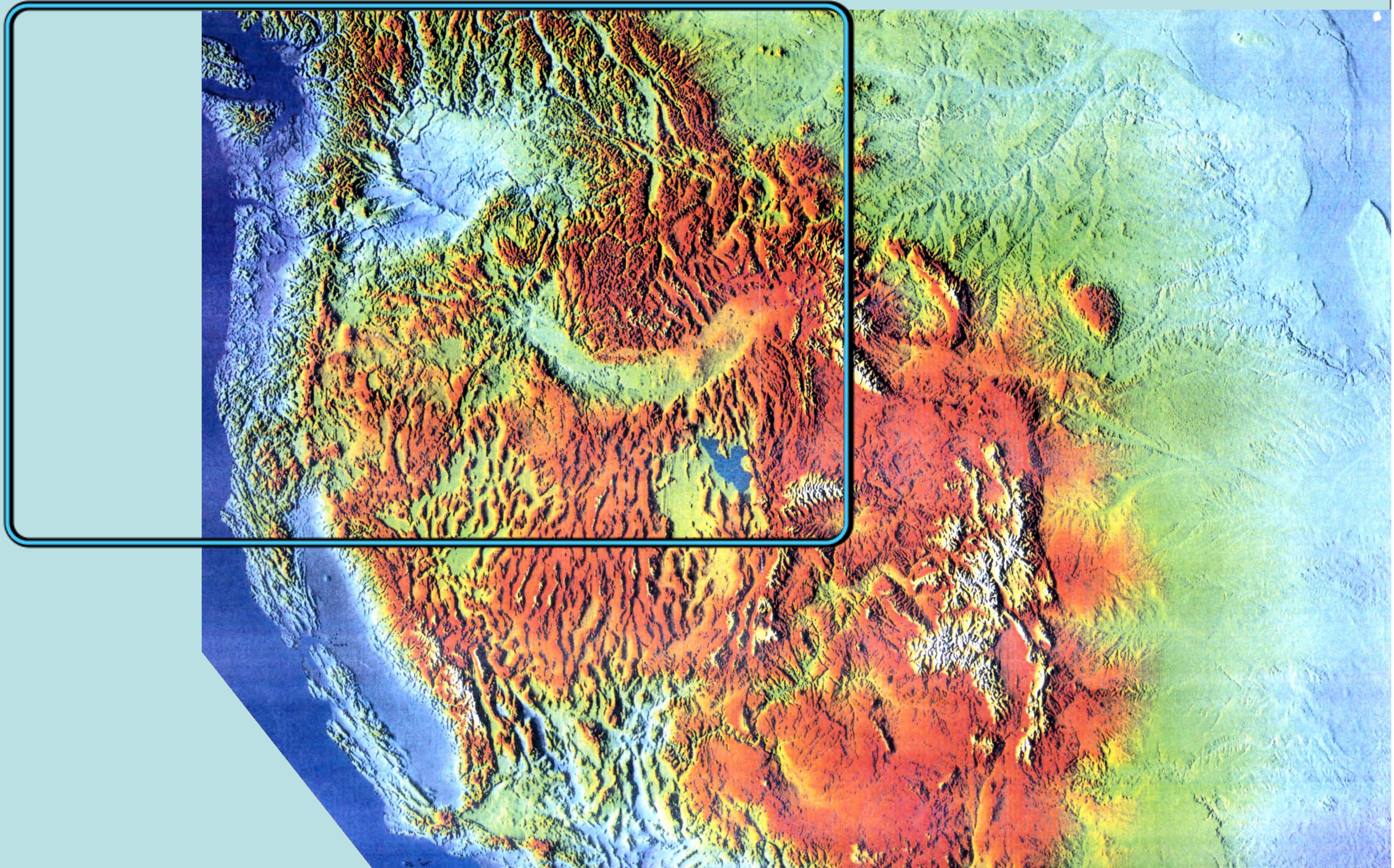
Geodynamic context of Cascadia

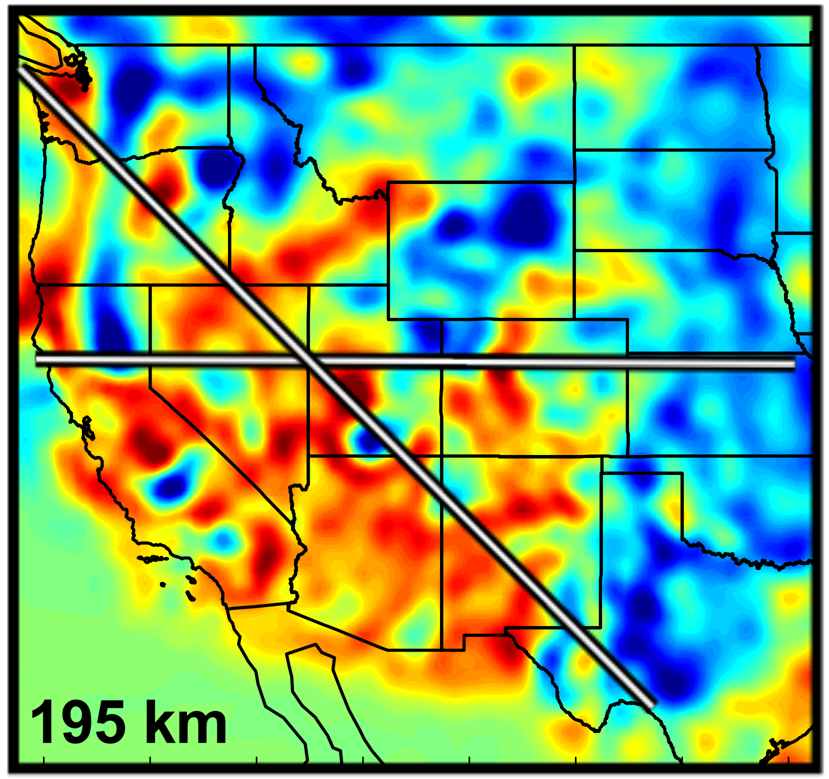


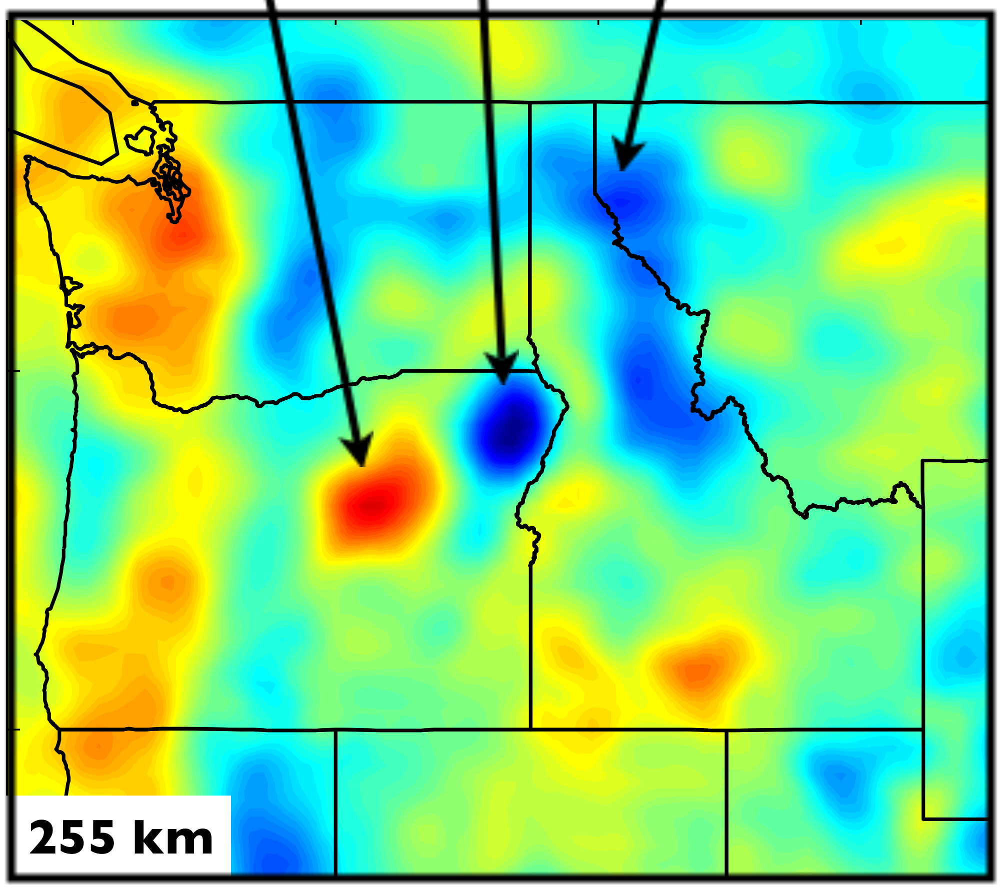
New upper mantle images provide-

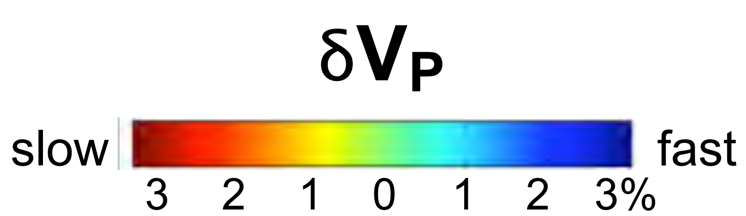
Better constraint on things we basically understood
(like recent subduction)

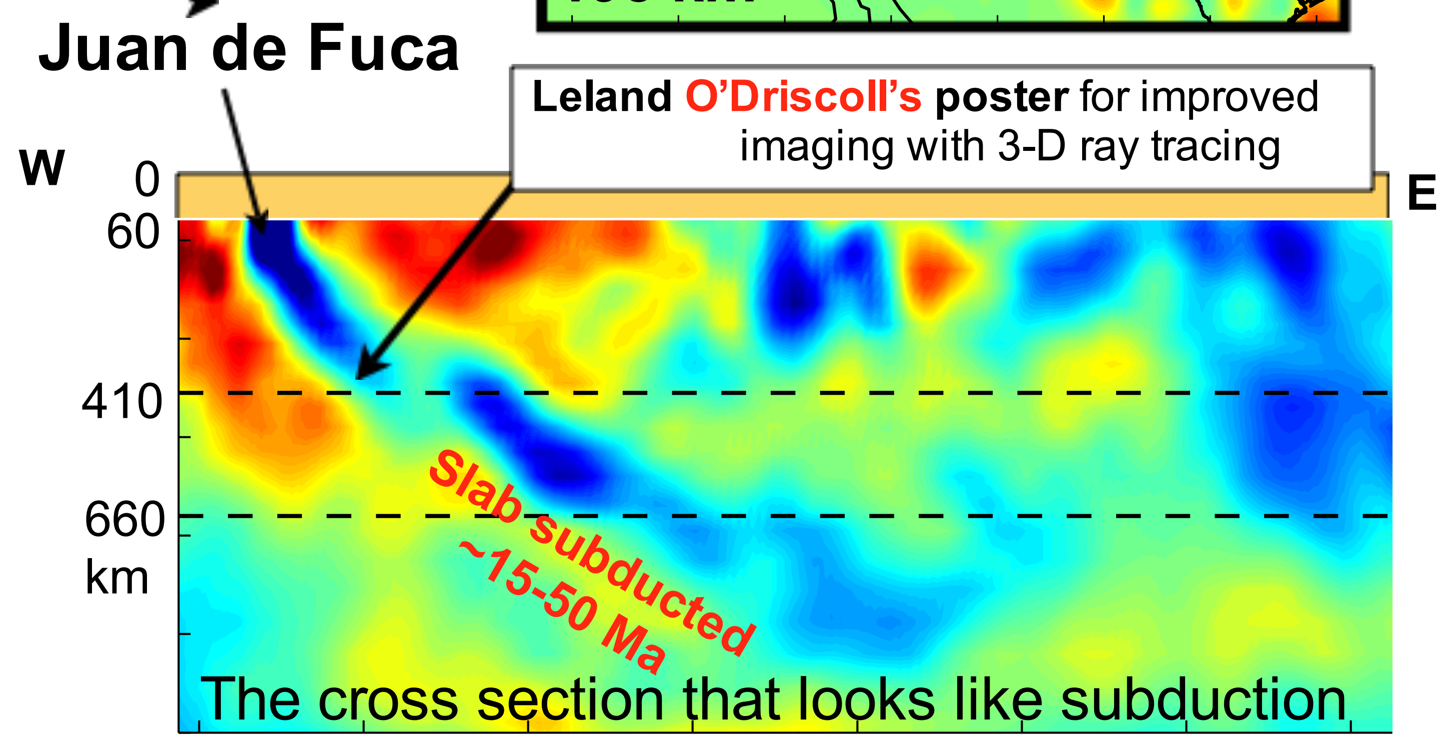
and

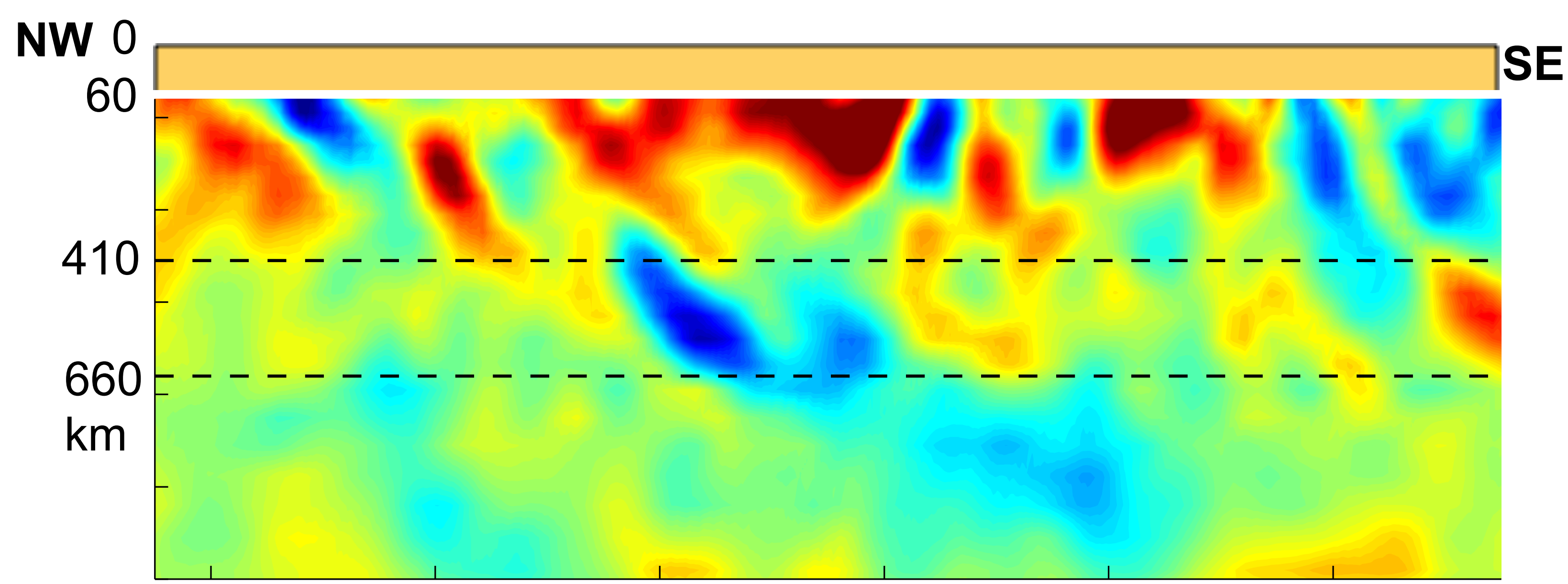
Often surprising **new insight** and mysteries.











