3D flow in subduction zones: Implications for slab temperature and seismic anisotropy

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Geoprisms Alaska Planning meeting
Portland, OR, September 2011

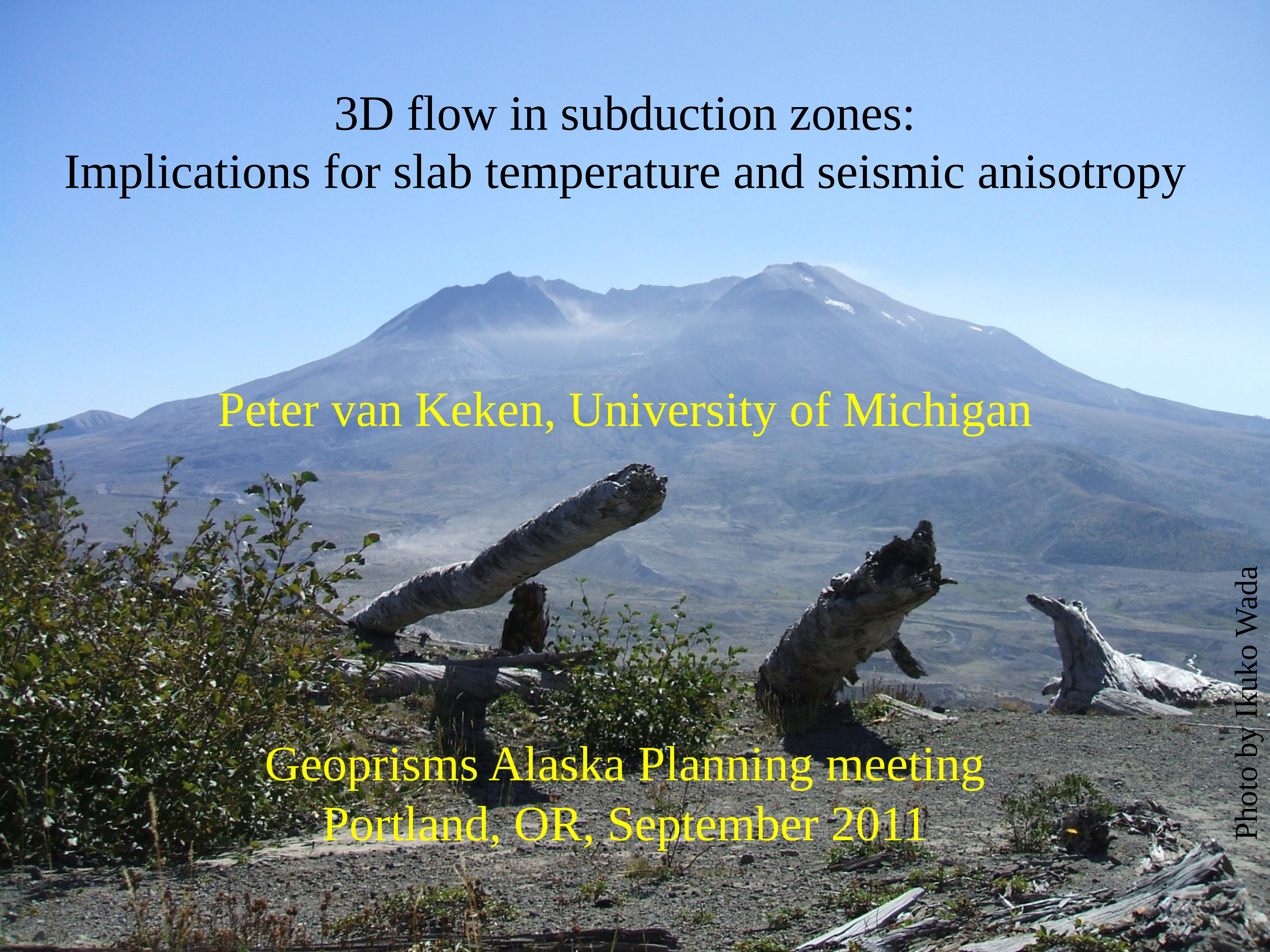

Photo by Ikuko Wada


With thanks to:
Geoff Abers, Brad Hacker, Ellen Syracuse,
Amy Bengtson, Jun Nakajima, Saeko Kita
MARGINS
NSF
Geo
PRISMS
Geodynamic Processes
at Rifting and
Subducting
Margins
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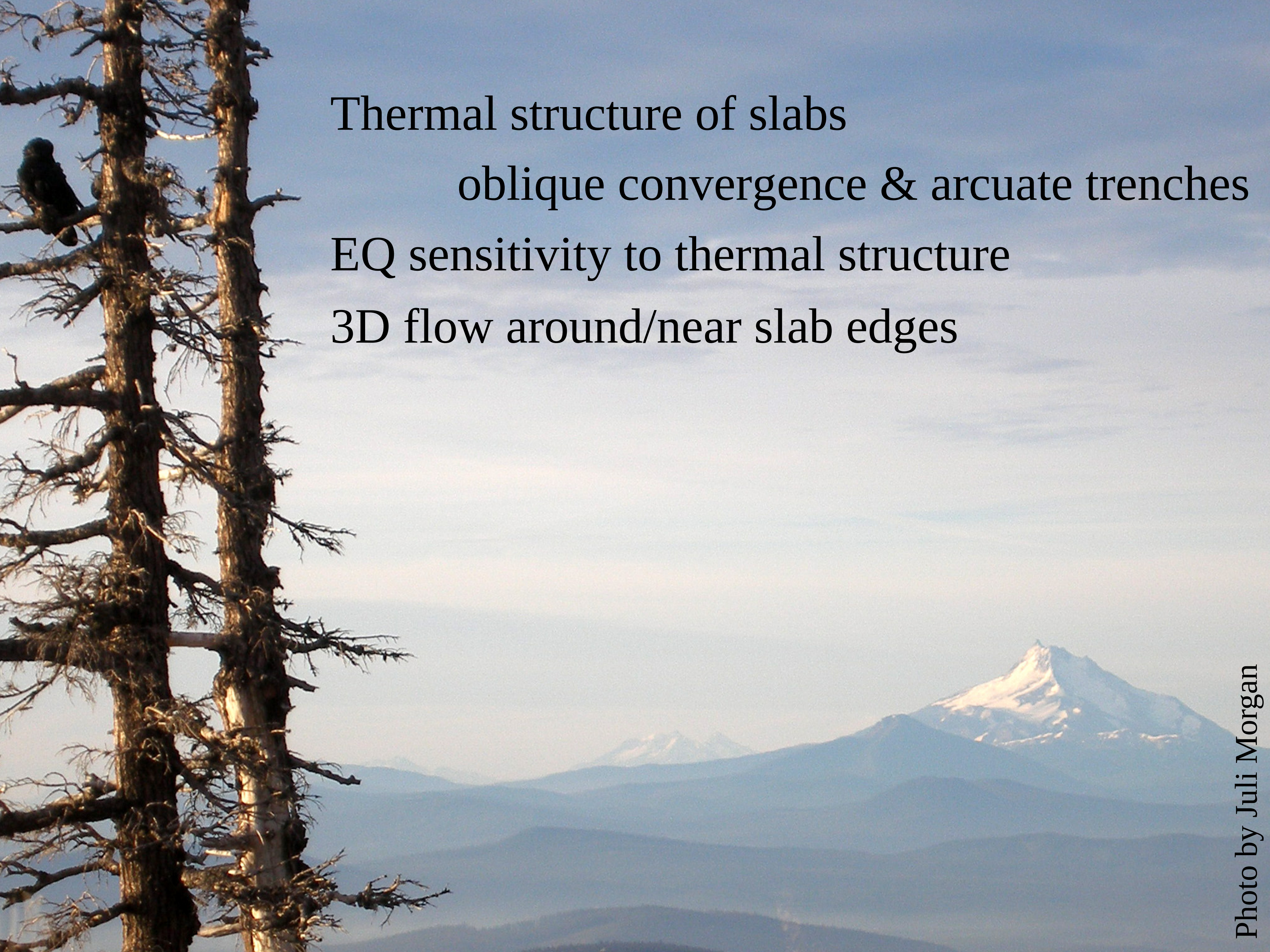
Thermal structure of slabs

