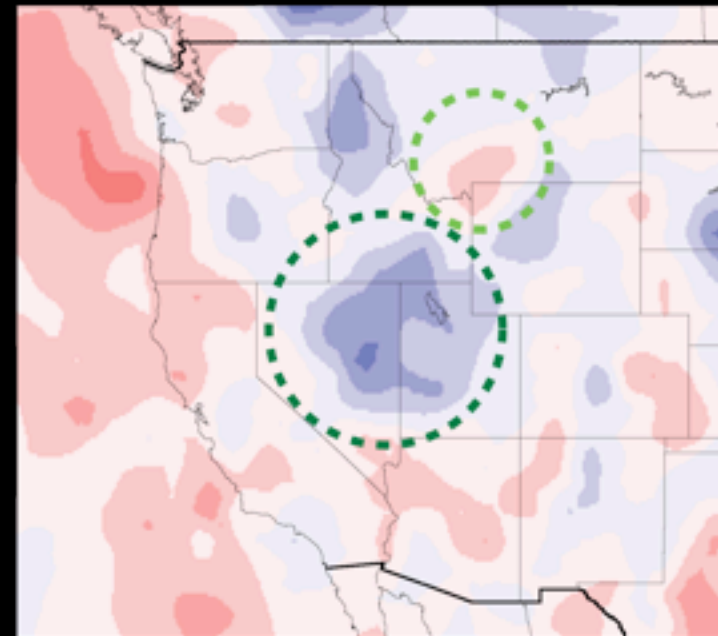
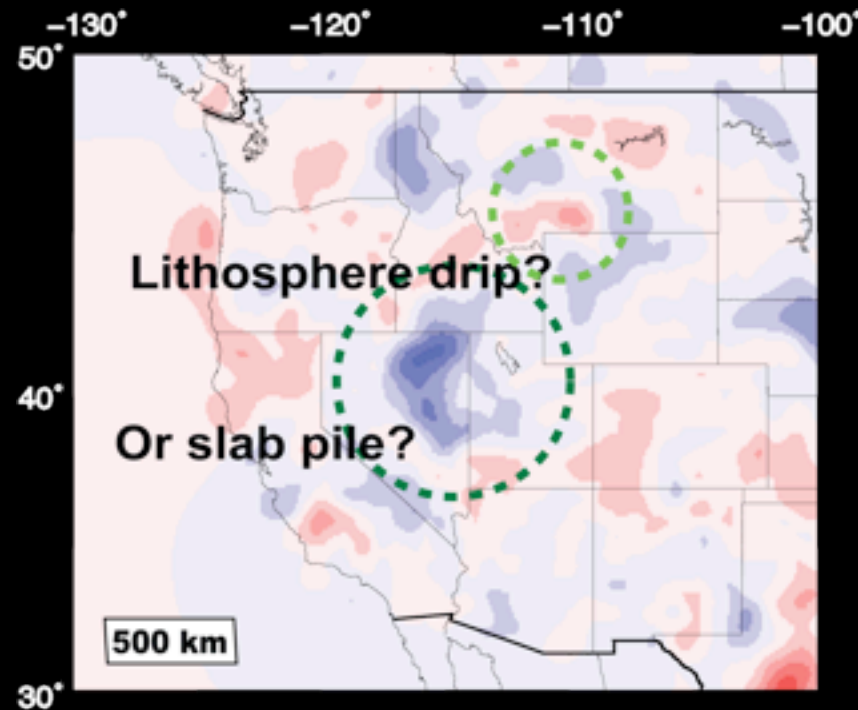
Where is the Farallon Slab?



Schmandt and Humphreys, 2010

Sigloch, 2011

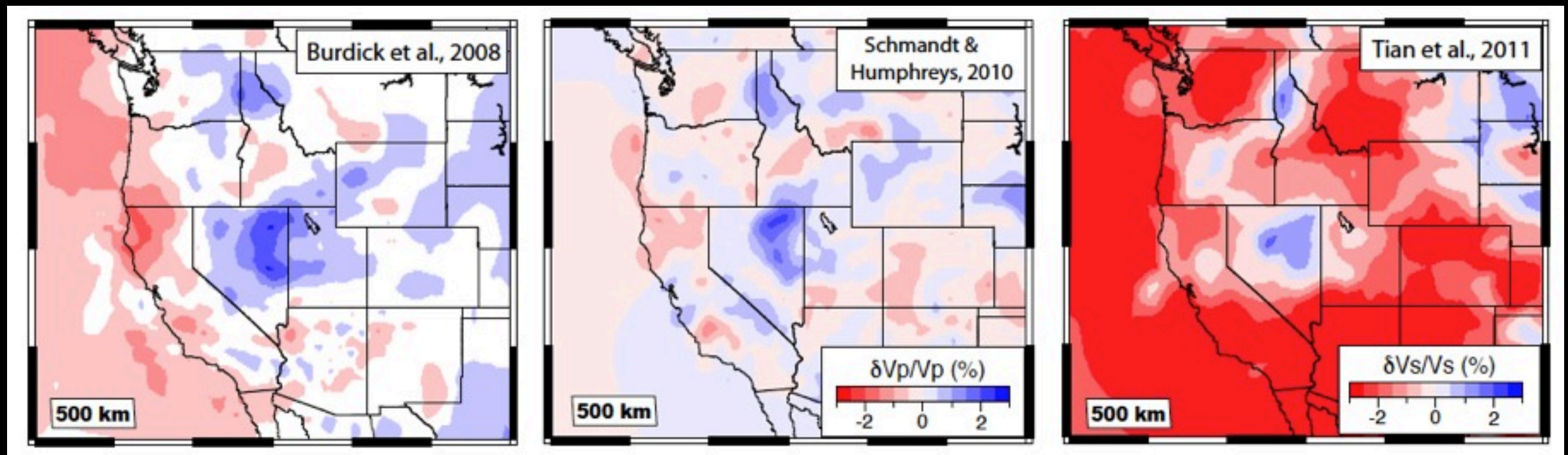
Where is the Farallon Slab?



Schmandt and Humphreys, 2010

Sigloch, 2011

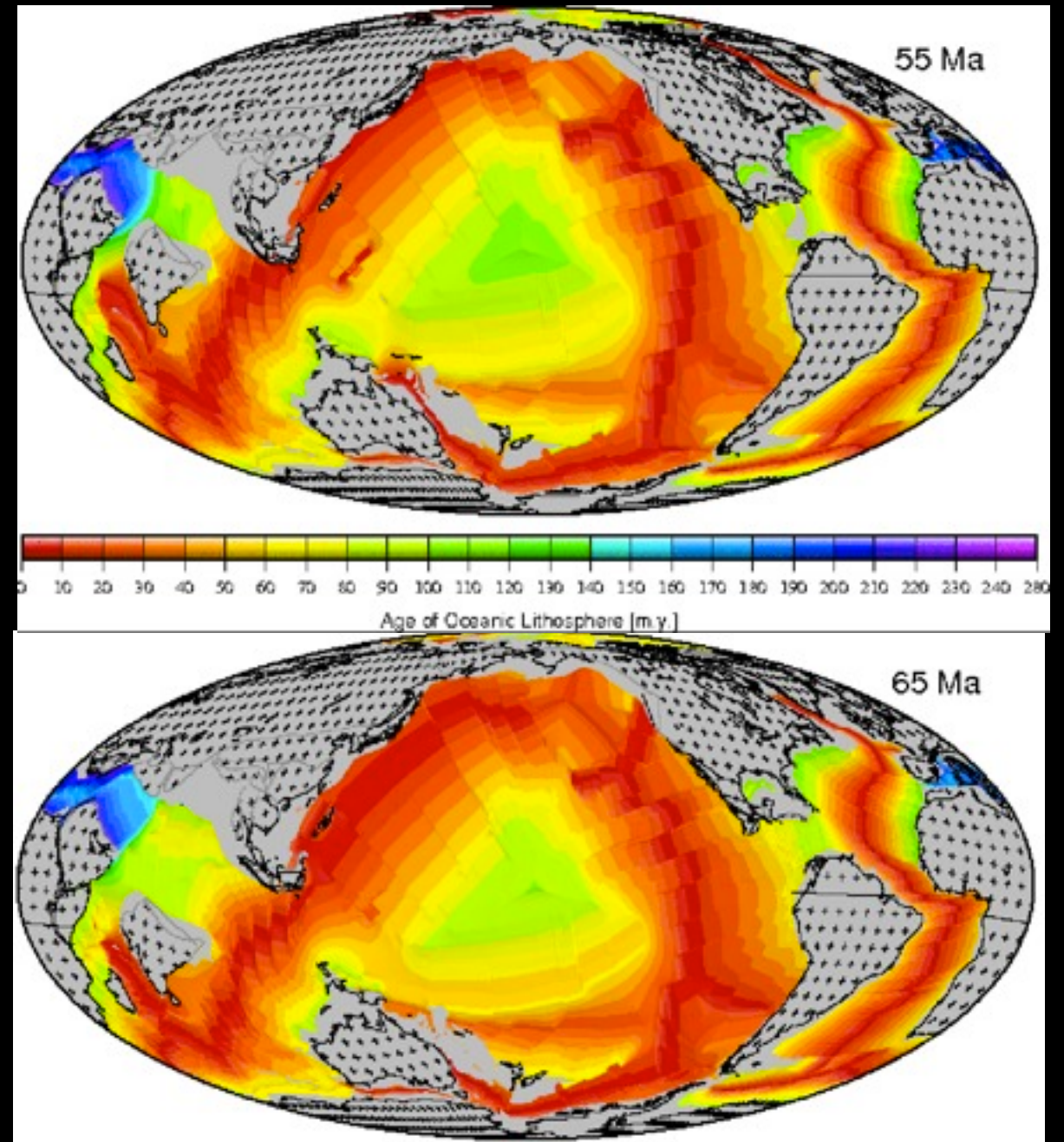
Where is the Farallon Slab?



Data Assimilation Model of Farallon Slab

- Past Plate Motions (1 Myr plate stages)
- Paleo Age Grid

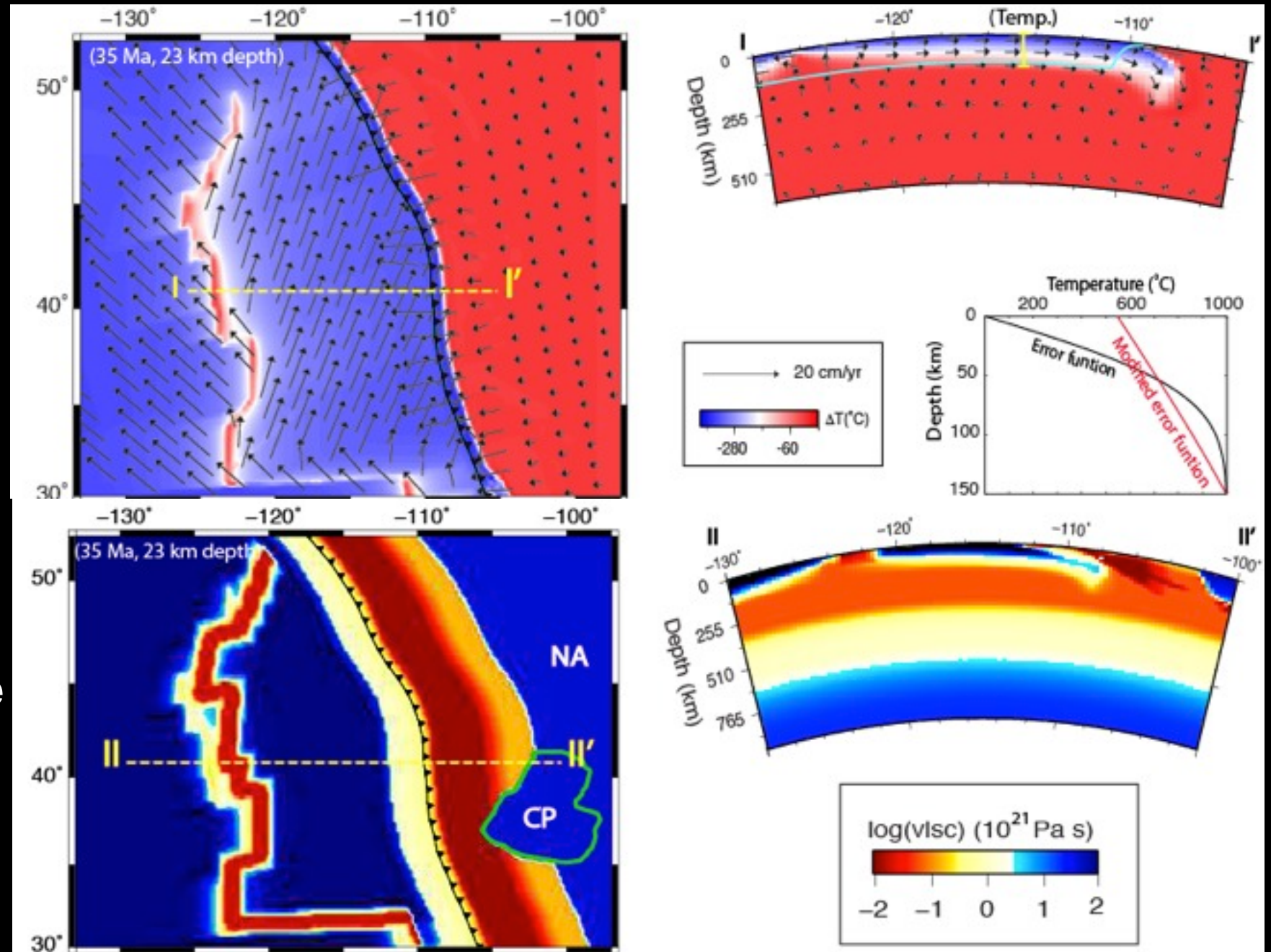
Plate reconstructions (~1 Myr stages)



Mueller et al, 2008

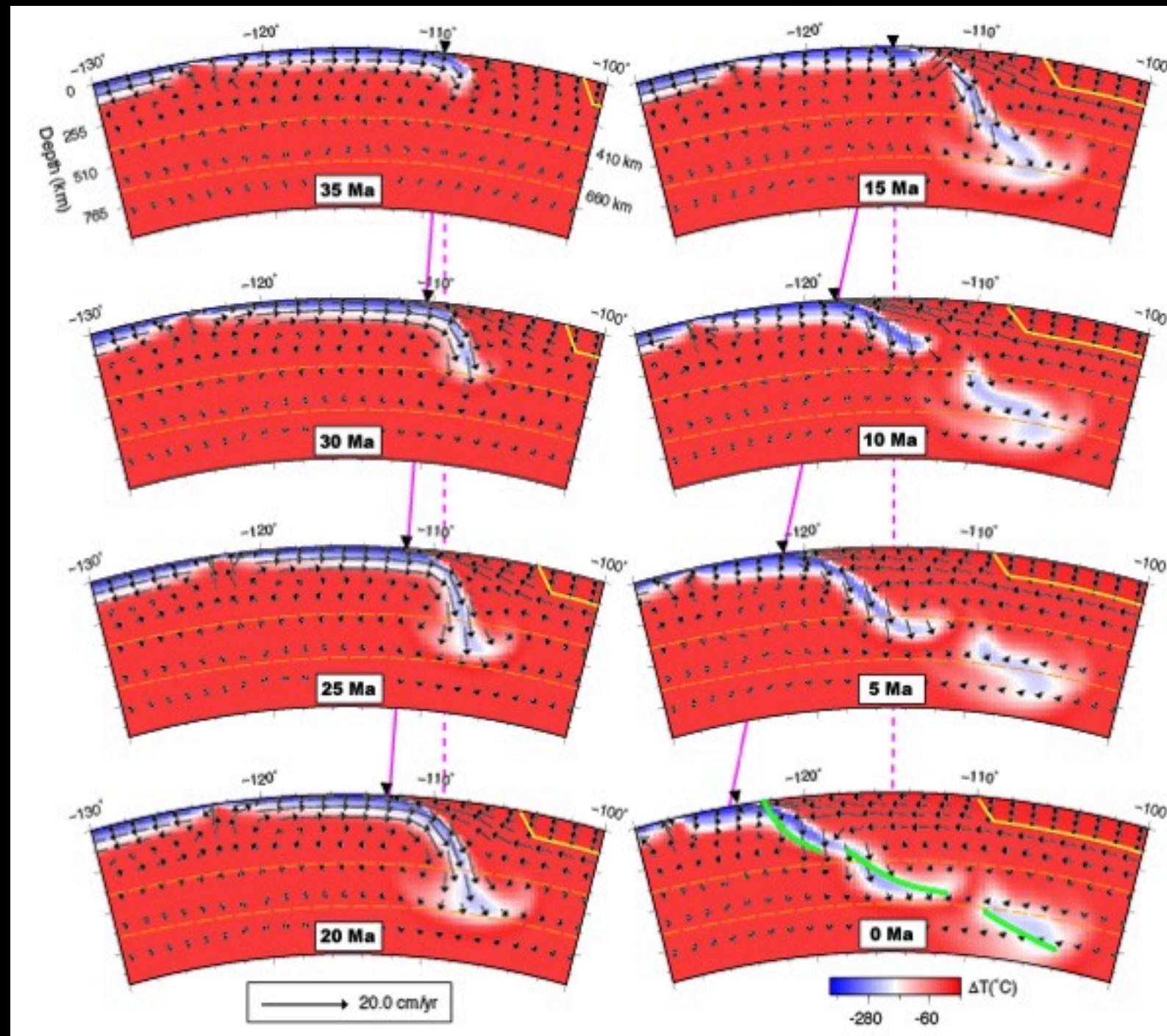
Data Assimilation Model of Farallon Slab

- Past Plate Motions (1 Myr plate stages)
- Paleo Age Grid
- Radial viscosity
- Weak plate boundaries
- Weak slab hinge
- Low viscosity wedge
- Sticky Air
- Uniform temperature upper mantle



