

Seismic anisotropy in the vicinity of slabs in the transition zone

Andy Nowacki

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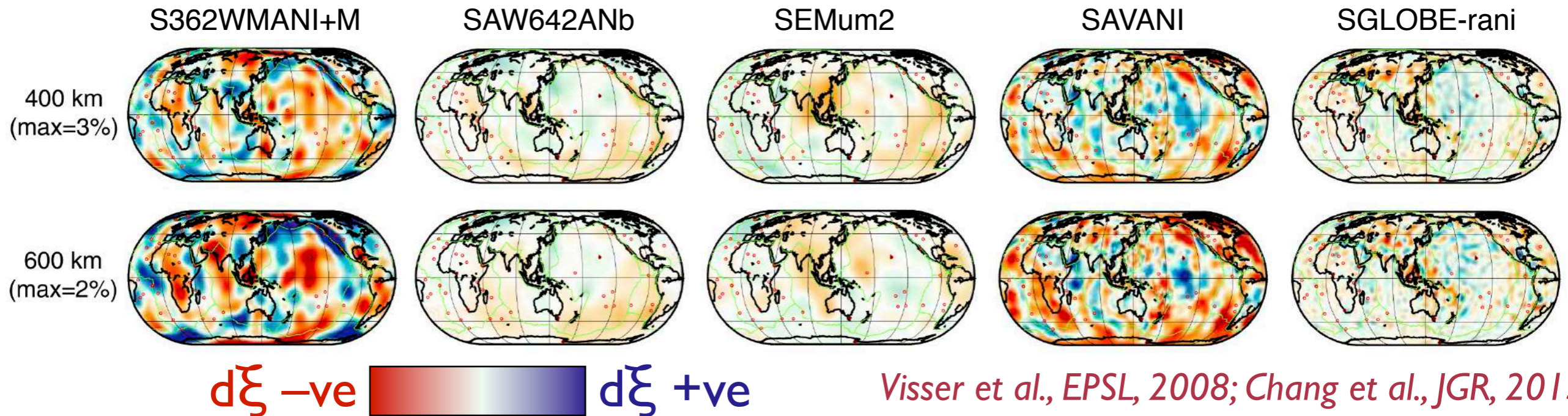
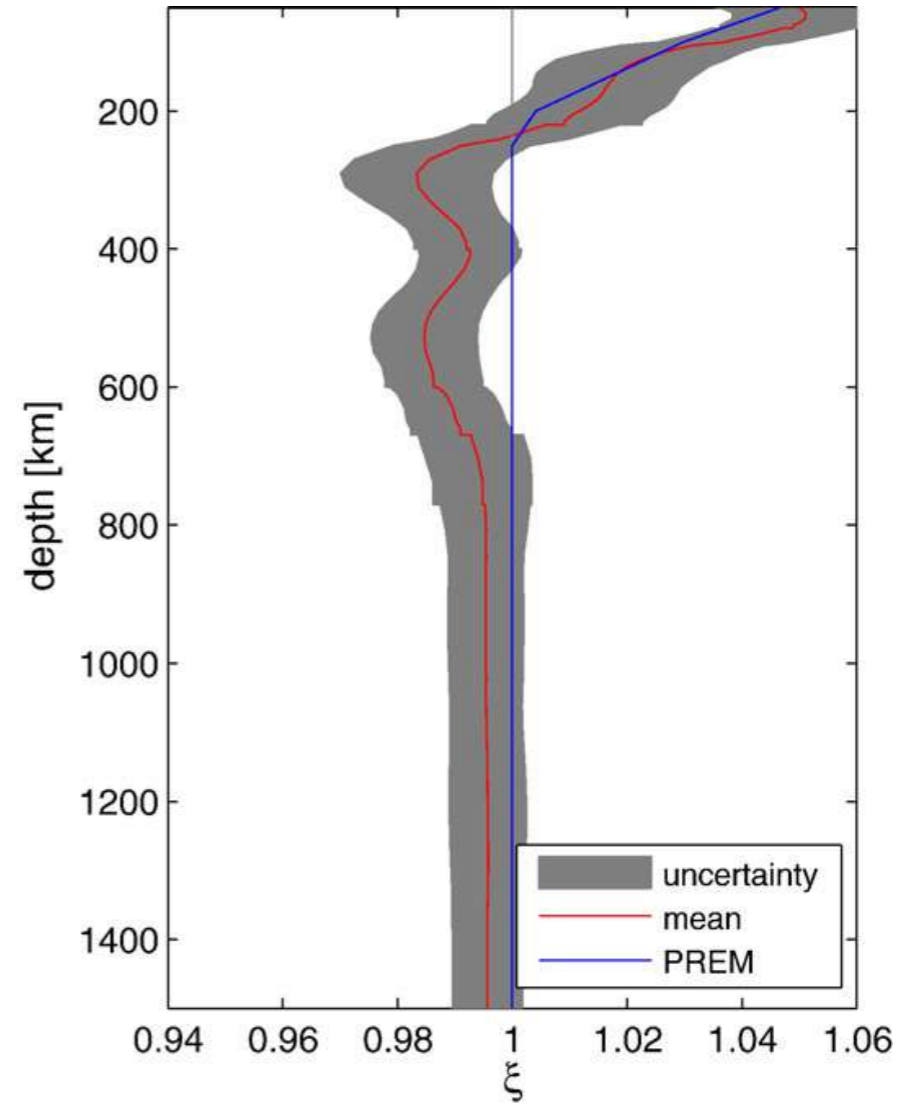
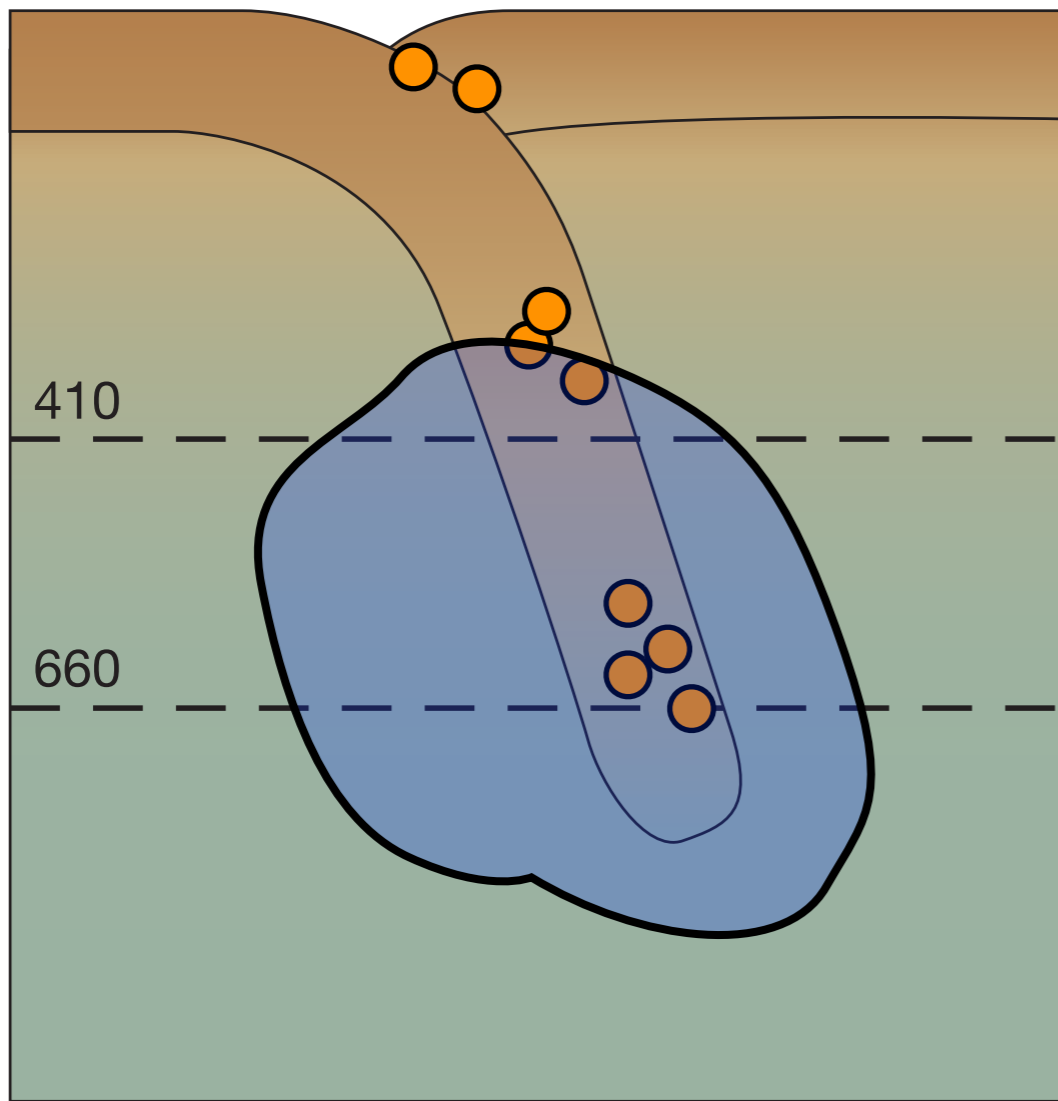