Plan: improved understanding first, then surprises

1. PNW geodynamics (somewhat improved; can now do much better)

2. PNW surprises

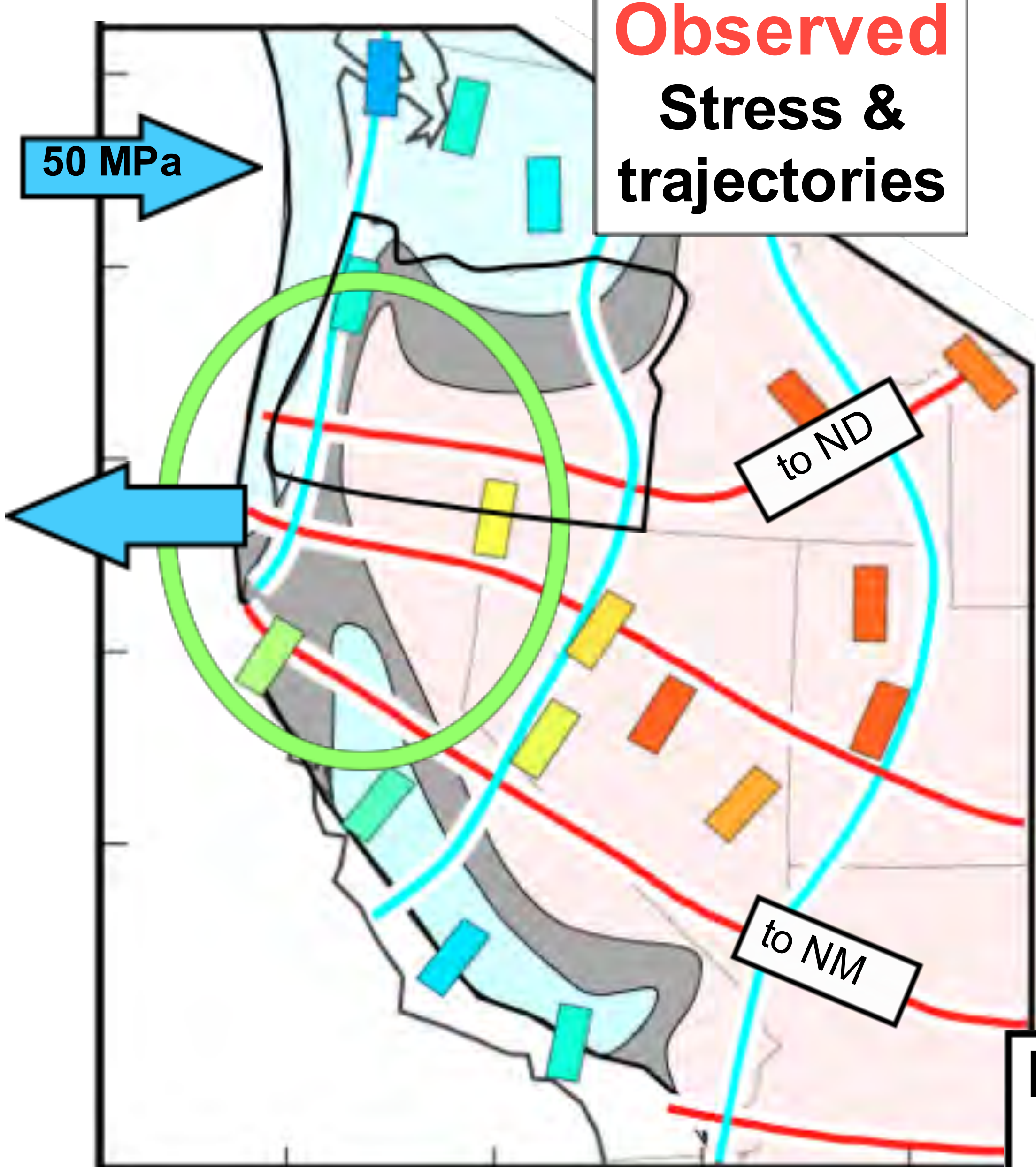
Geodynamics: **forces** that deform & the **strengths** that resist

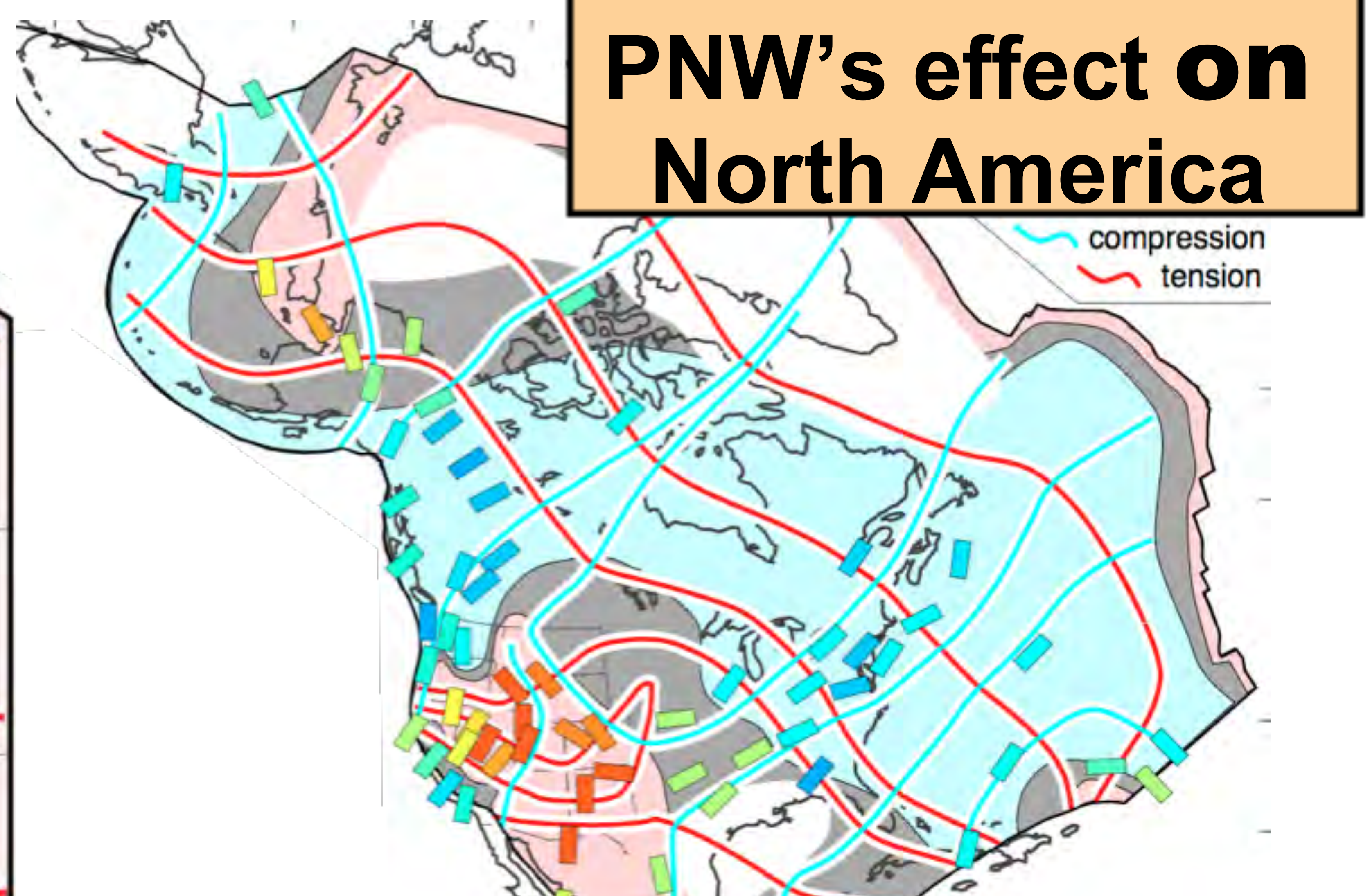
The three **forces** acting on a plate

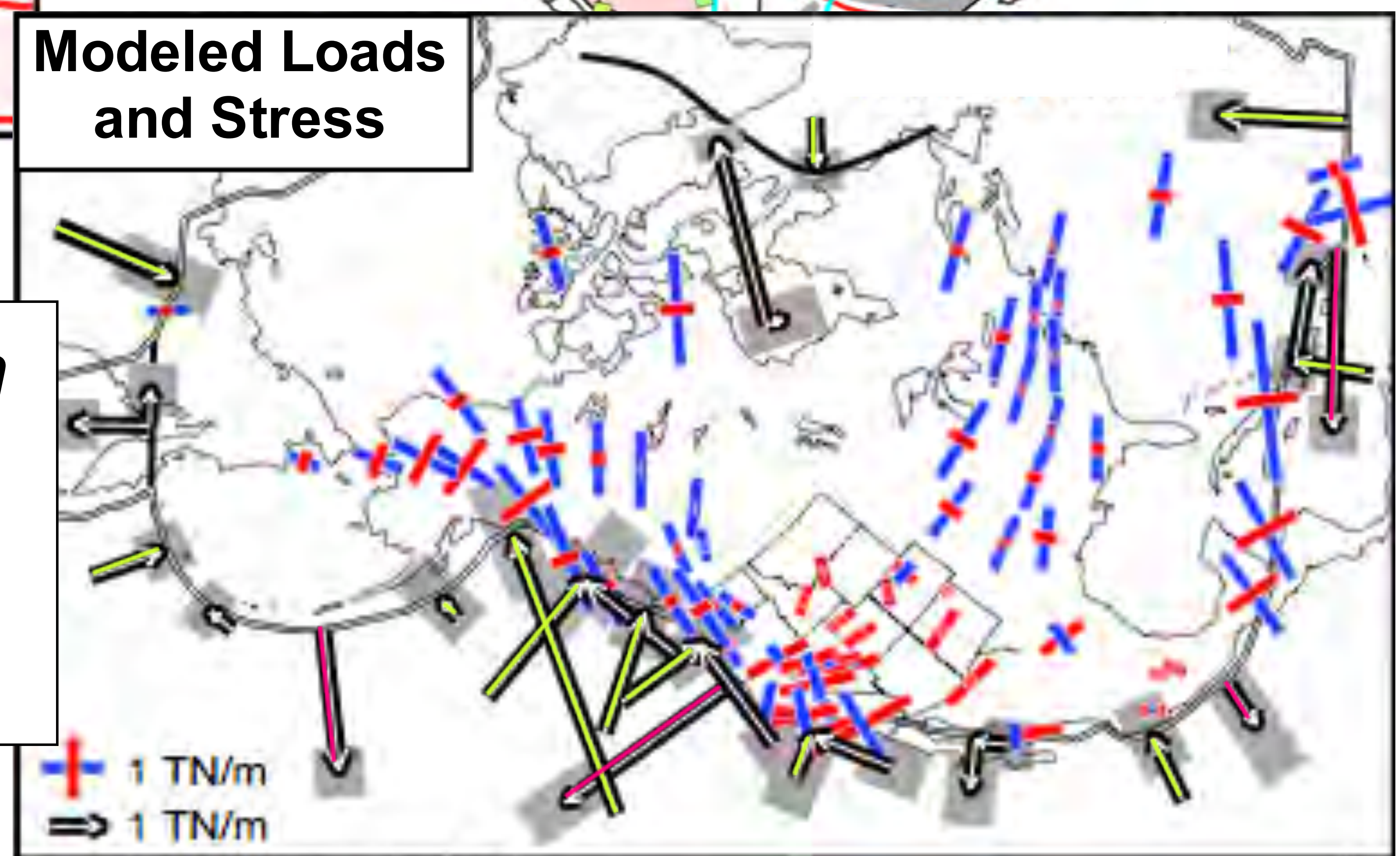
- > plate interactions
- > gravitational potential energy
- > basal tractions (from asthenosphere flow)

Strength, later

PNW's effect **on** North America





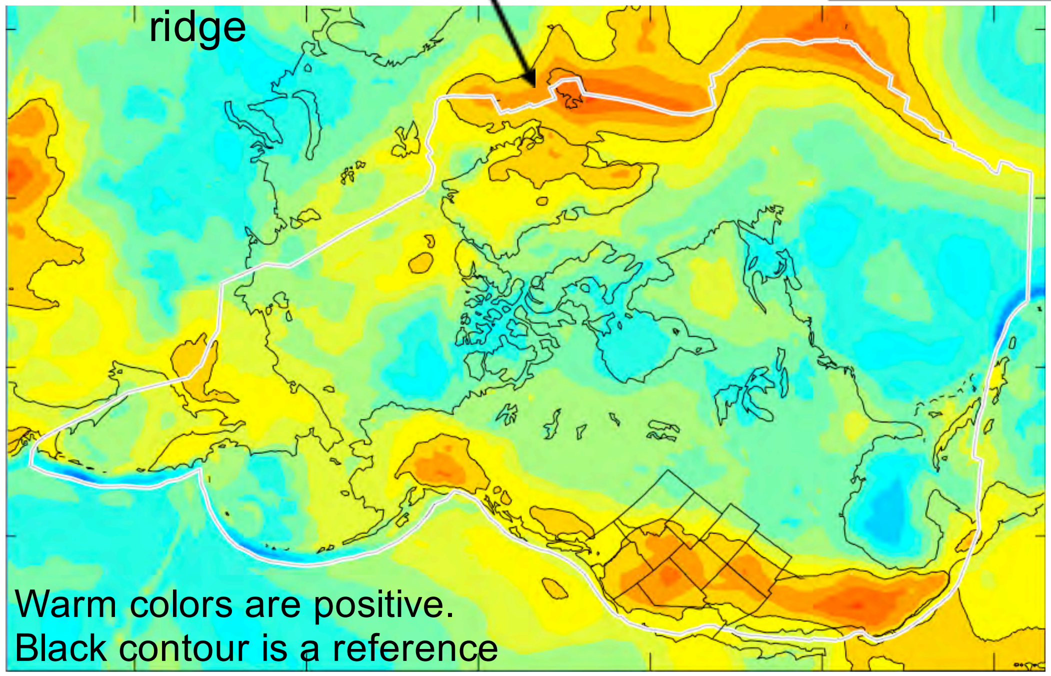


Modeled load acting ***on***
North America...

push on N. Cascadia
big pull on S. Cascadia

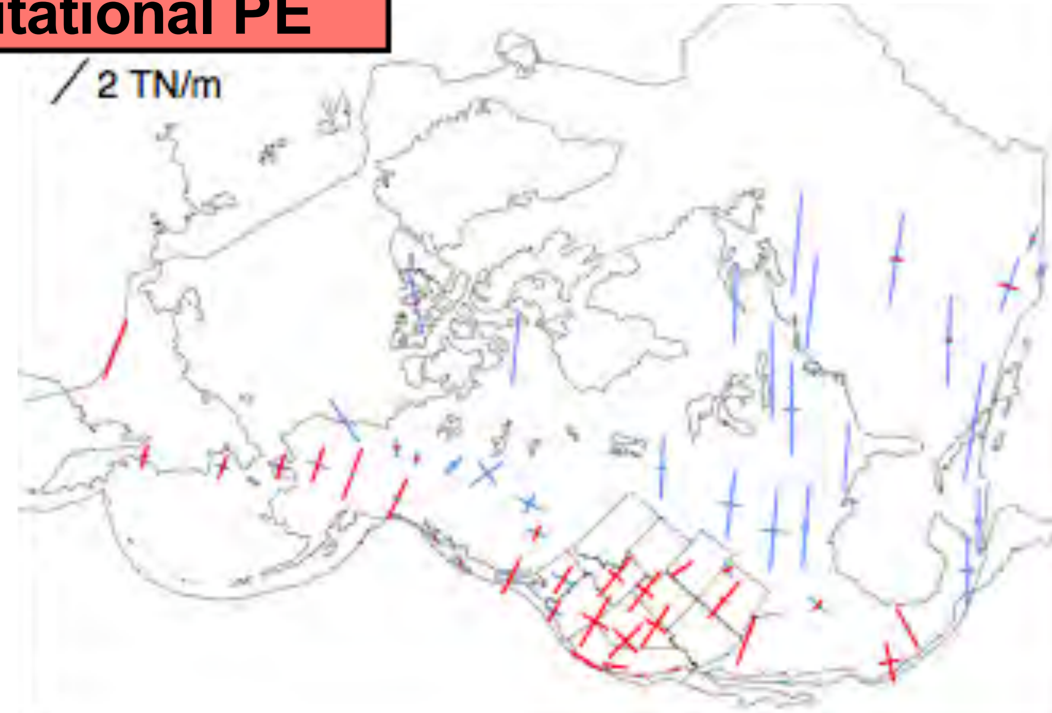
Plate stress caused by **3 types of force** acting on the plate