oblique convergence & arcuate trenches

EQ sensitivity to thermal structure

3D flow around/near slab edges



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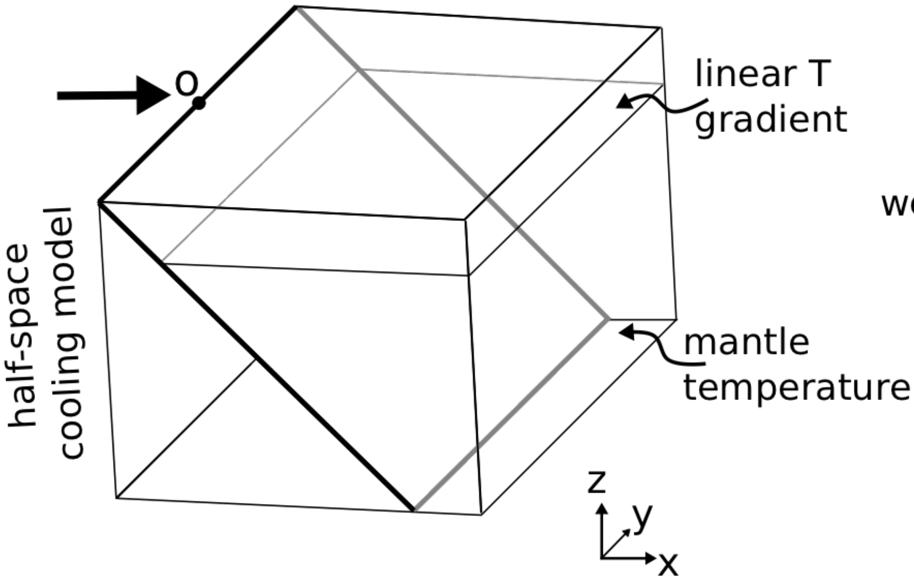
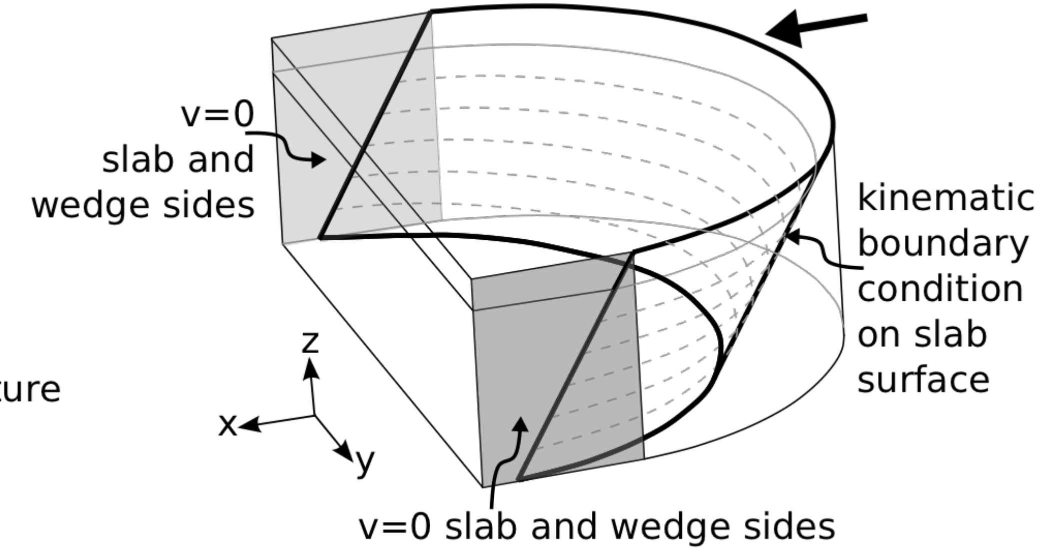
Two simple 3D geometries

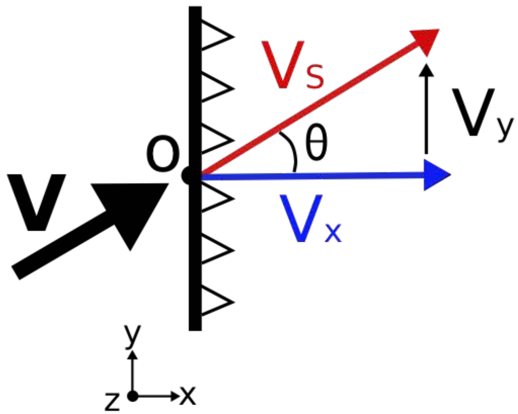


(a) temperature boundary conditions for 3D geometries

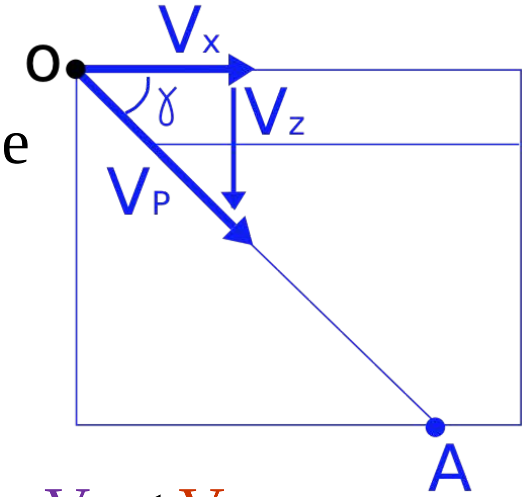


(b) velocity boundary conditions for curved trench

Bengtson and van Keken, in prep.

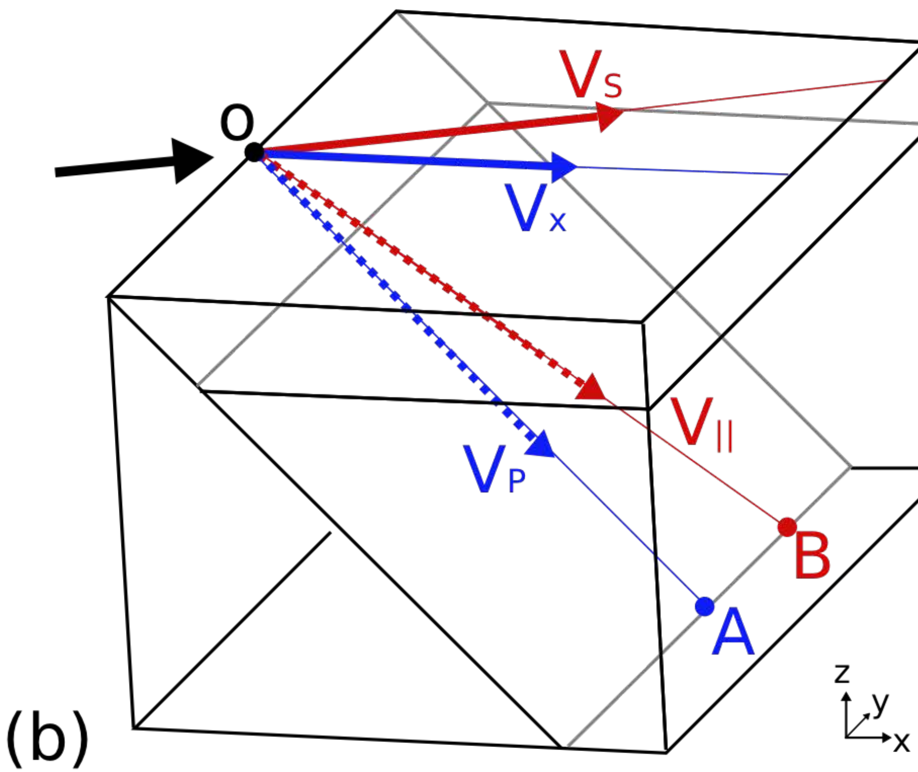


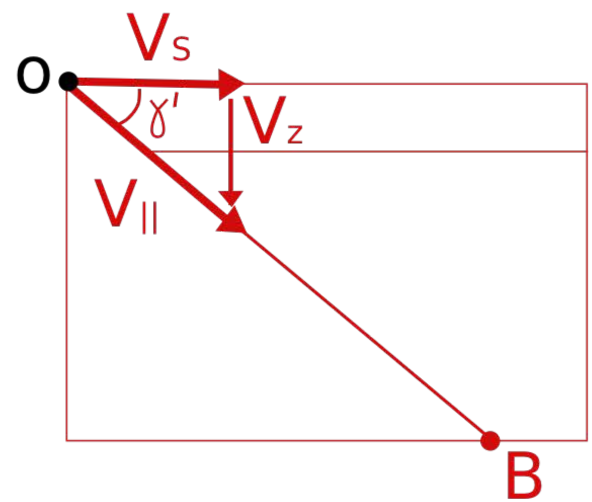
What is the best choice for 2D cross section in the case of oblique subduction?