*Deep earthquakes: observations,
experiments and explanations*

RAS discussion meeting
London, 10 May 2019

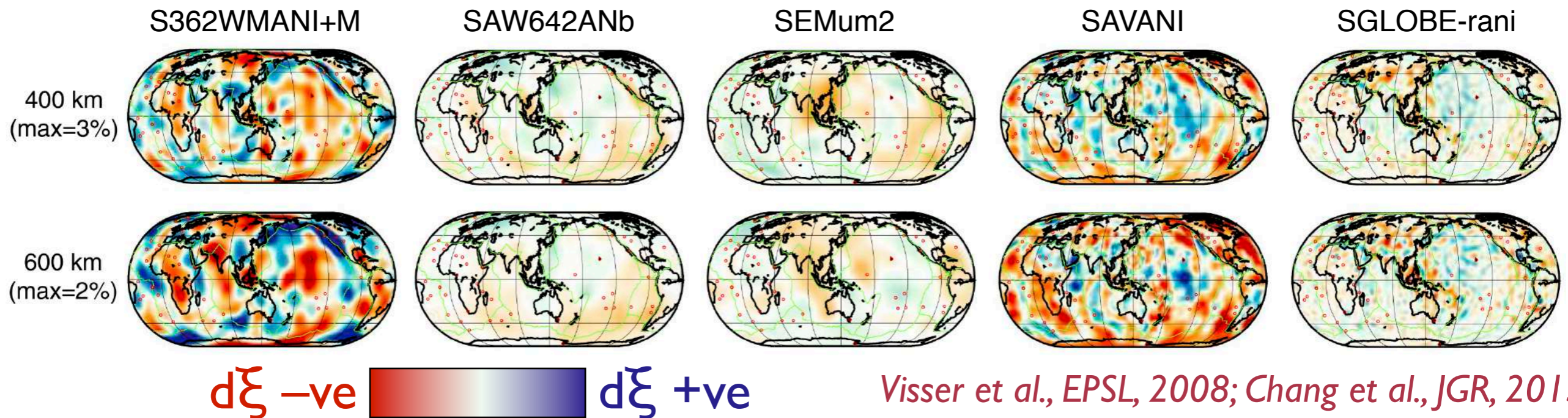
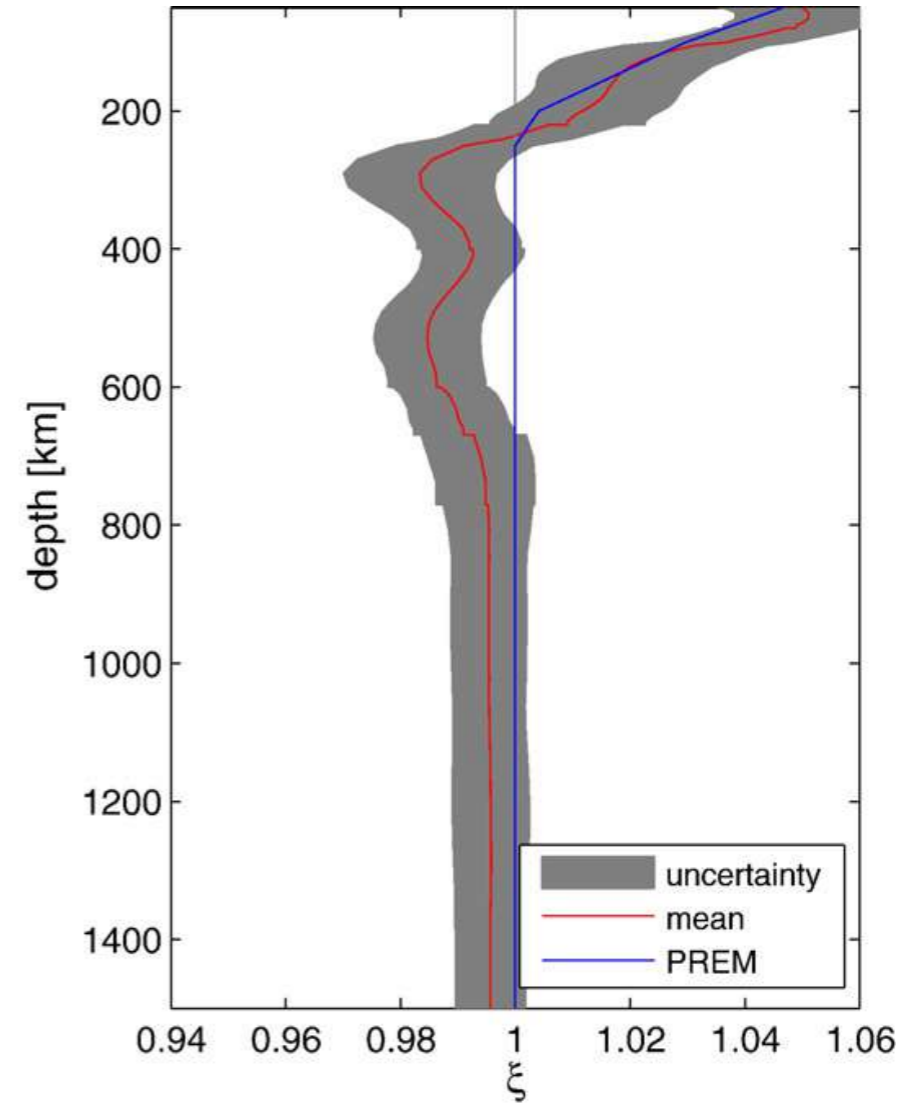
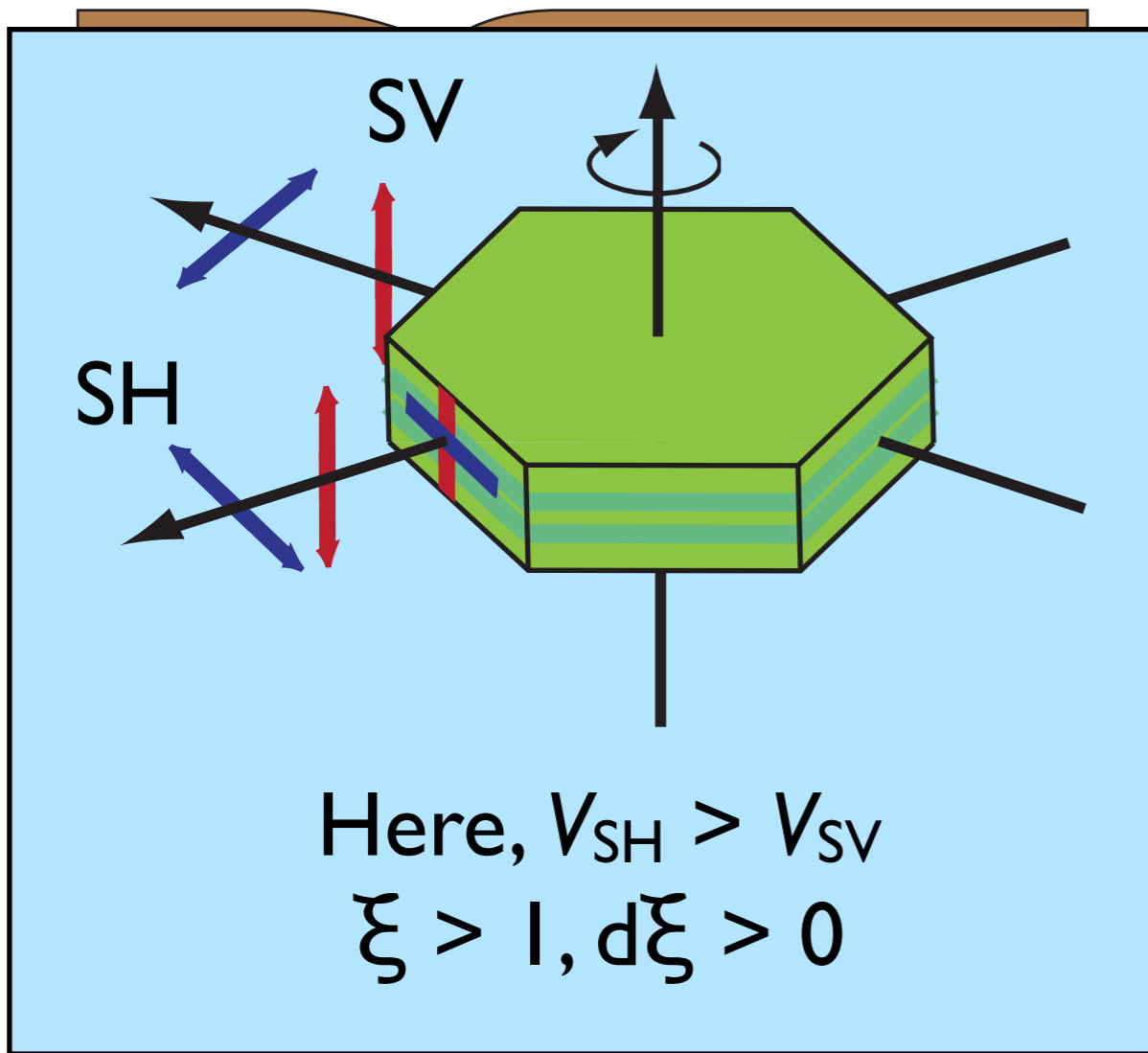
(Friday after UK-SEDI 2019 @ UCL)

Anisotropic TZ?