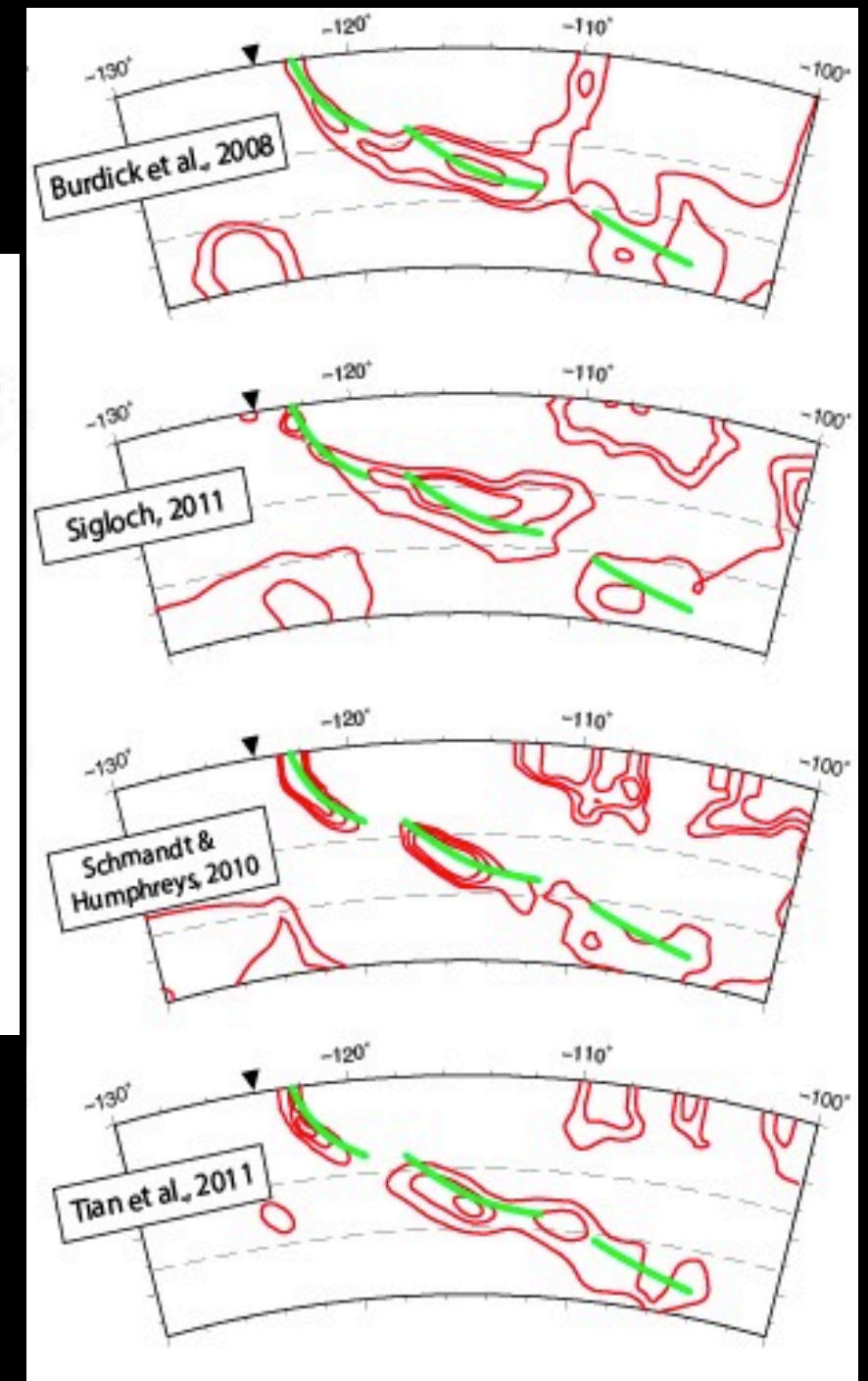
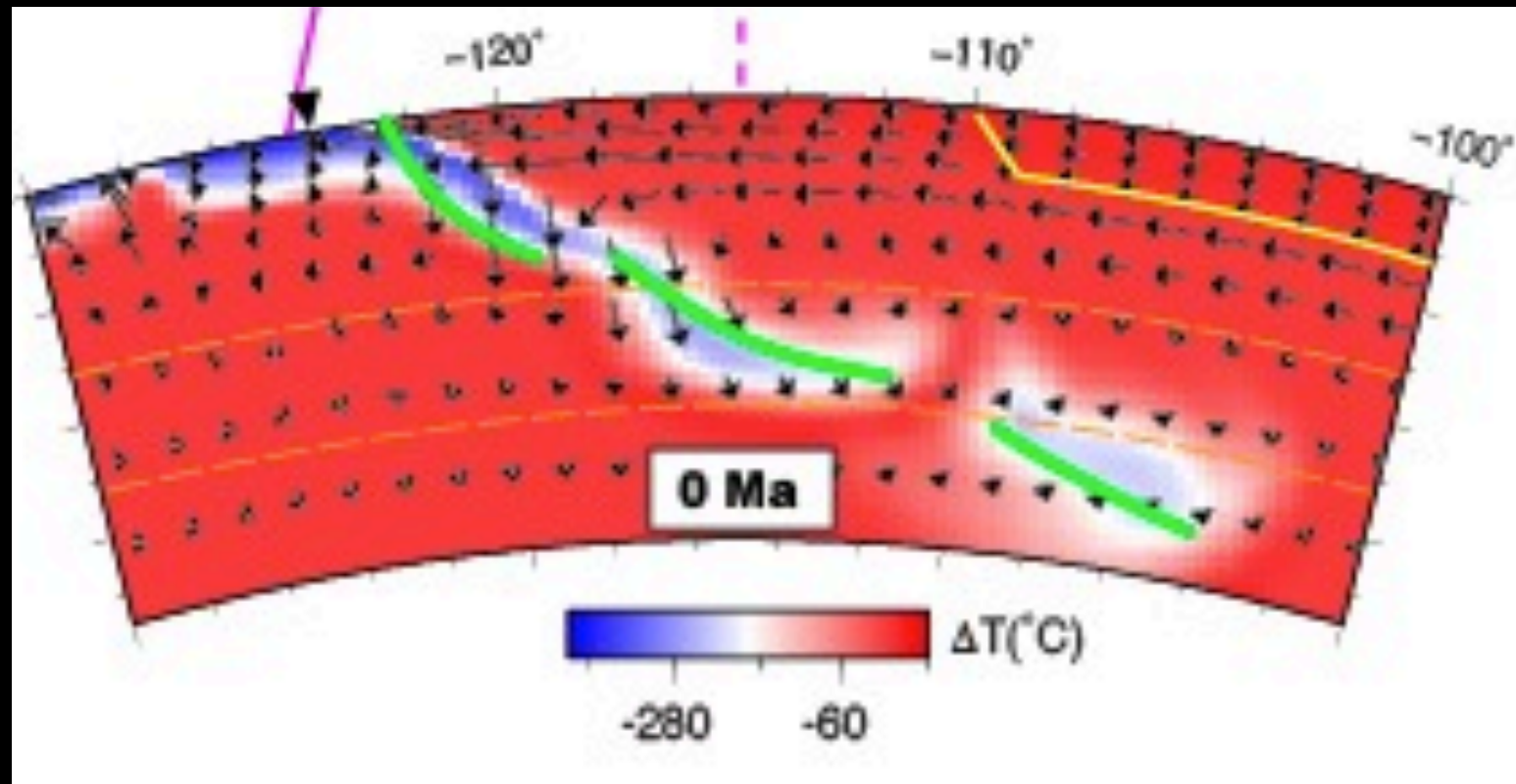
Liu and Stegman, *EPSL*, 2011

Segmentation of the Farallon Slab



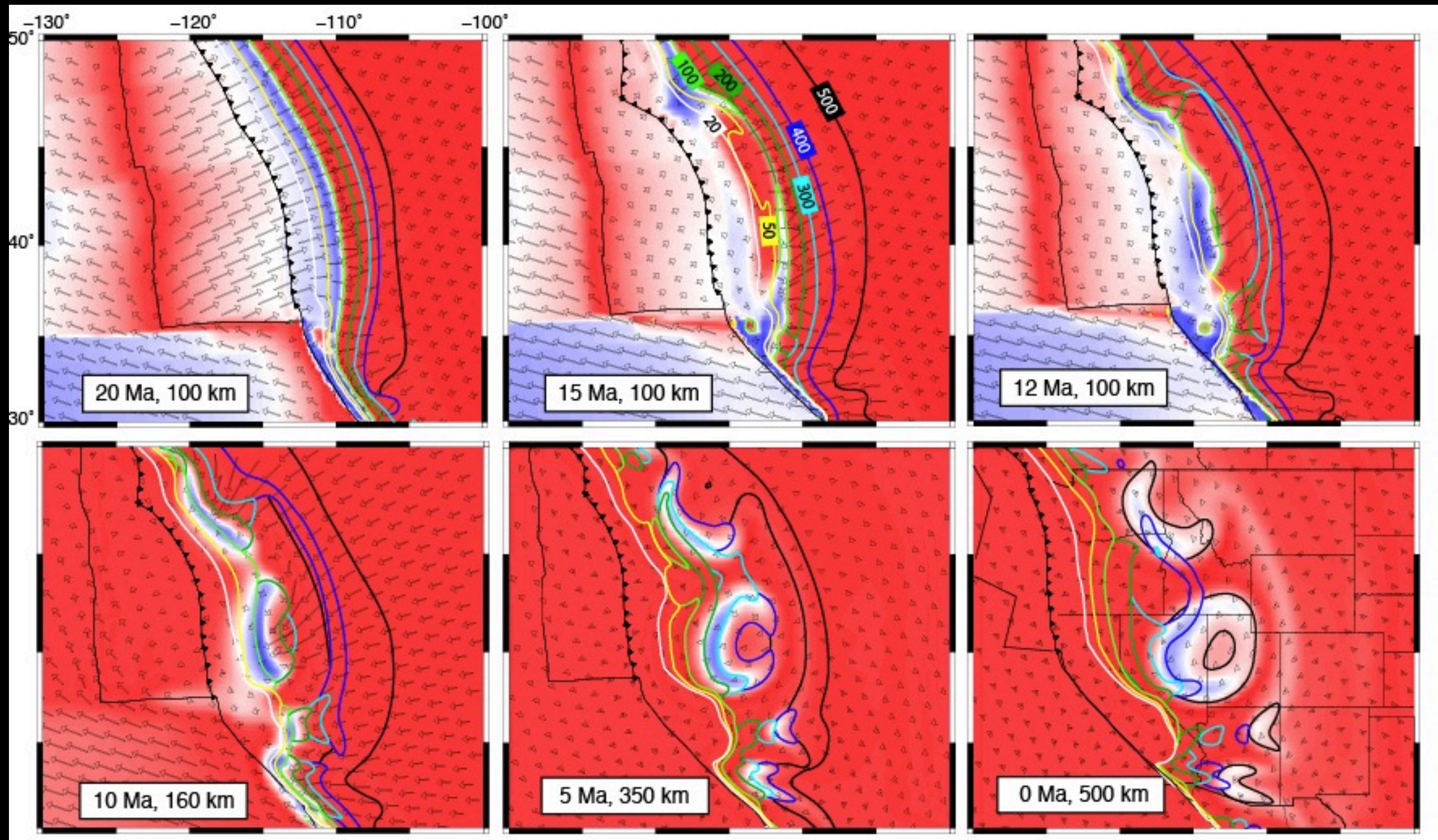
Liu and Stegman, *EPSL*, 2011

Segmentation of the Farallon Slab



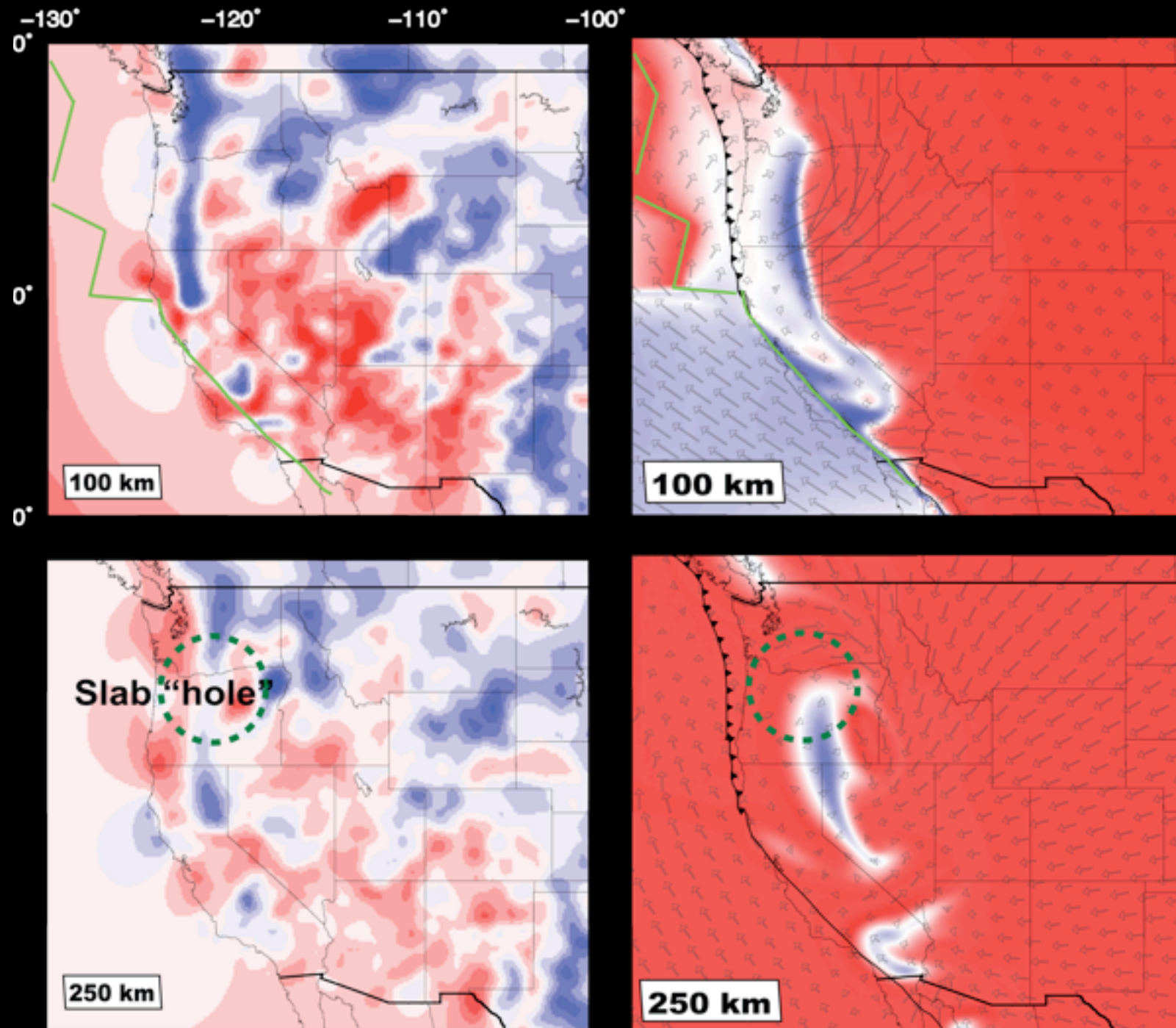
Liu and Stegman, EPSL, 2011

Segmentation of the Farallon Slab



Liu and Stegman, EPSL, 2011

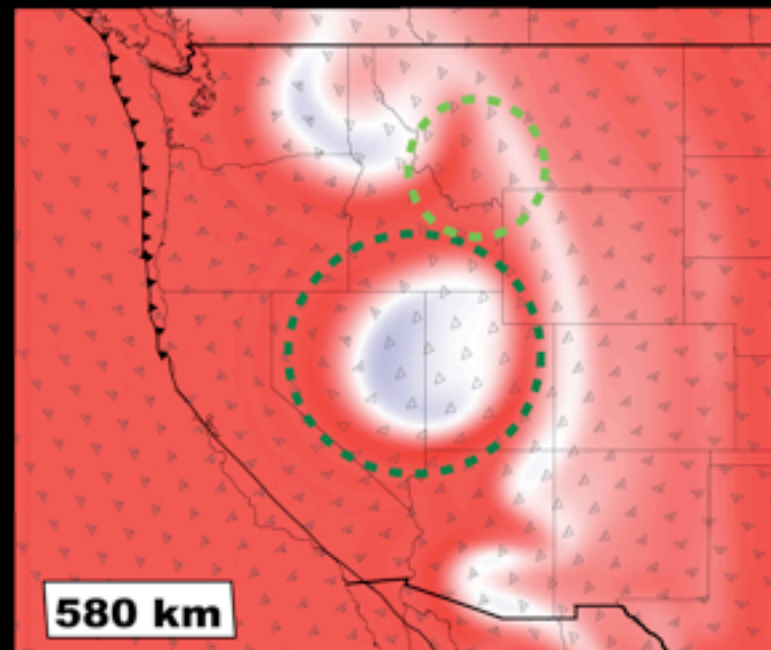
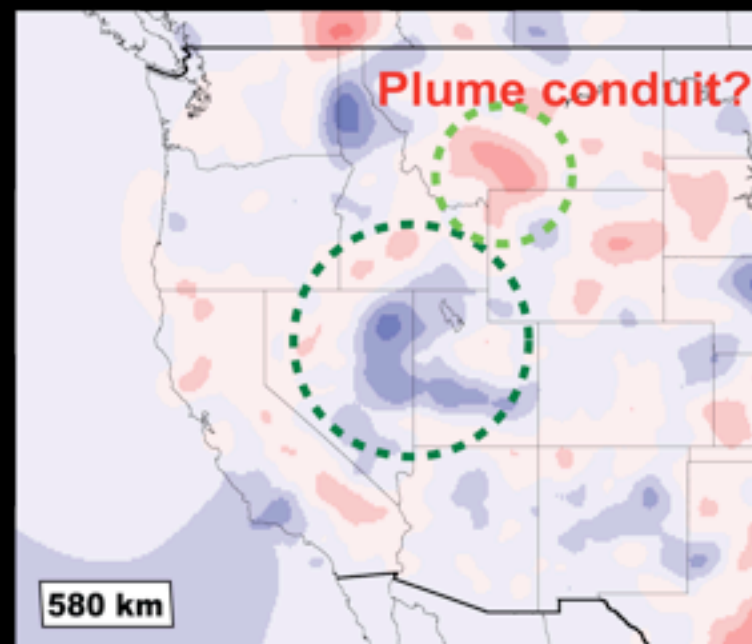
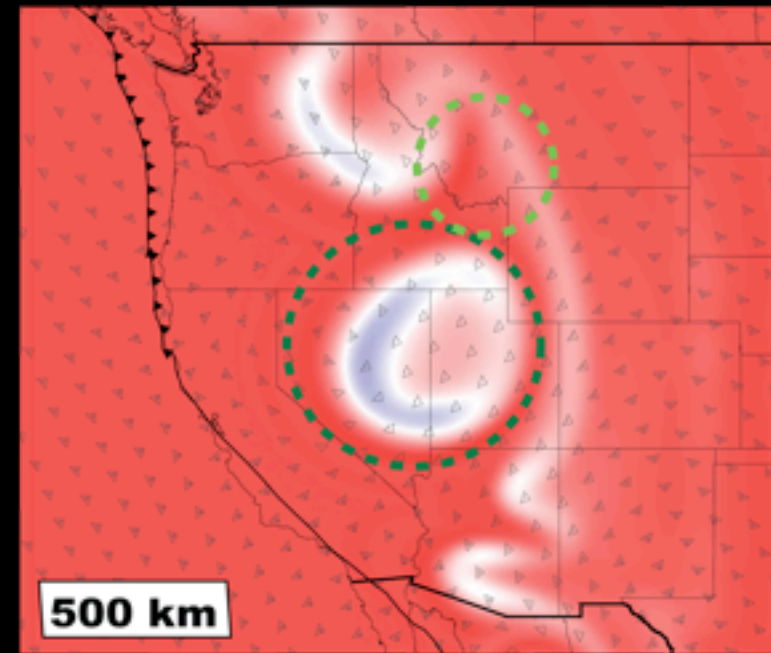
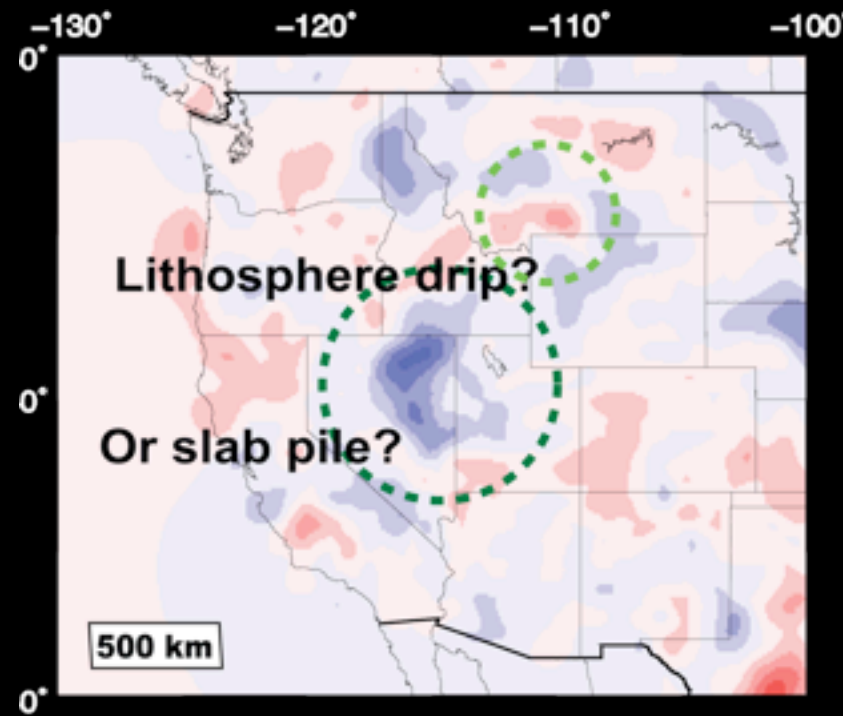
Segmentation of the Farallon Slab