$V_x < V_s$

$\gamma > \gamma'$



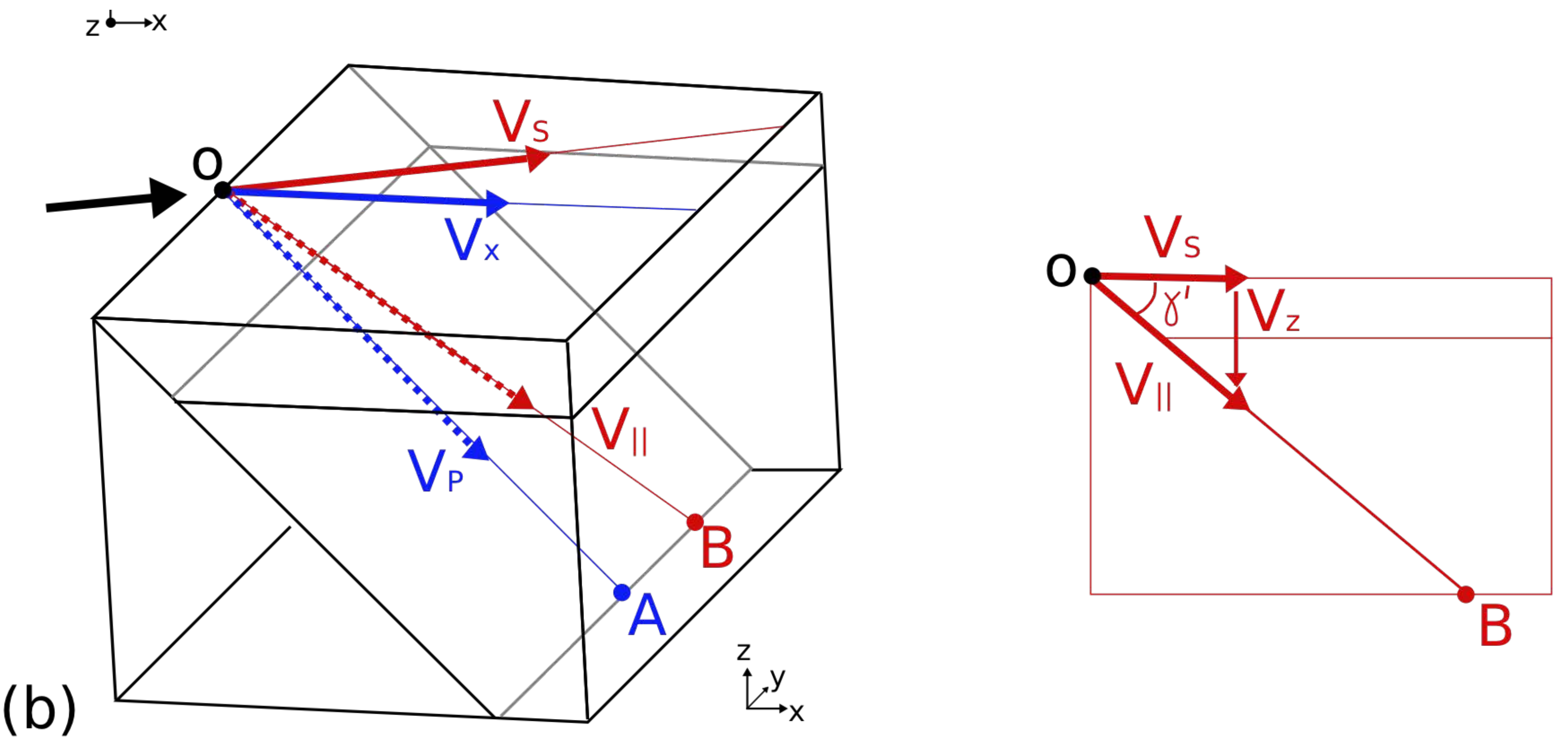


3D generalization of 2D benchmark (van Keken et al., 2008)

Oblique convergence in 3D: which 2D cross section is appropriate?

Angle θ = 60 degrees; isoviscous

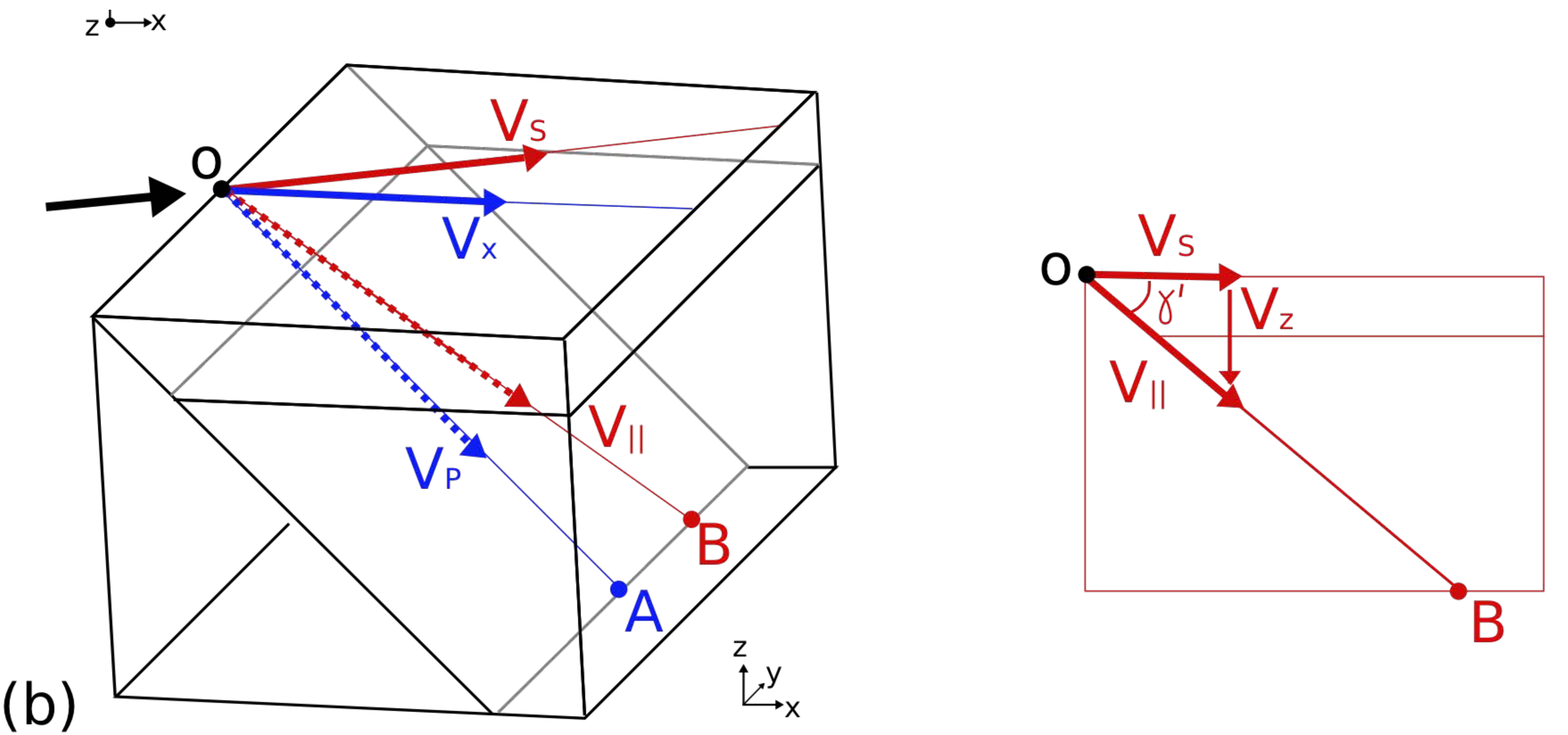
T (C) at slab depth:	60 km	100 km	200 km
3D results	442	614	747
2D trench normal	439	613	746
2D velocity parallel	350	549	681



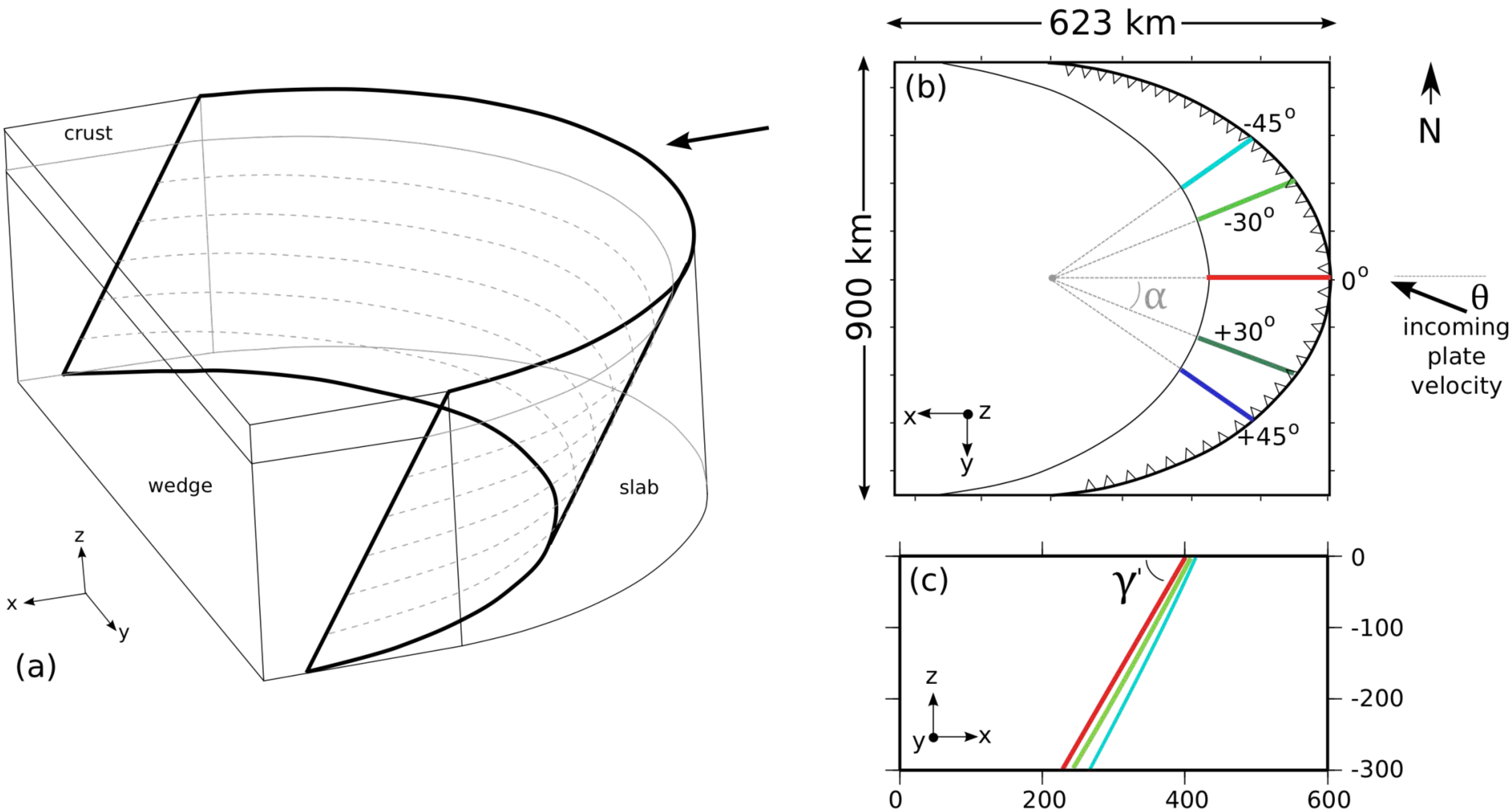
Oblique convergence in 3D: which 2D cross section is appropriate?