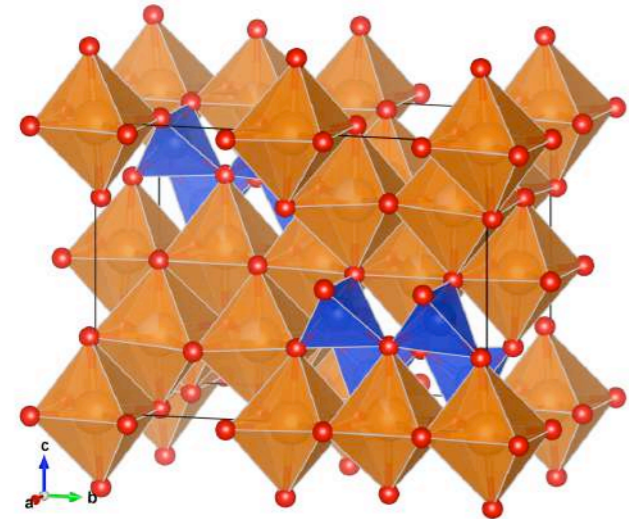
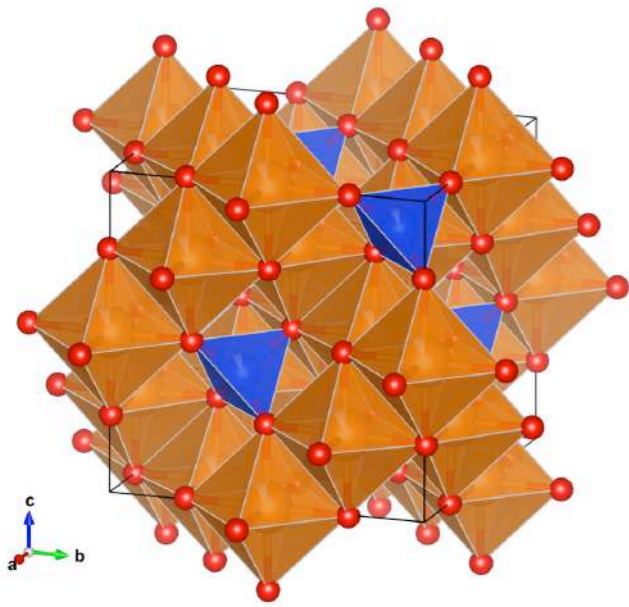


Visser et al., EPSL, 2008; Chang et al., JGR, 2015

Anisotropic TZ?



Major phases in TZ

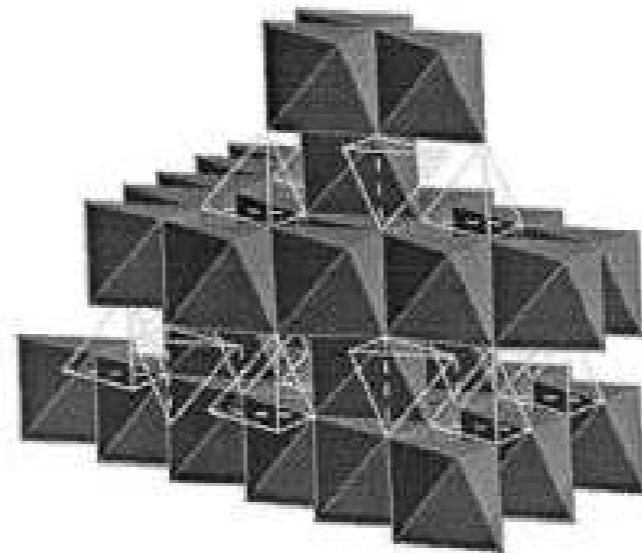
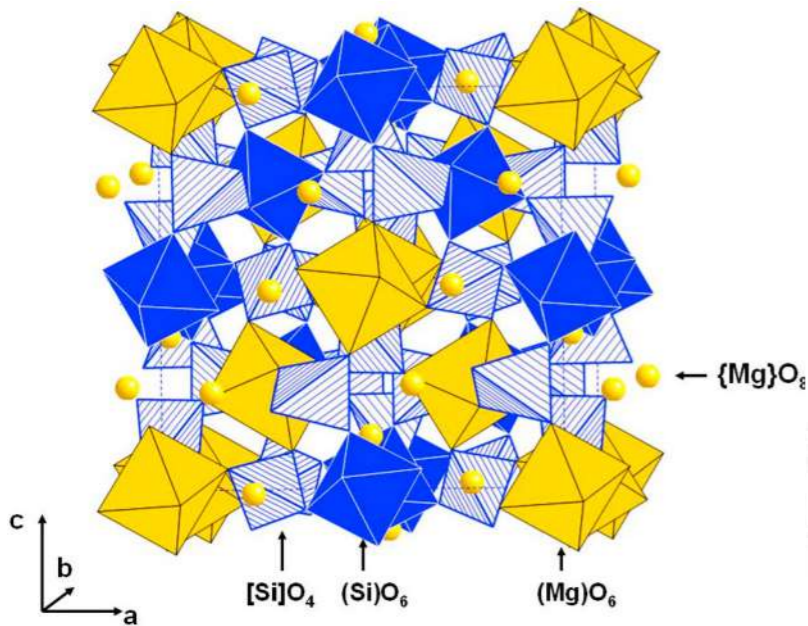