Schmandt and Humphreys, 2010

Liu and Stegman, EPSL, 2011

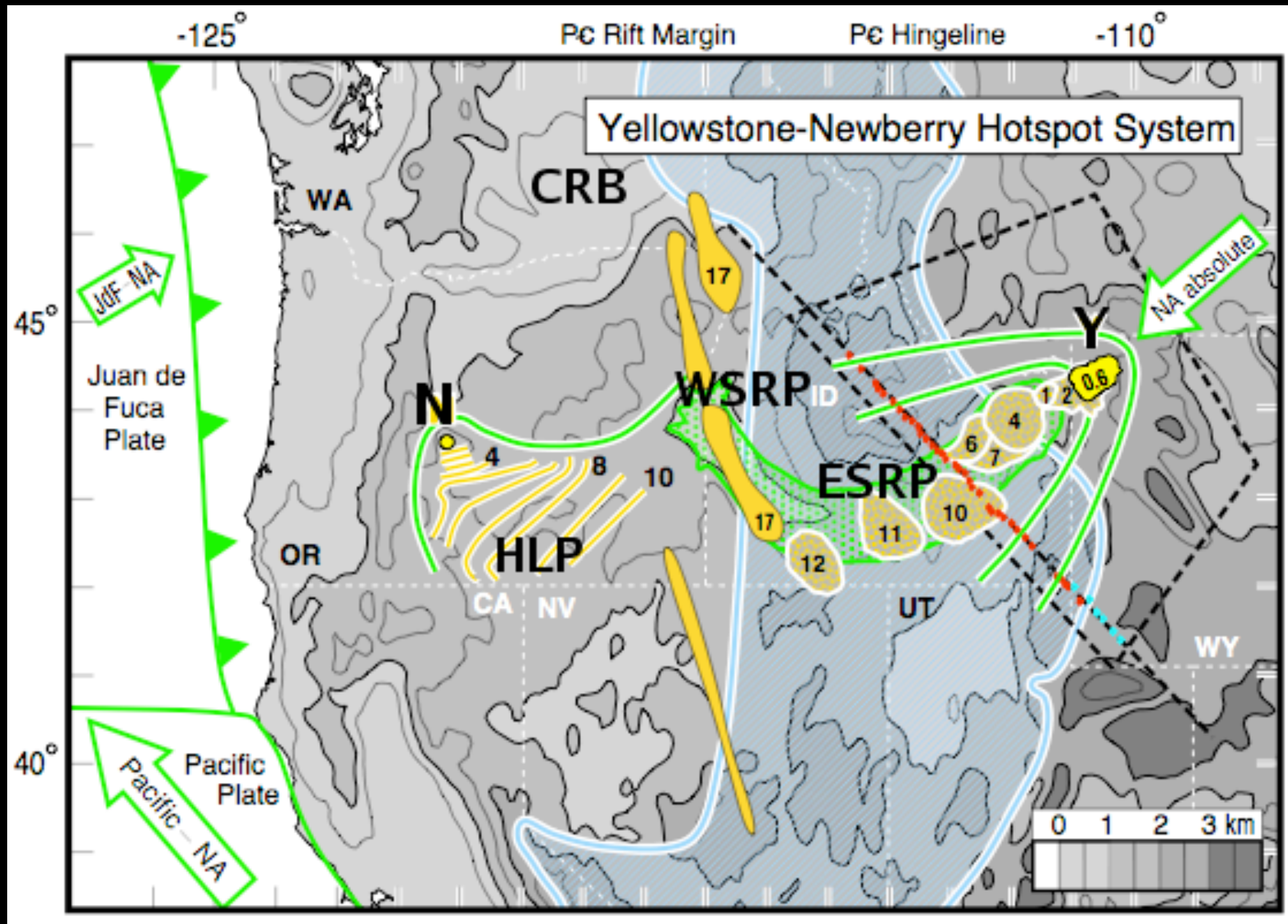
Segmentation of the Farallon Slab



Schmandt and Humphreys, 2010

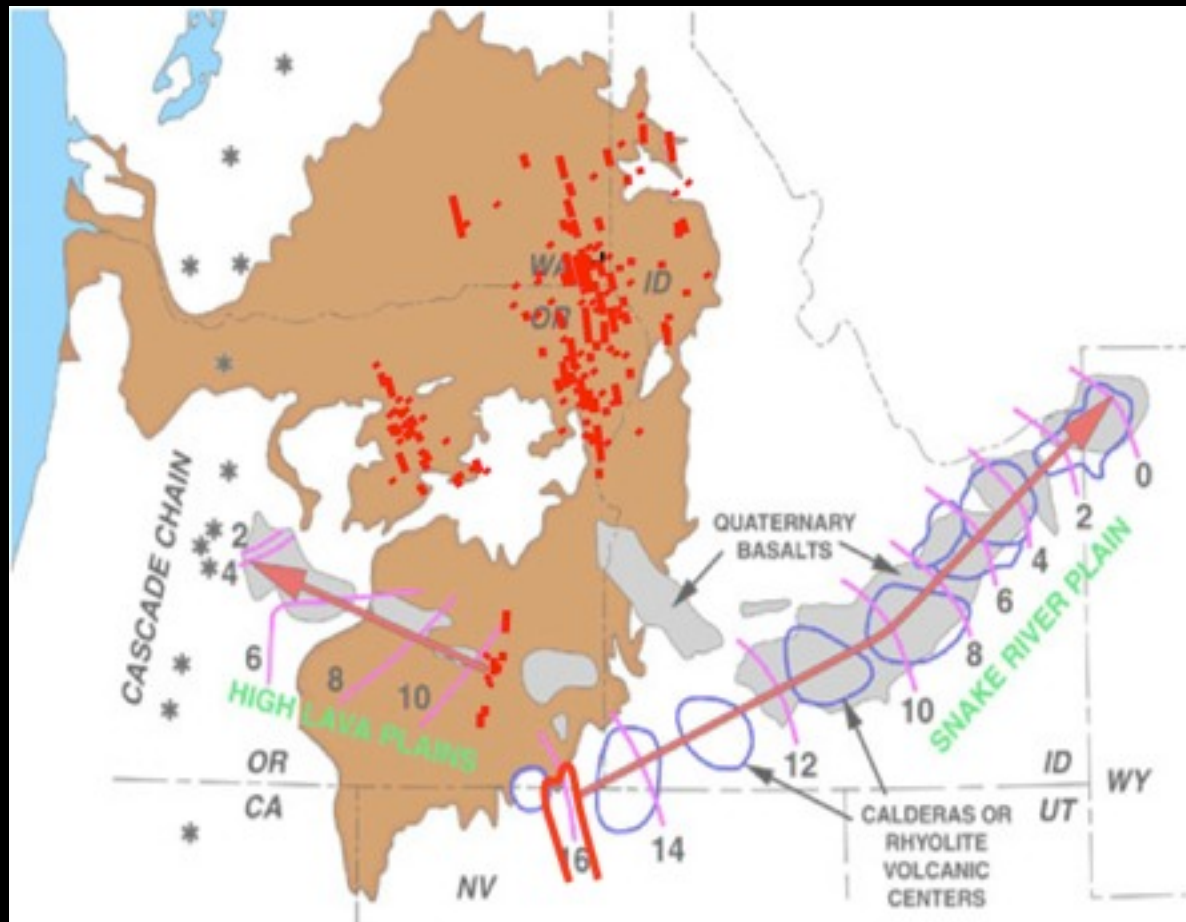
Liu and Stegman, EPSL, 2011

Volcanic trends in Western N. America

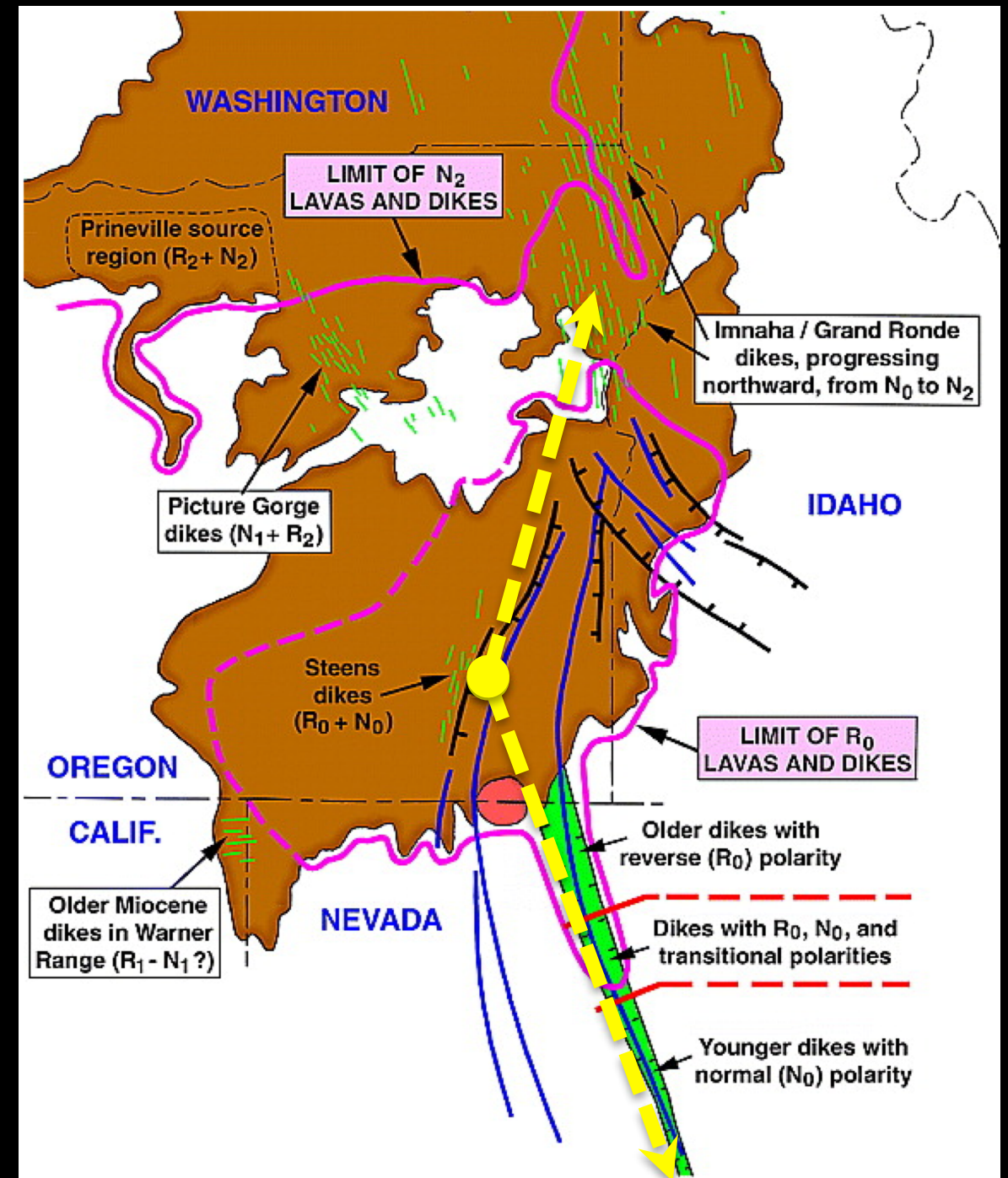


Humphreys et al. (2000)

Pattern of Volcanism

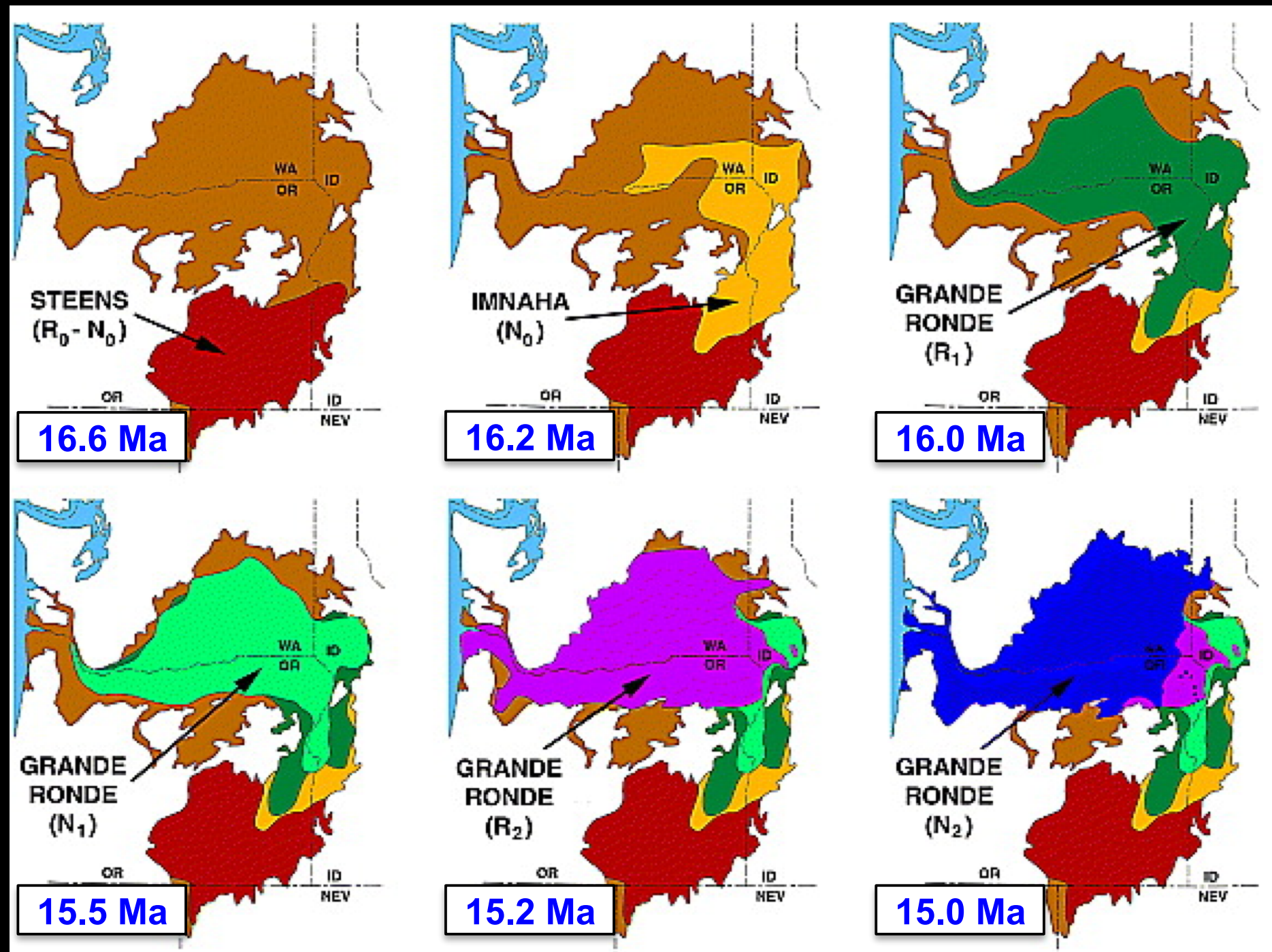


Humphreys (pers. comm.)



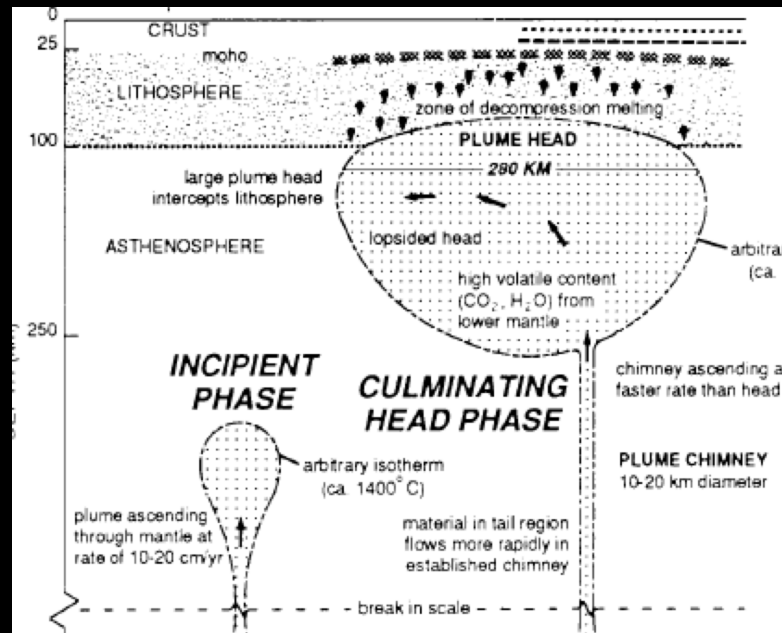
Camp et al., 2004

Pattern of Volcanism

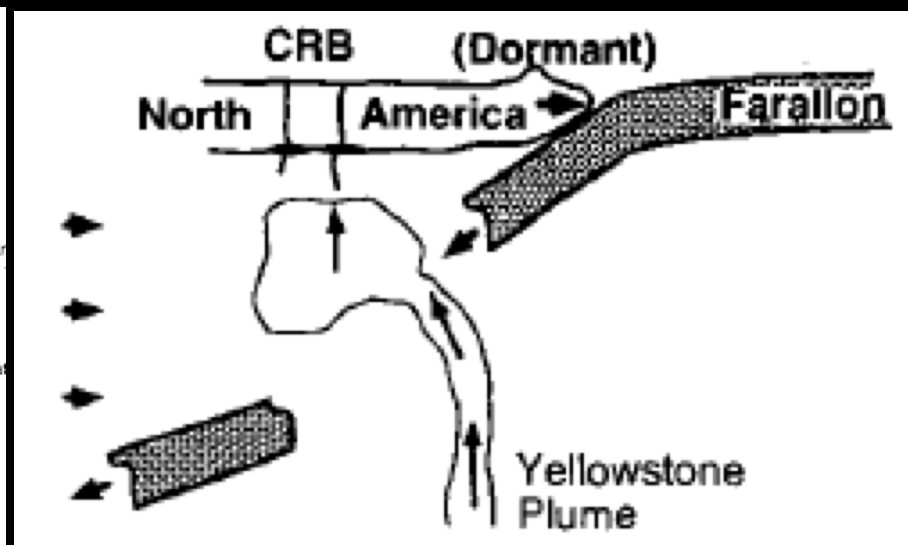


Camp et al. (2004)