reference ridge

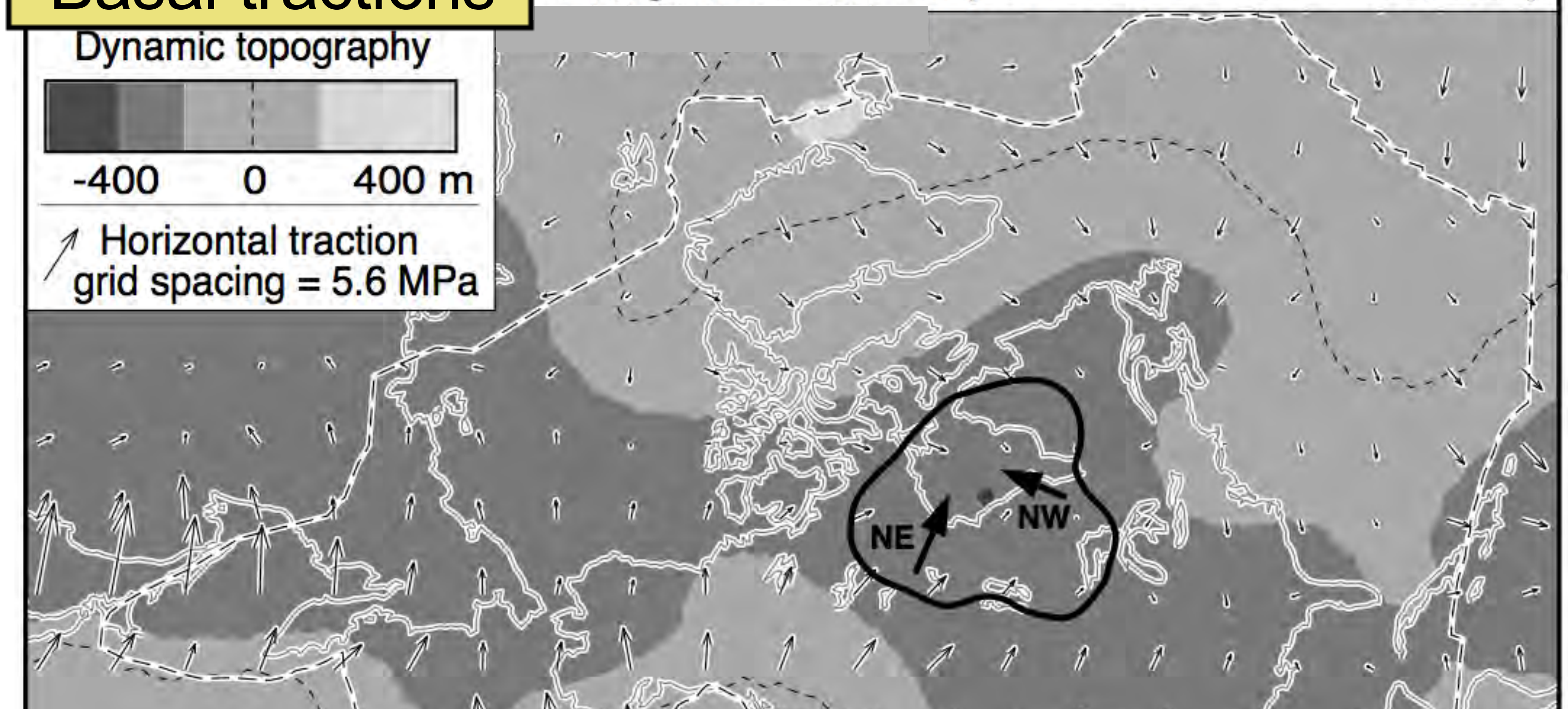


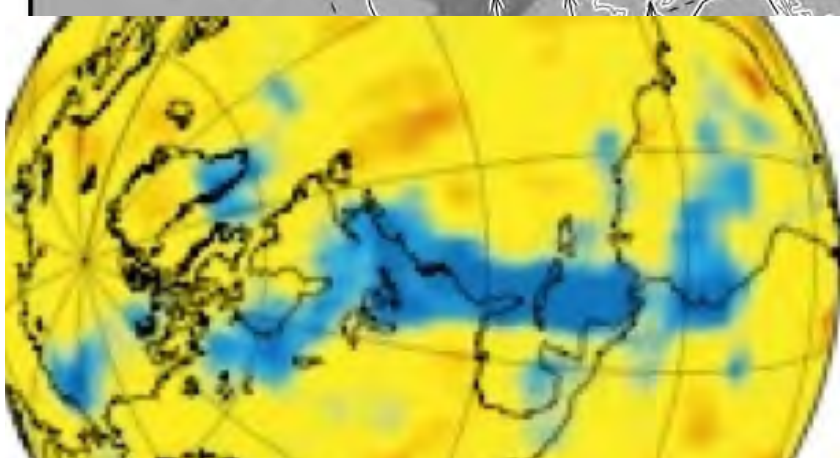
Warm colors are positive. Black contour is a reference ridge.

Gravitational PE



Basal tractions arrising from Global Flow [from *Becker and O'Connell*, 2001]