- Ringwoodite

- Wadsleyite

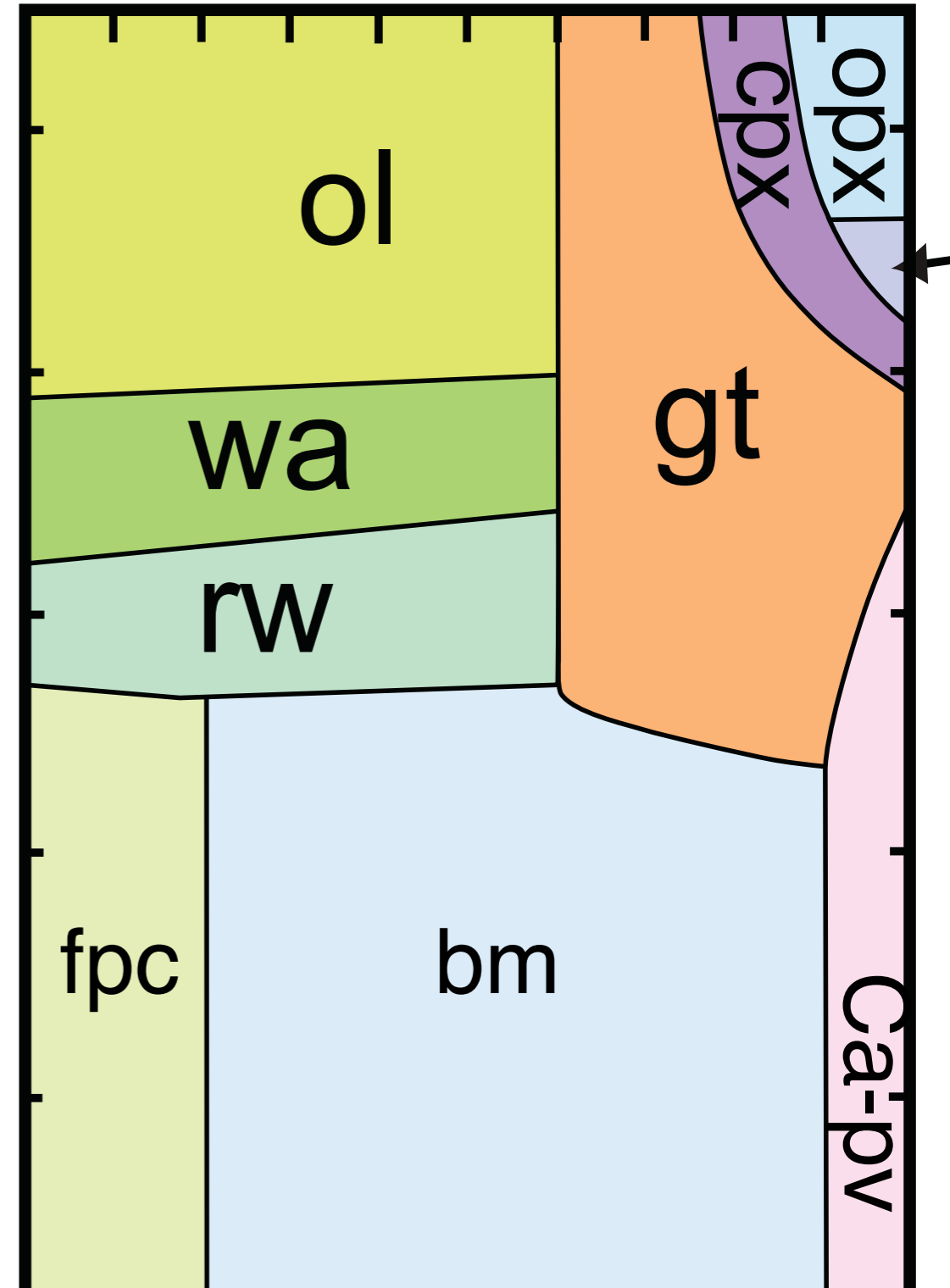
- Majorite

- Ca-perovskite



% prop. in pyrolite

20 40 60 80



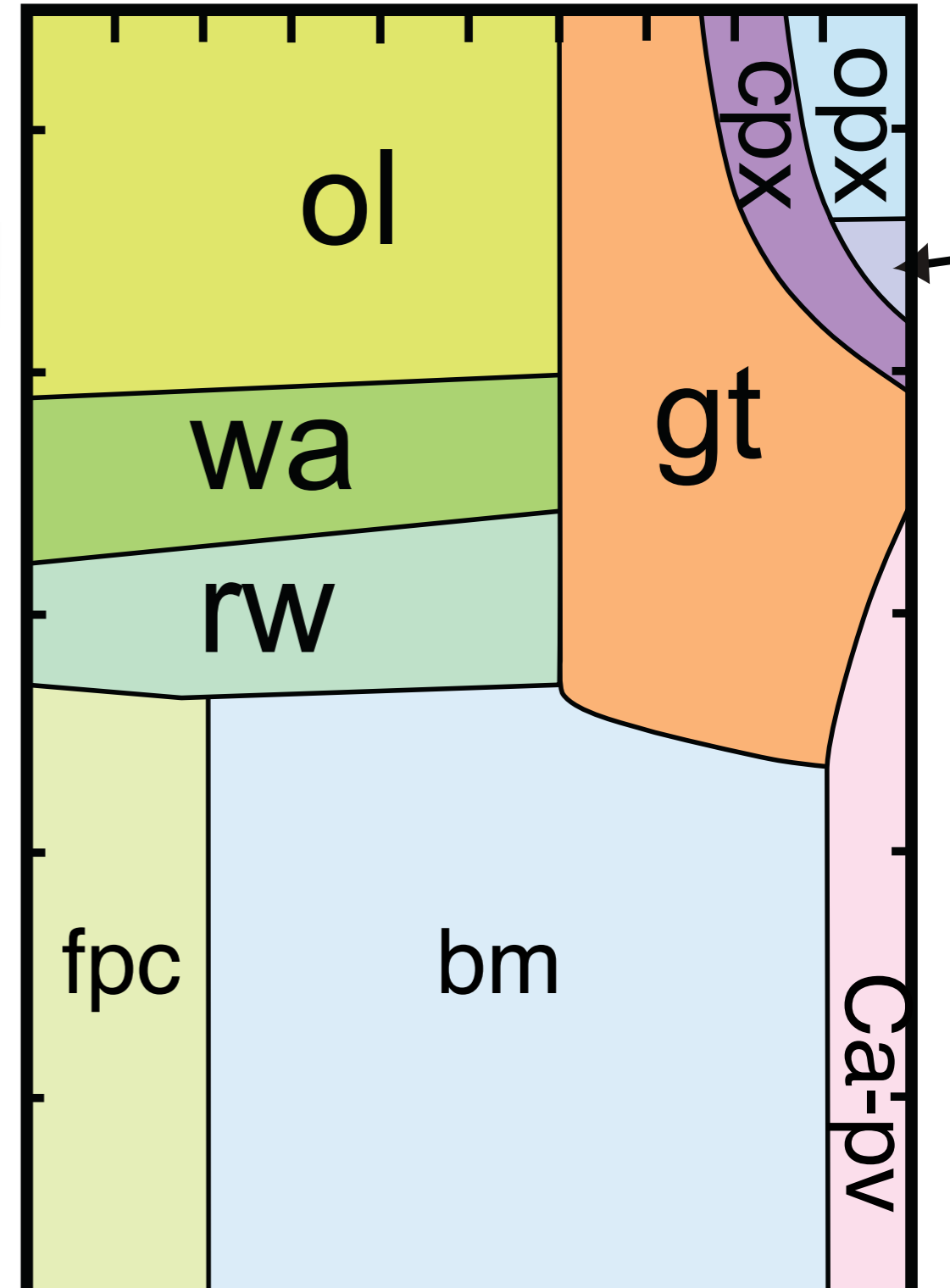
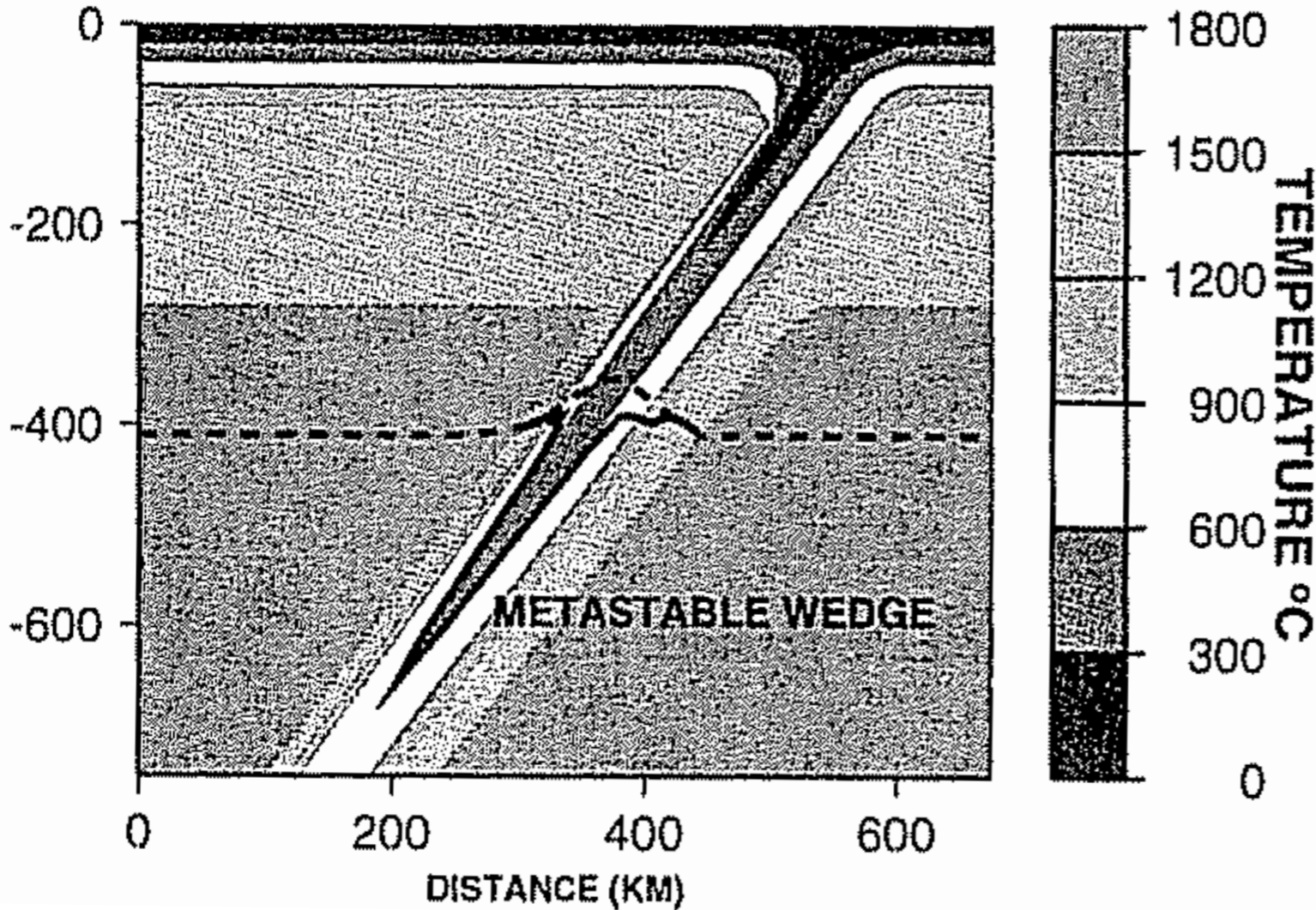
Major phases in TZ