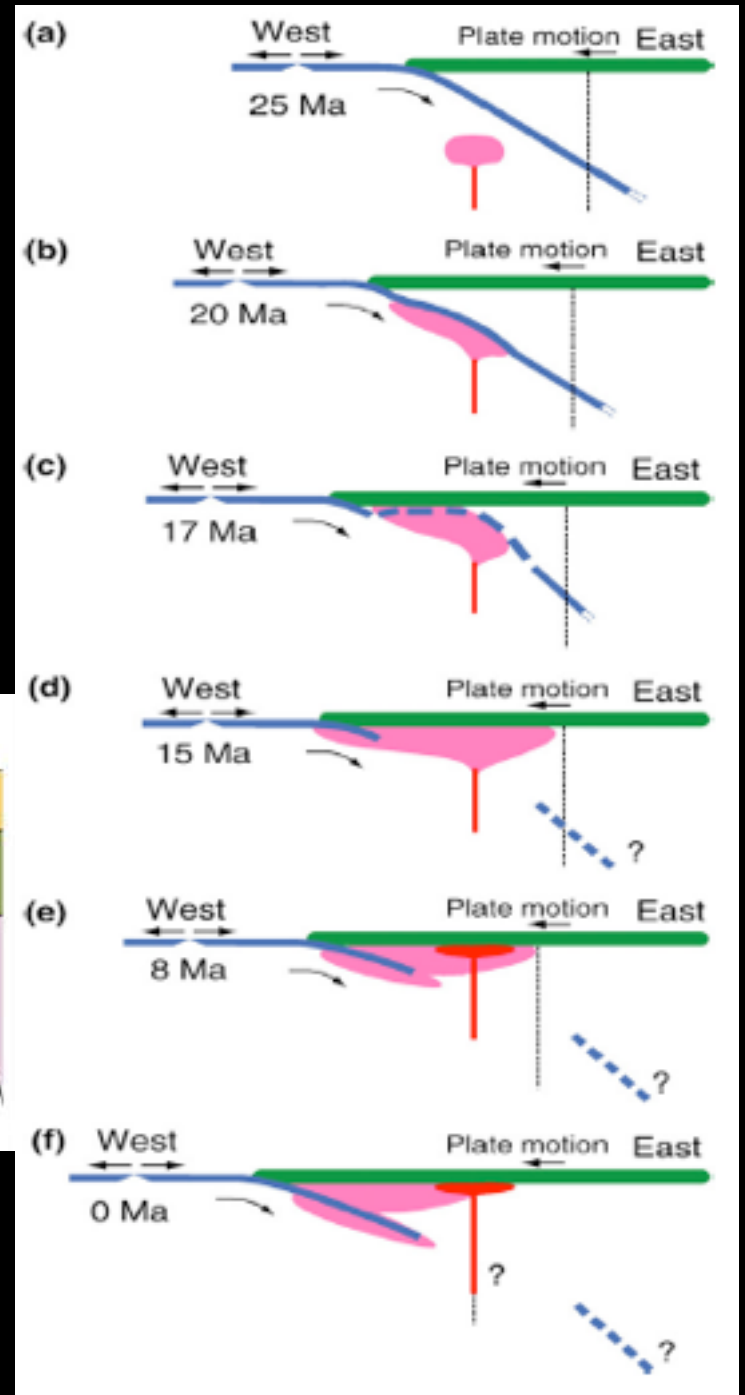
Models for origin of SCRB



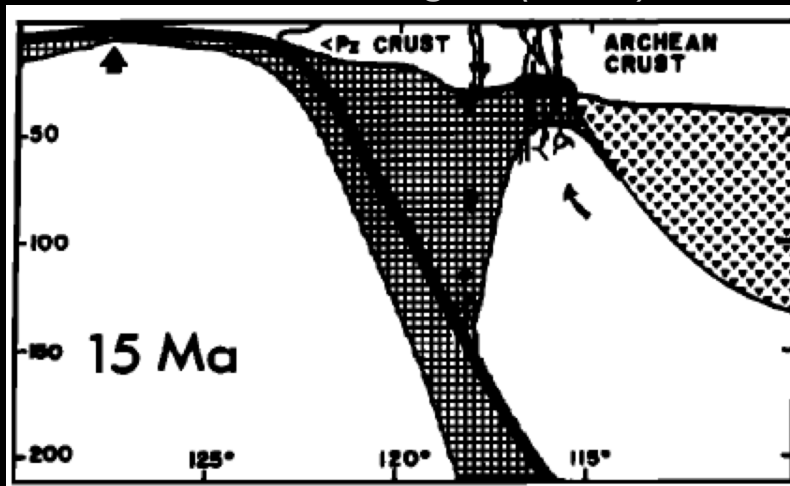
Pierce and Morgan (1992)



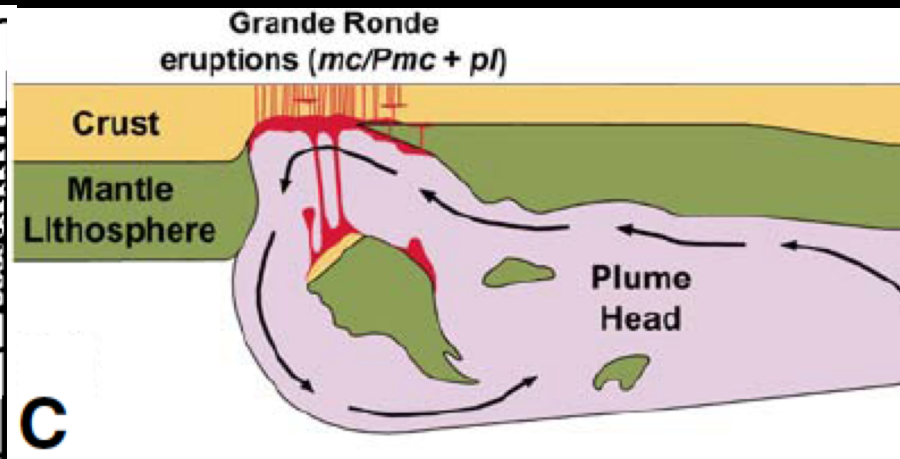
Geist and Richards (1993)



Xue and Allen (2007)

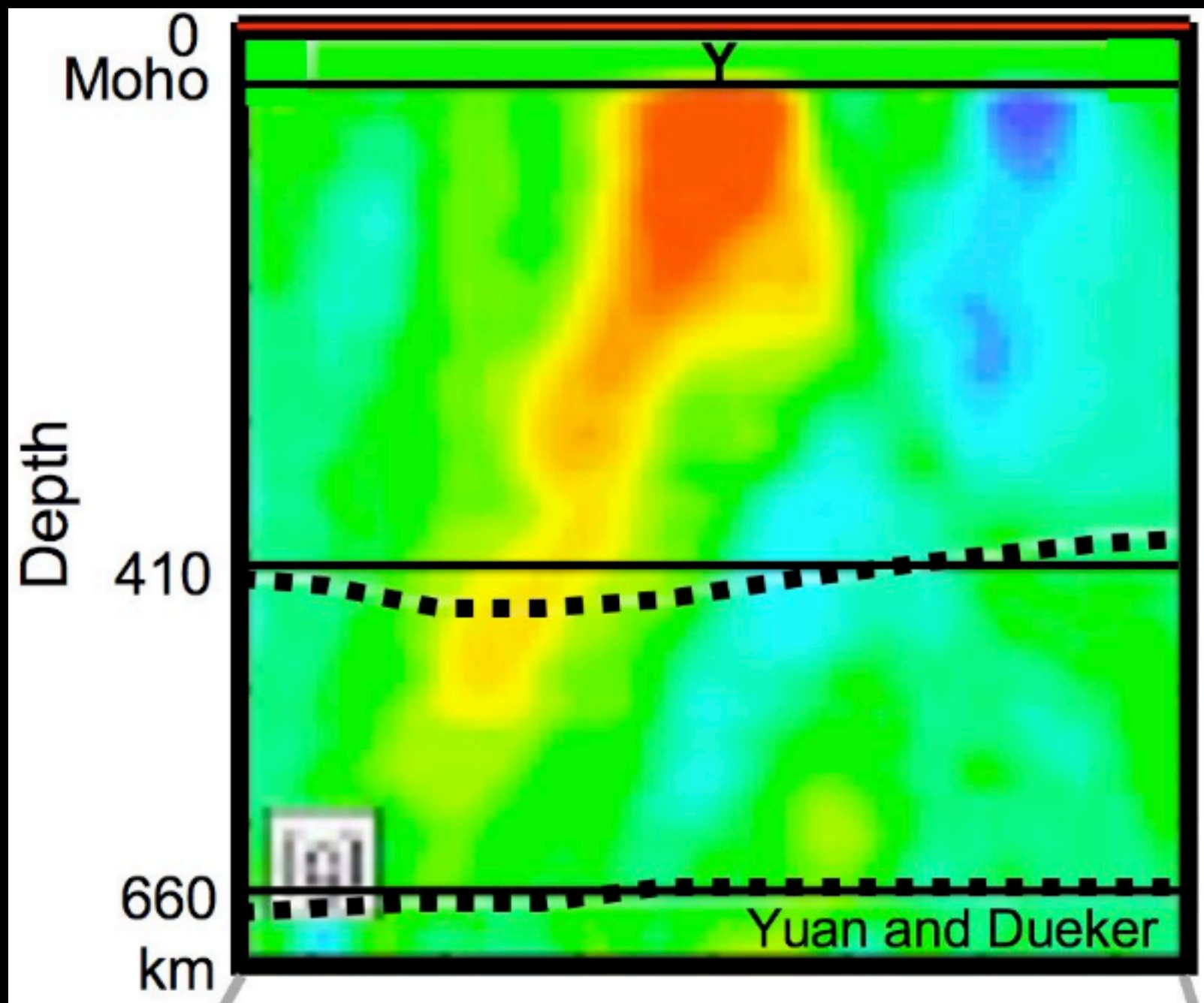


Carlson and Hart (1987)



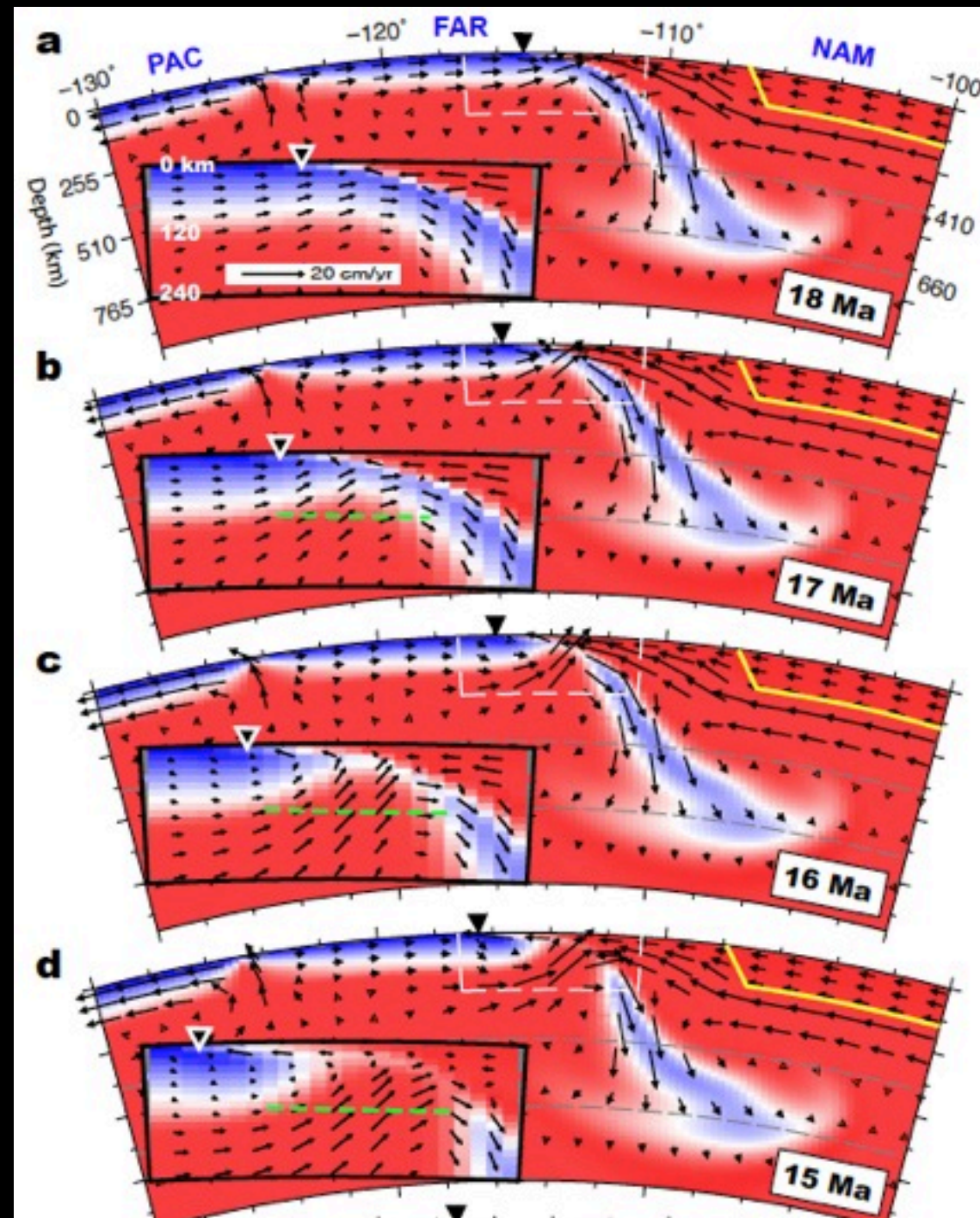
Camp and Hanan (2008)

Evidence for mantle plume?



Yuan and Dueker (2005)

Propagating Rupture of Farallon Slab



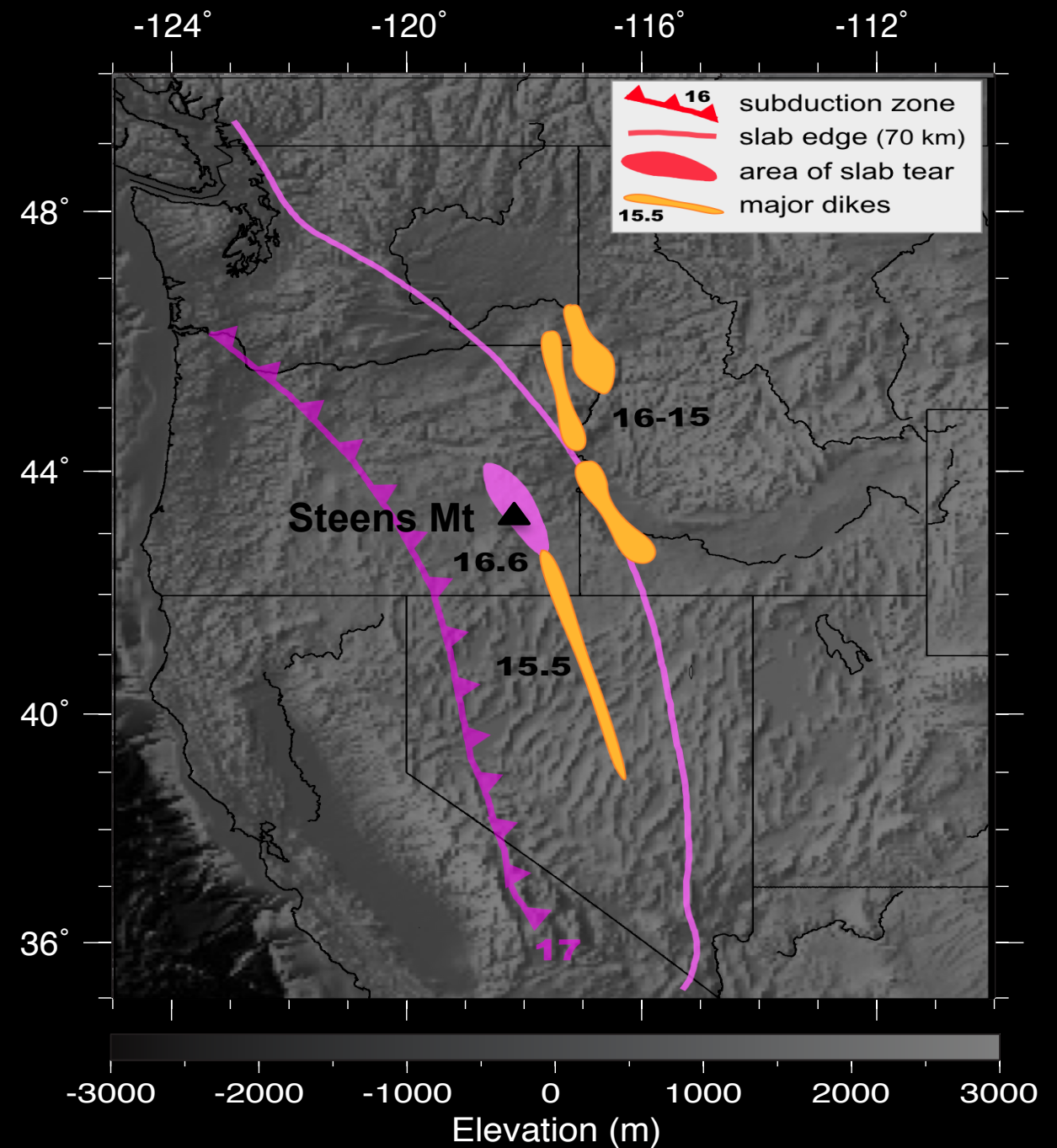
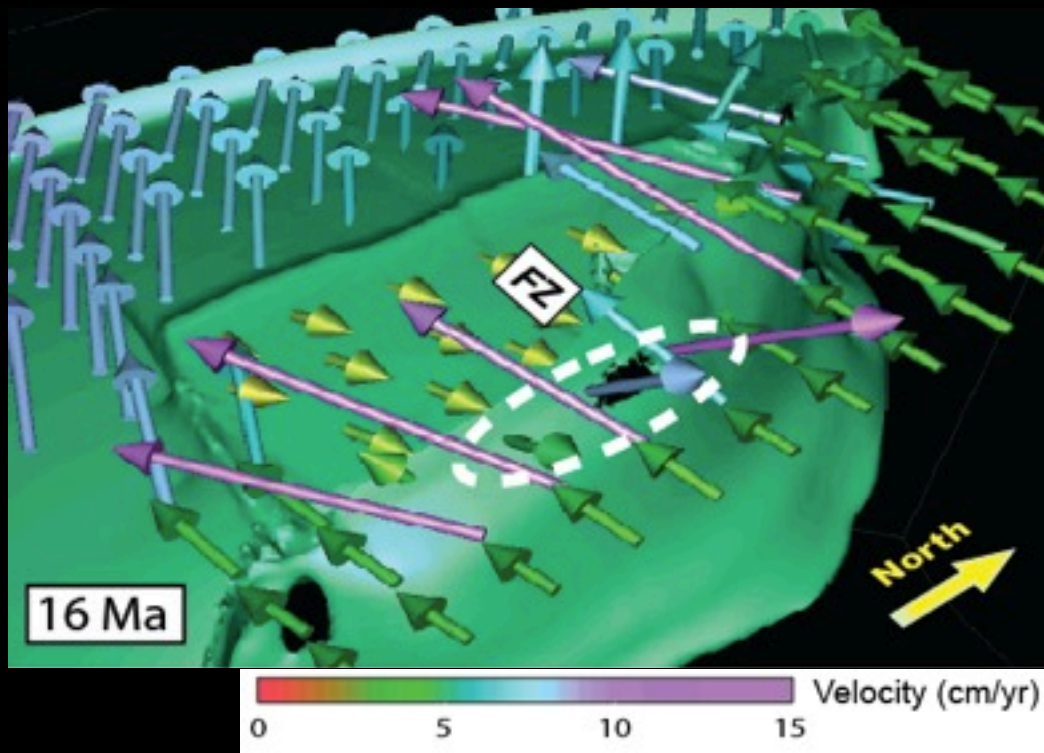
Lui and Stegman, Nature, 2012



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Comparison with SCRB history