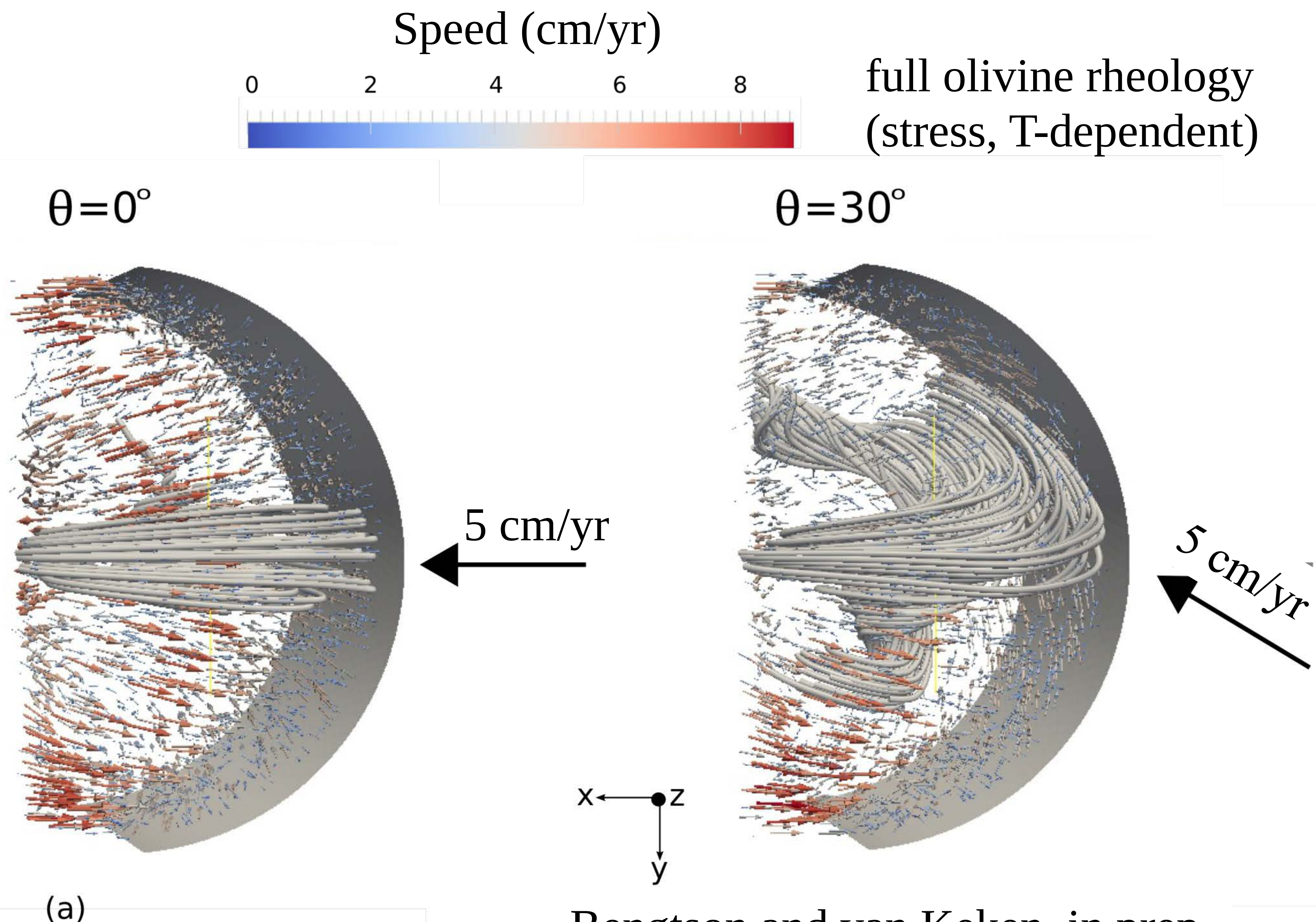
Angle of 60 degrees; diffusion-creep (T-sensitive)

T (C) at slab depth:	60 km	100 km	200 km
3D results	577	703	787
2D trench normal	577	703	786
2D velocity parallel	529	654	733

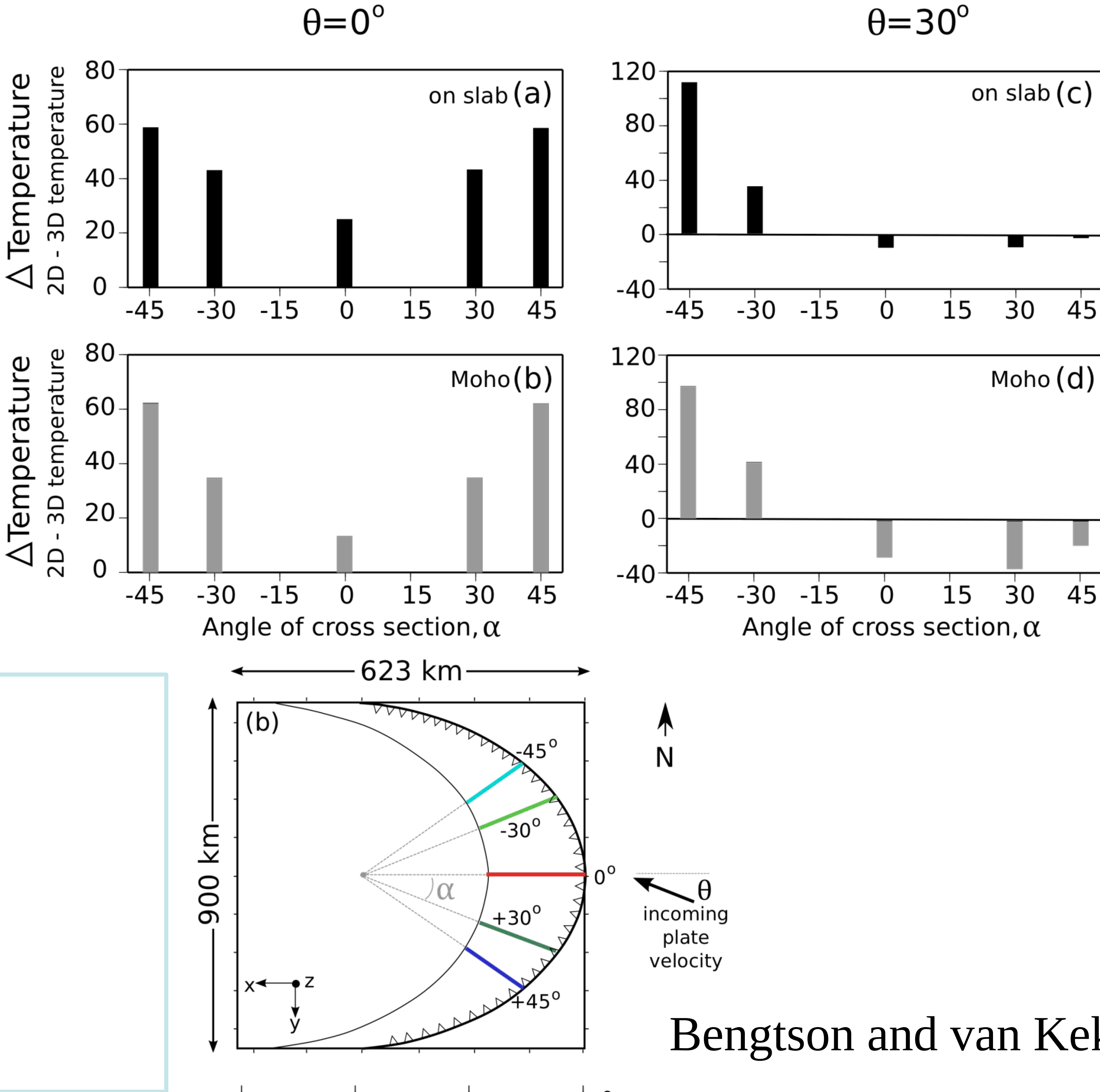


oblique convergence in arcuate trenches (Marianas, Aleutians)