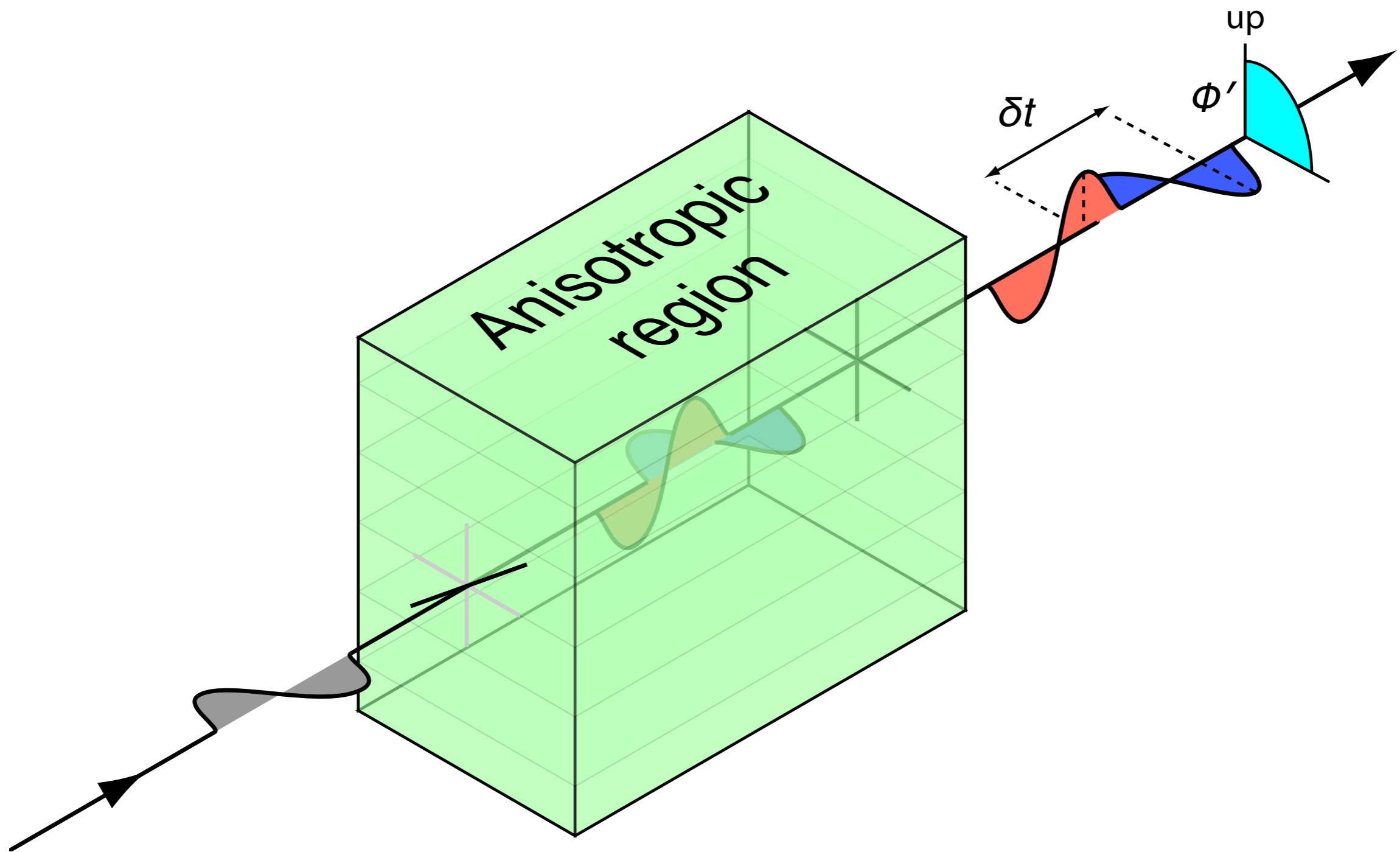
- Metastable olivine

% prop. in pyrolite

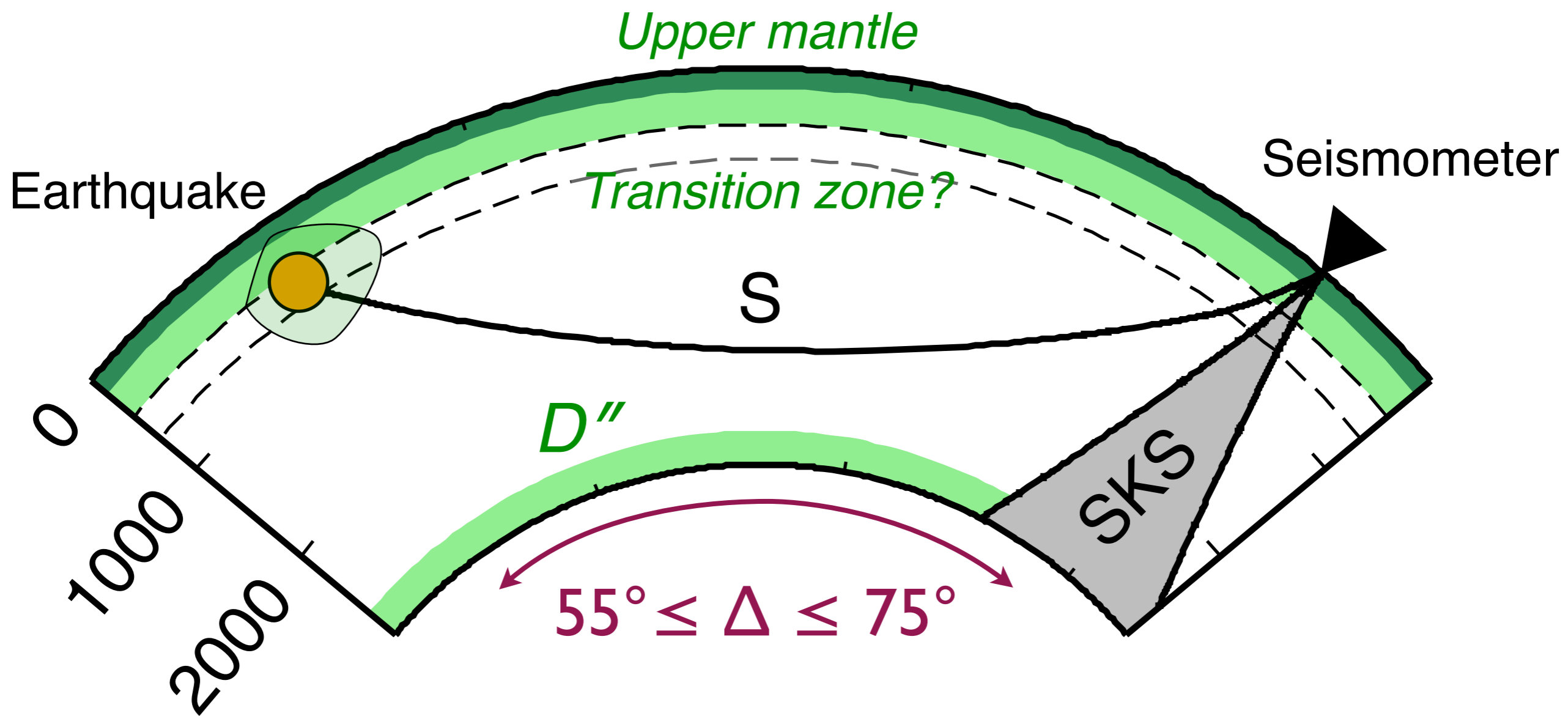
20 40 60 80