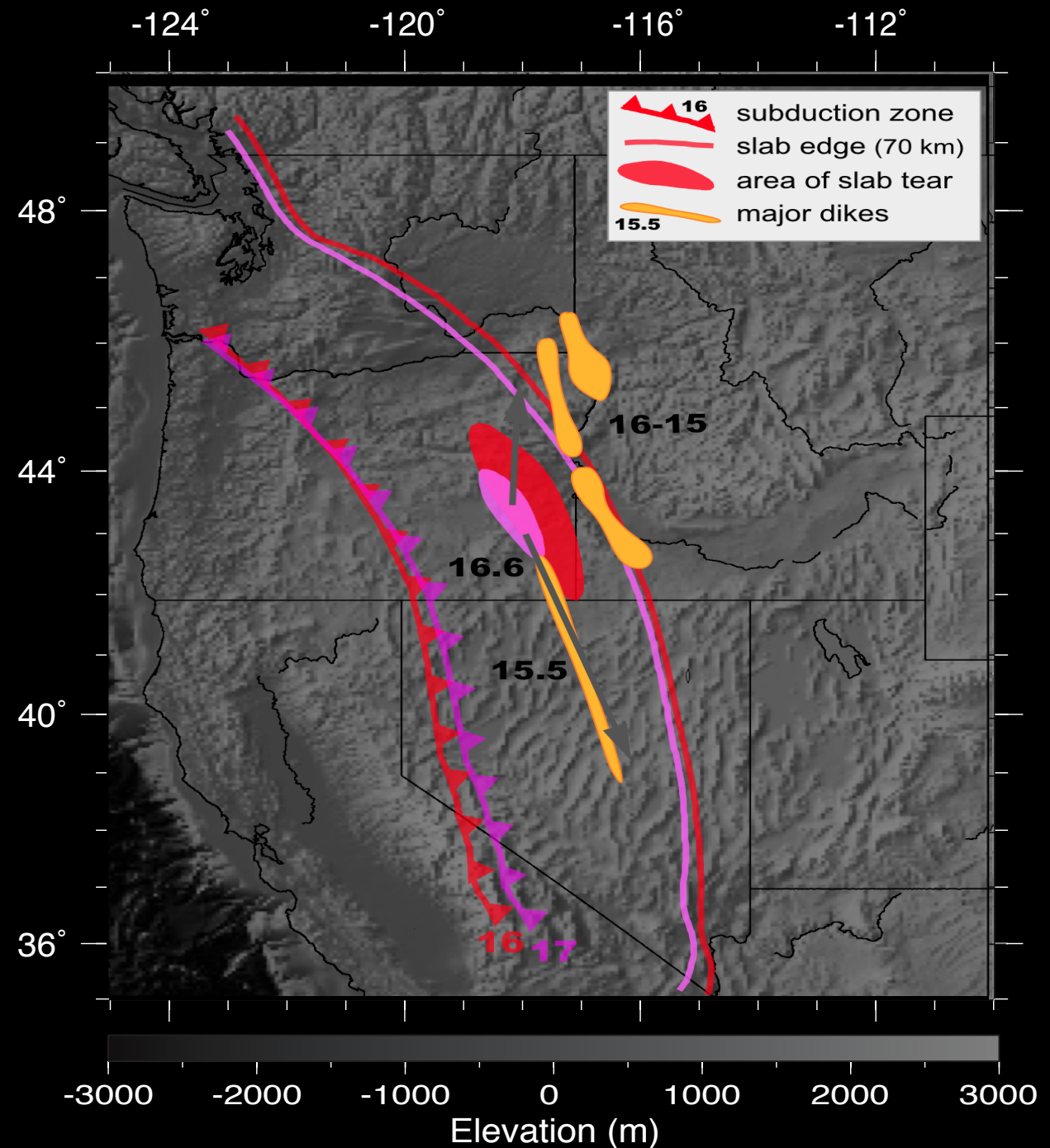
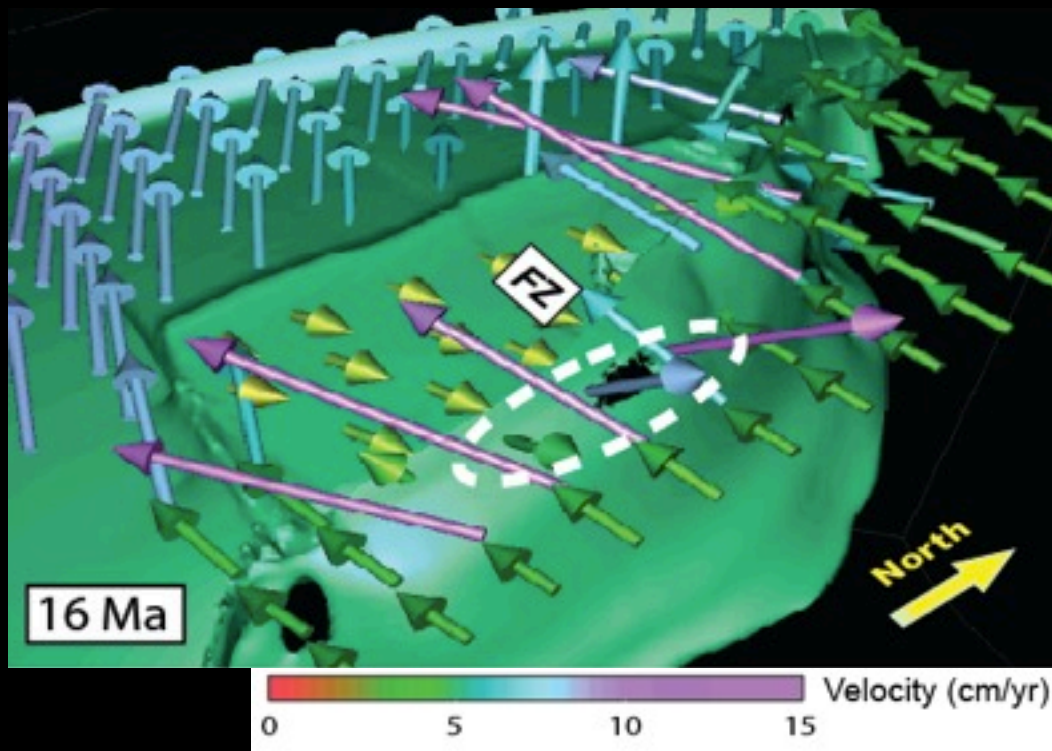
- initial SCRB eruption at 16.6 Ma at Steens Mountain (SM)
- First tear observed in model 17 Ma



Lui and Stegman, Nature, 2012

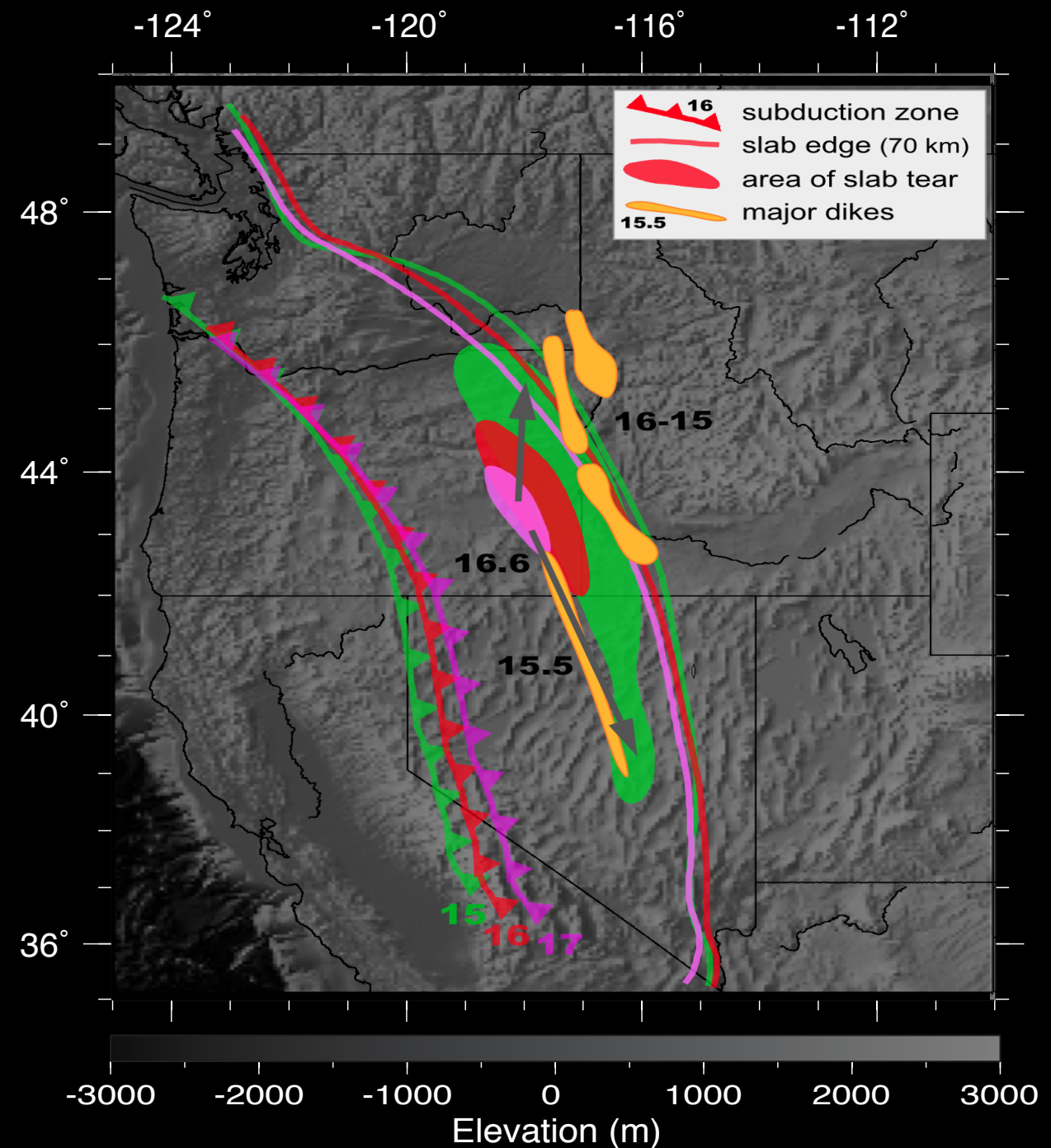
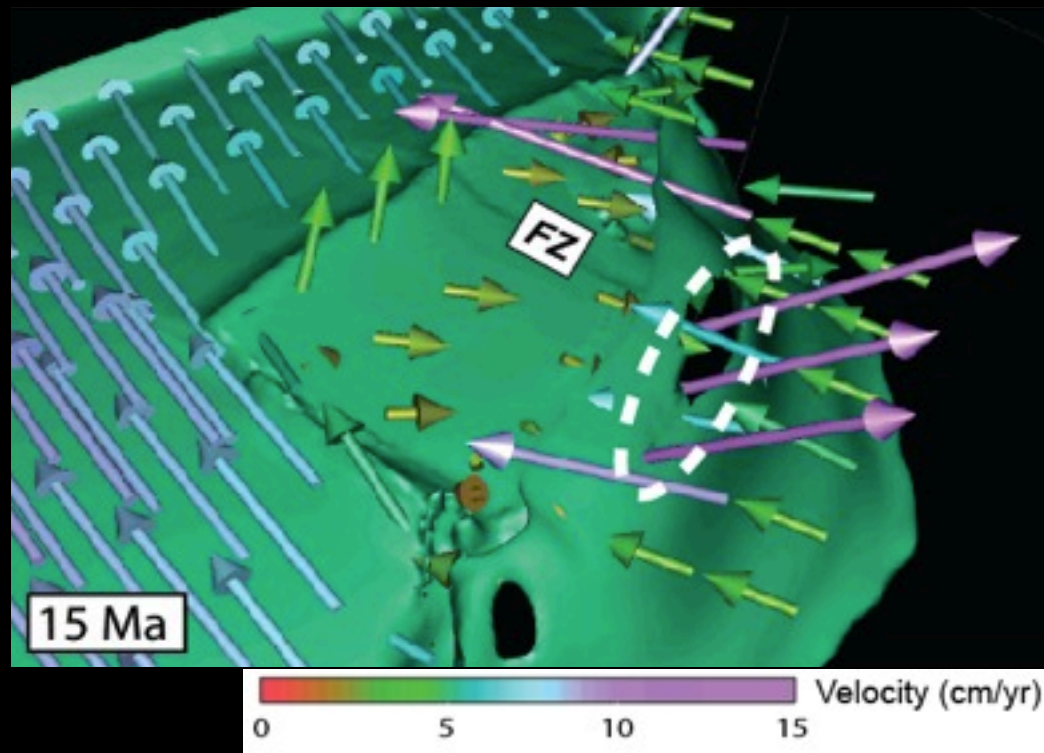
Comparison with SCRB history

- Sub-slab pressure much larger than mantle wedge pressure
- Upwelling & advected heat thermally erode slab from the bottom-up



Comparison with SCRB history

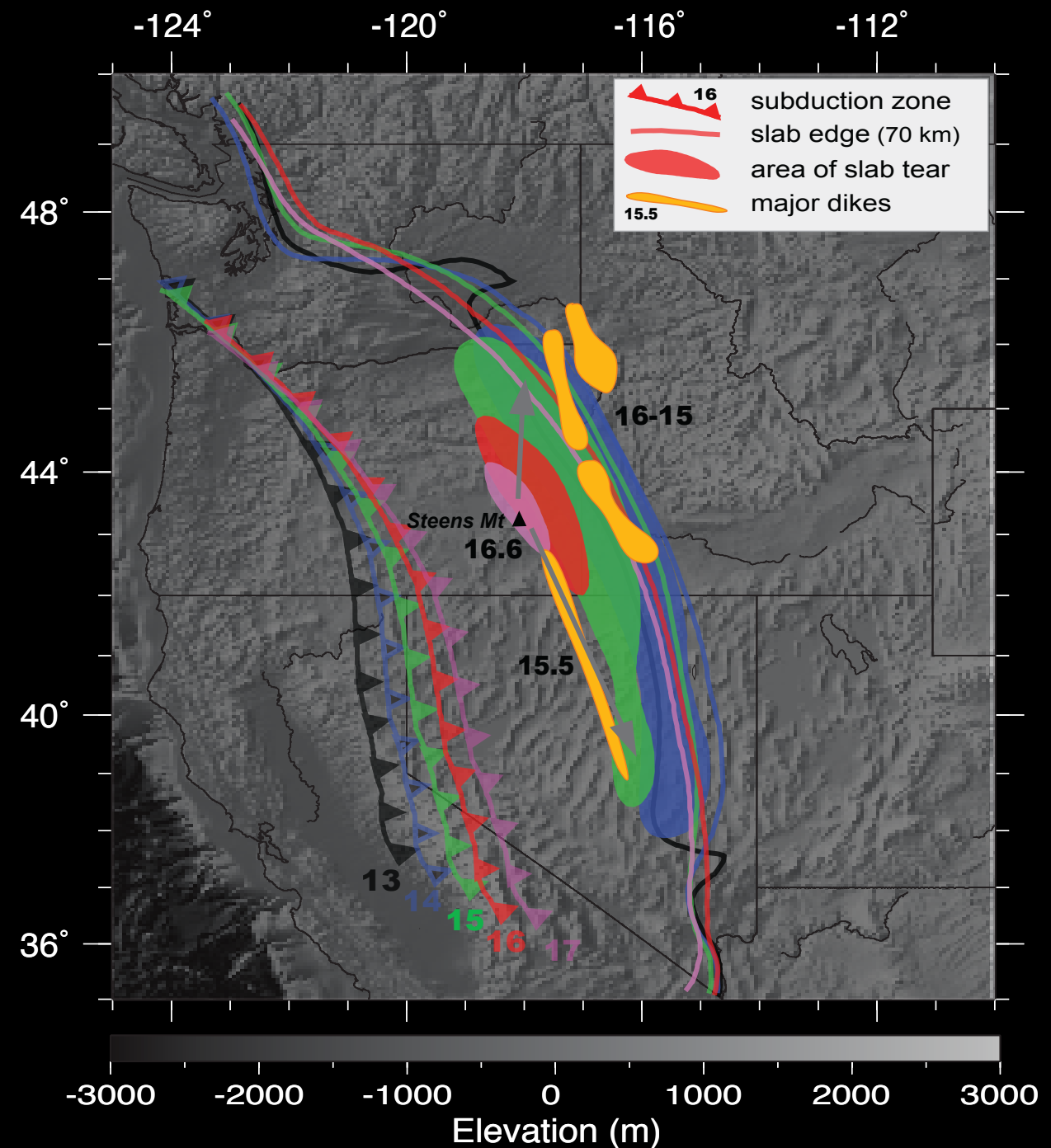
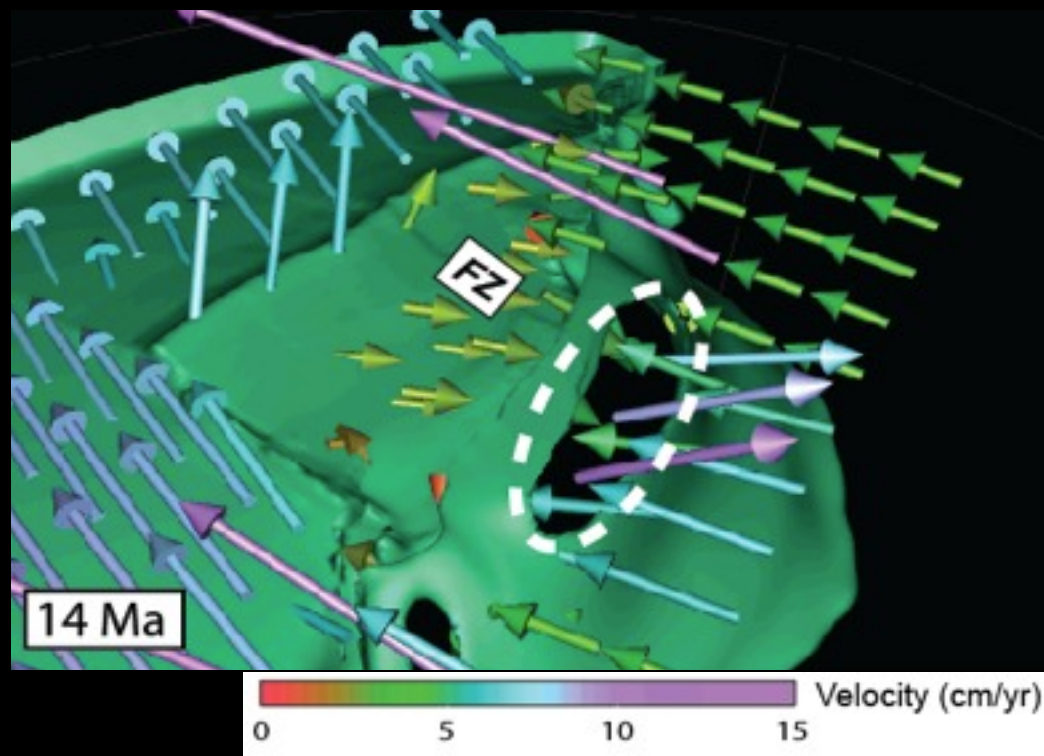
- North-South propagating volcanism towards major feeder dykes and Northern Nevada Rift (NNR)
- Tear propagates along slab