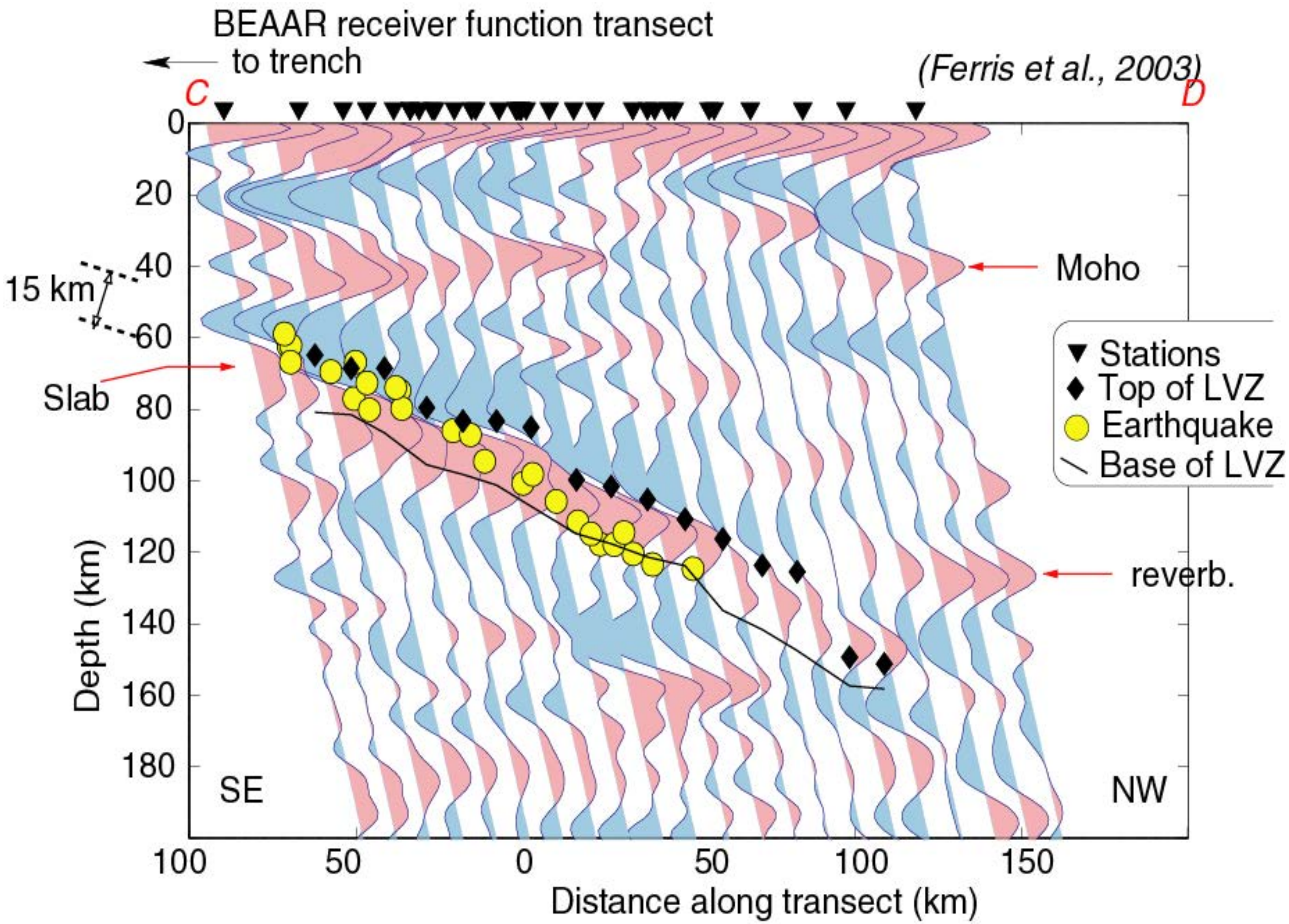


Bengtson and van Keken, in prep.



Bengtson and van Keken, in prep.

Central Alaska



EQs follow Clapeyron slope 0.1 MPa/K (Abers et al., 2006)

Tohoku

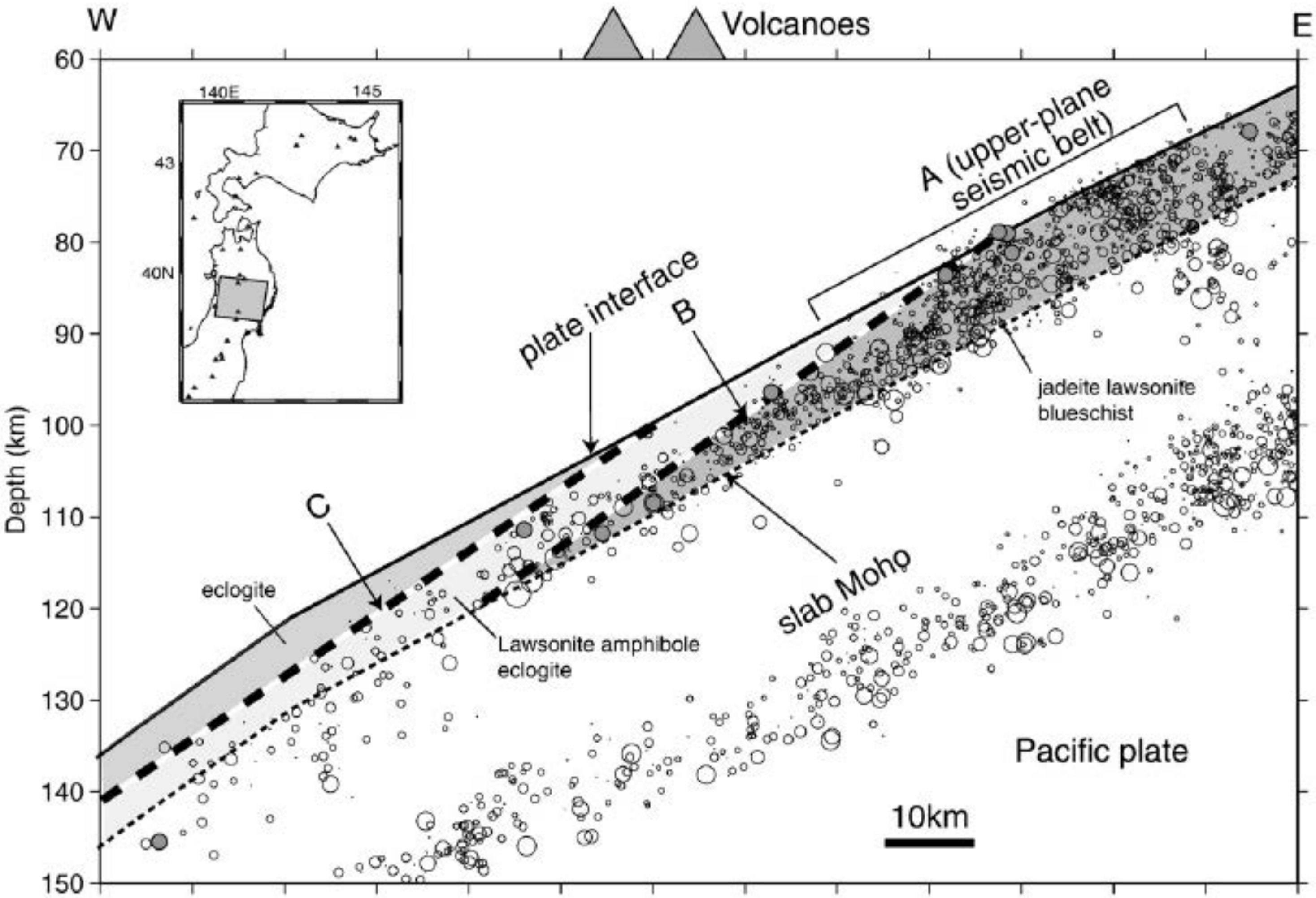
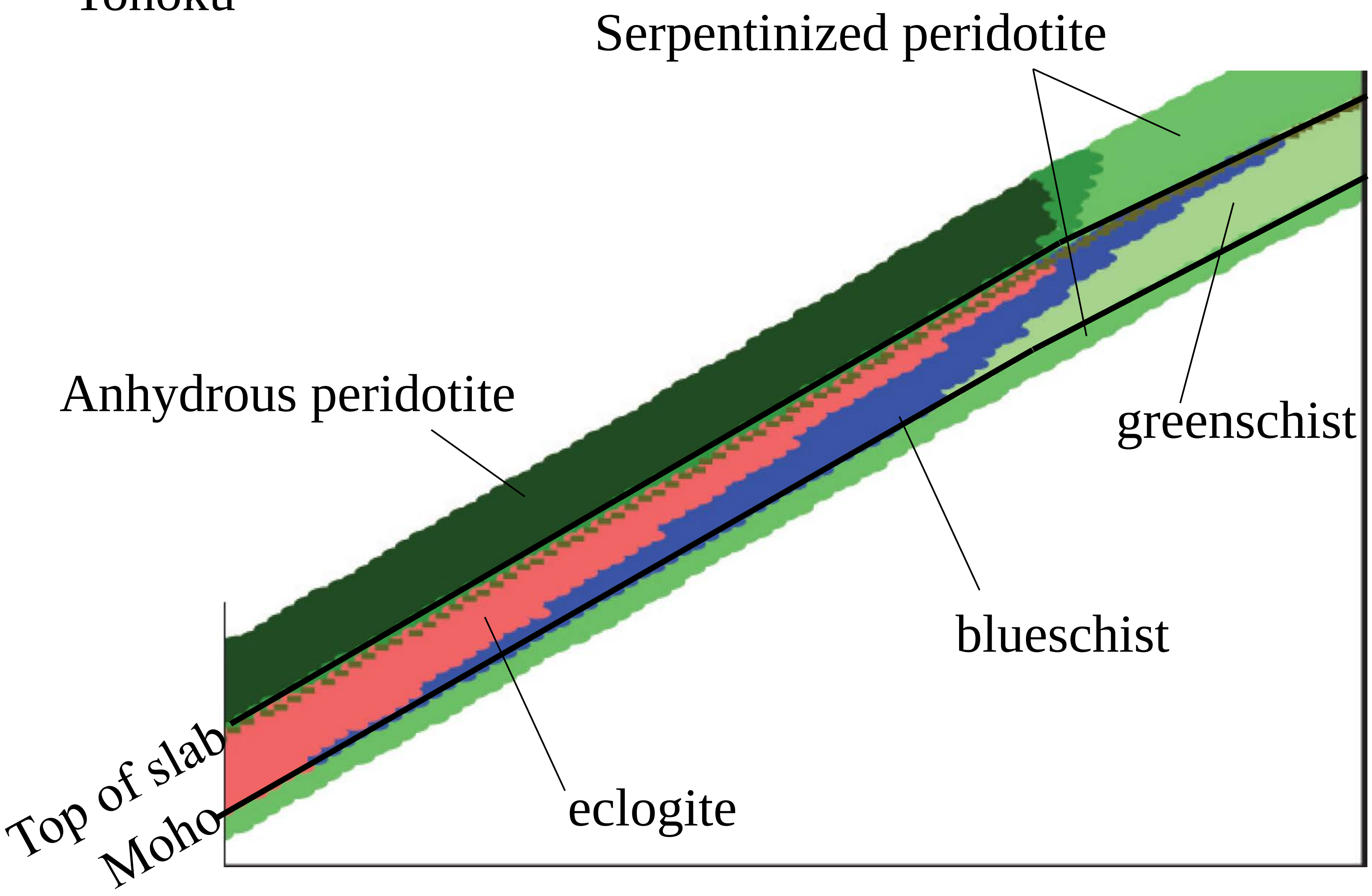


Fig. 14. Cross-arc vertical cross-section of intraslab earthquakes in central Tohoku (Kita et al., 2006). Relocated earthquakes are shown by open circles. A, upper-plane seismic belt; B JLB–LAE phase boundary; C, LAE–eclogite phase boundary (Hacker et al., 2003b).