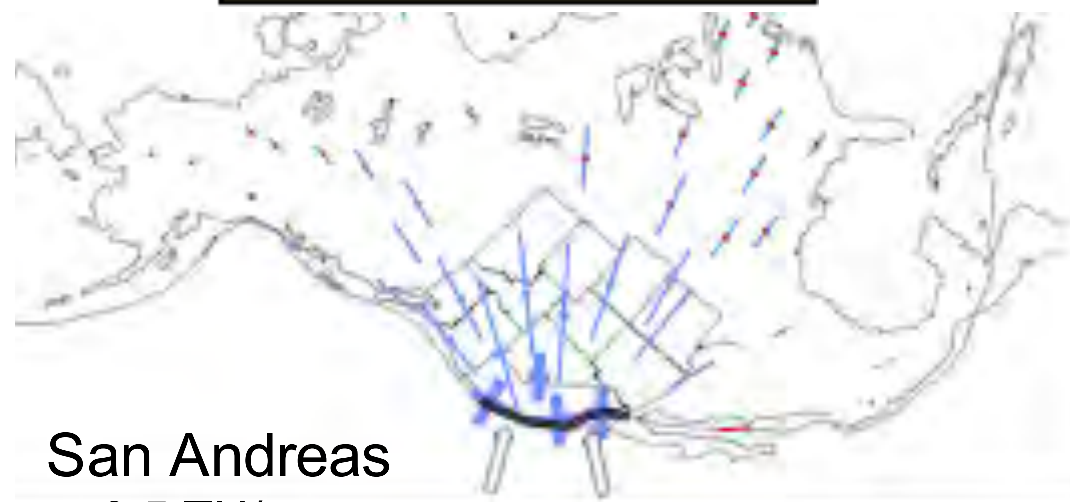




Grand 1300

Humphreys & Coblentz, 2007

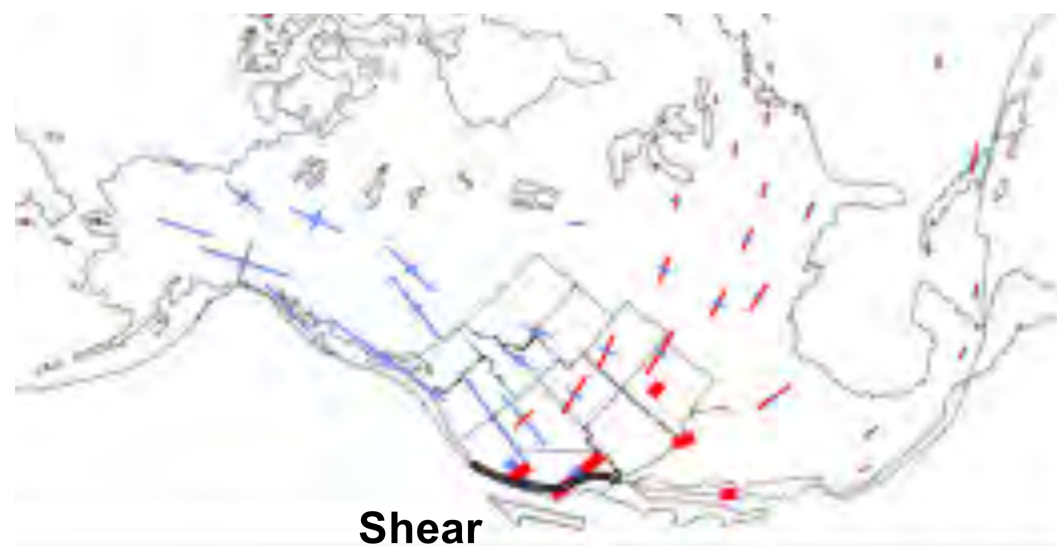
Plate margin loads



San Andreas

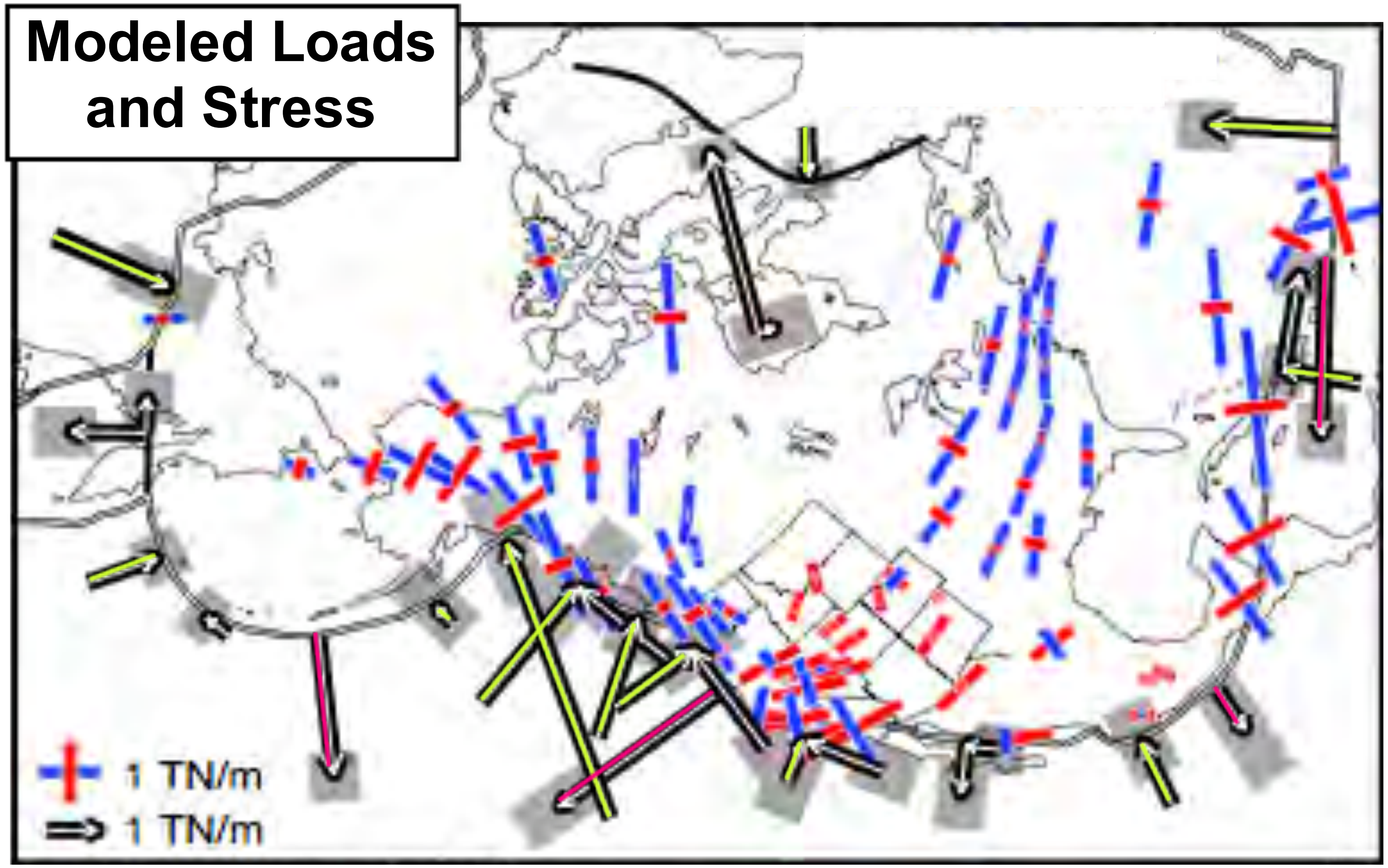
0.5 TN/m

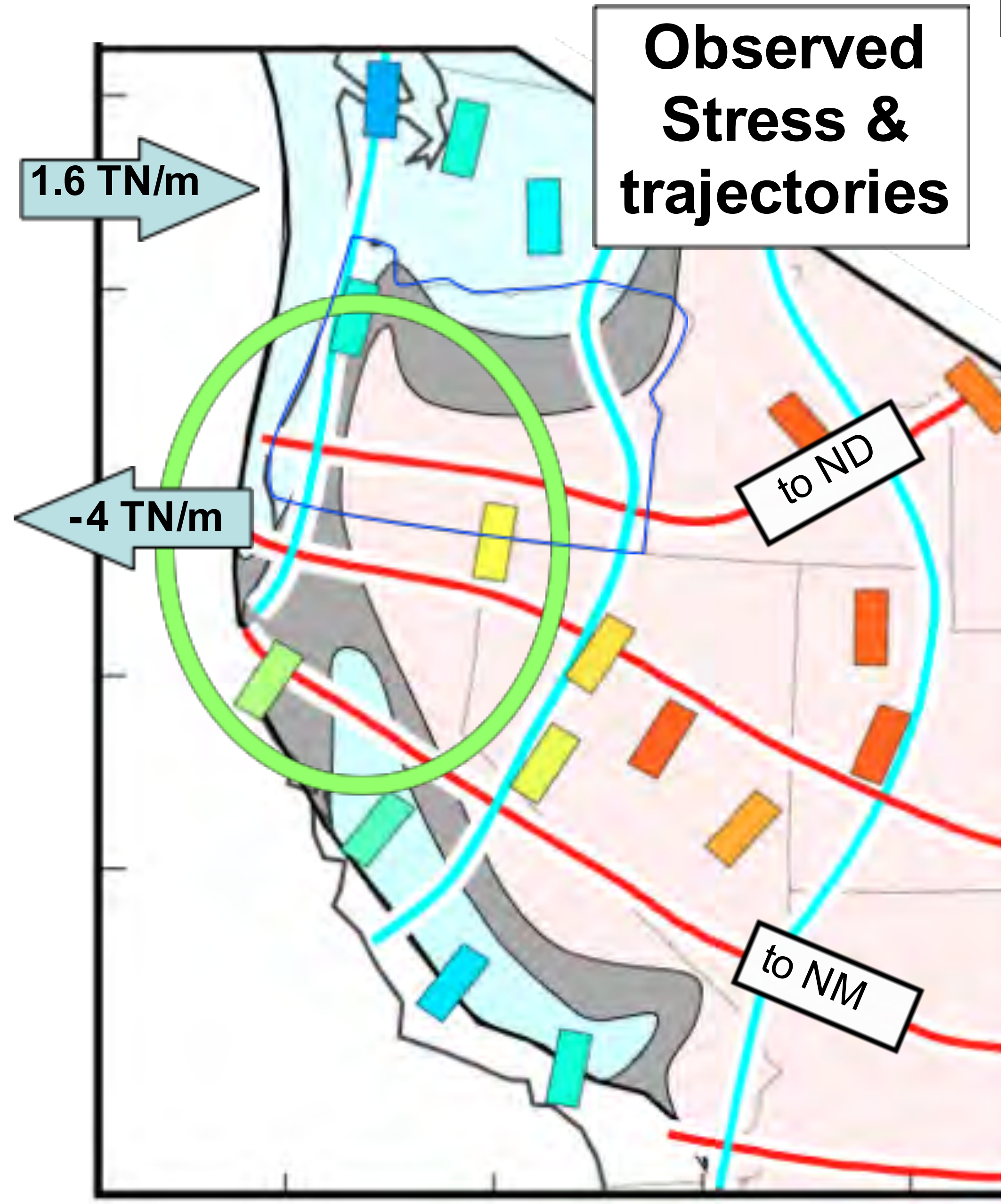
Normal

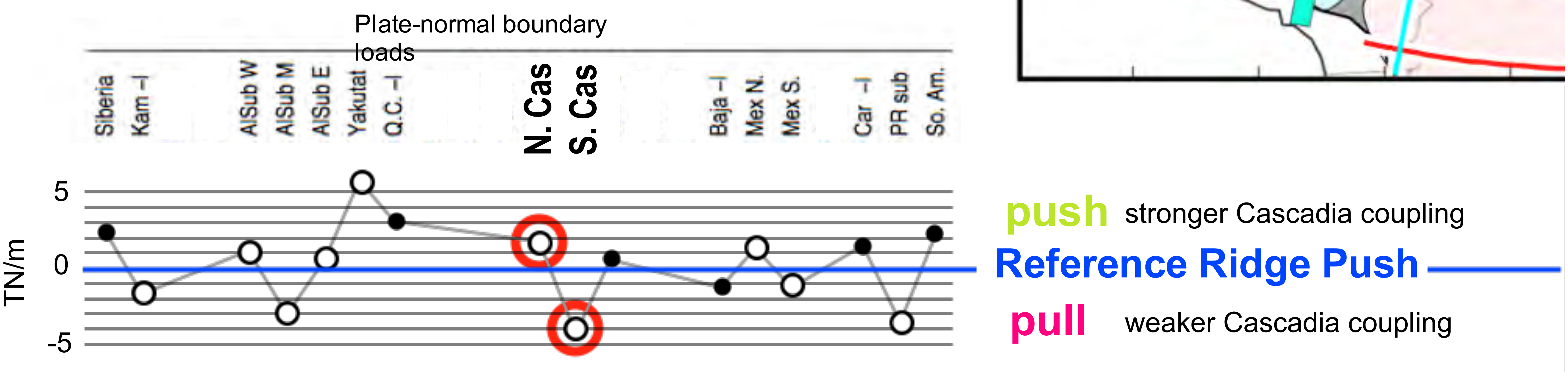


Shear

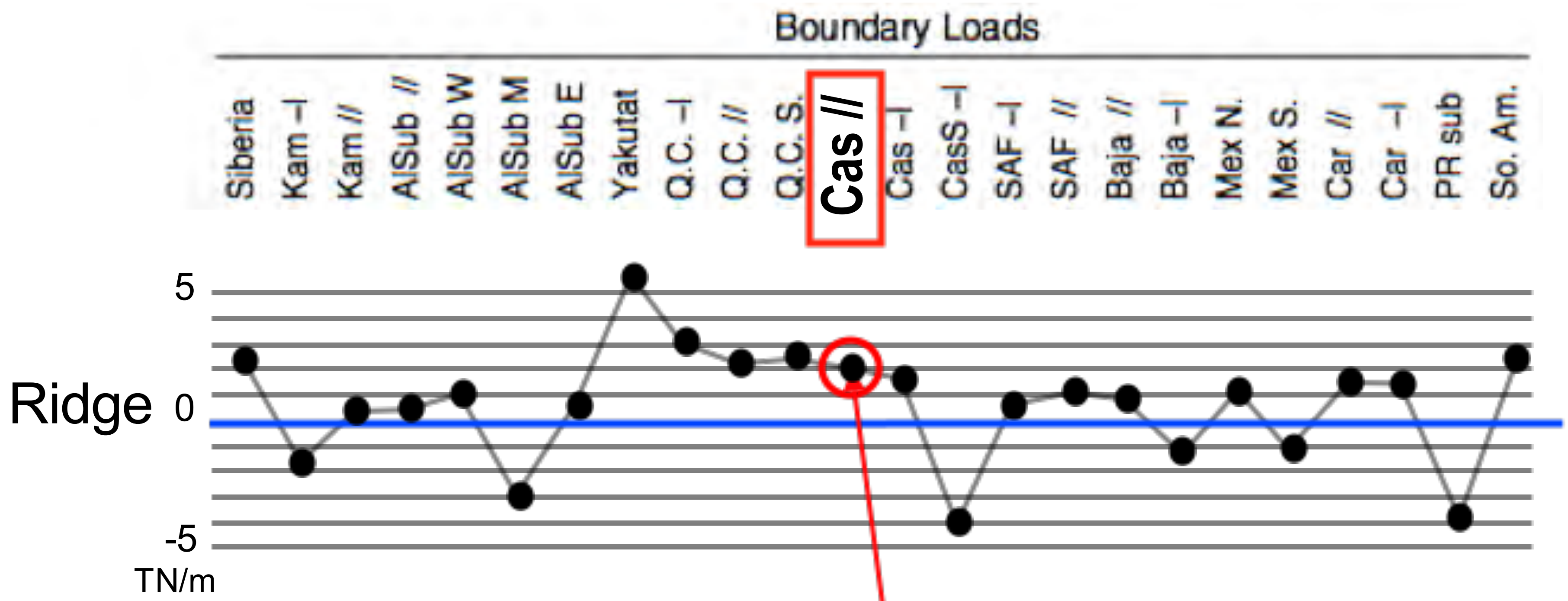
Modeled load acting ***on*** North America







Absolute Cascadia fault strength



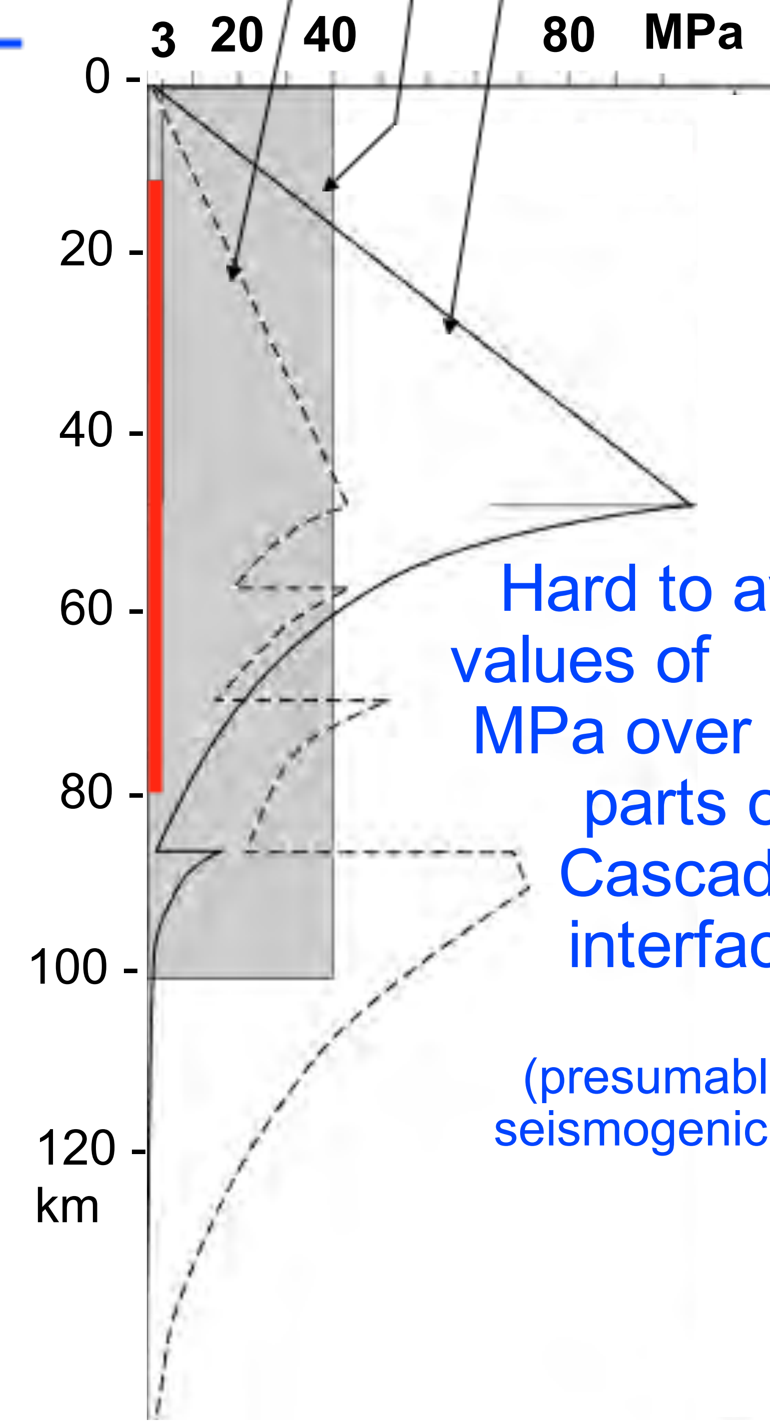
Modeling results:
~2 TN/m for oblique component

For total stress on Cascadia boundary:
~4 TN/m

- This yields a friction coefficient of 0.05 - 0.2 (weak by rock mechanics standards)

- But this stress is many times that of a typical earthquake stress drop of 3 MPa

What does 4 TN/m look like?
All three strength profiles apply 4 TN/m



Hard to avoid values of ~40 MPa over large parts of Cascadia interface

(presumably on seismogenic fault)

Forces stressing the **Juan de Fuca Plate**

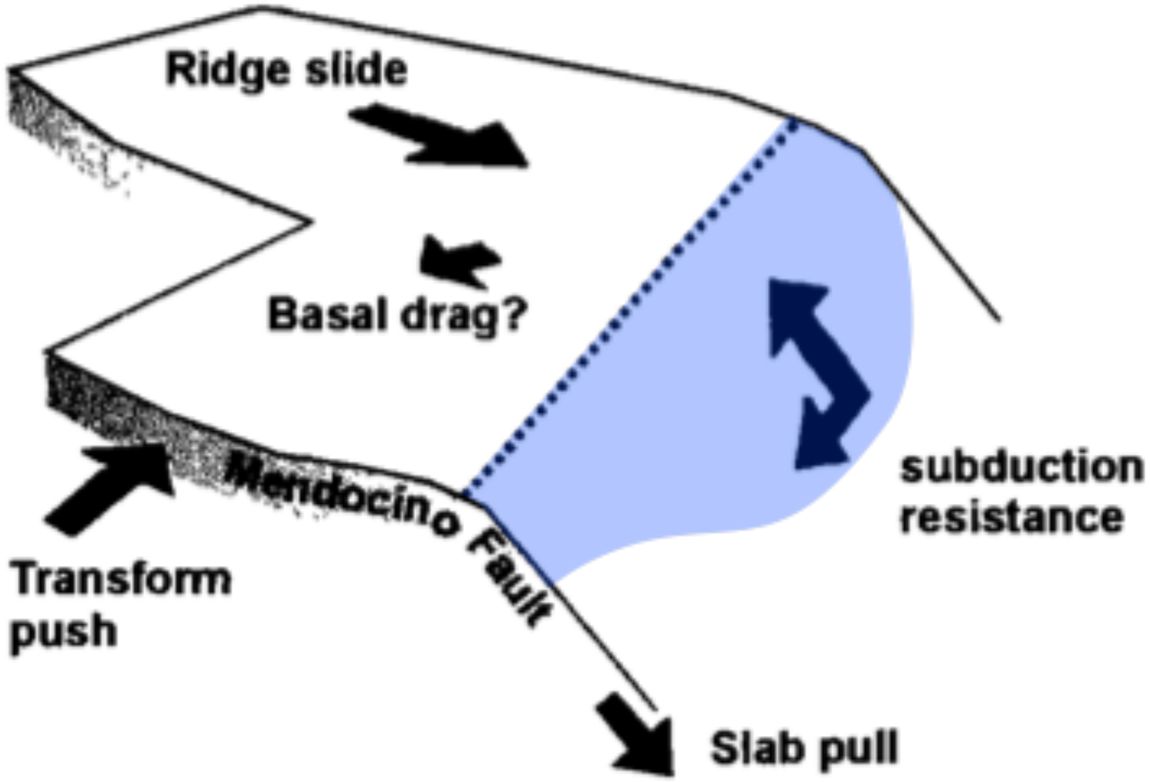
Wang et al., 1997

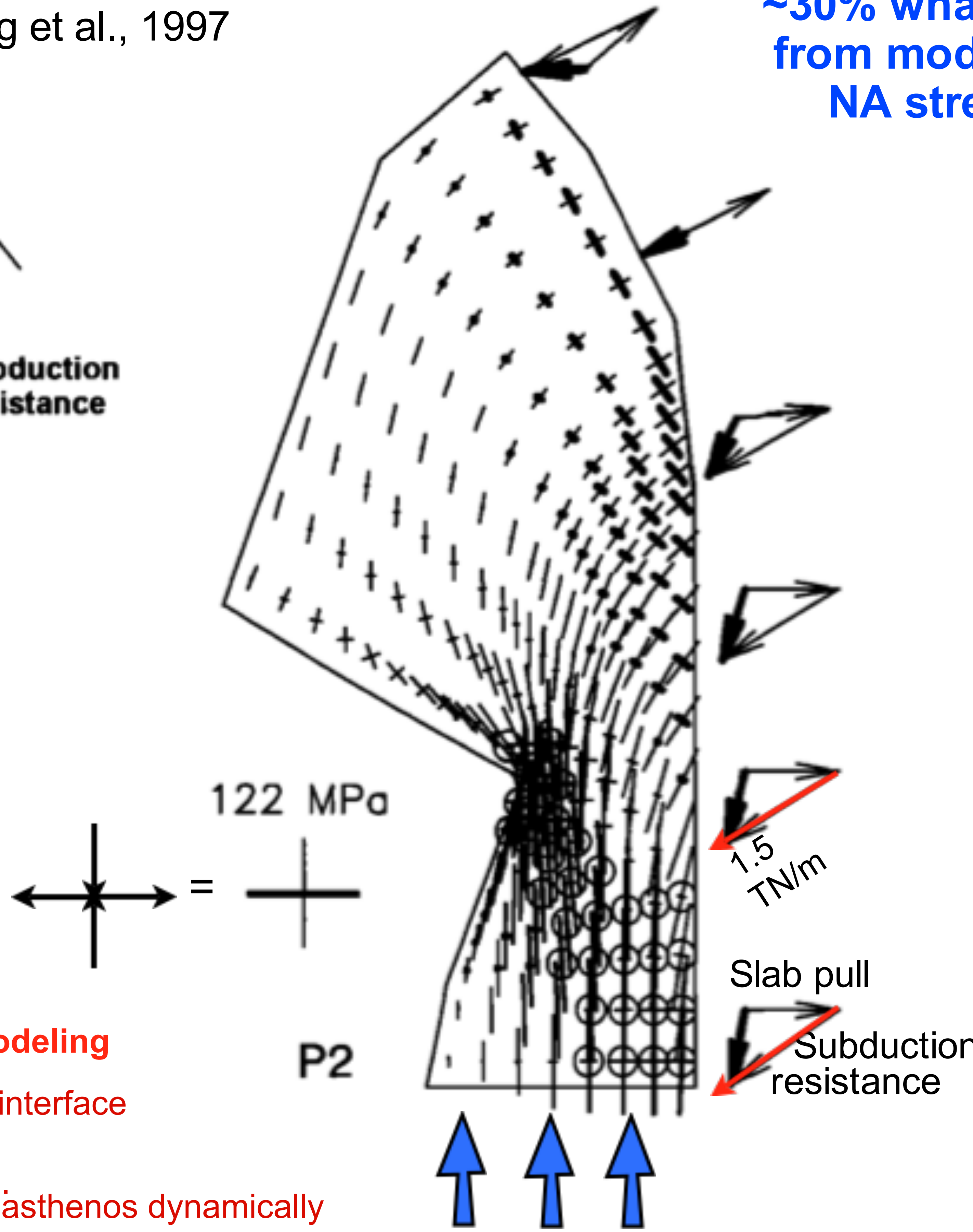
Main conclusions:

Large transform push on Mendo.