Lui and Stegman, Nature, 2012

Comparison with SCRB history

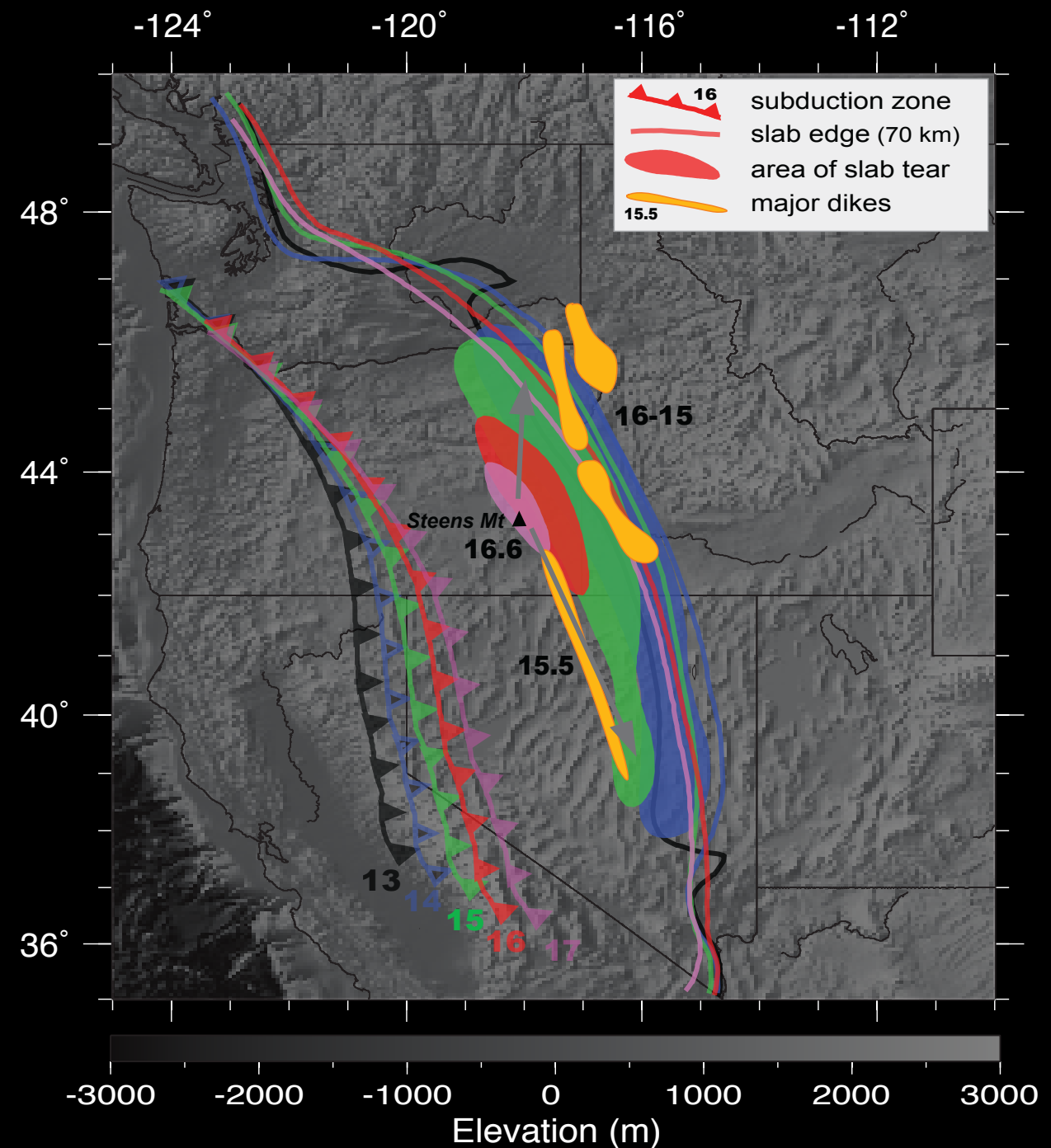
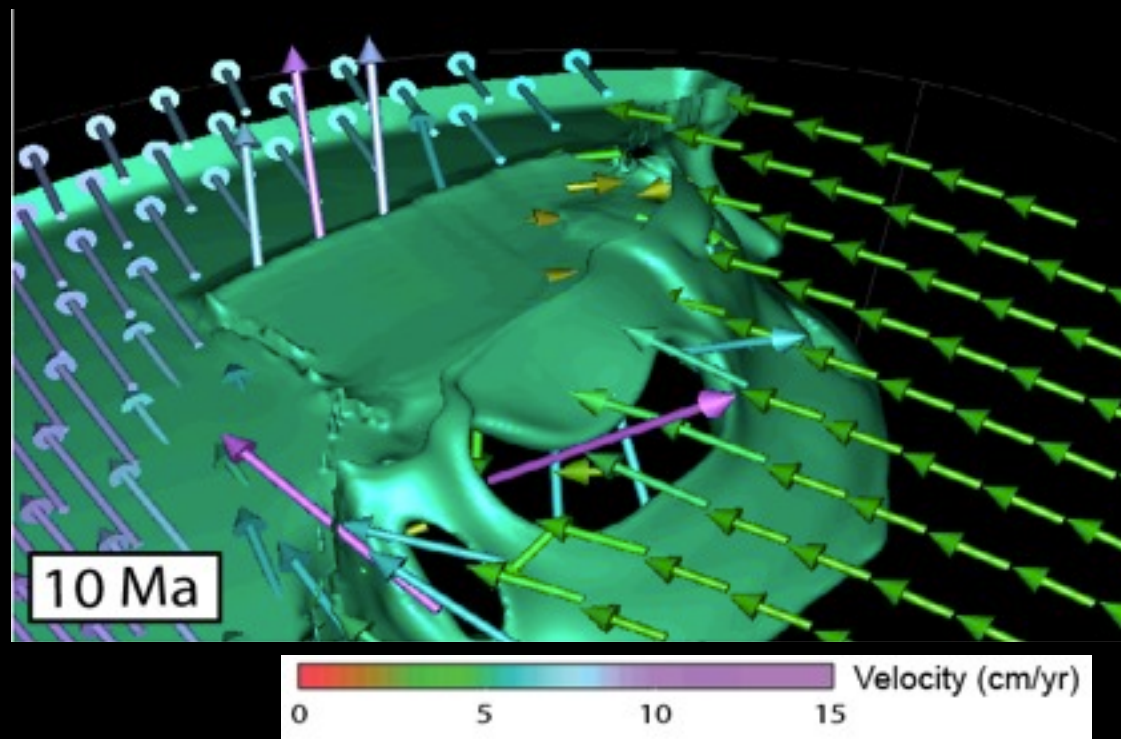
- Peak eruption at Chief Joseph dyke Swarm (15 Ma)
- Tear continues to increase in size



Lui and Stegman, Nature, 2012

Comparison with SCRB history

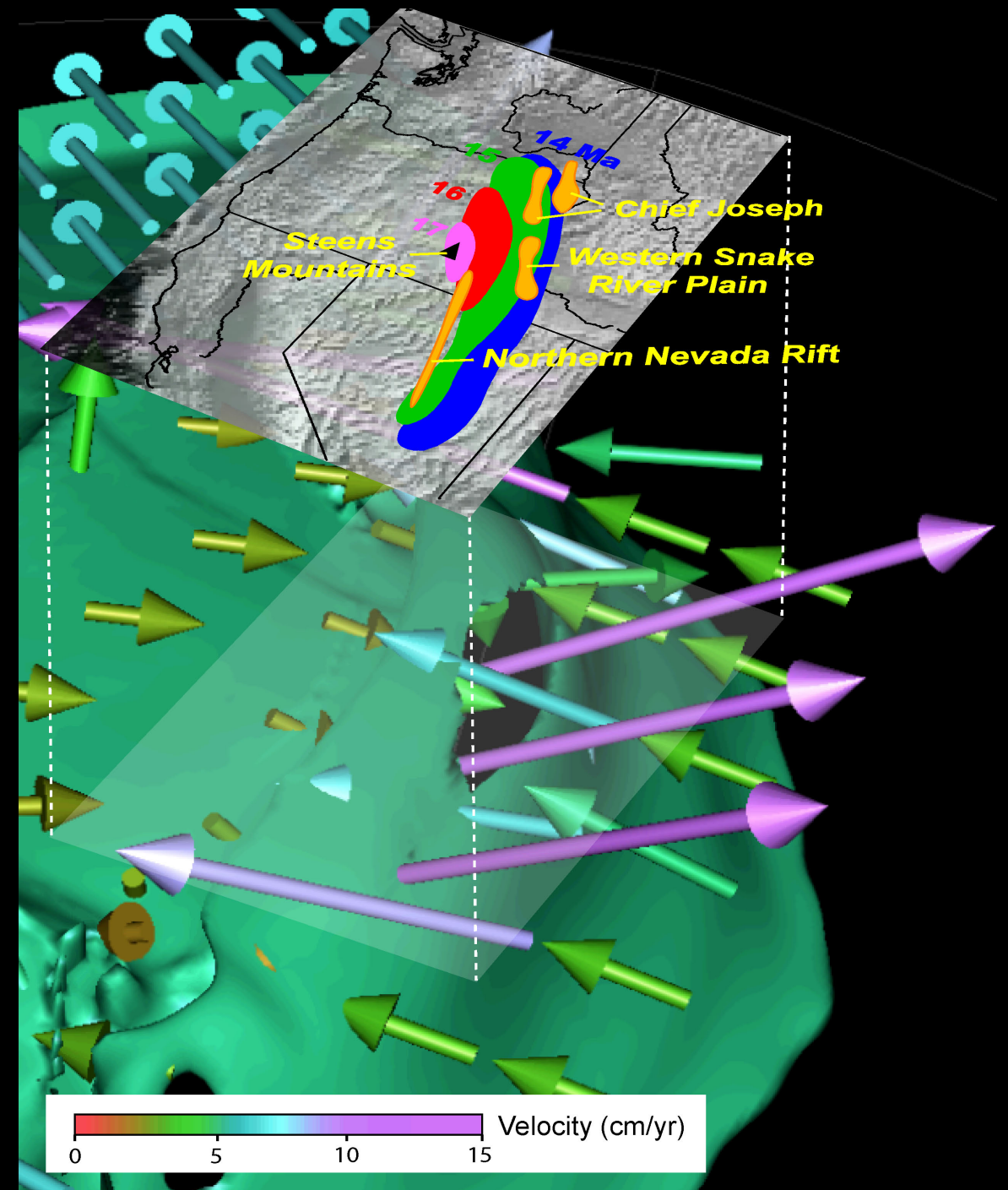
- Waning stage of SCRB eruption (14-10 Ma)
- Rupture stops, pressure equilibrated



Lui and Stegman, Nature, 2012

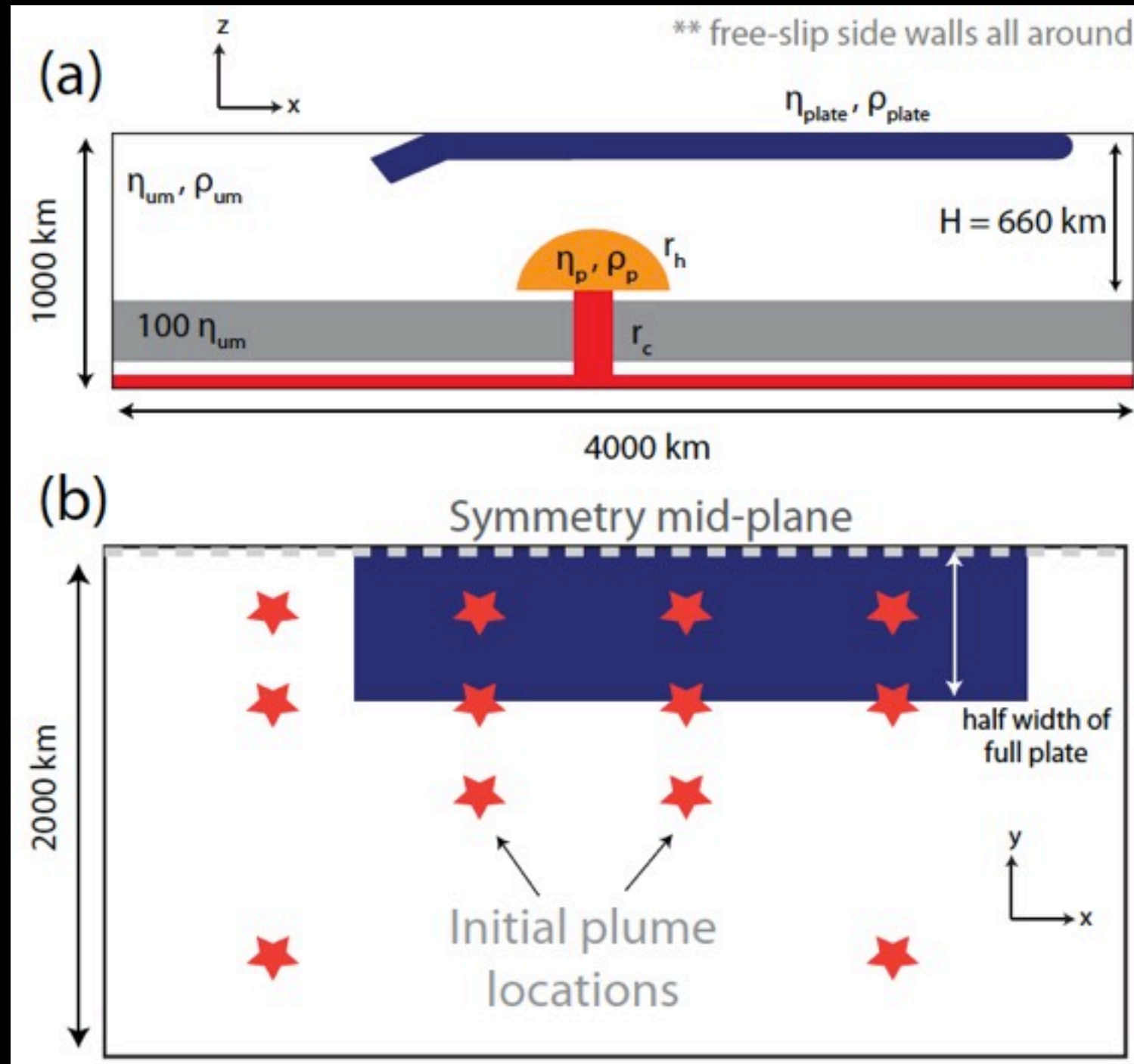
Mechanism of Intraplate Volcanism

- New way to form LIPs
- Model forward predicts the spatio-temporal pattern of SCRB volcanism
- Consistent with seismic tomography, plate tectonic reconstructions, geology, geochemistry



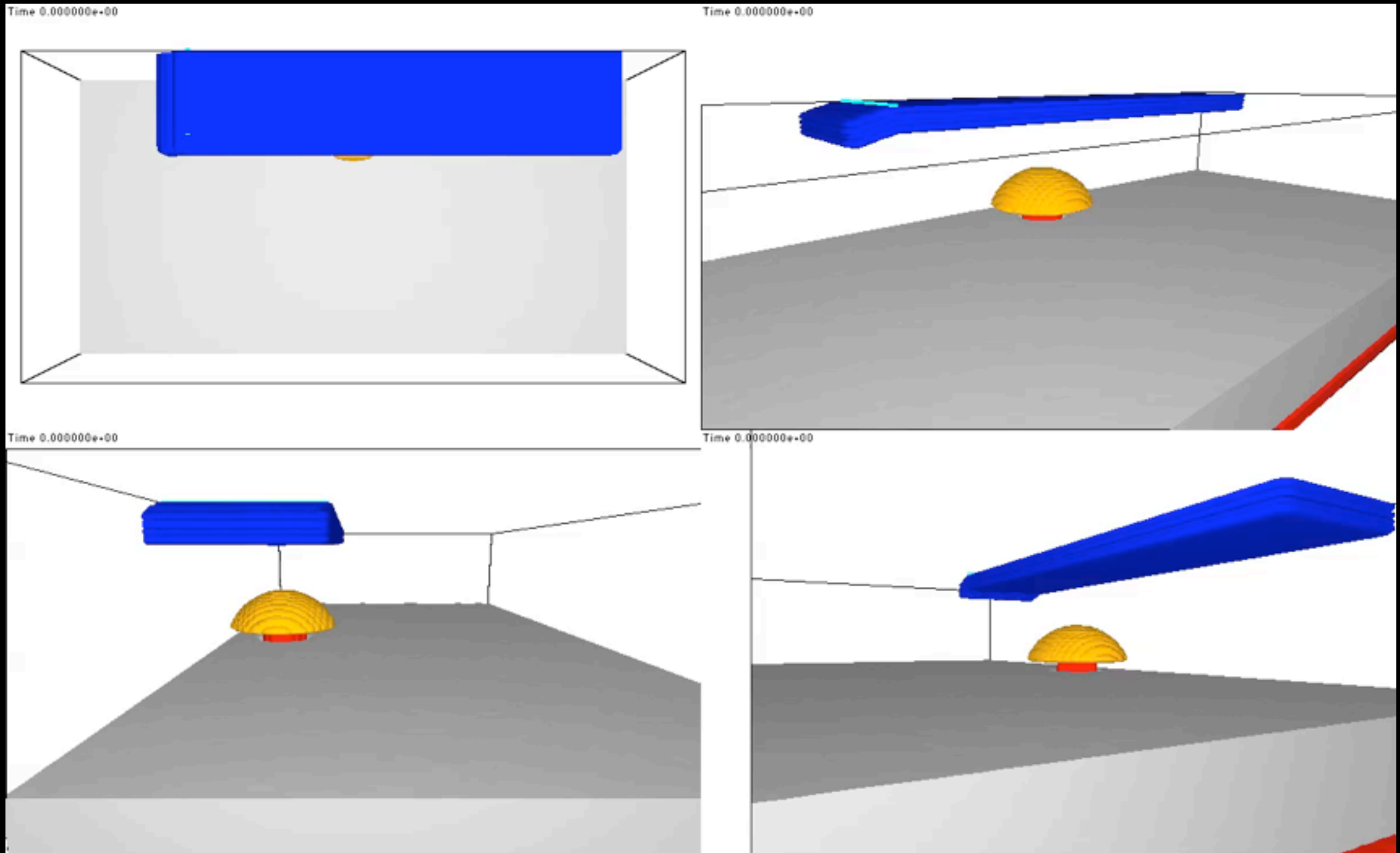
Lui and Stegman, Nature, 2012

Plume-Slab Interaction

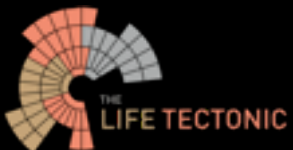


Druken, Stegman, et al (in prep)