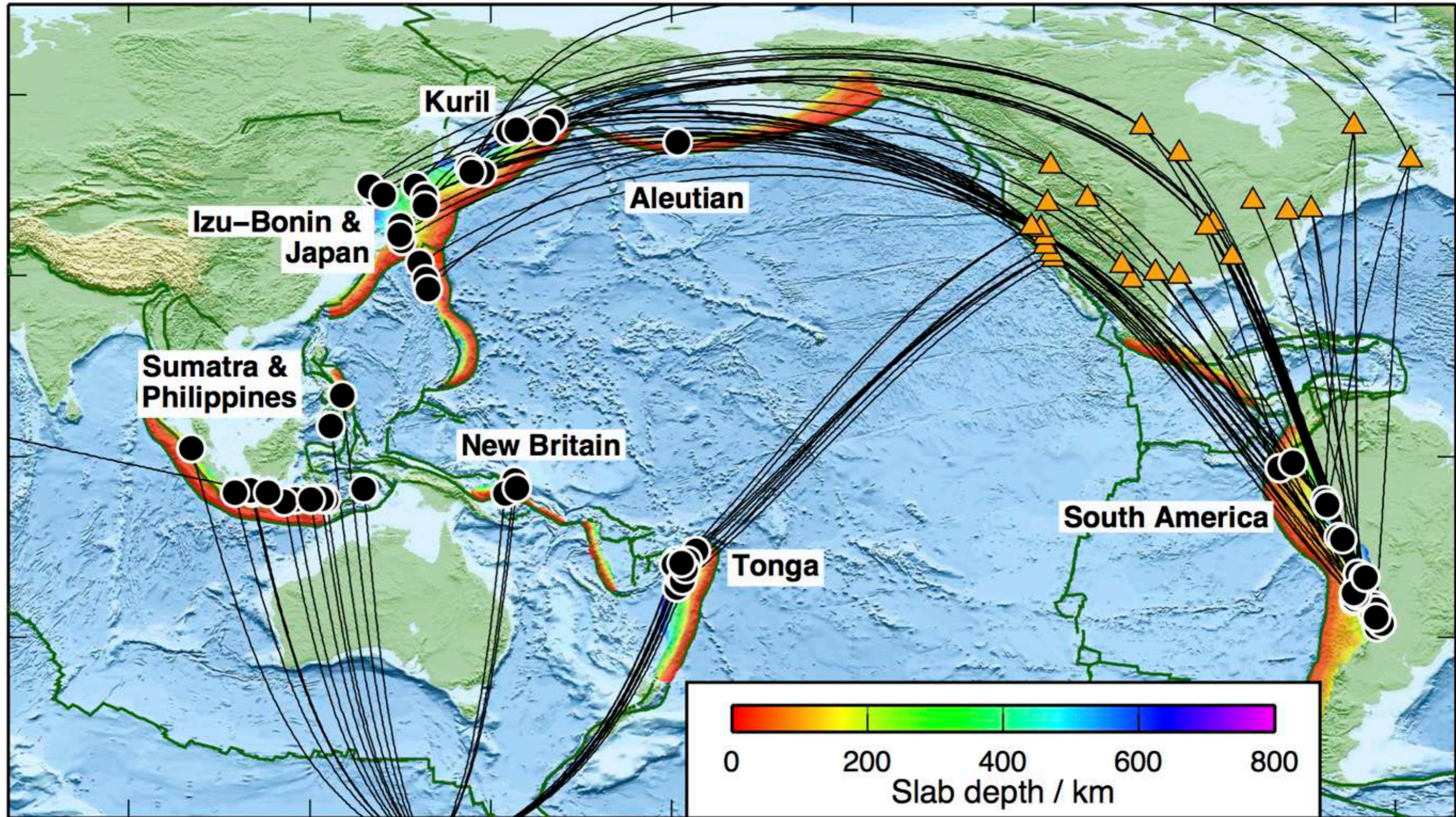
Anisotropy and shear wave splitting



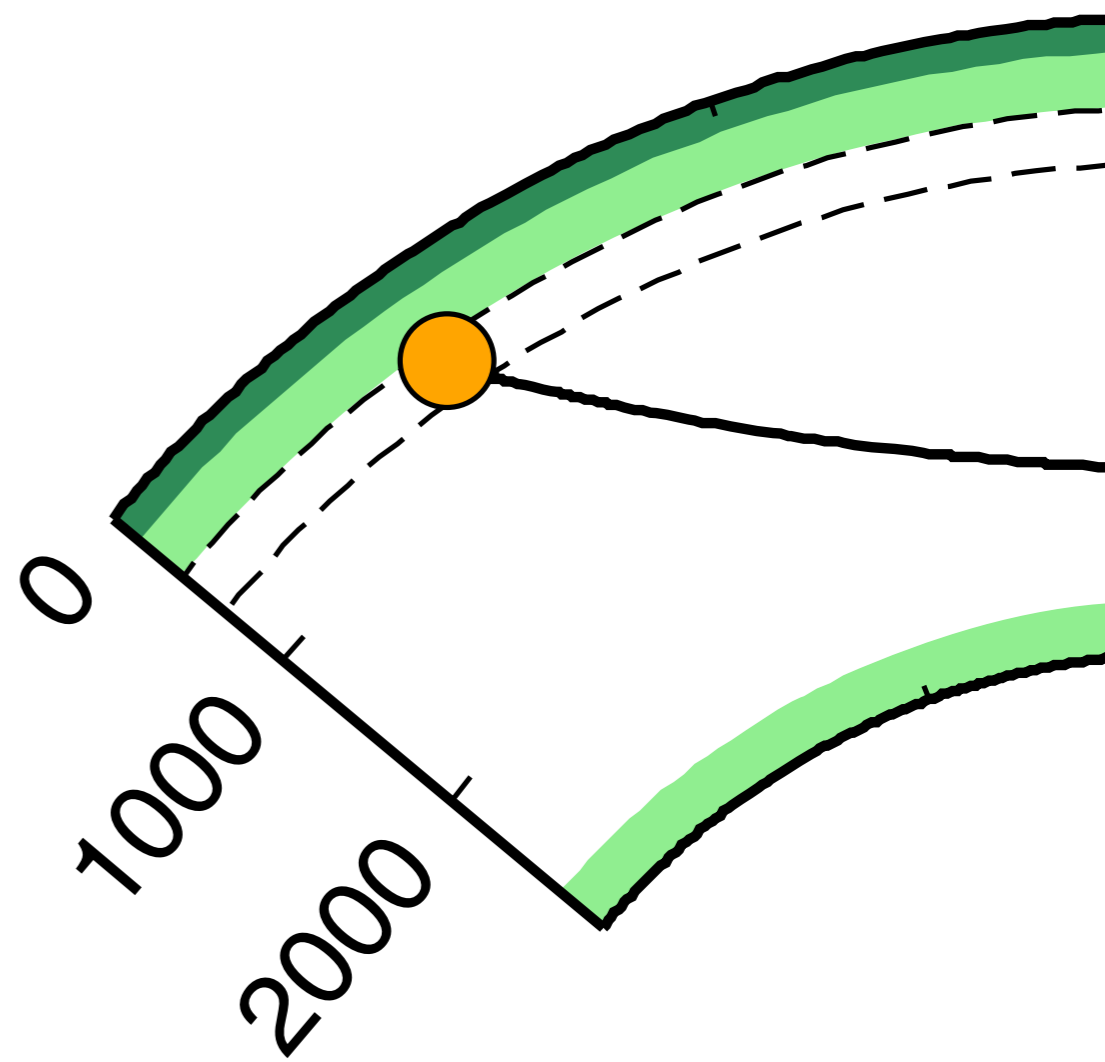
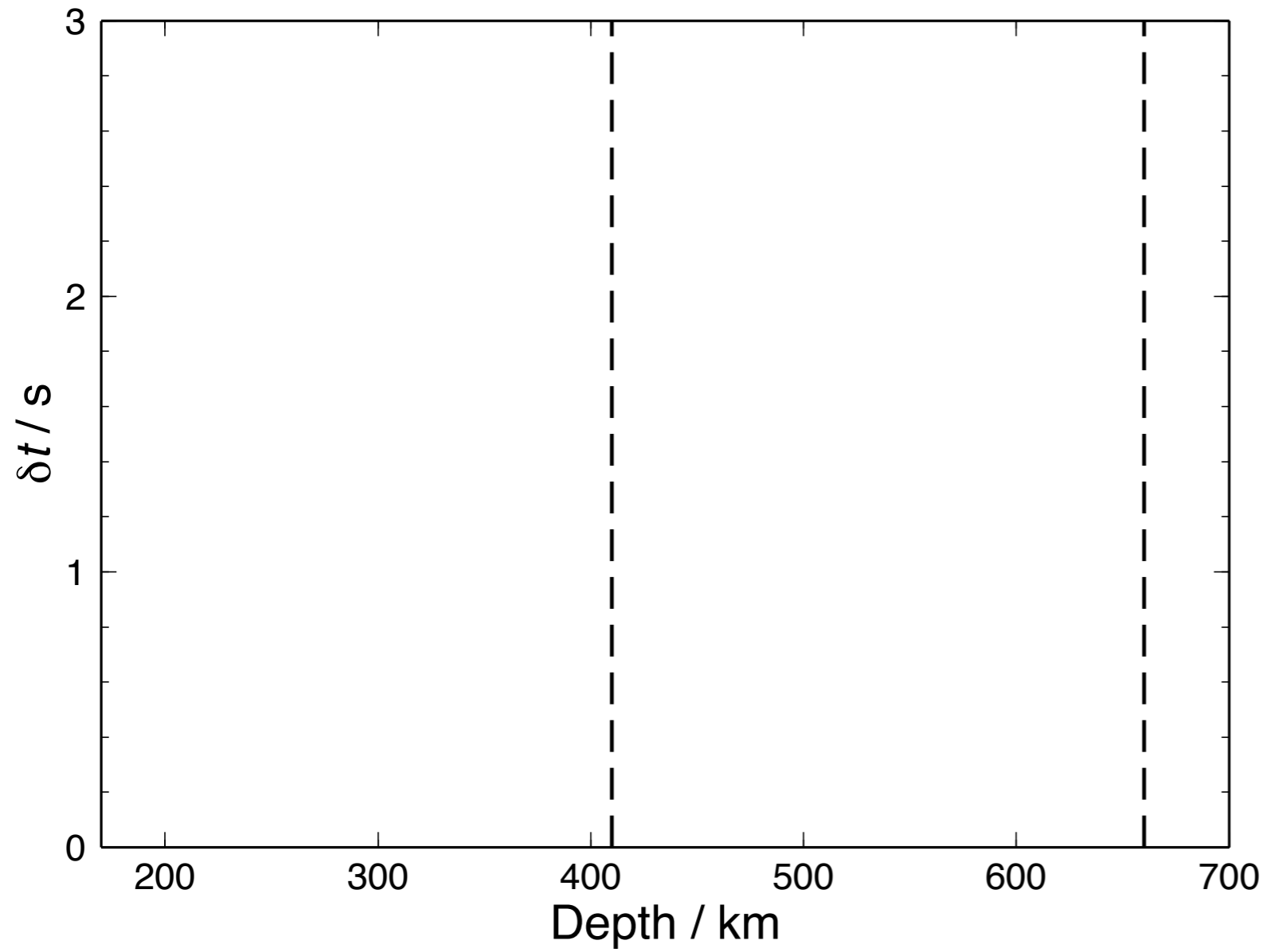
Method