Cascadia stresses of 1.5 TN/m

~30% what I get from modeling NA stress



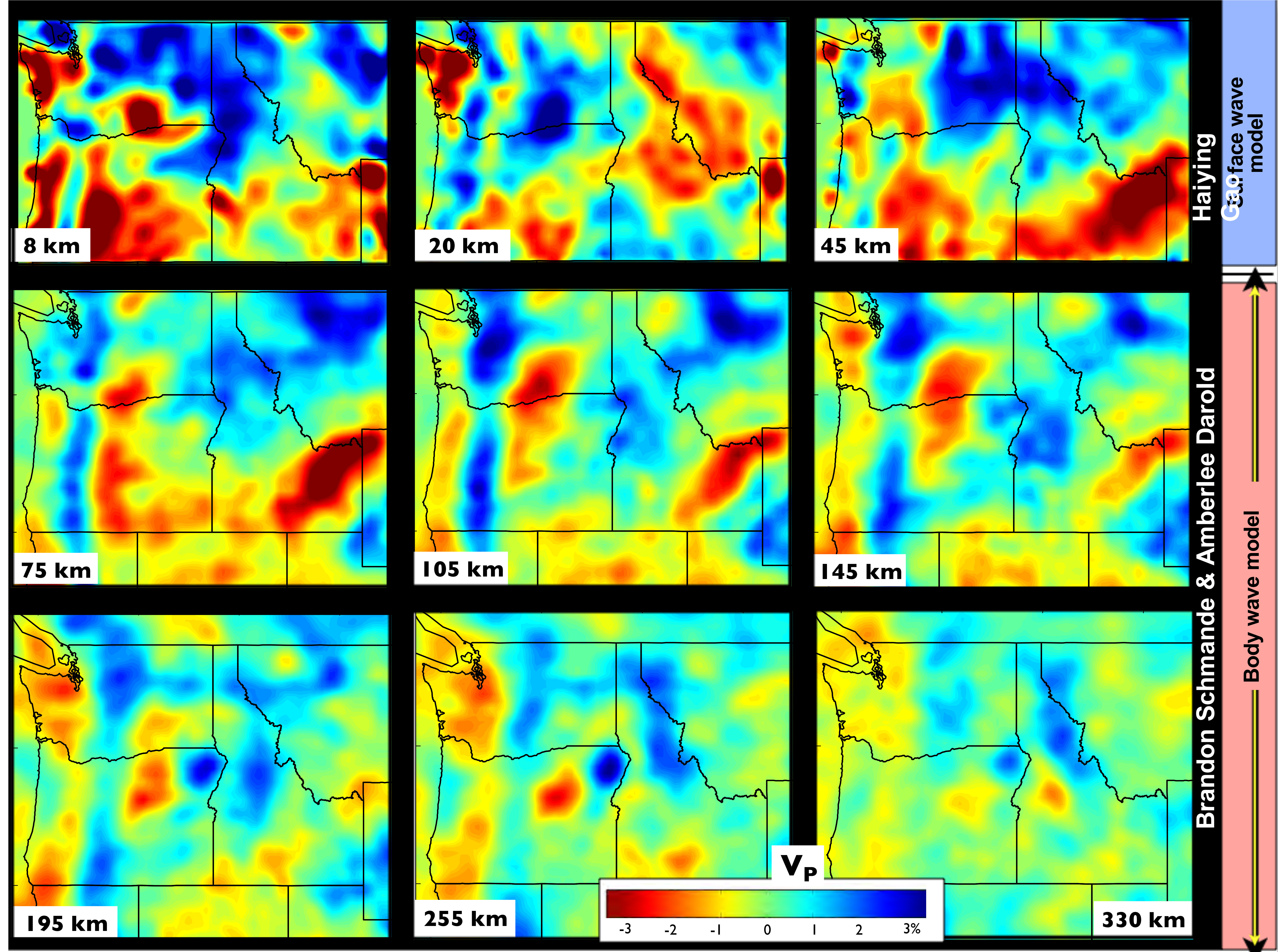


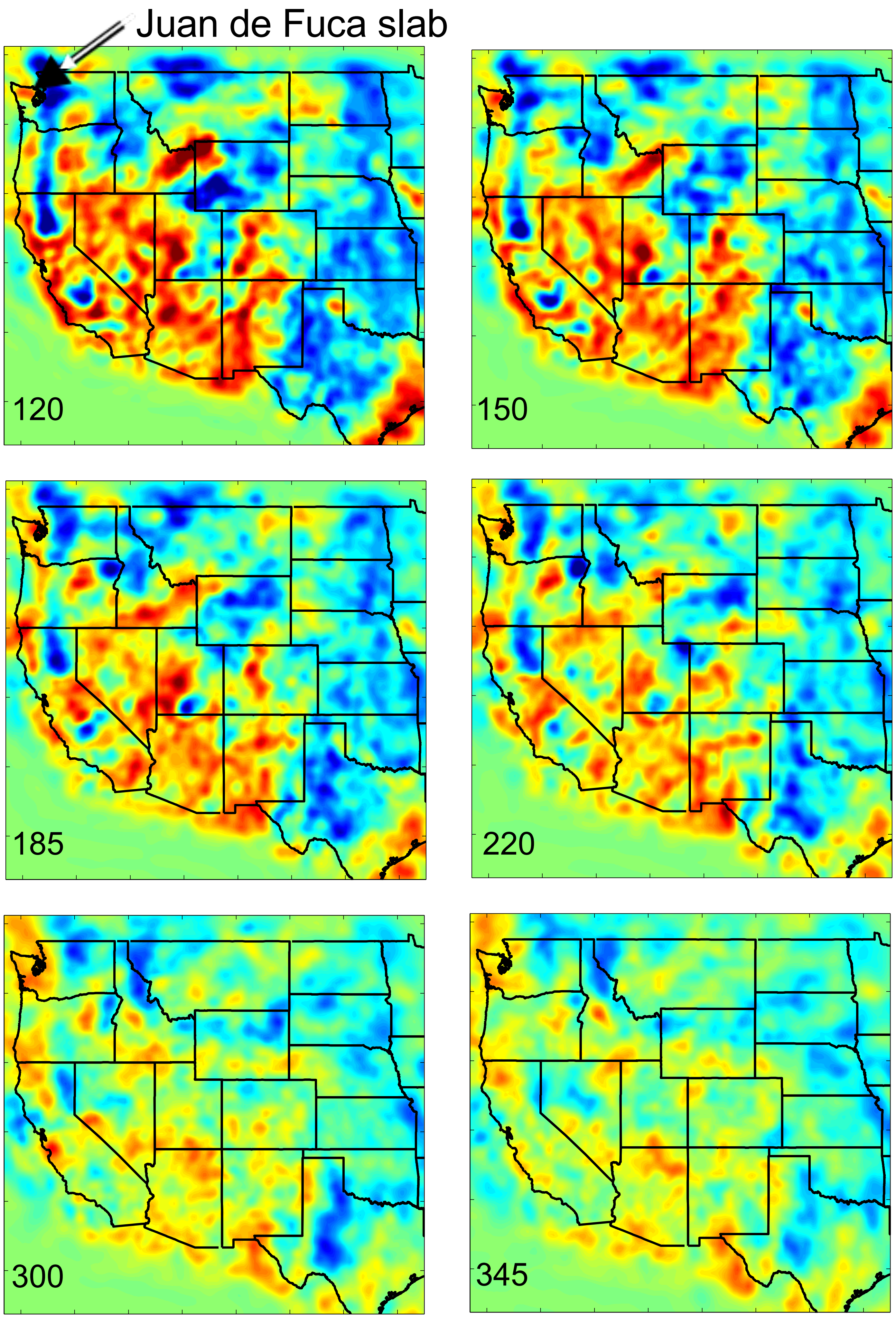
Time for new modeling!

match JdF & NA interface stress

for a joint model...

...and, inc slab & asthenos dynamically


8 km
20 km
45 km
75 km
105 km
145 km
195 km
255 km
330 km
Haiying Gao
Surface wave model
Brandon Schmande & Amberlee Darold
Body wave model
V_P
-3
-2
-1
0
1
2
3%

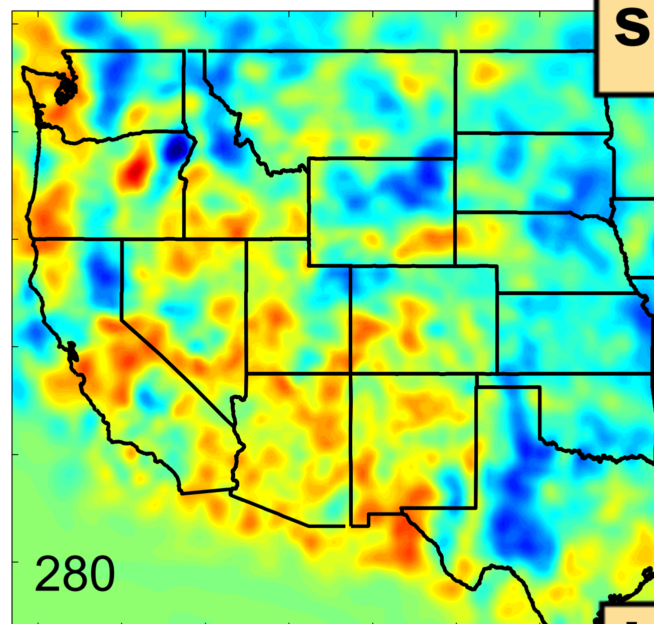


2,500 km of subduction at Cascadia...

where's the slab?

Brandon Schmandt

Relatively little JdF slab pull...

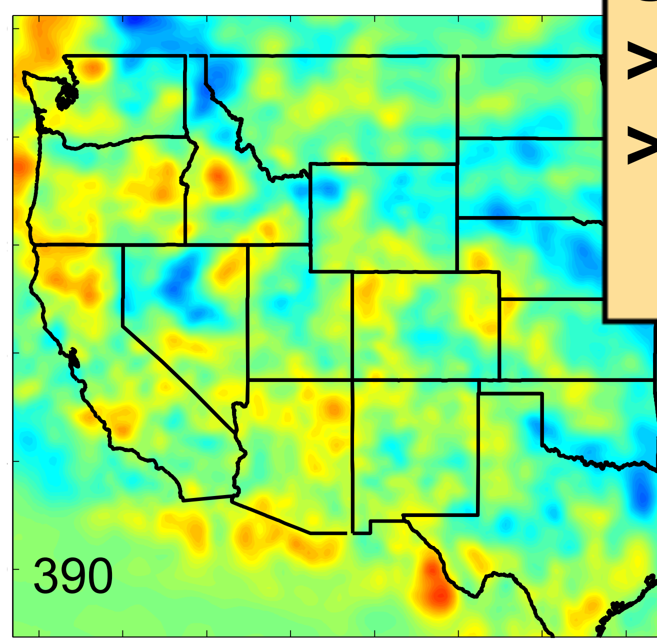


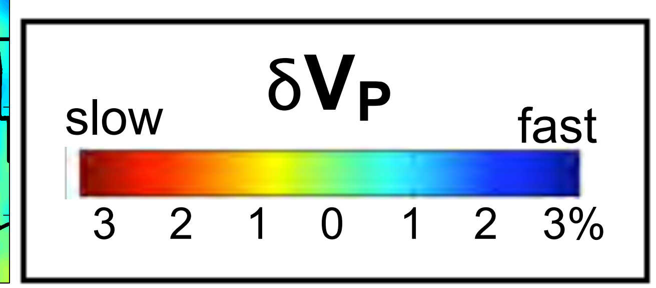
...but lots of flow-driving loads in the asthenosphere

Unknown:

> magnitude

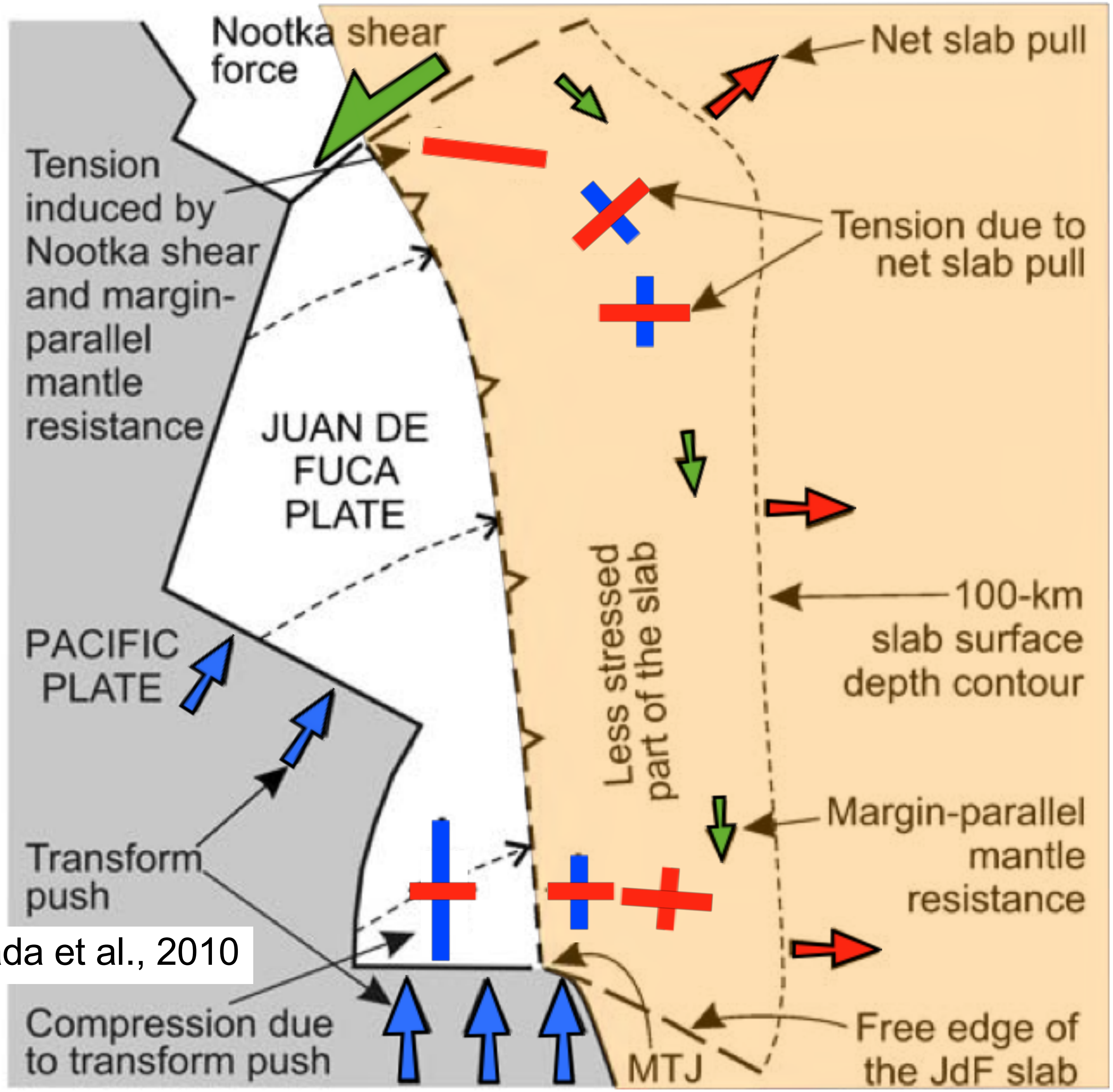
> amount of flow-induced coupling





Forces stressing the Juan de Fuca Plate

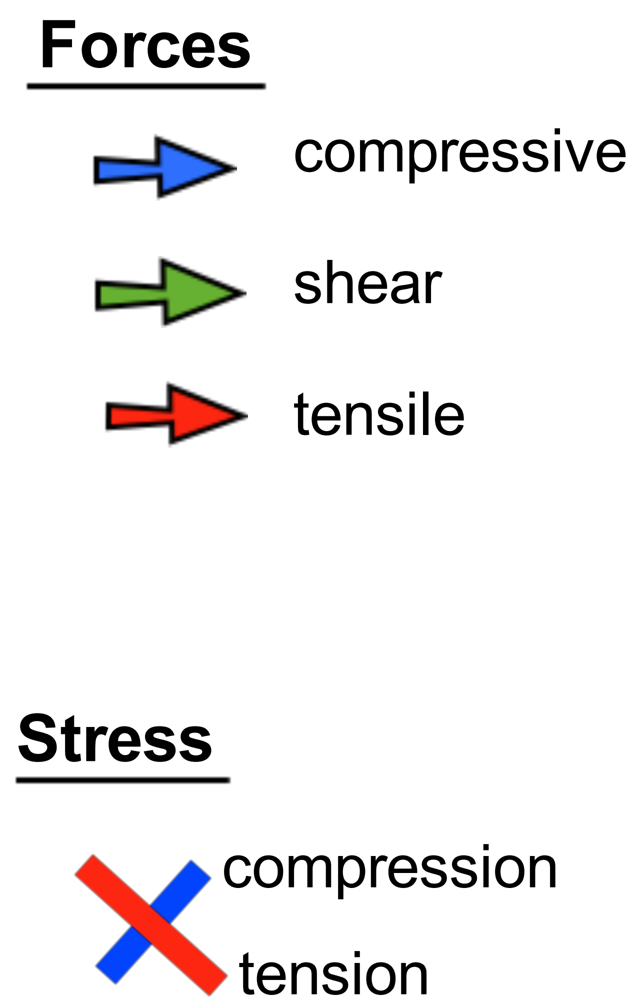
More recent look, using seismicity, but without stress modeling



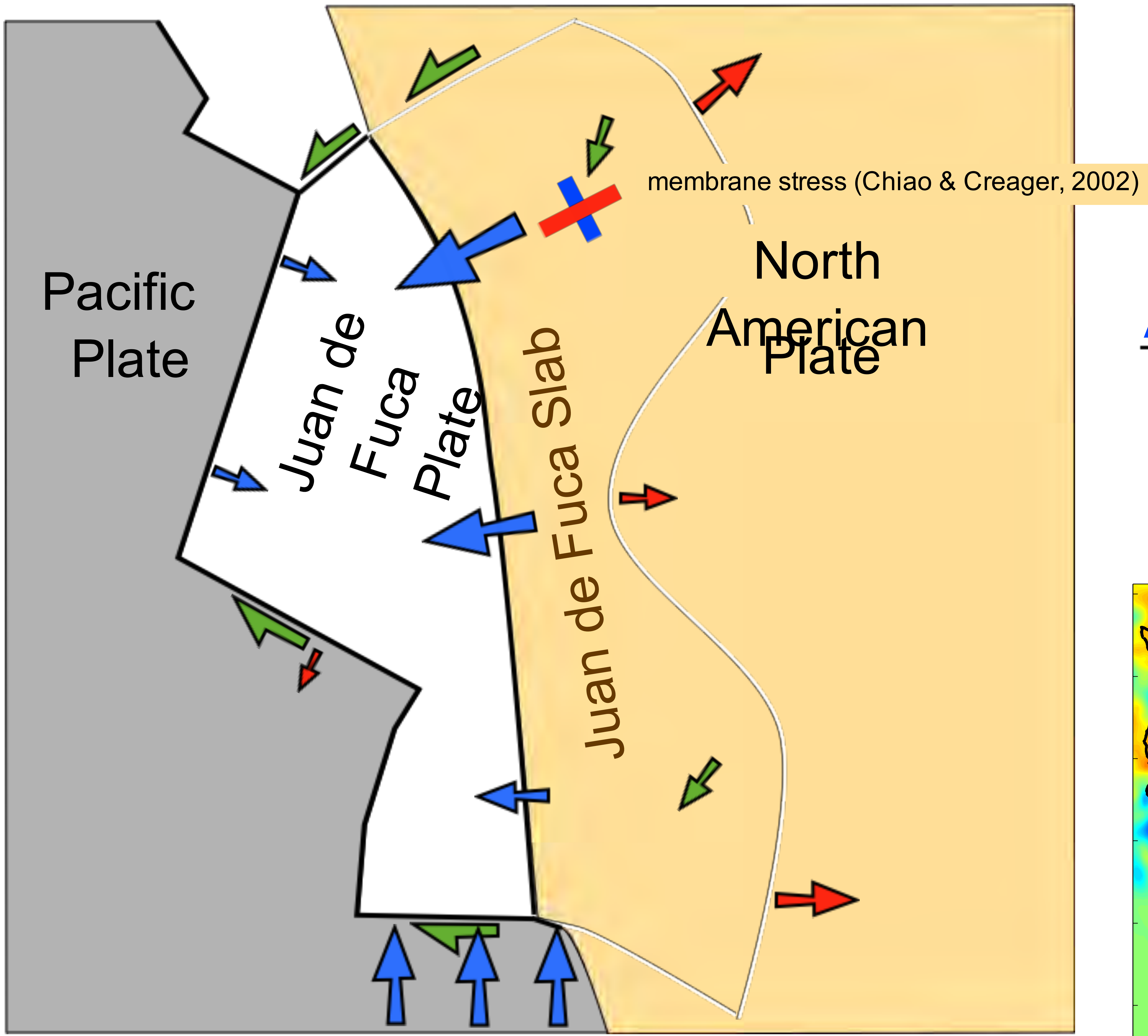
Wada et al., 2010

Many questions
(addressed in their paper)
need to be modeled
simultaneously with NA stress