Plume-Slab Interaction

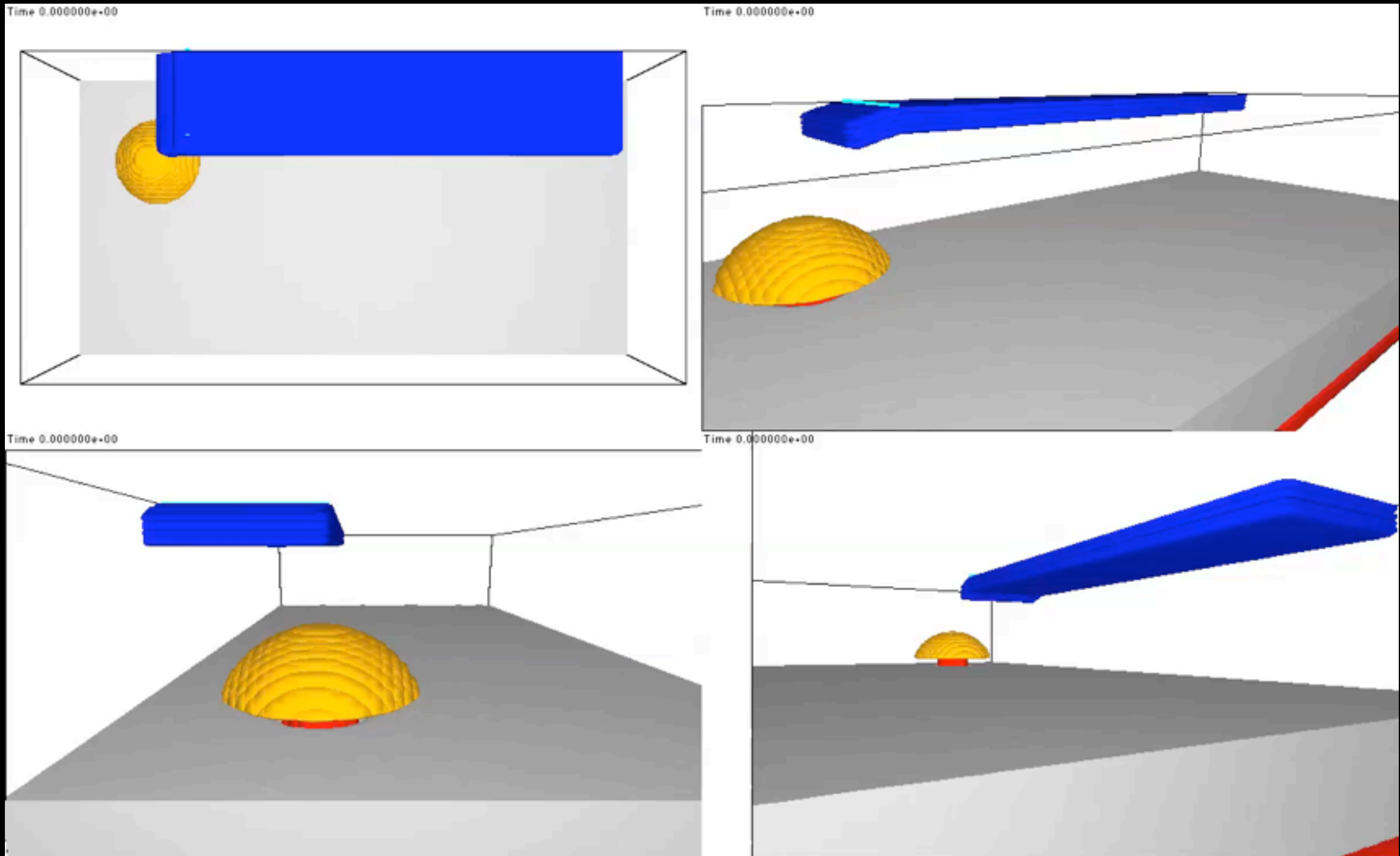


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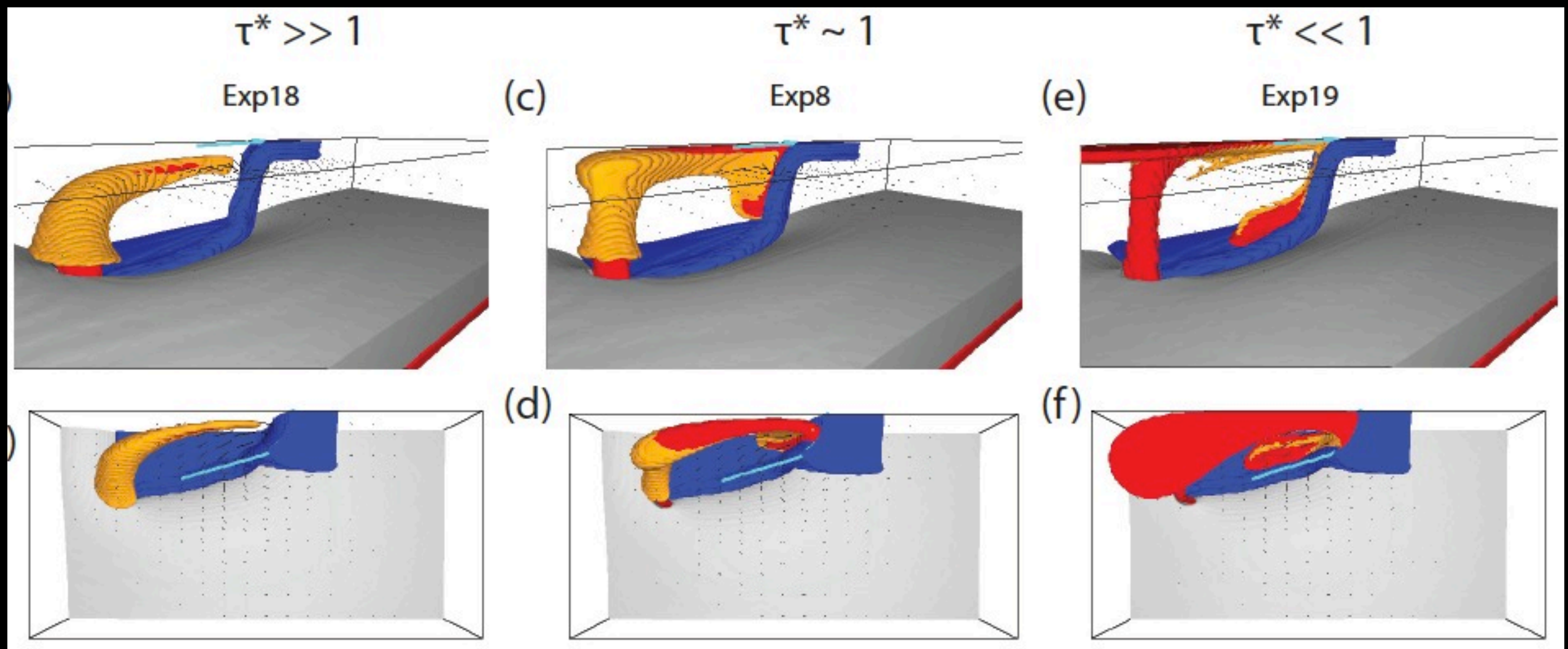
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Plume-Slab Interaction



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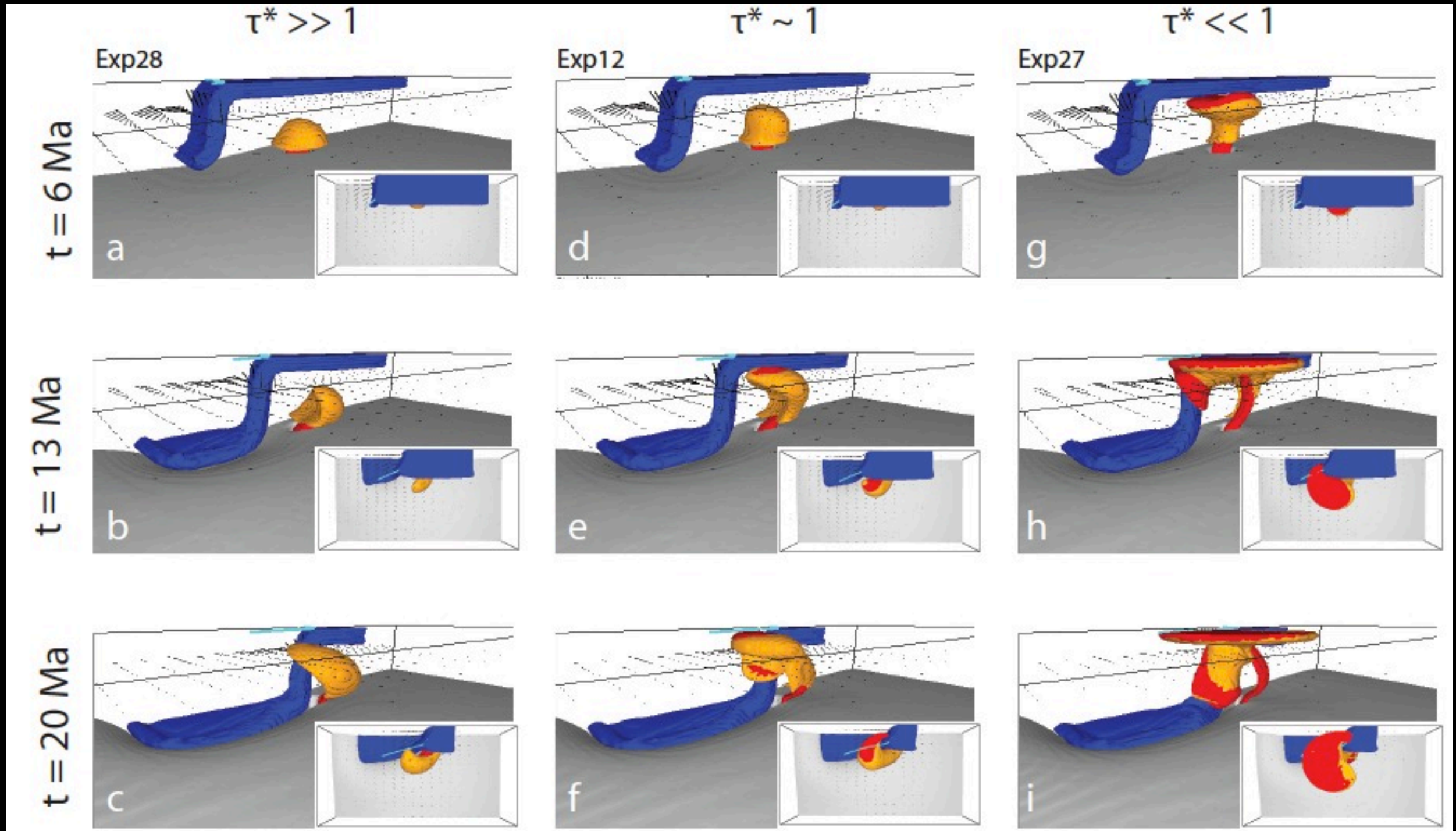


Druken, Stegman, et al (in prep)



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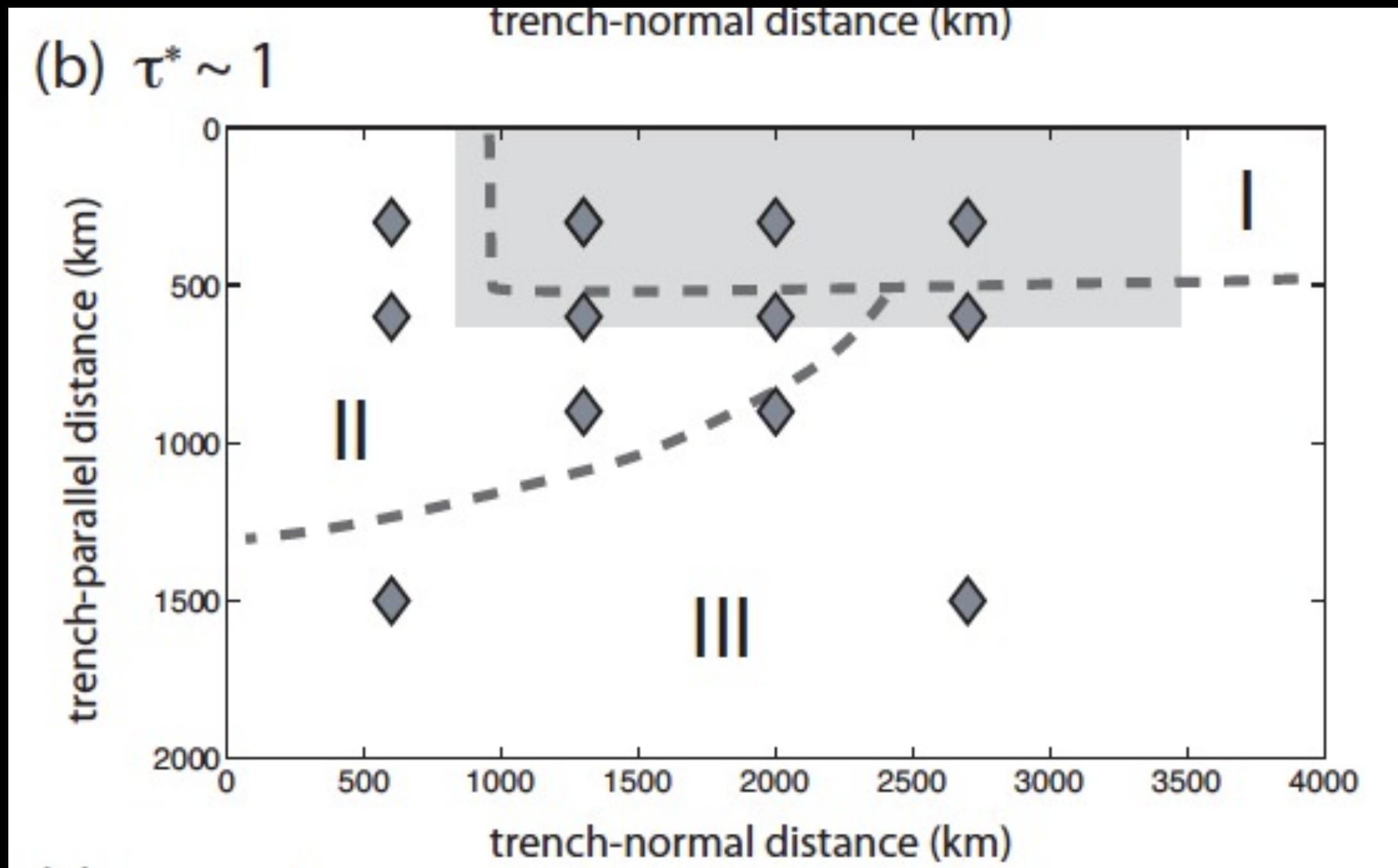


Druken, Stegman, et al (in prep)



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Plume-Slab Interaction



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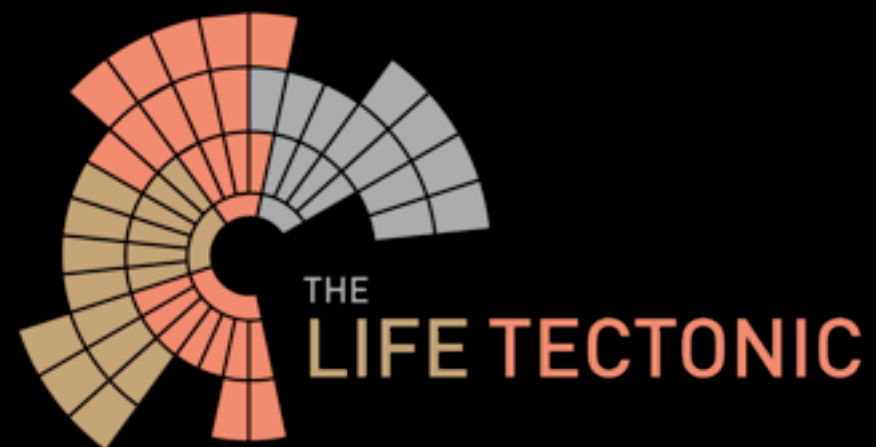
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A different sort of laboratory



- **simulation software**
- **visualization software**
- **high-performance computing**
- **develop computer models that help us understand planets**





www.thelifetectonic.com
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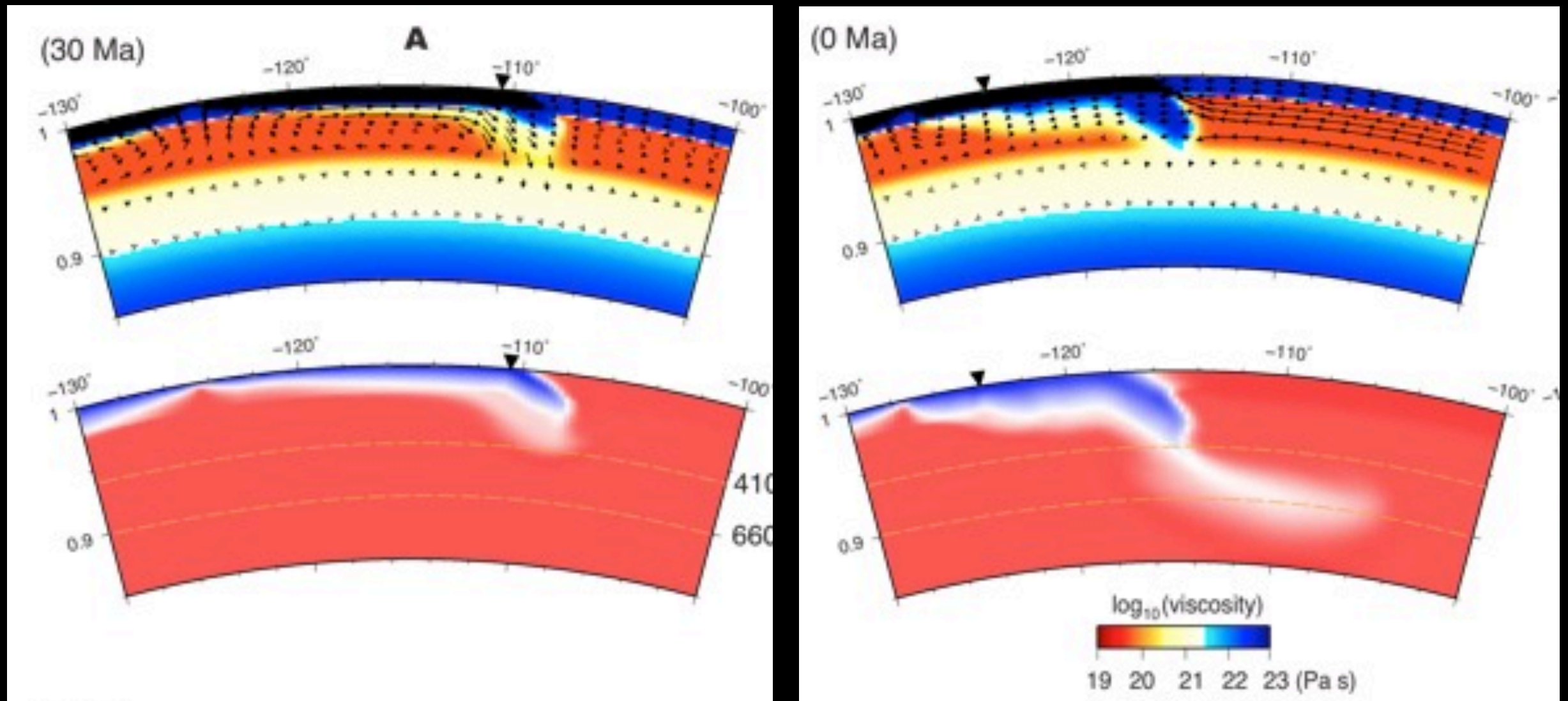
visit us at Scripps or online

Extra slides



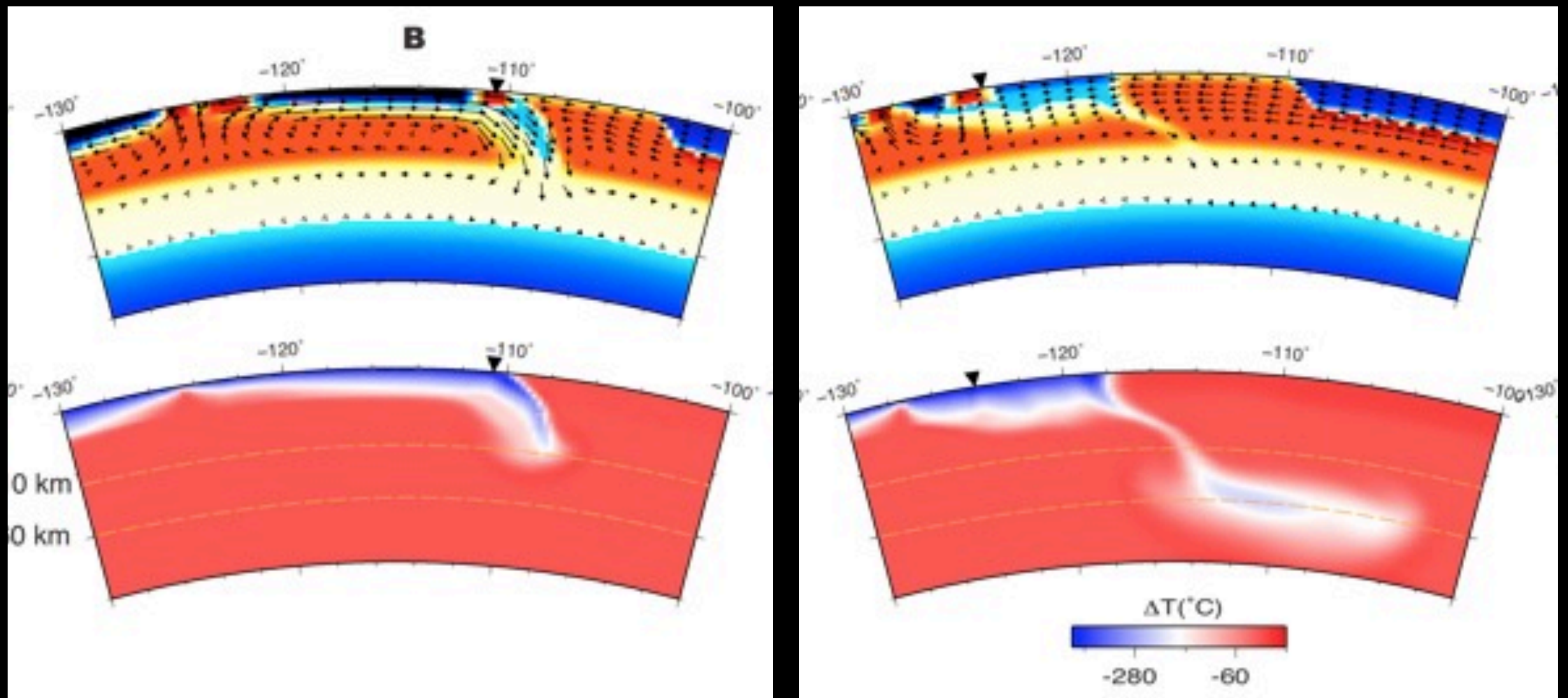
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Without Weak Plate Boundaries