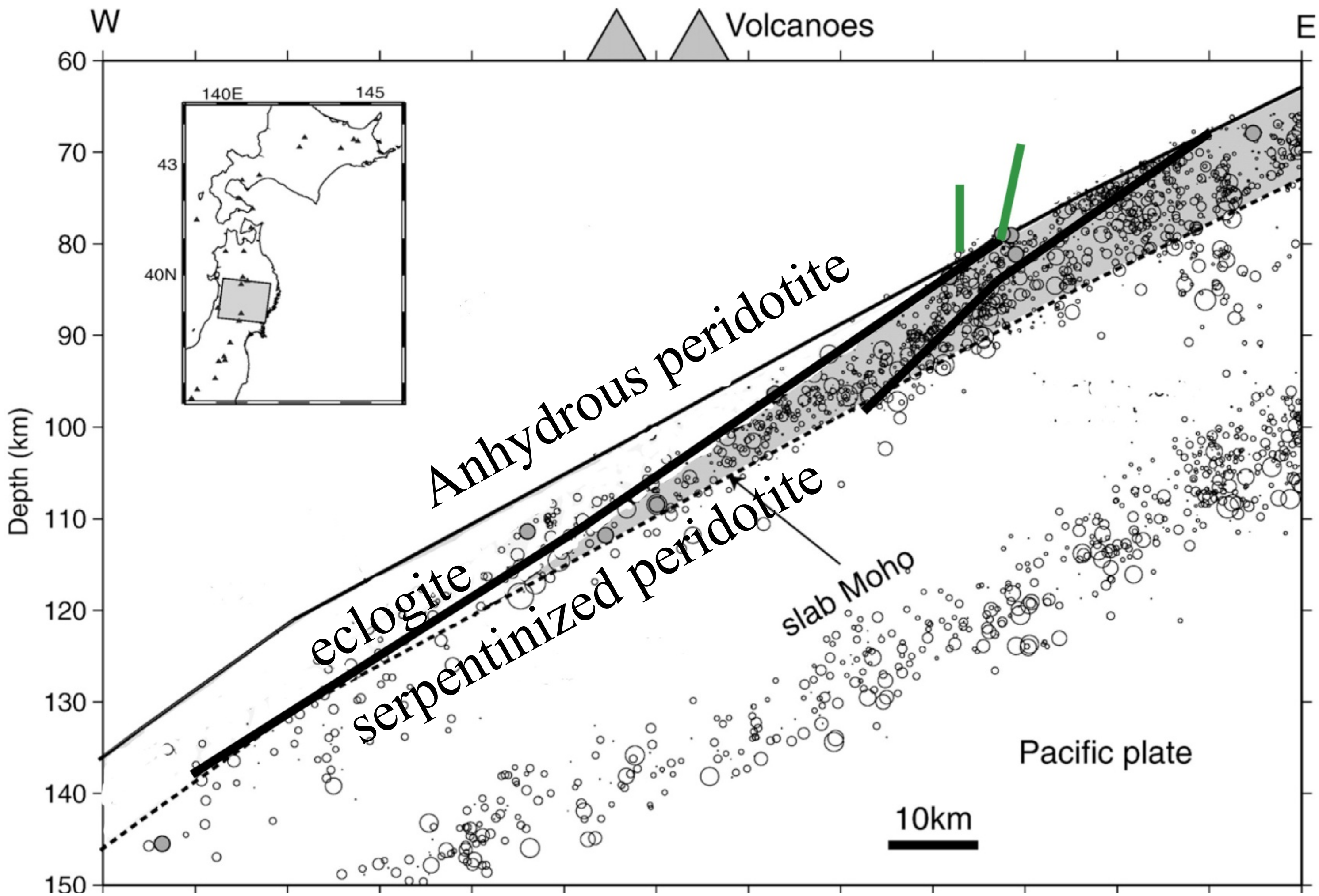
Kita et al., 2006

Tohoku



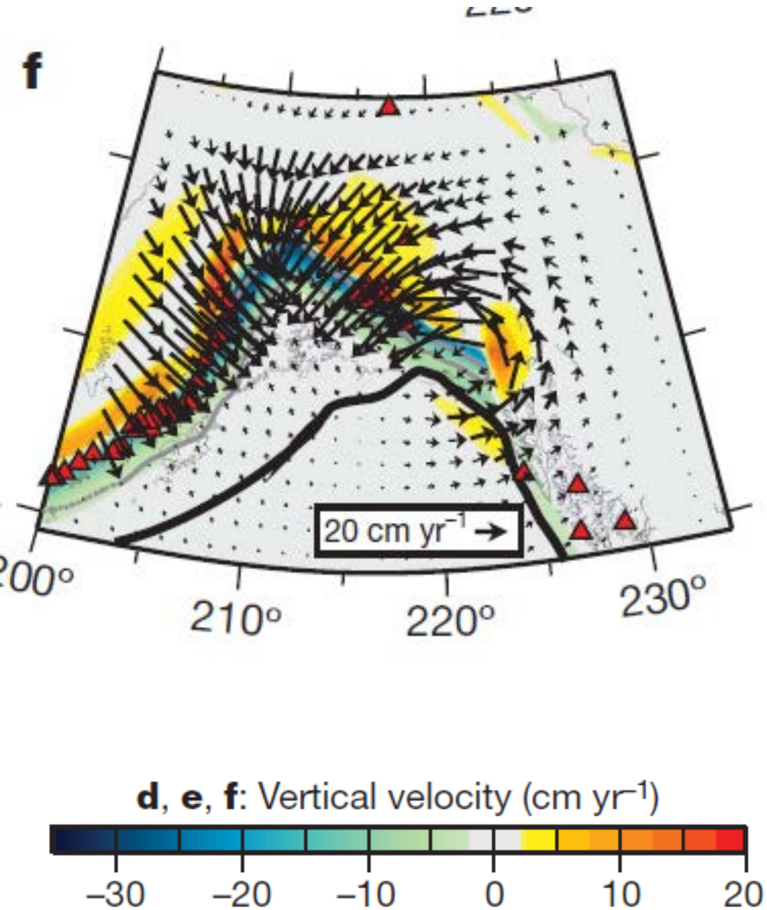
Temperature and metamorphic facies following van Keken et al., 2010