> plate interaction
> slab pull
> asthenosphere flow



Forces stressing the Juan de Fuca Plate

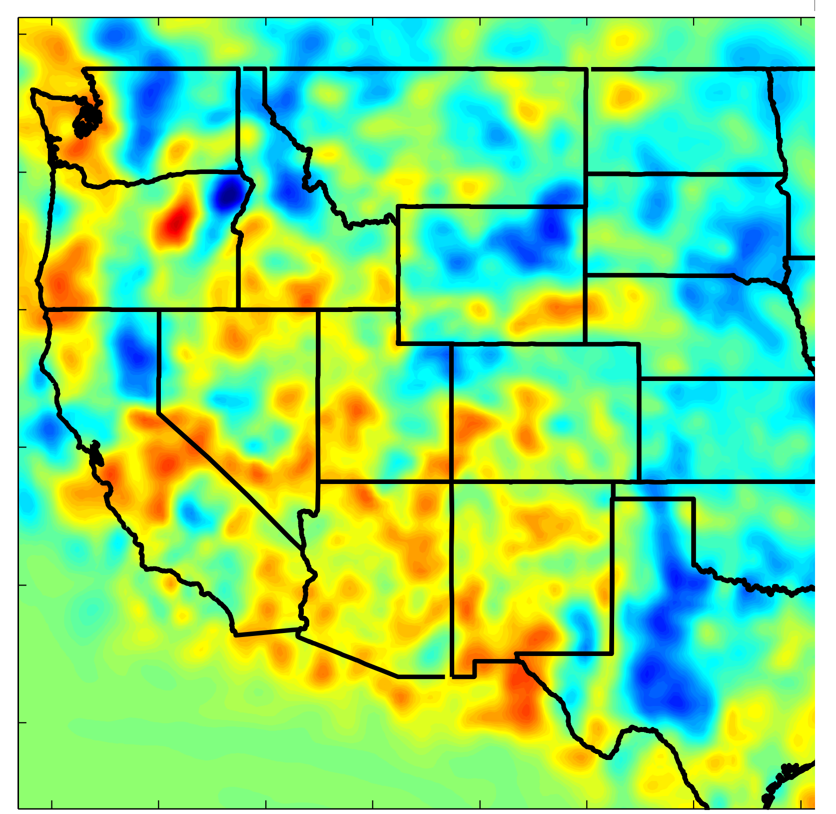


Need to include

- NA, JdF and Pacific
- load JdF with imaged slab
- include full asthenos flow calculation