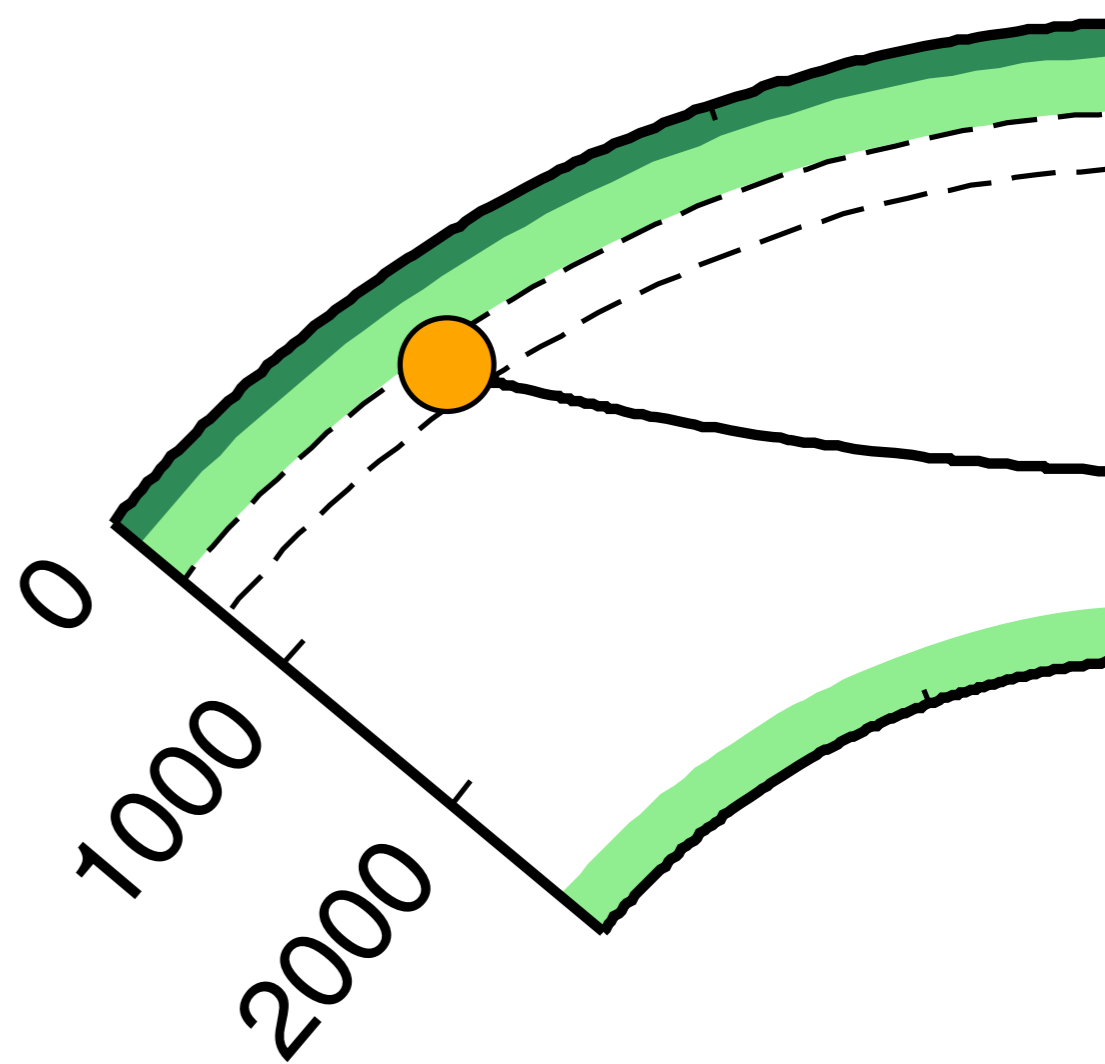
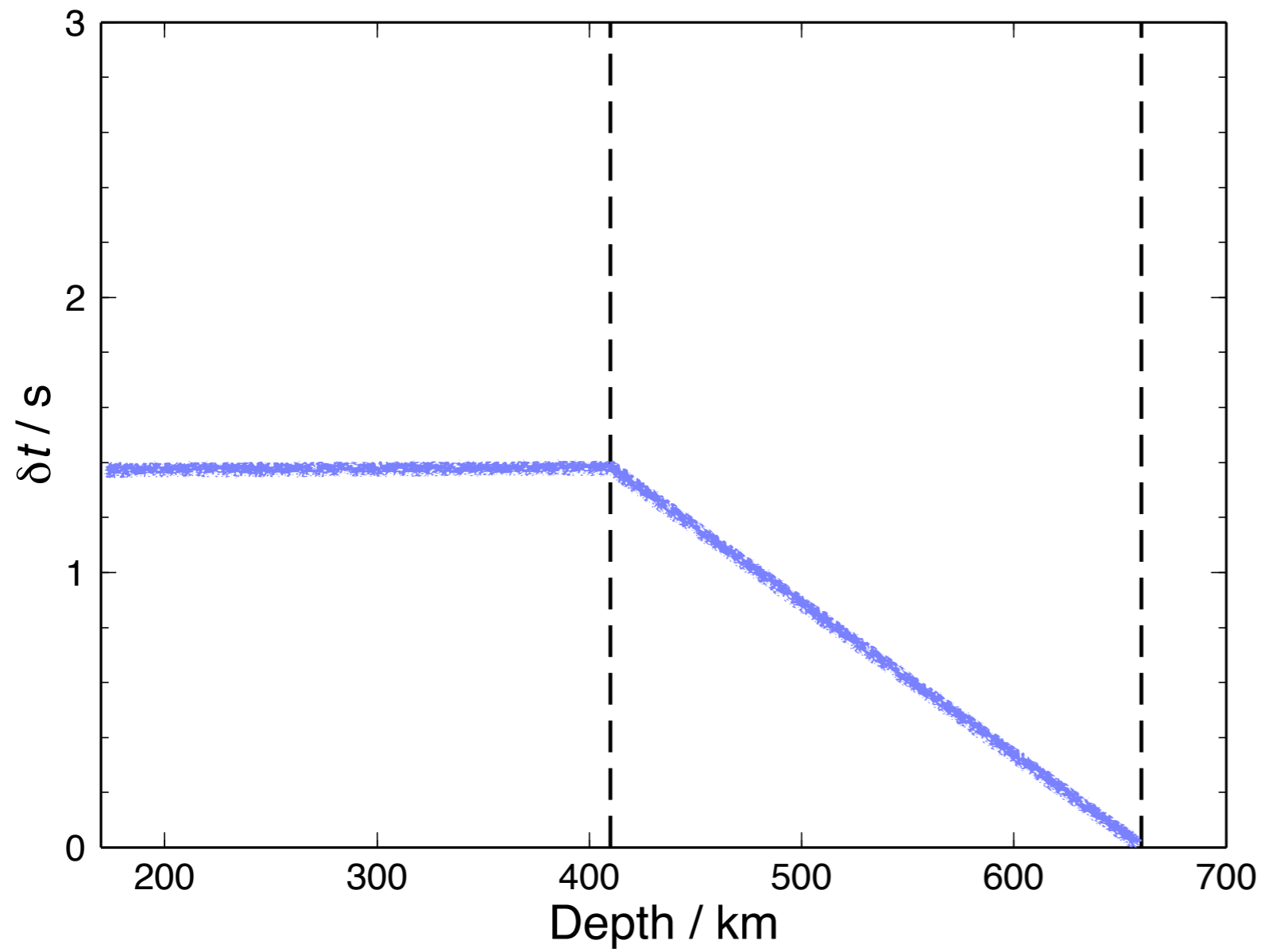
Method



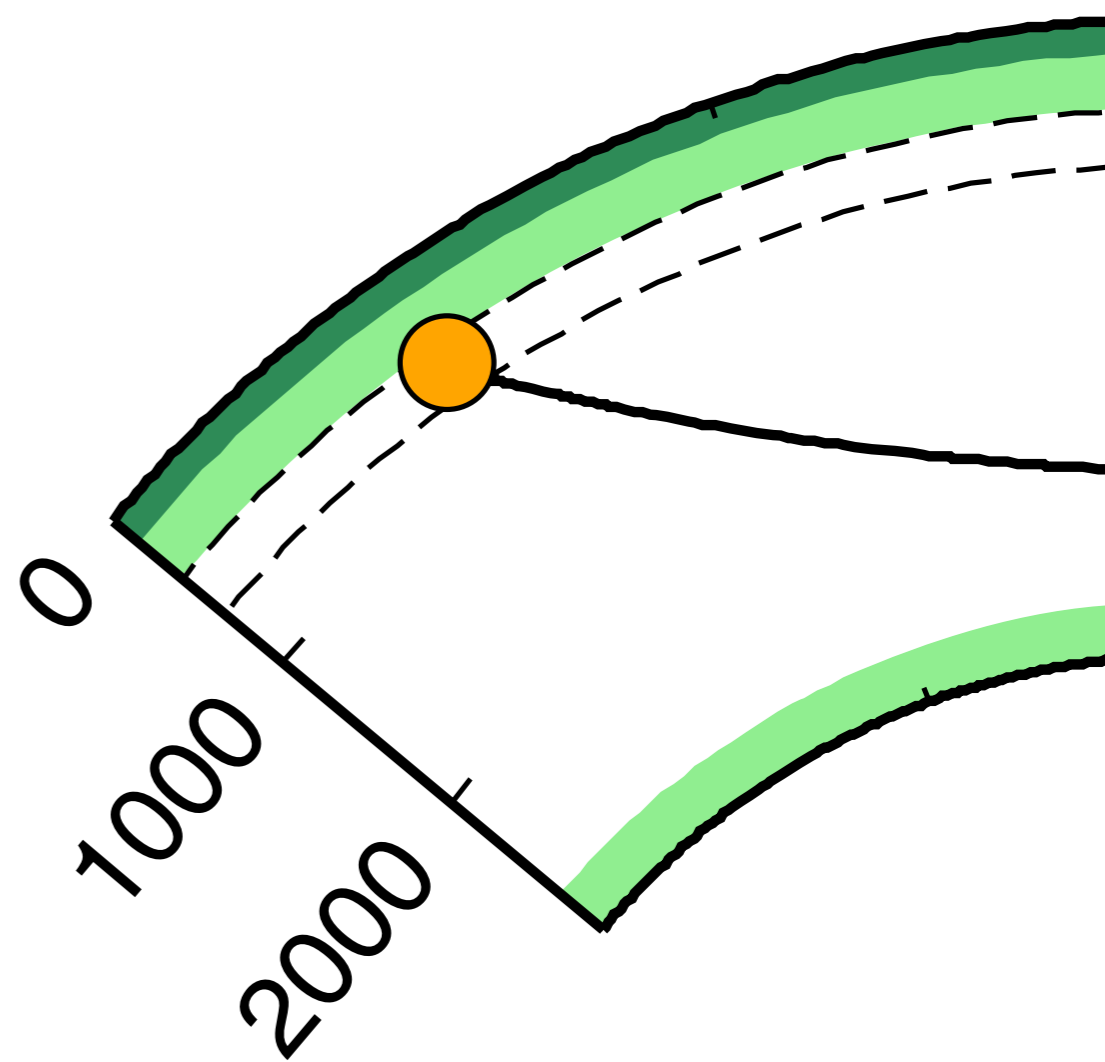
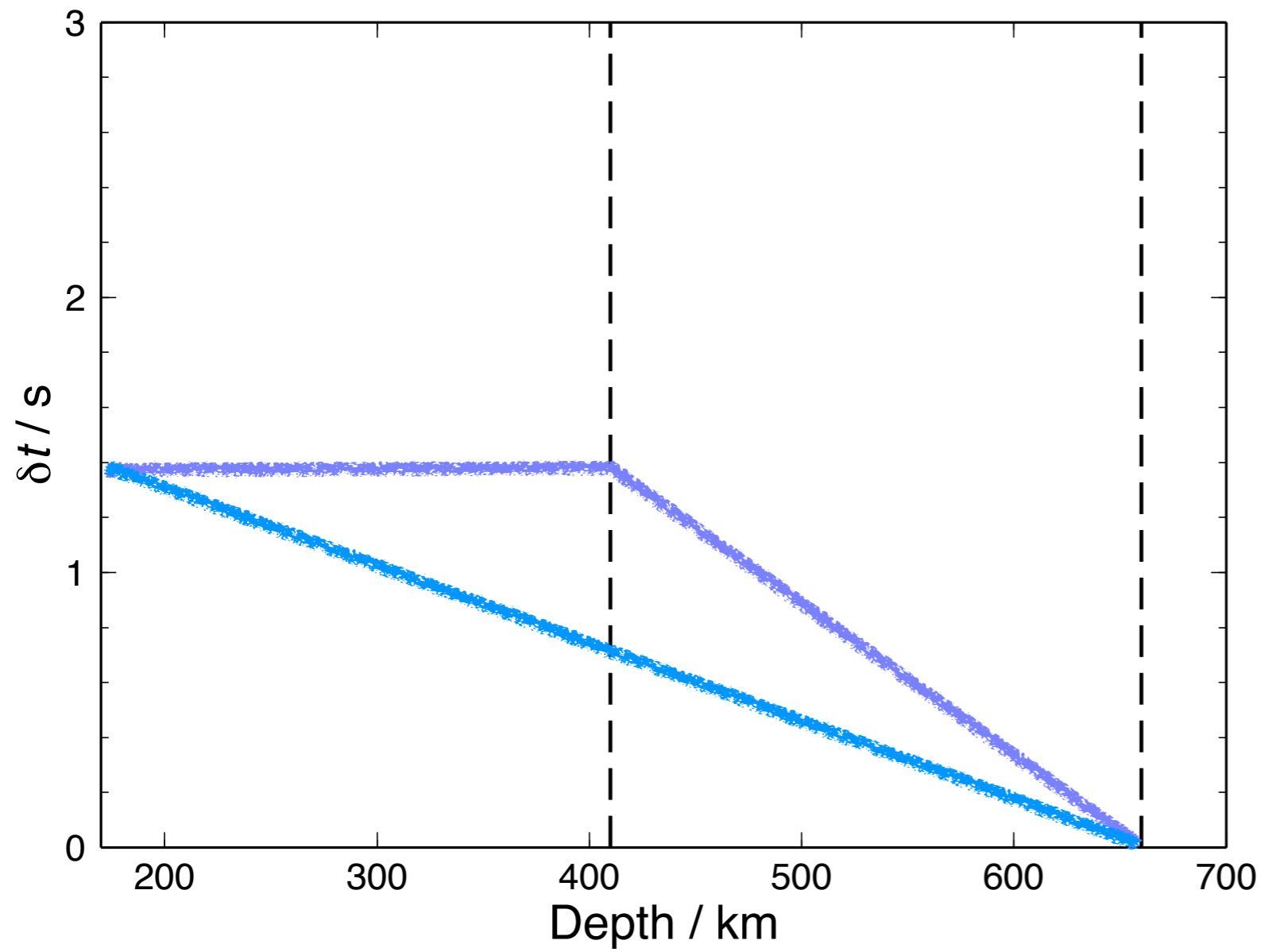
Results