Tohoku

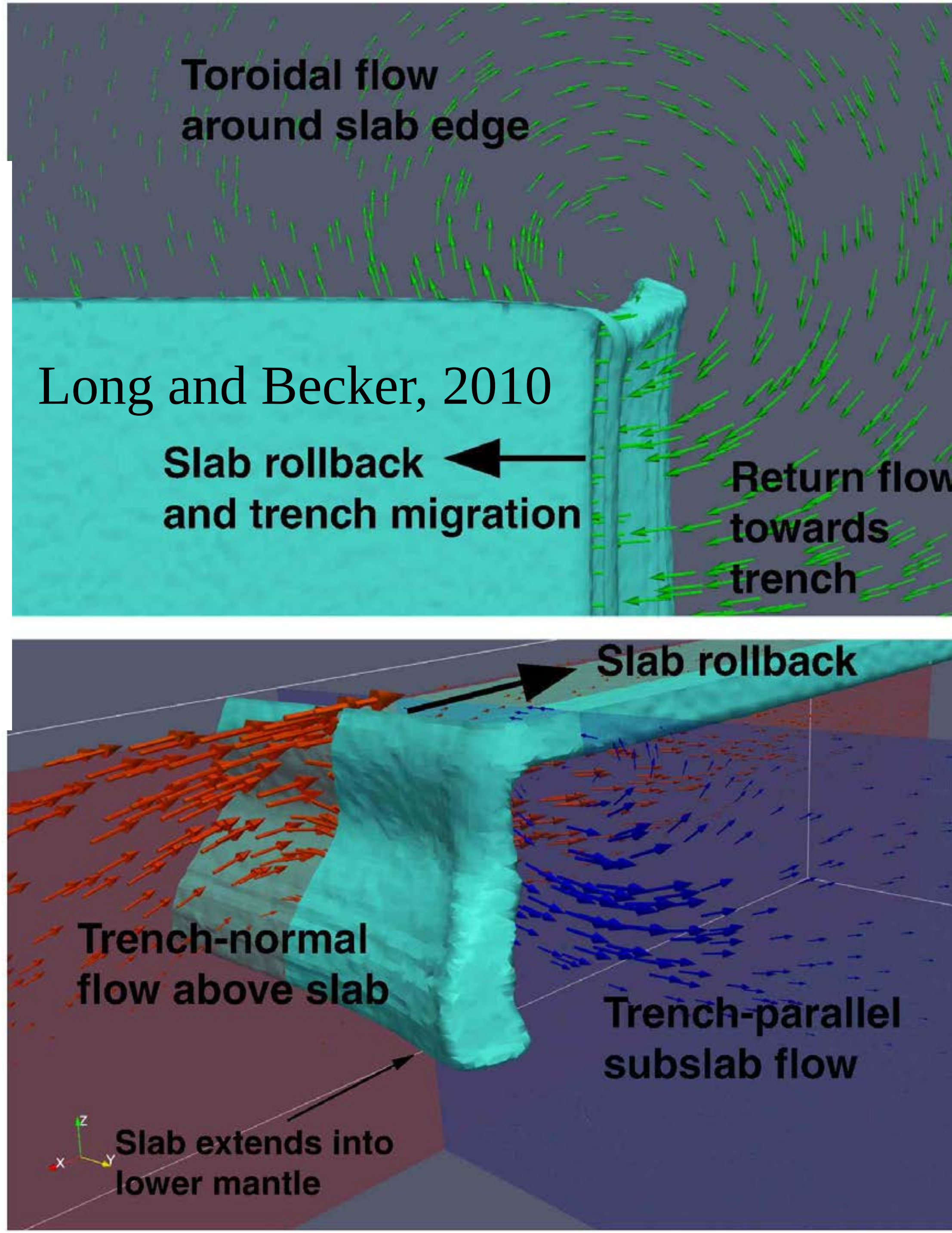


W
Volcanoes
E
60
70
80
90
100
110
120
130
140
150
Depth (km)
140E
145
43
40N
Anhydrous peridotite
eclogite
serpentinized peridotite
slab Moho
Pacific plate
10km