A major goal

- resolve Cascadia interface stress field



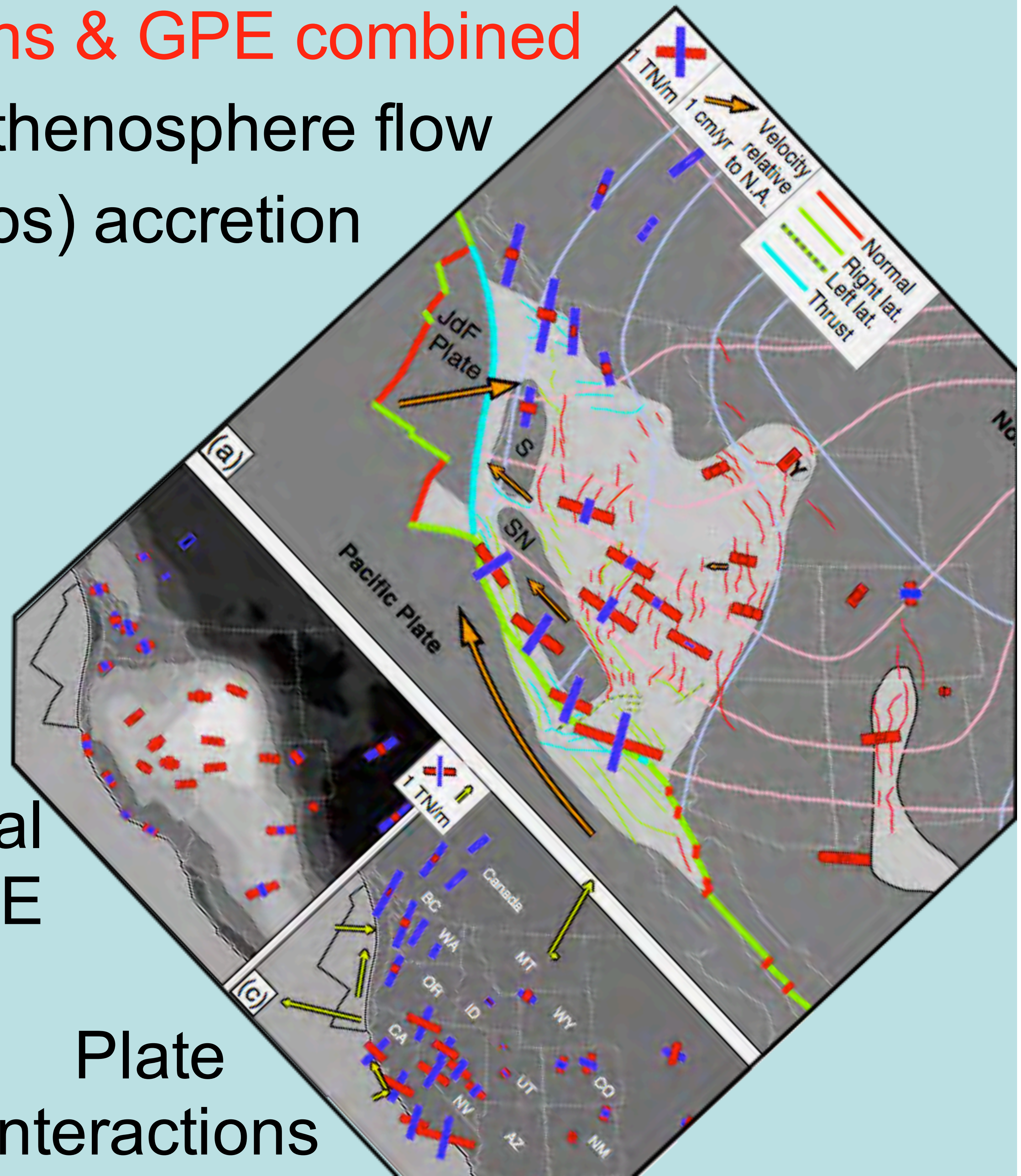
Geodynamic context of Cascadia

effect of Cascadia on NA, and sub zone coupling

wUS context: plate interactions & GPE combined

basal tractions created by asthenosphere flow

History of Siletzia (ocean lithos) accretion

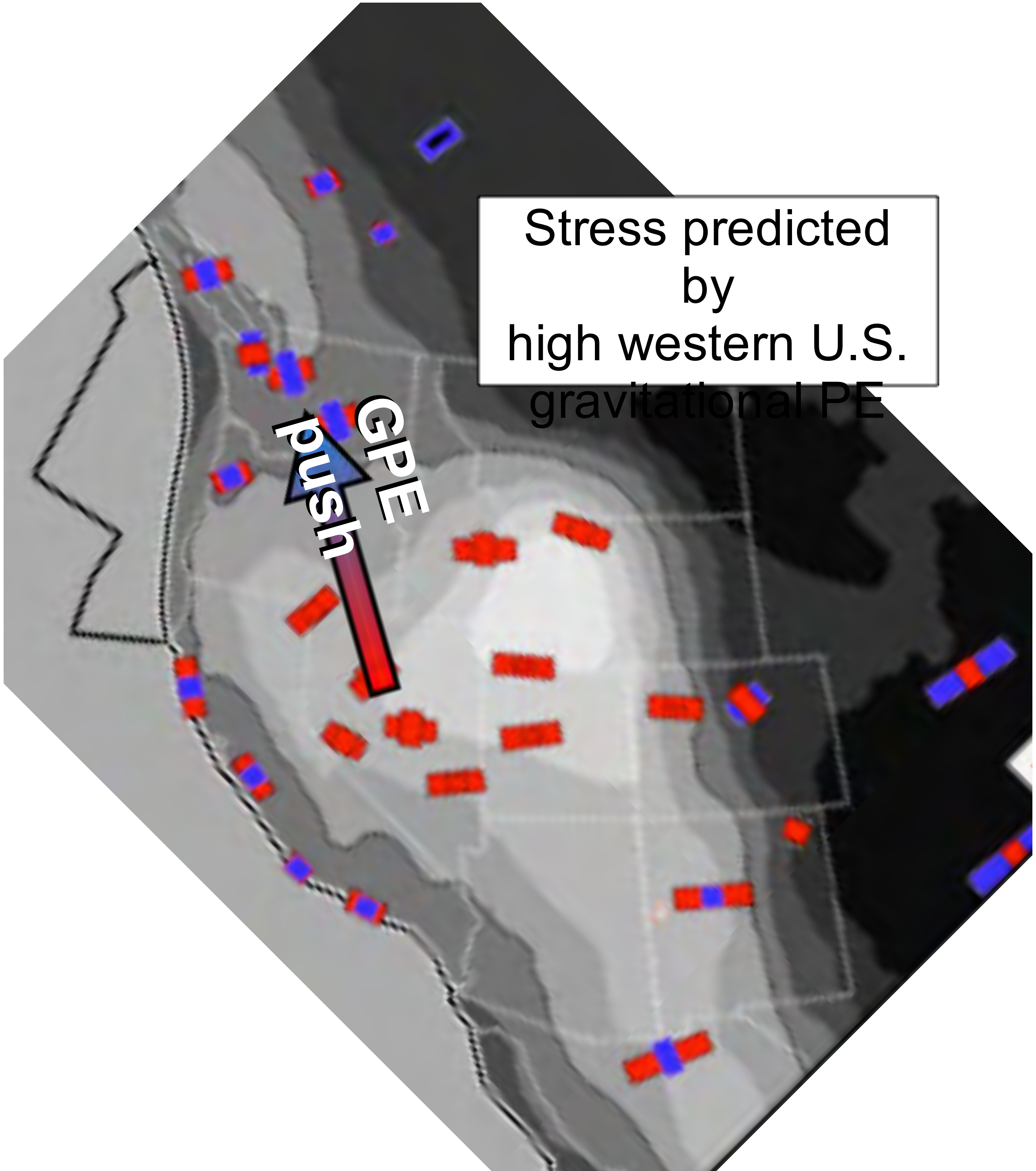


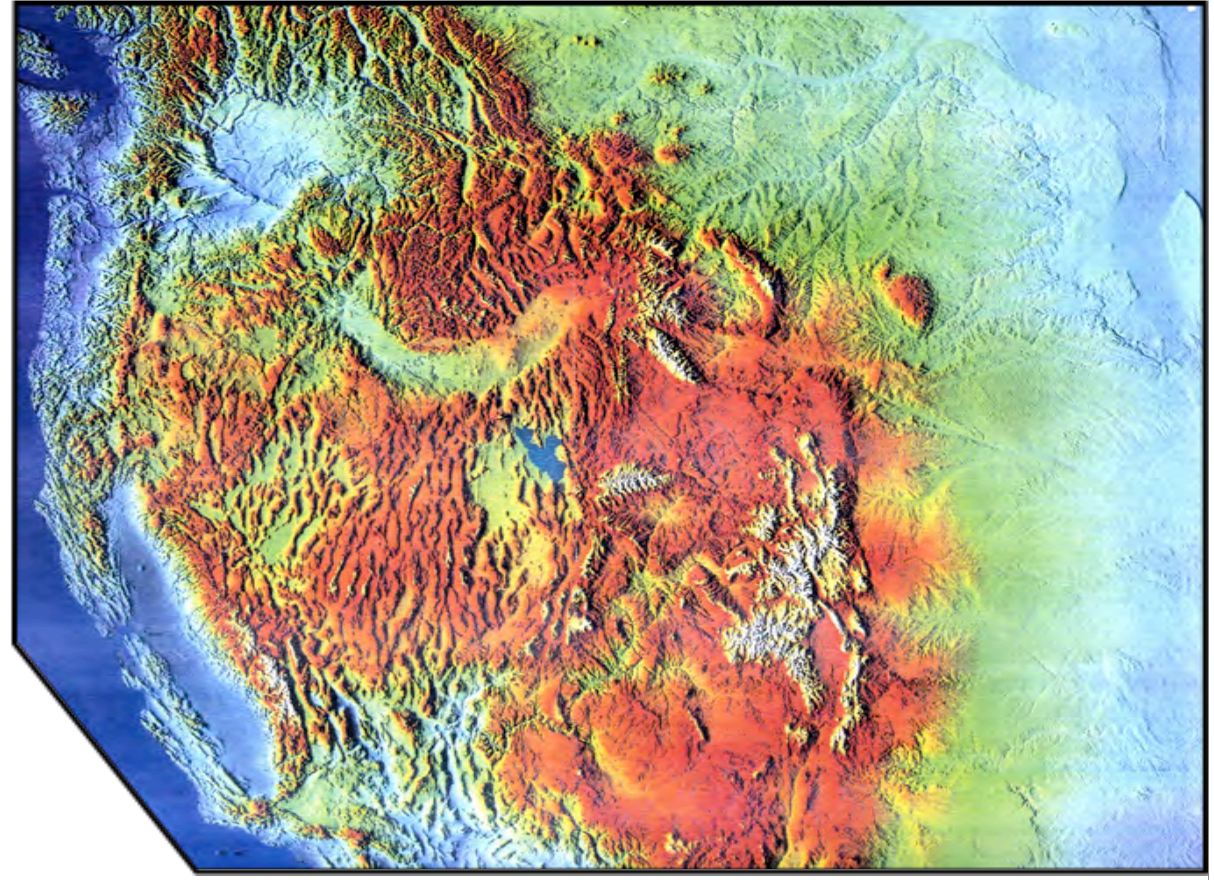
gravitational PE

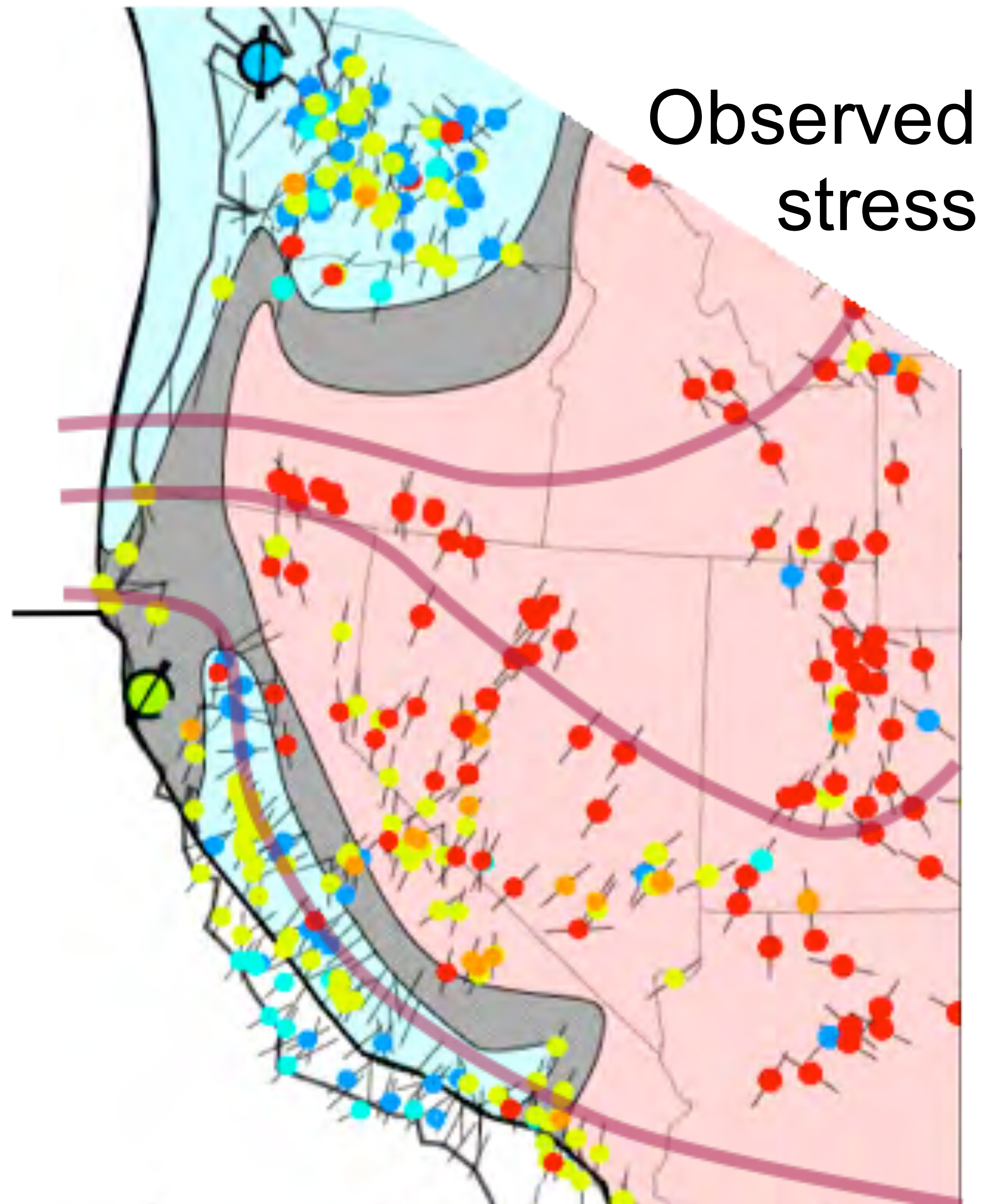
Plate interactions

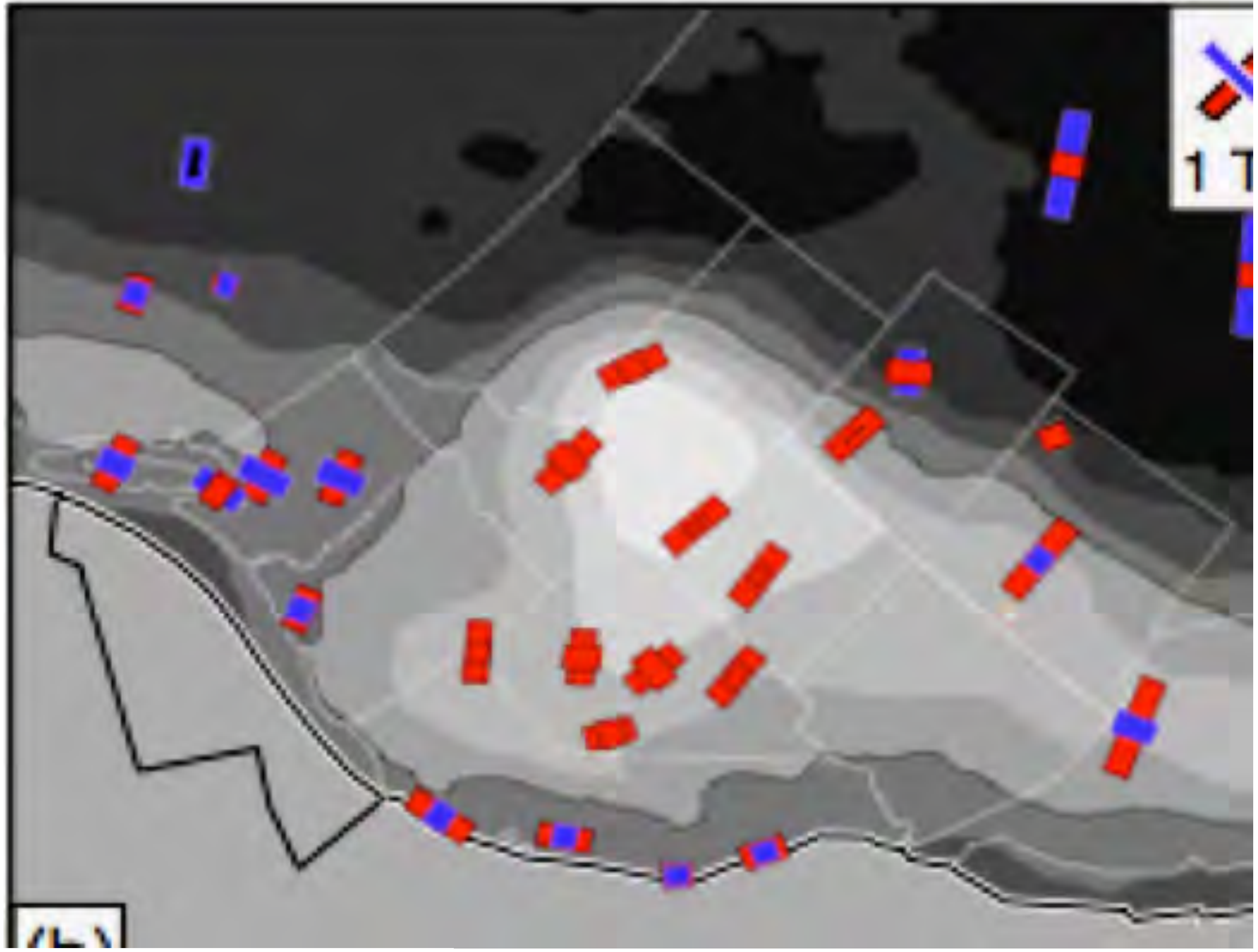
Tension of high-GPE areas

(and compression of the lowlands)