Liu and Stegman, EPSL, 2011

Weak Plate Boundaries Only

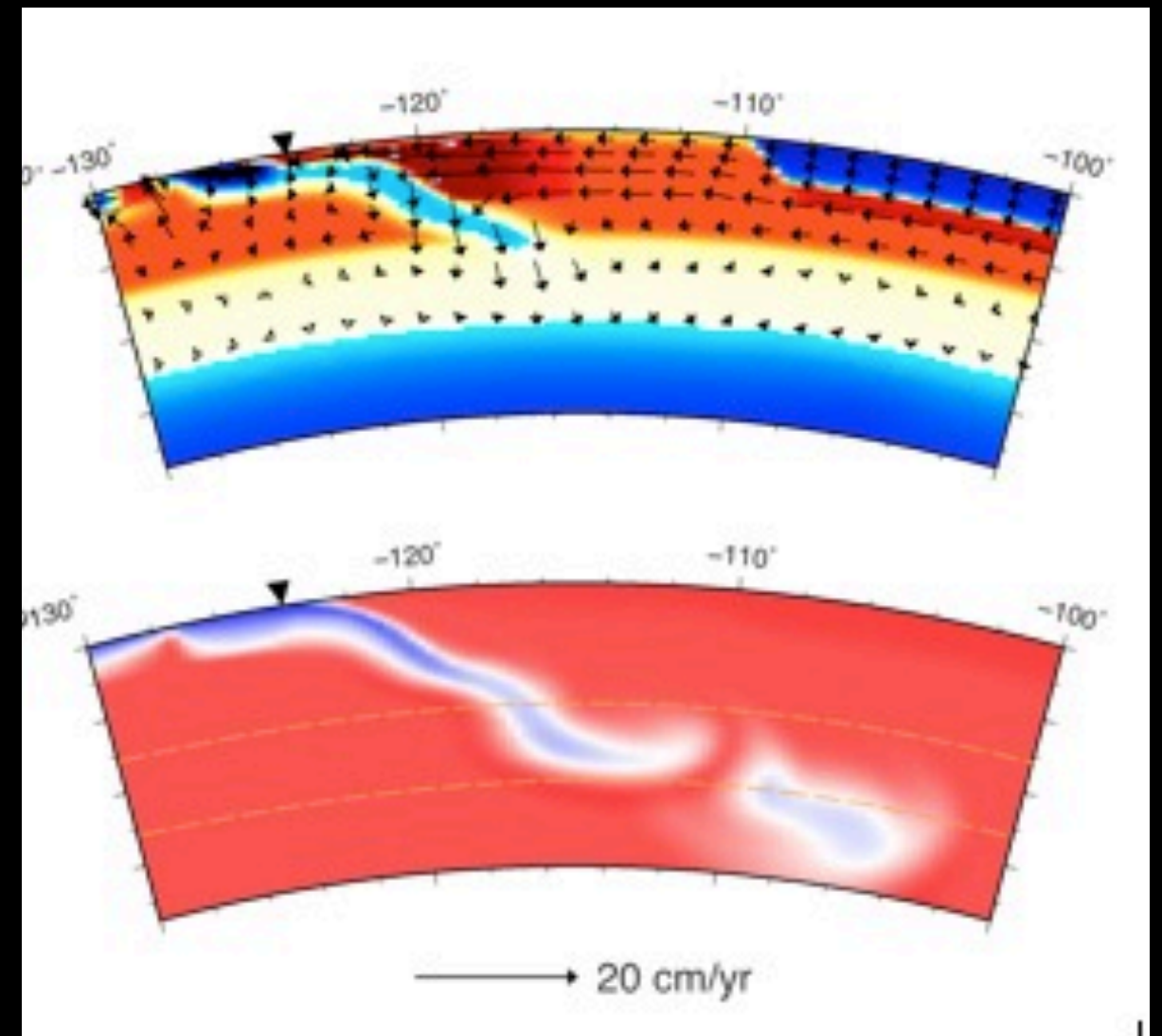
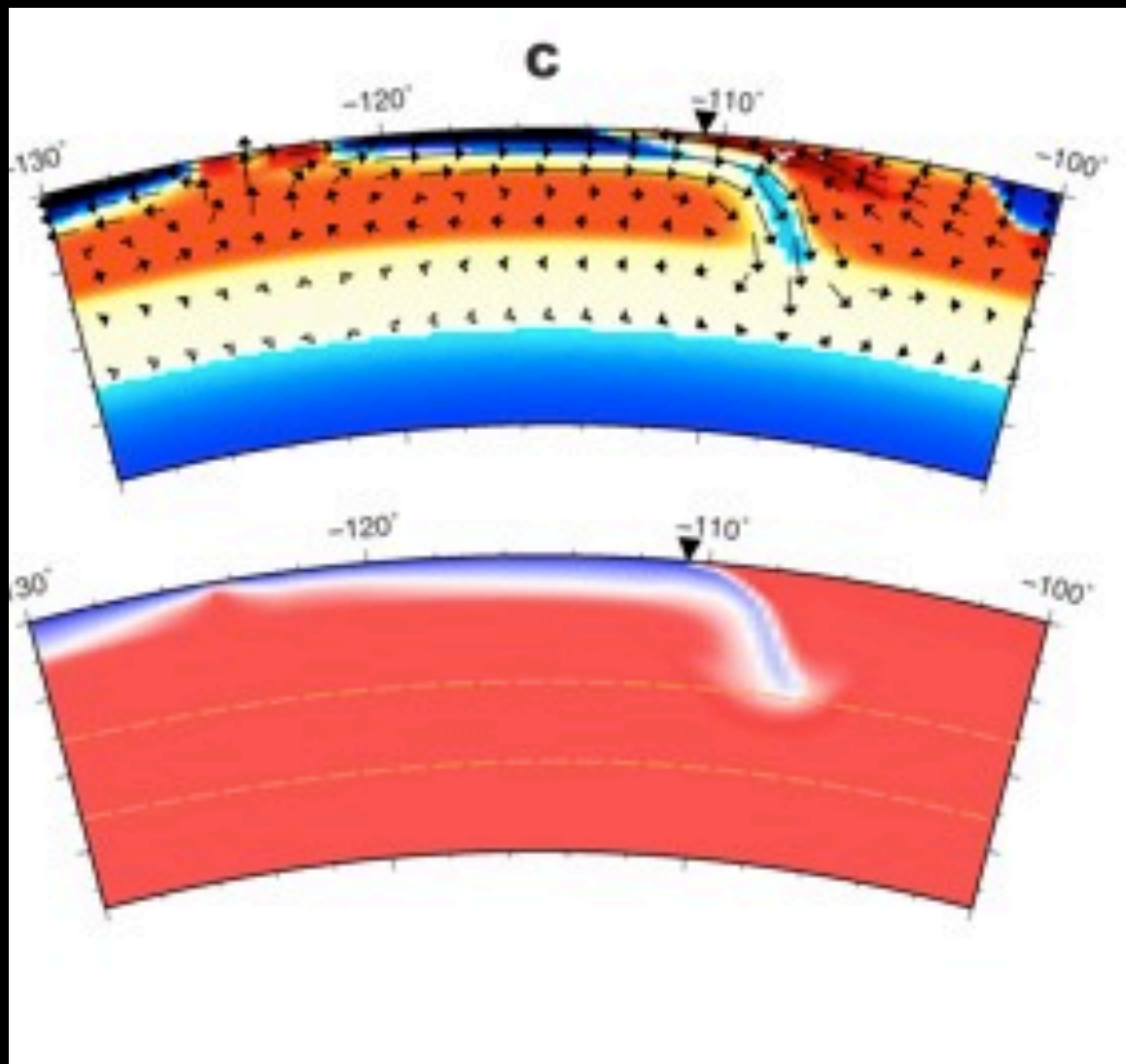


Liu and Stegman, EPSL, 2011



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Weak Plate Boundaries + Mantle Wedge

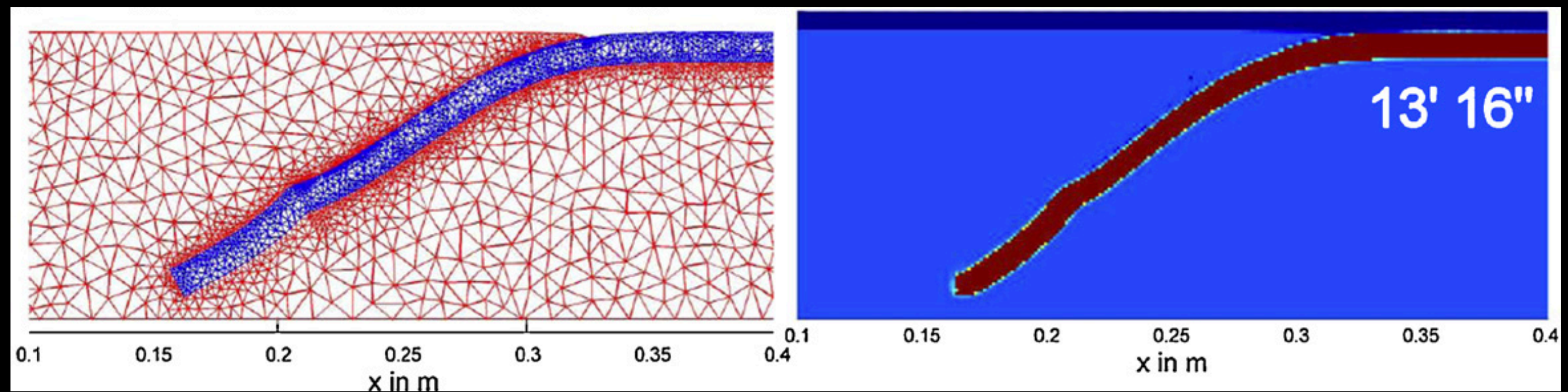
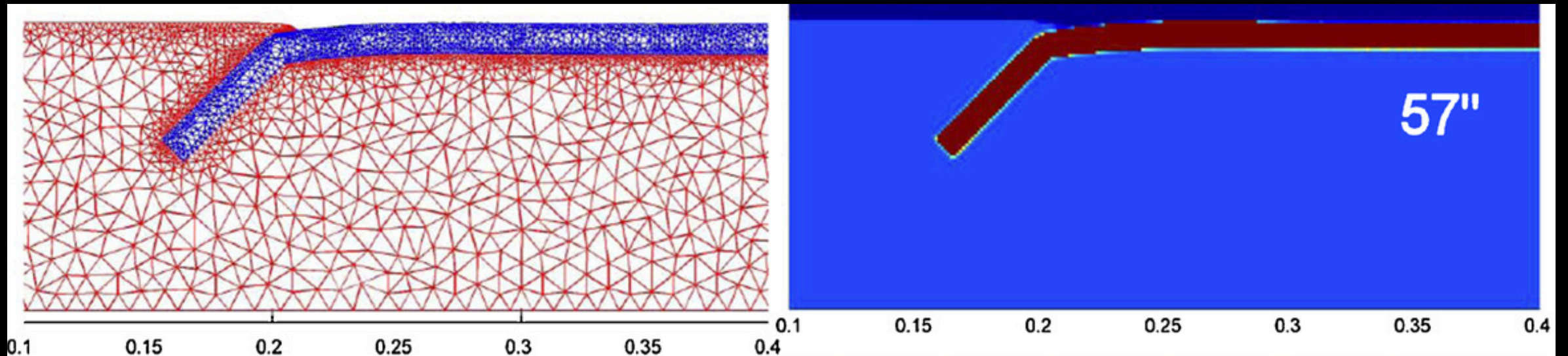


Liu and Stegman, EPSL, 2011



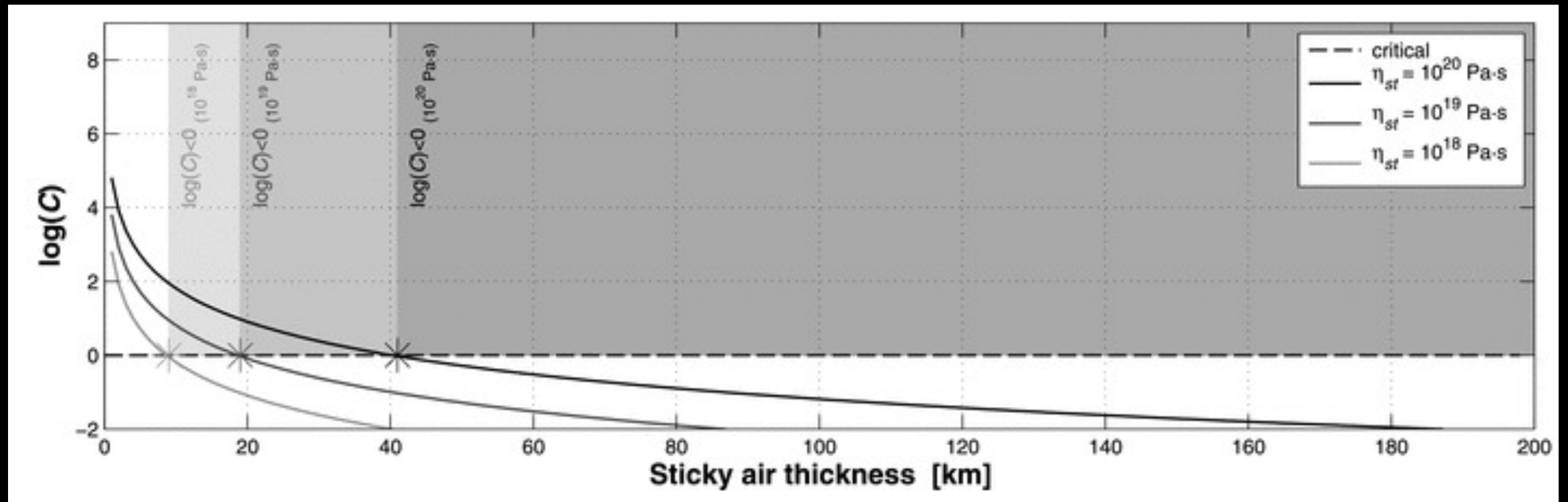
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Free-Surface vs. Sticky Air

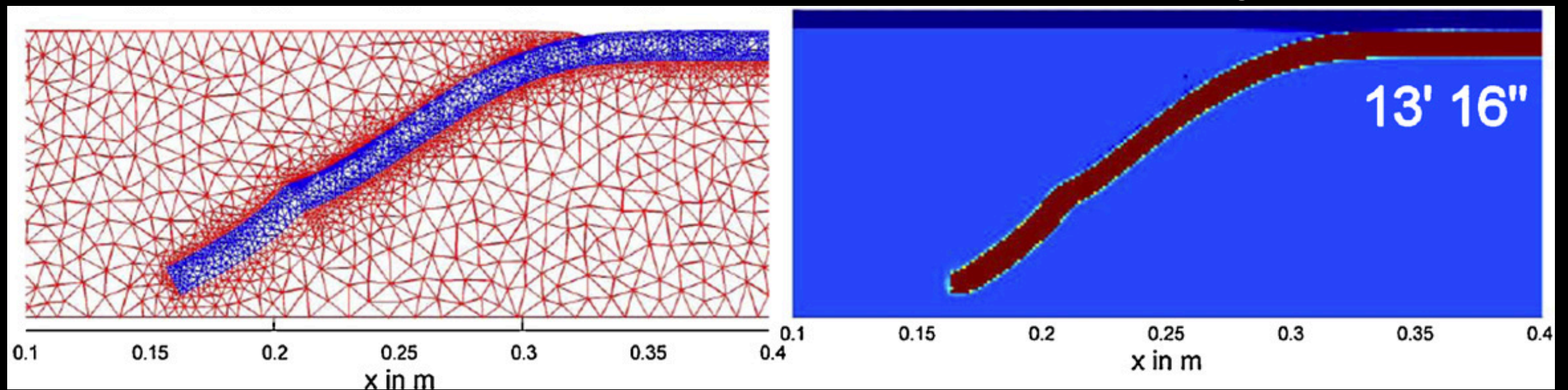


Schmeling et al., PEPI, 2008

Free-Surface vs. Sticky Air

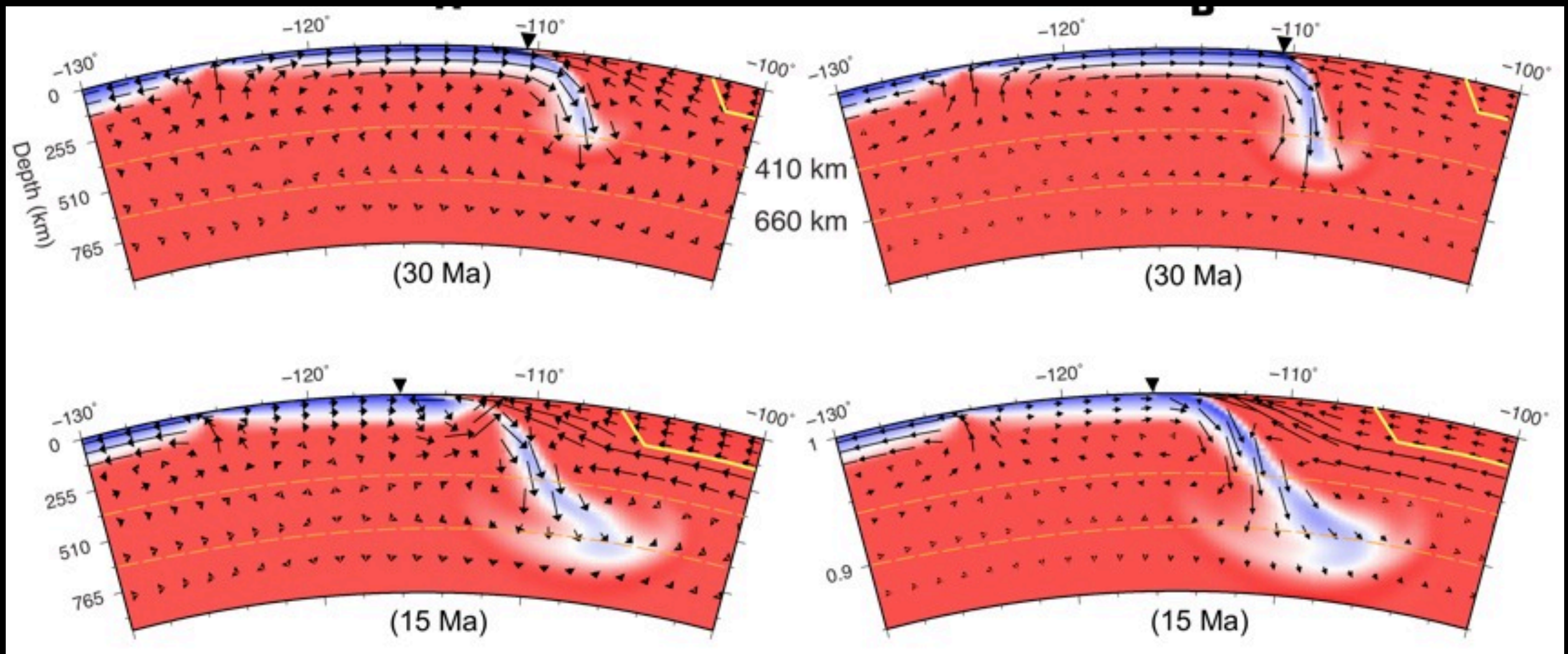


Crameri, Schmeling et al., GJI, 2012



Schmeling et al., PEPI, 2008

With and Without Sticky Air



Liu and Stegman, EPSL, 2011



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Questions still unanswered

- Why do plates subduct the way they do?
- What controls the stability of a subduction zone?



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- **How do subduction zones evolve?**
- **How do subducting plates interact with the overriding plate?**
- **What controls the variation of the dip angle?**
- **When did plates start subducting like they do today?**
- **How did plate tectonics operate in the past?**
- **Is Earth-like subduction unique to Earth?**