Flow around slab edges

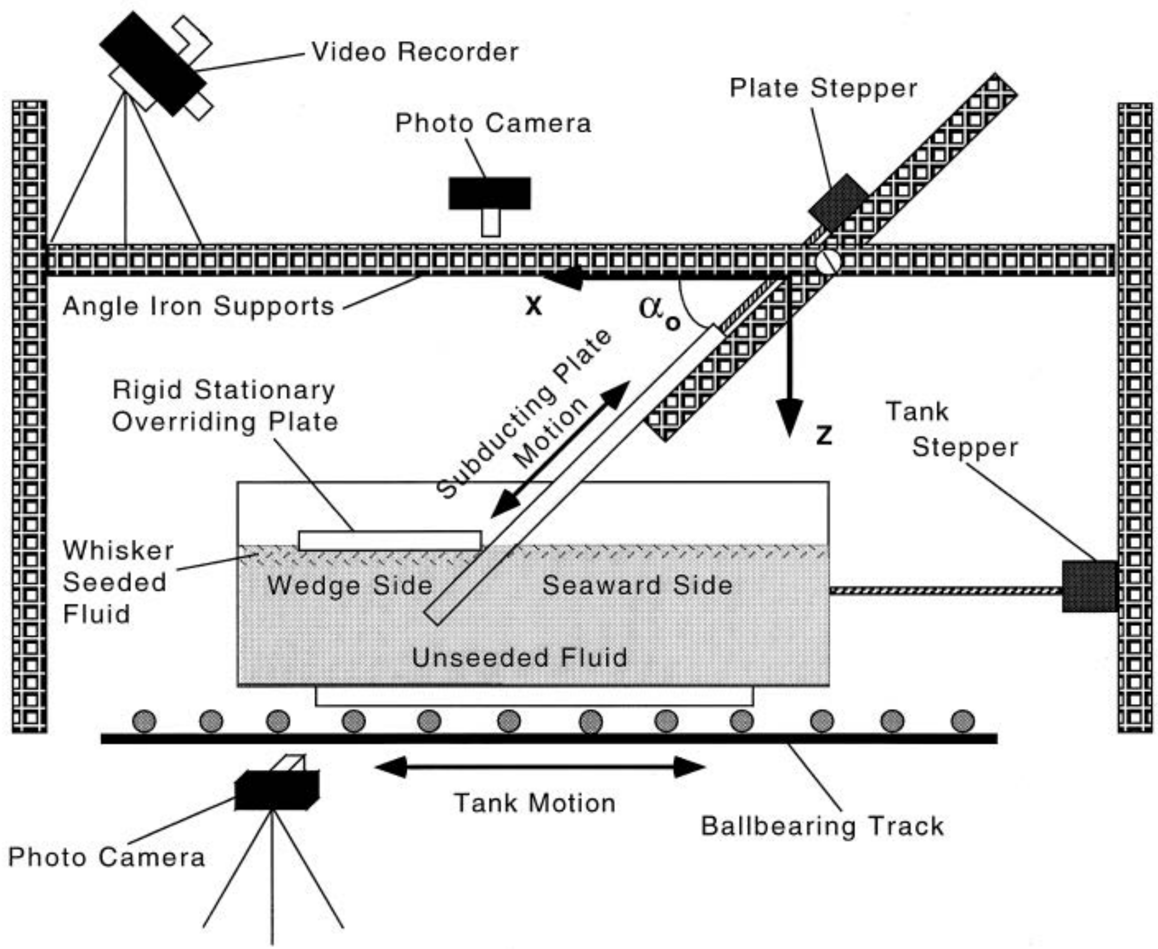


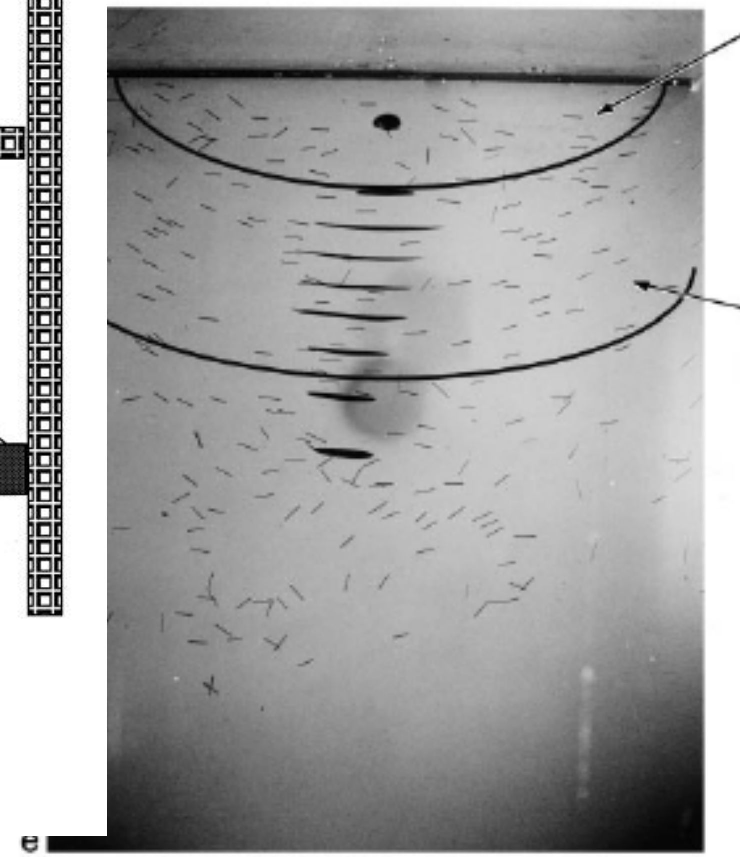
Jadamec and Billen, 2010



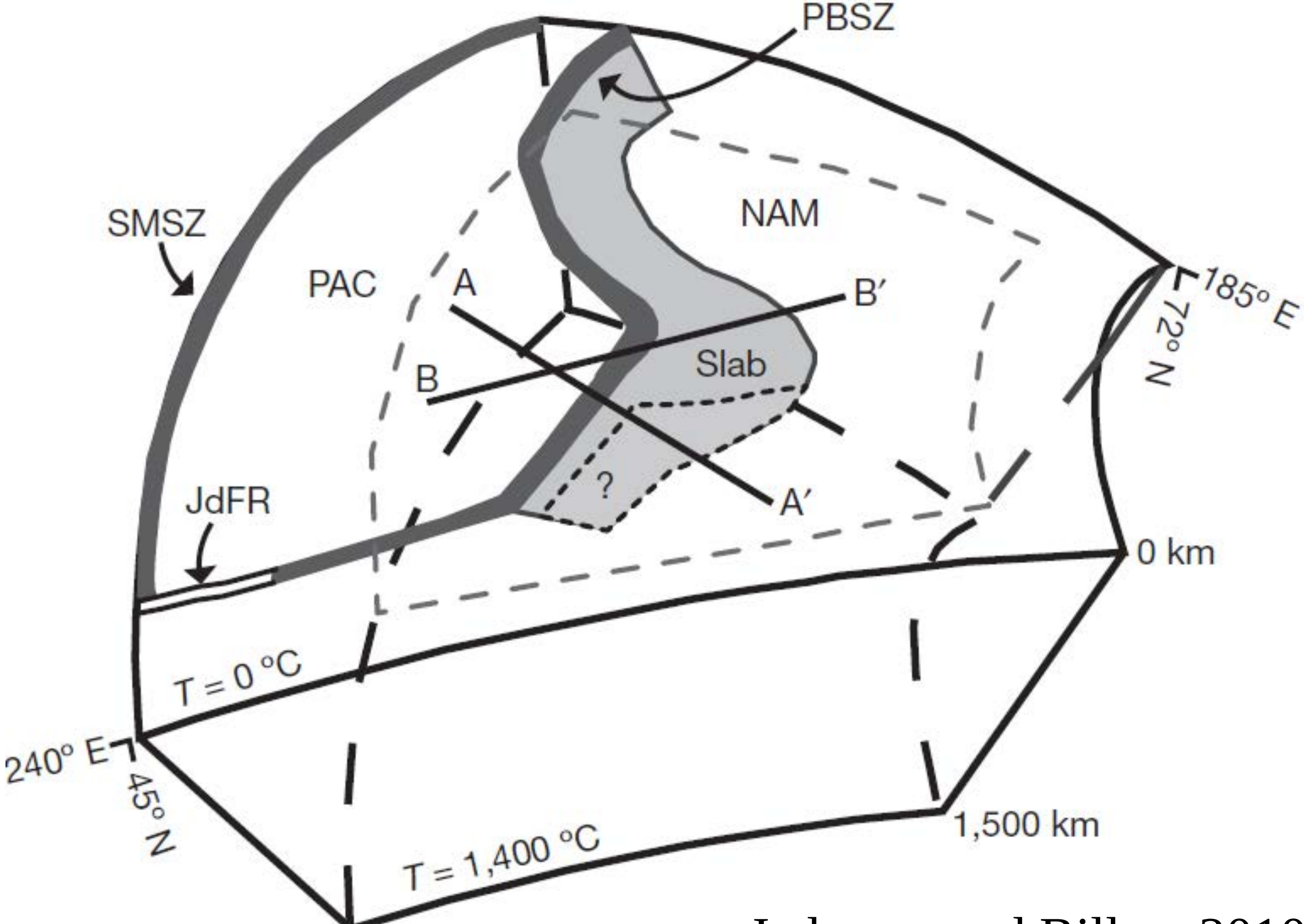
Long and Becker, 2010

J. Buttles, P. Olson / Earth and Planetary Science Letters 164 (1998) 245–262

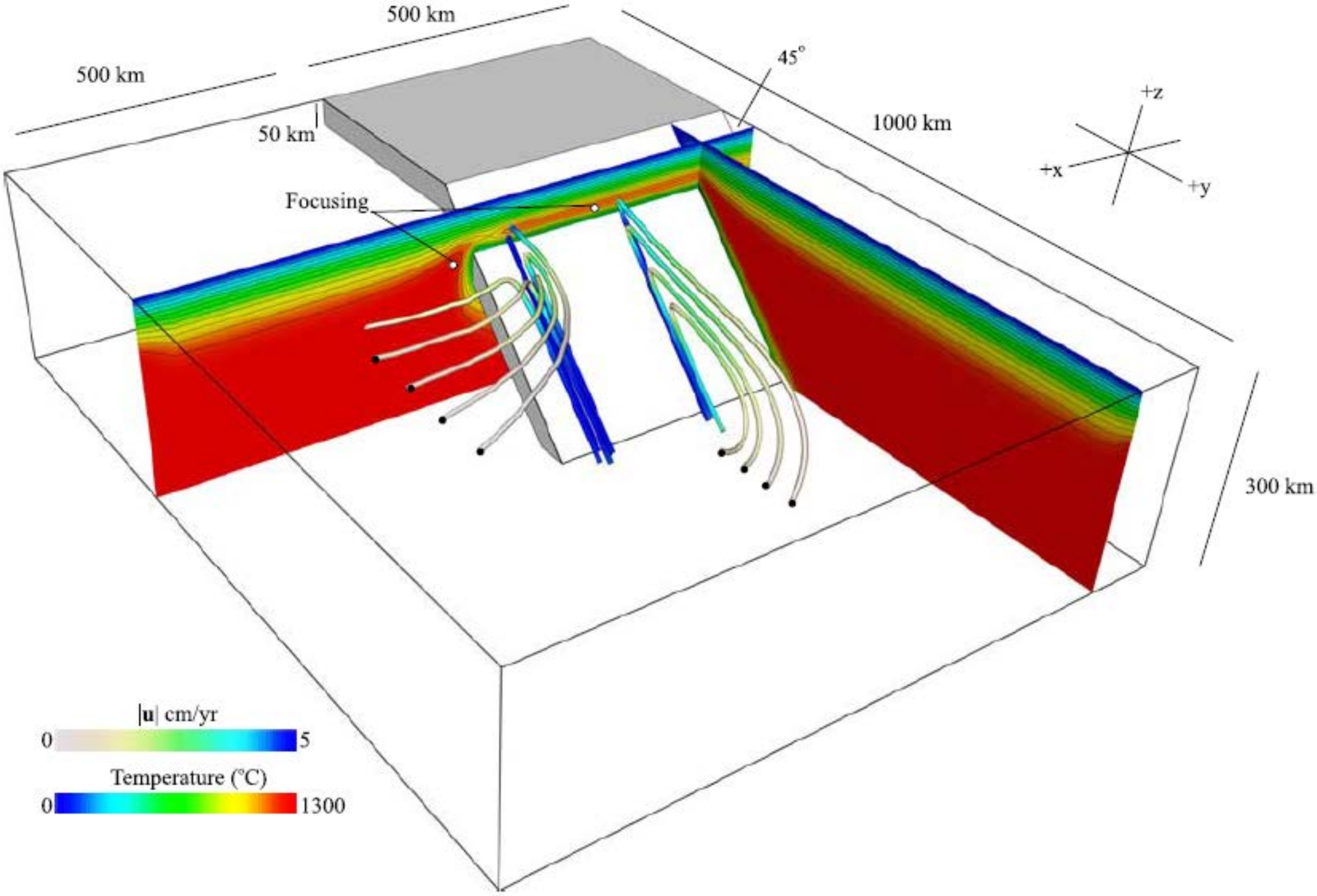




Buttles and Olson, 1998

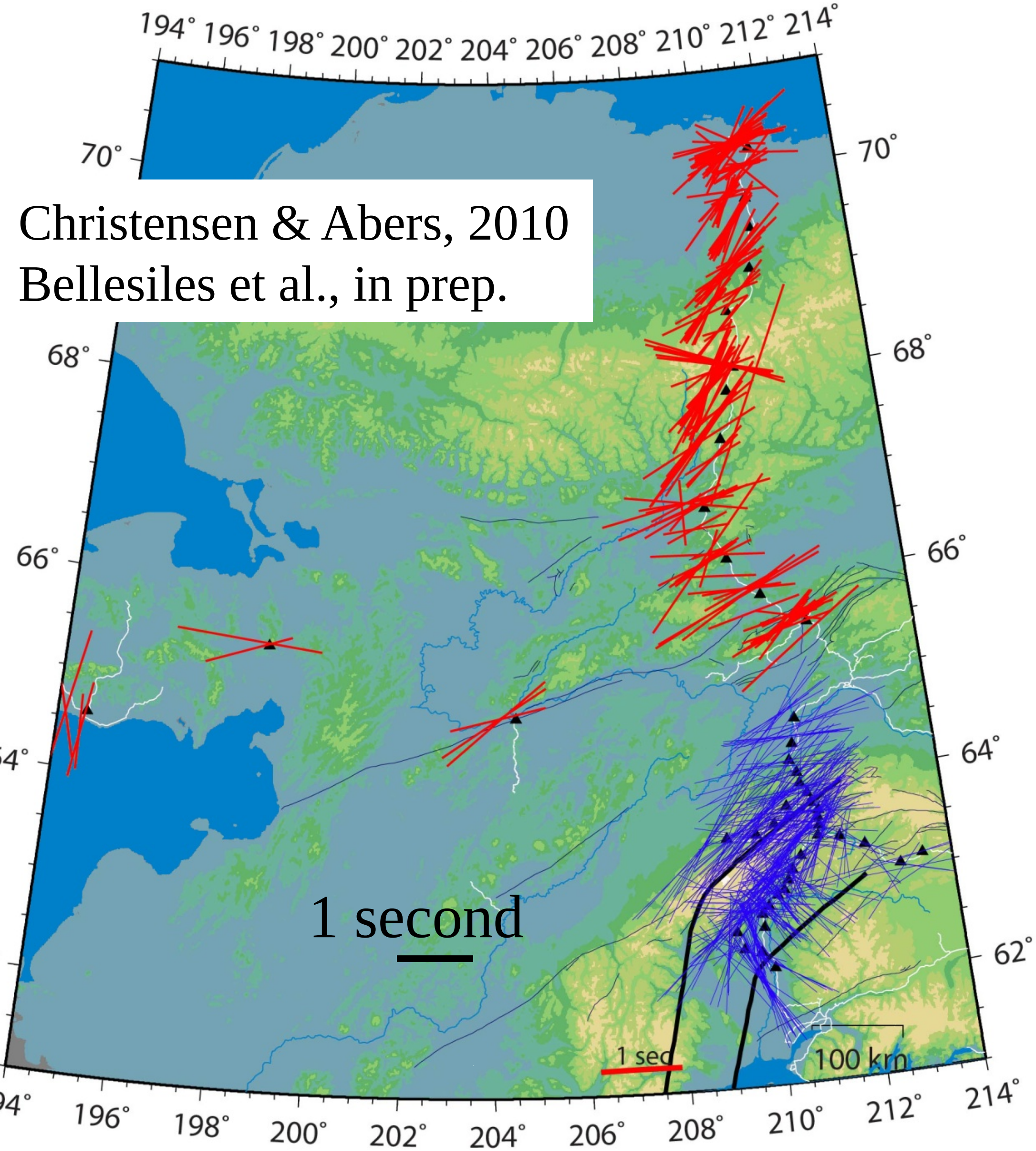


Jadamec and Billen, 2010



Kneller and van Keken, 2008

SKS Splitting Observations



SKS Splitting Observations