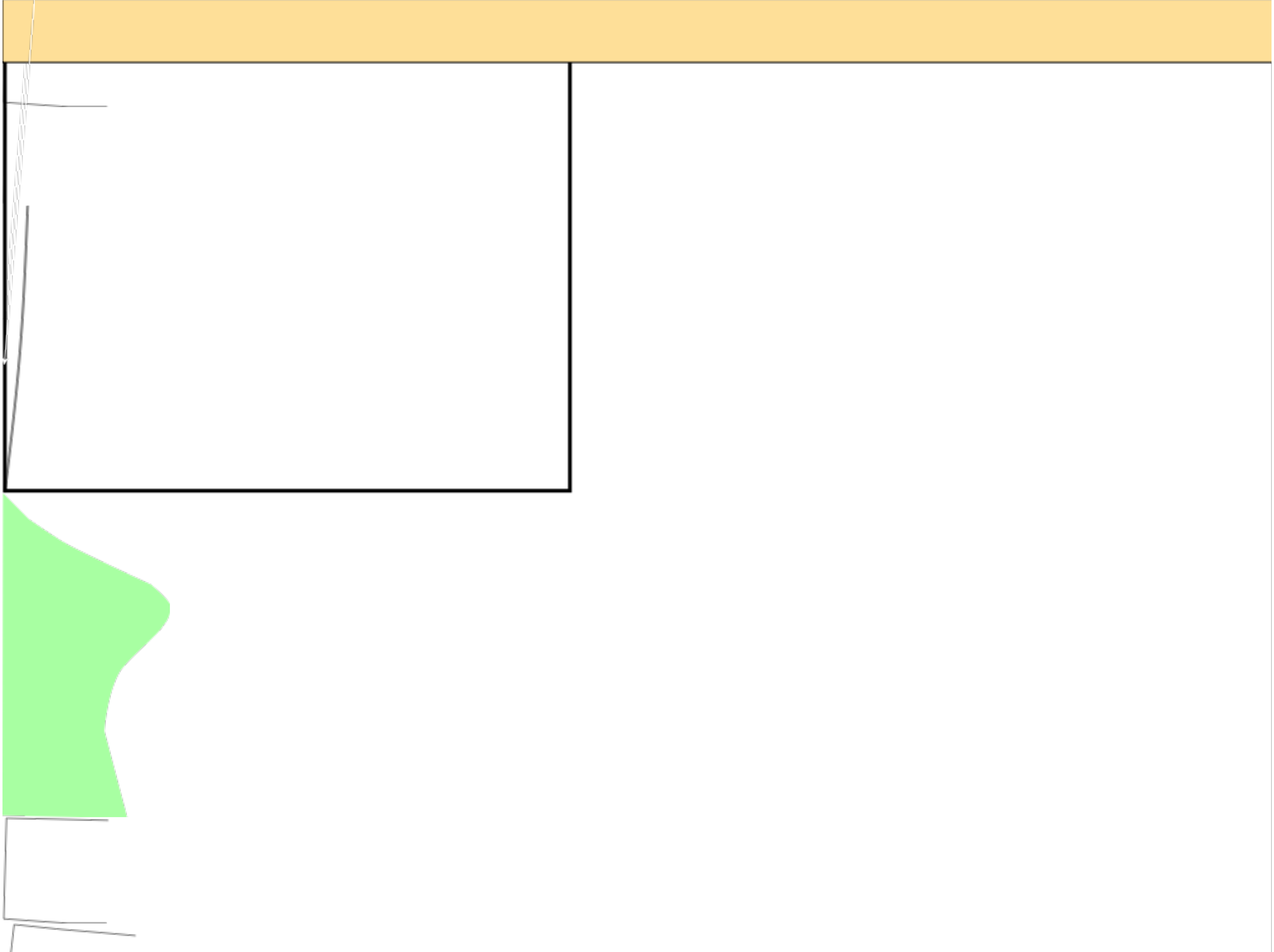


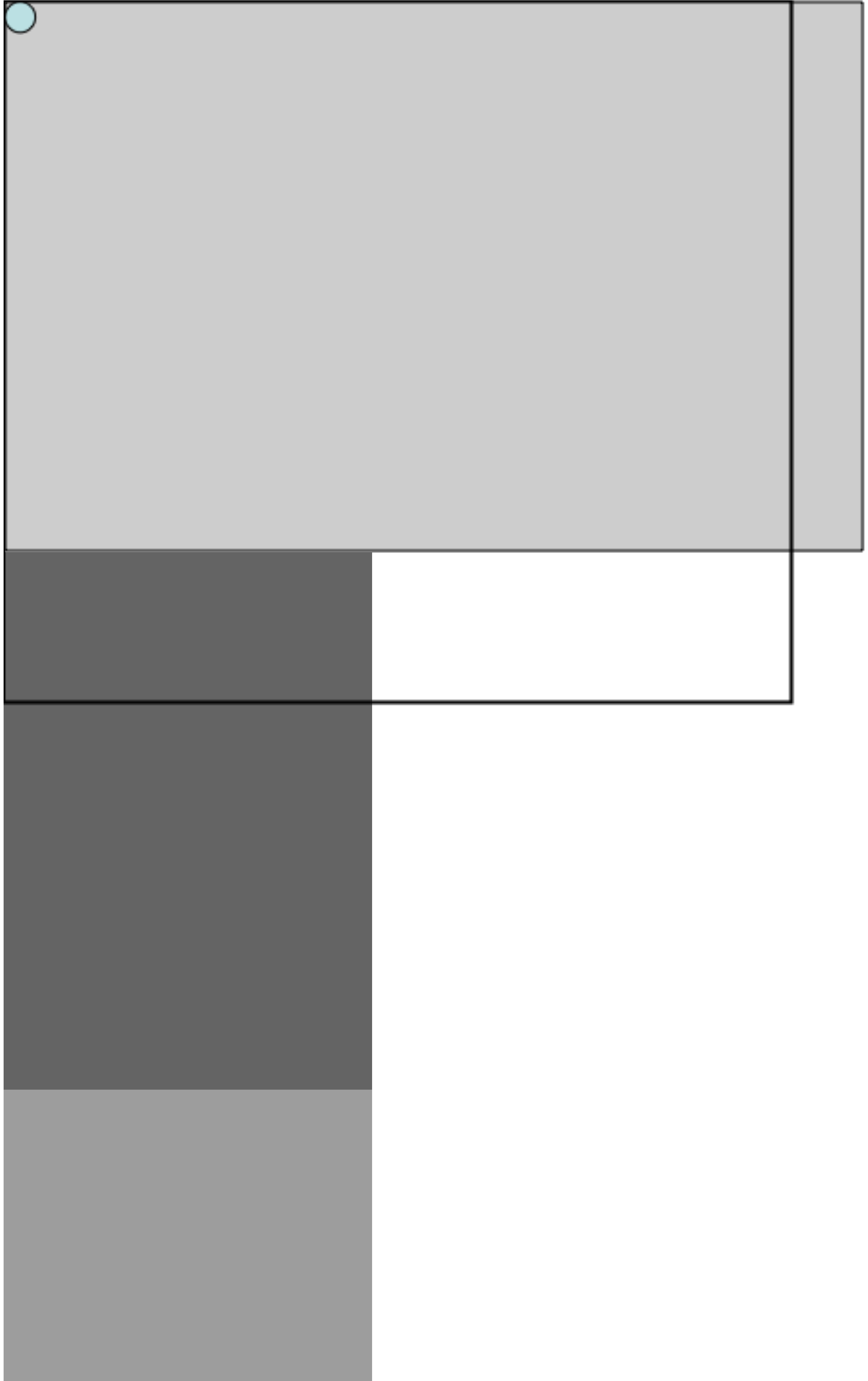


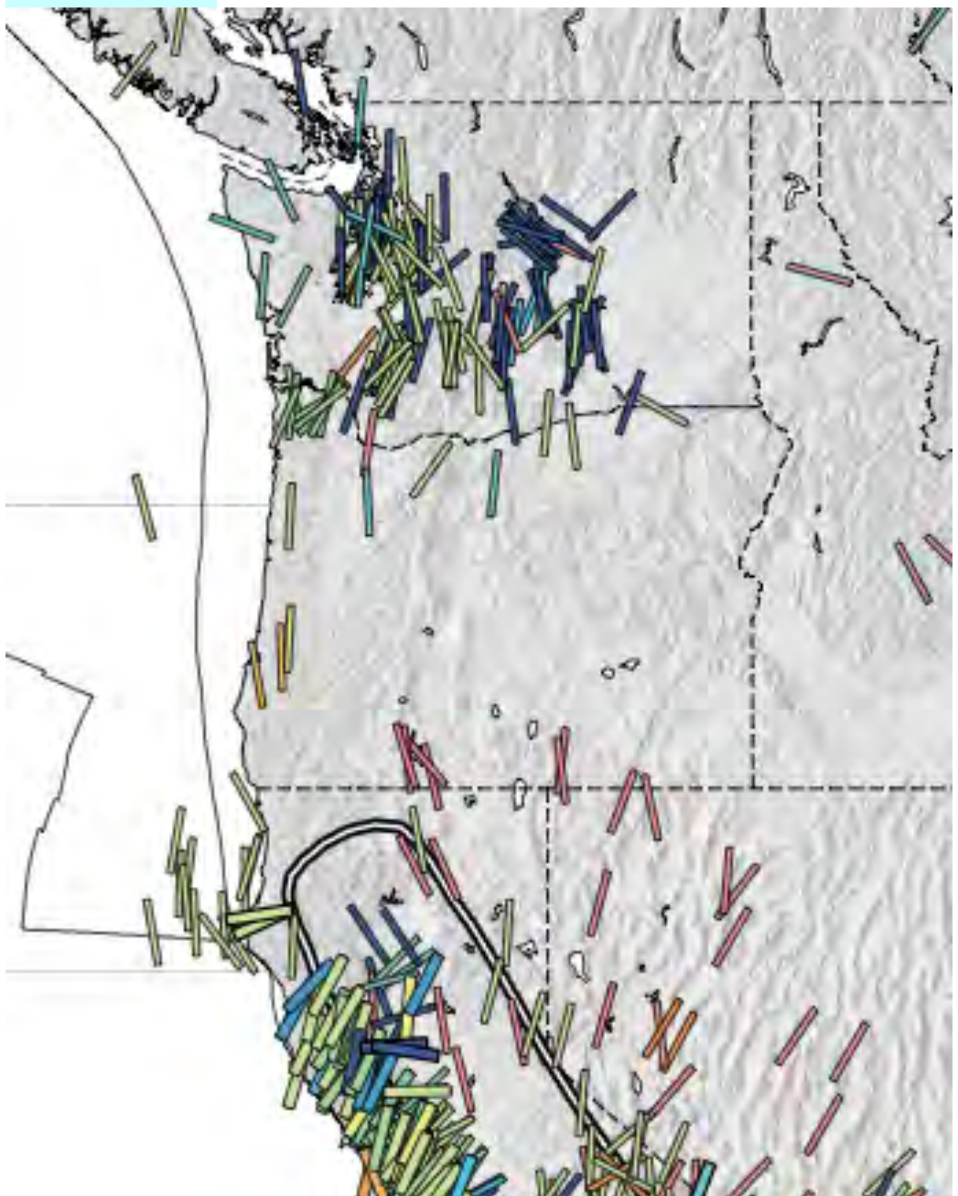


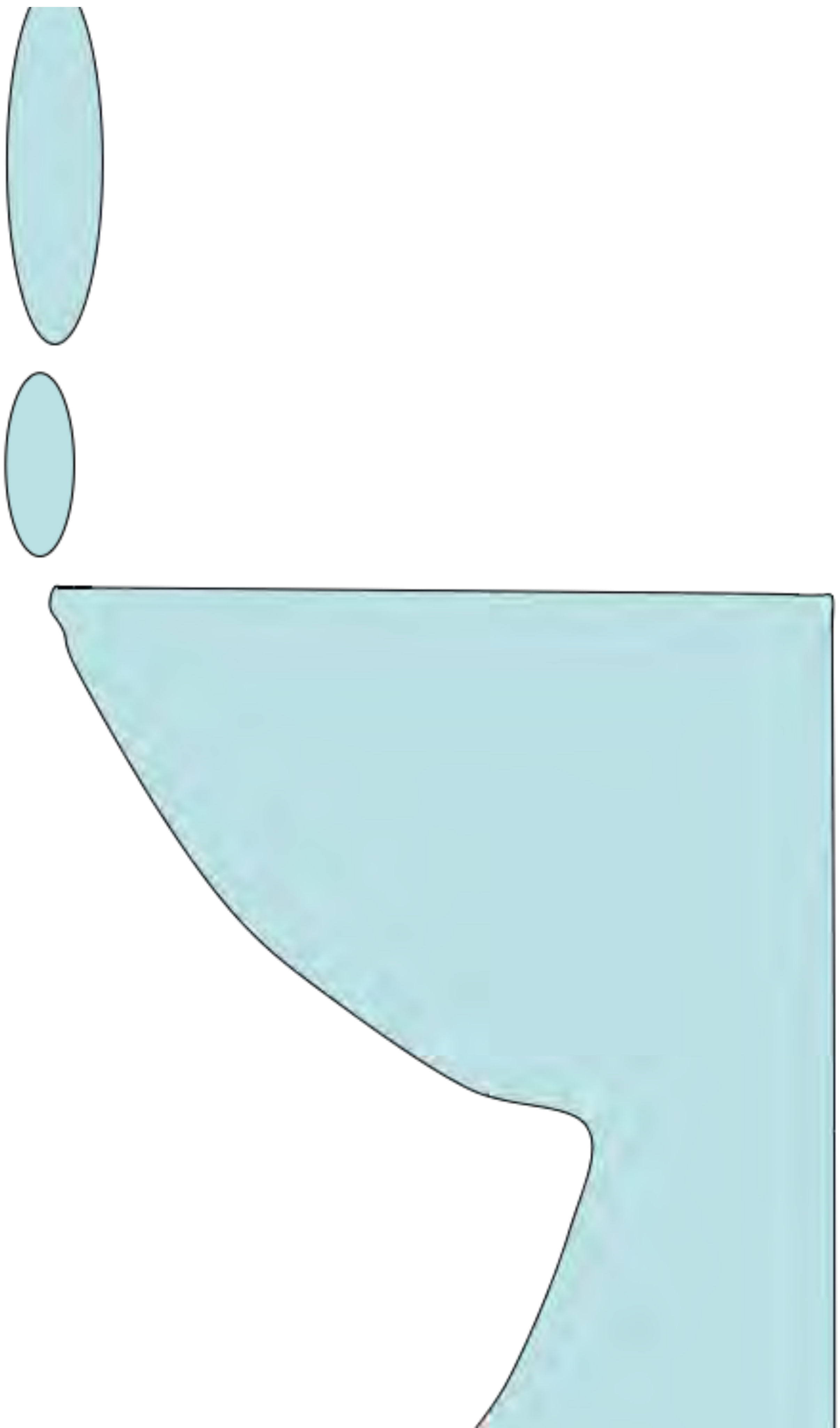


Gravitational
PE



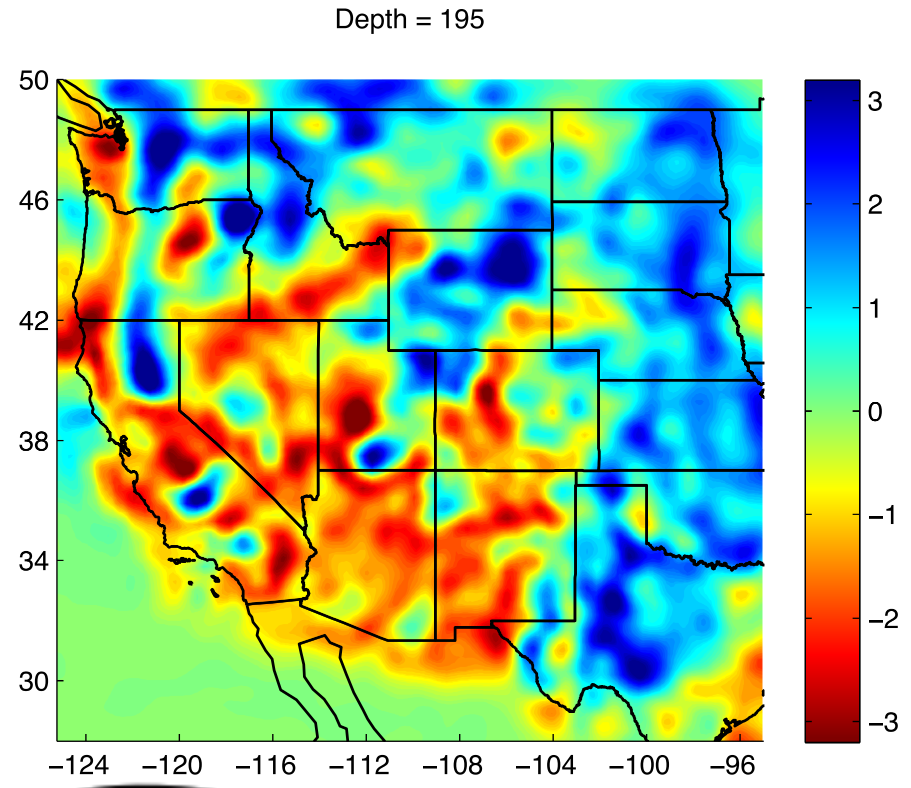






(a)

Geodynamic context of Cascadia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42
38
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−112
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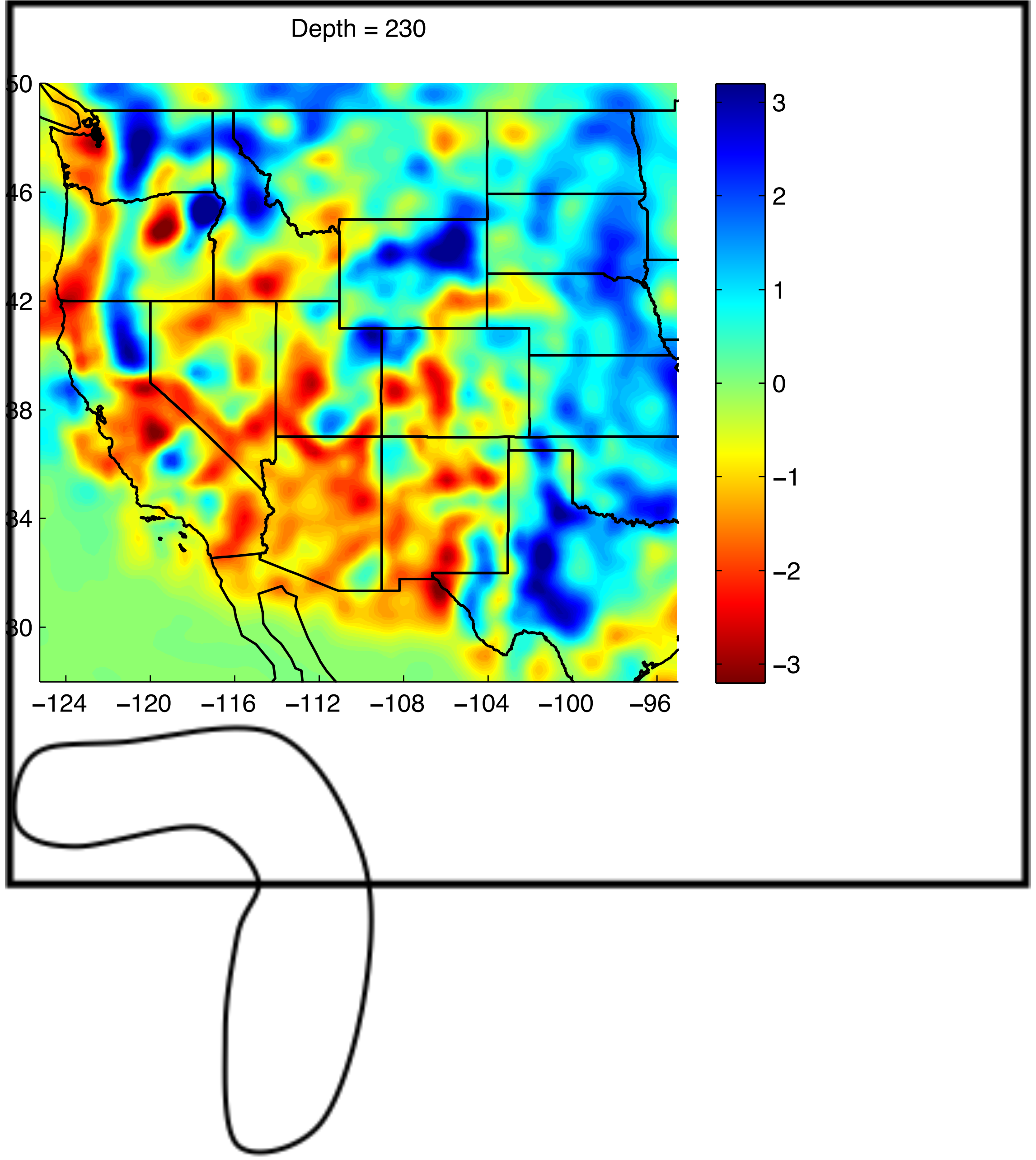
−104
−100
−96
3
2
1
0
−1
−2
−3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42
38
34
30
−124 −120 −116 −112 −108 −104 −100 −96
3
2
1
0
−1
−2
−3

230 km

50 Ma

60 Ma

40 Ma

~Amagmatic

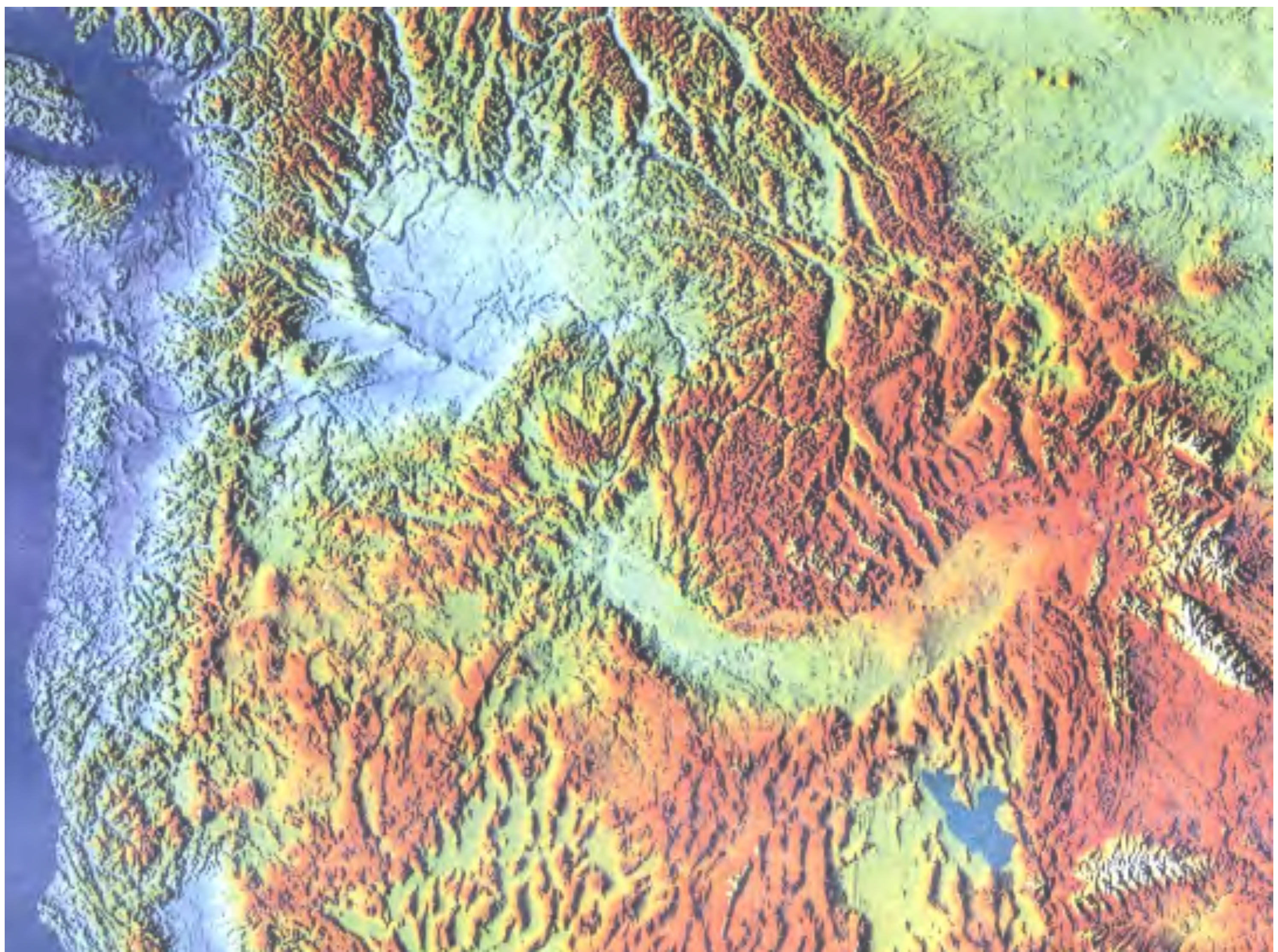
Challis magmatic

flareup

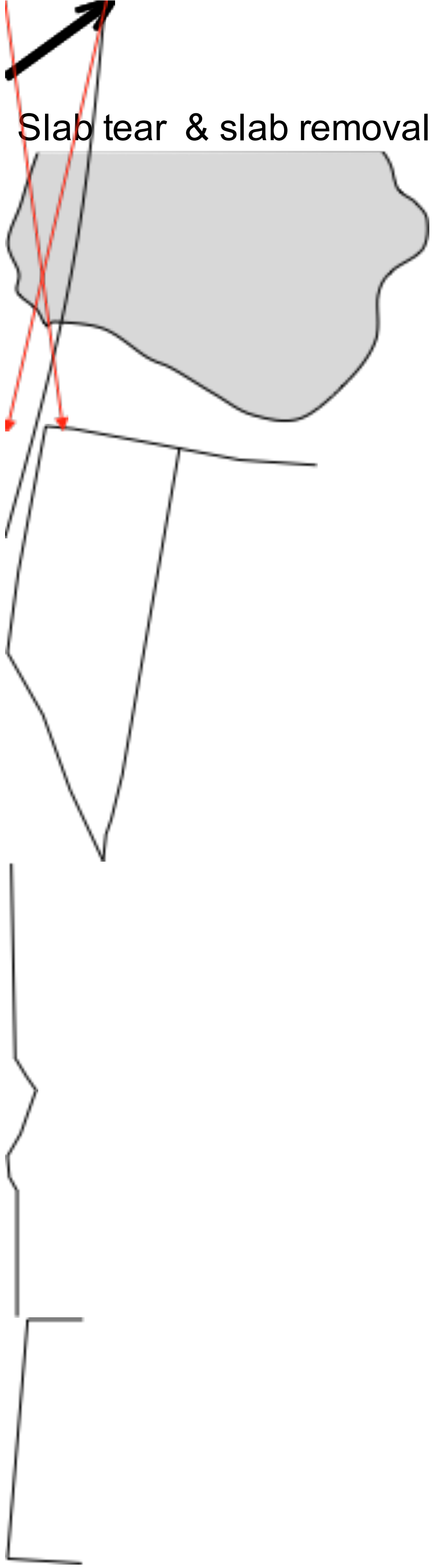
The southern edge of Siletzia...

Expected southern edge at 50 Ma

Southern margin of Siletzia under northern Oregon



Slab tear & slab removal (the ignimbrite flareup)



~50 Ma