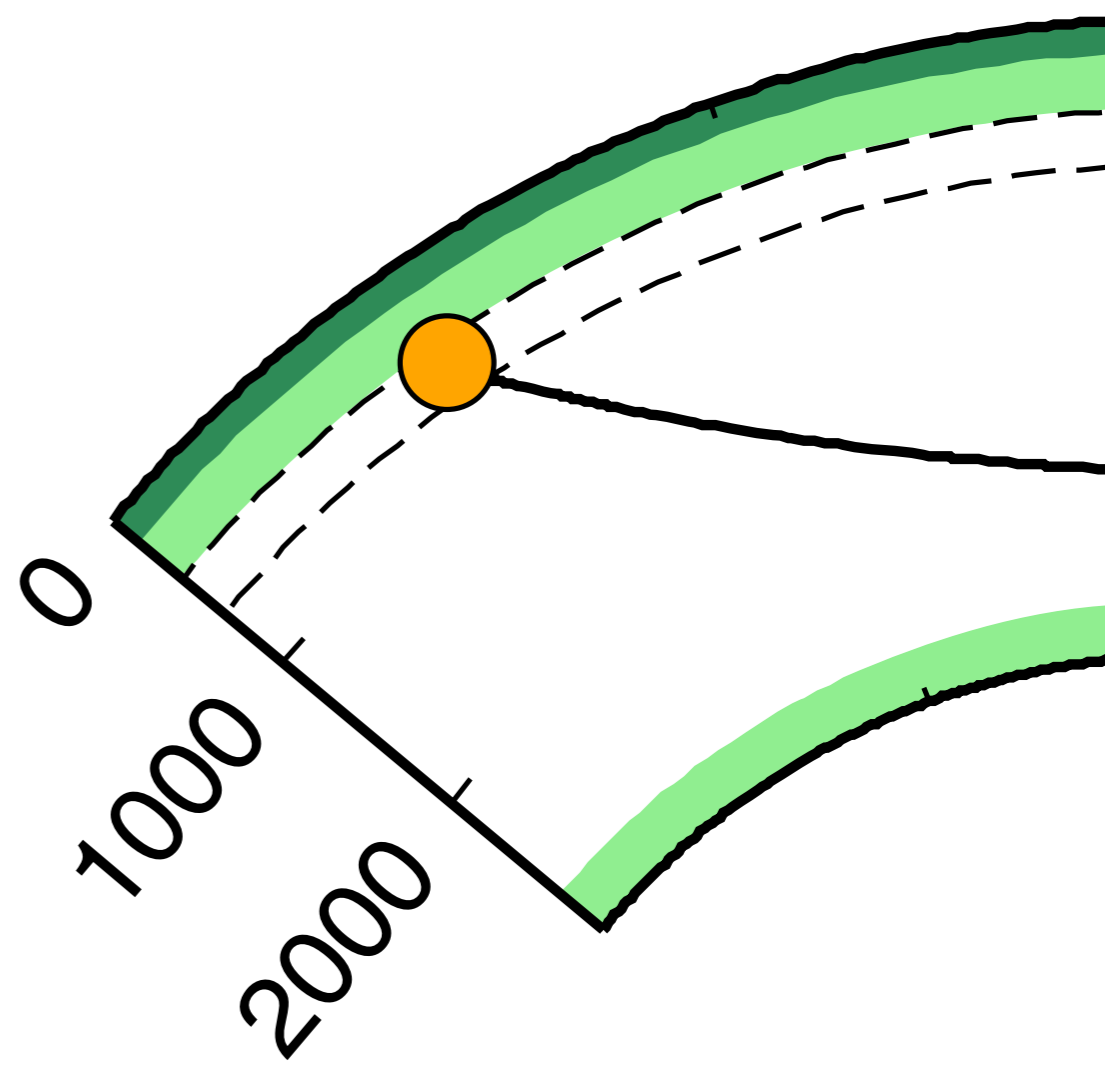
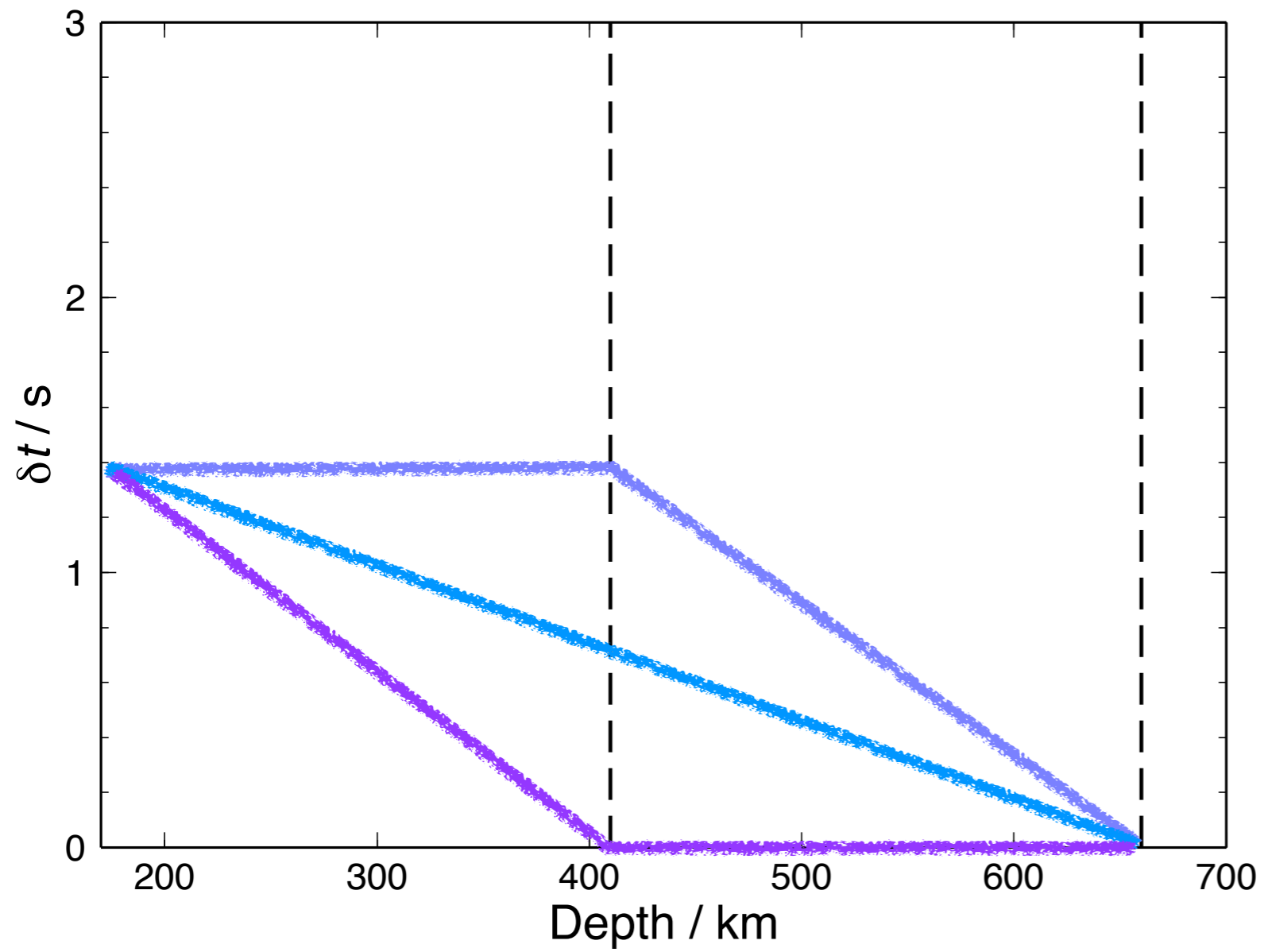
Results



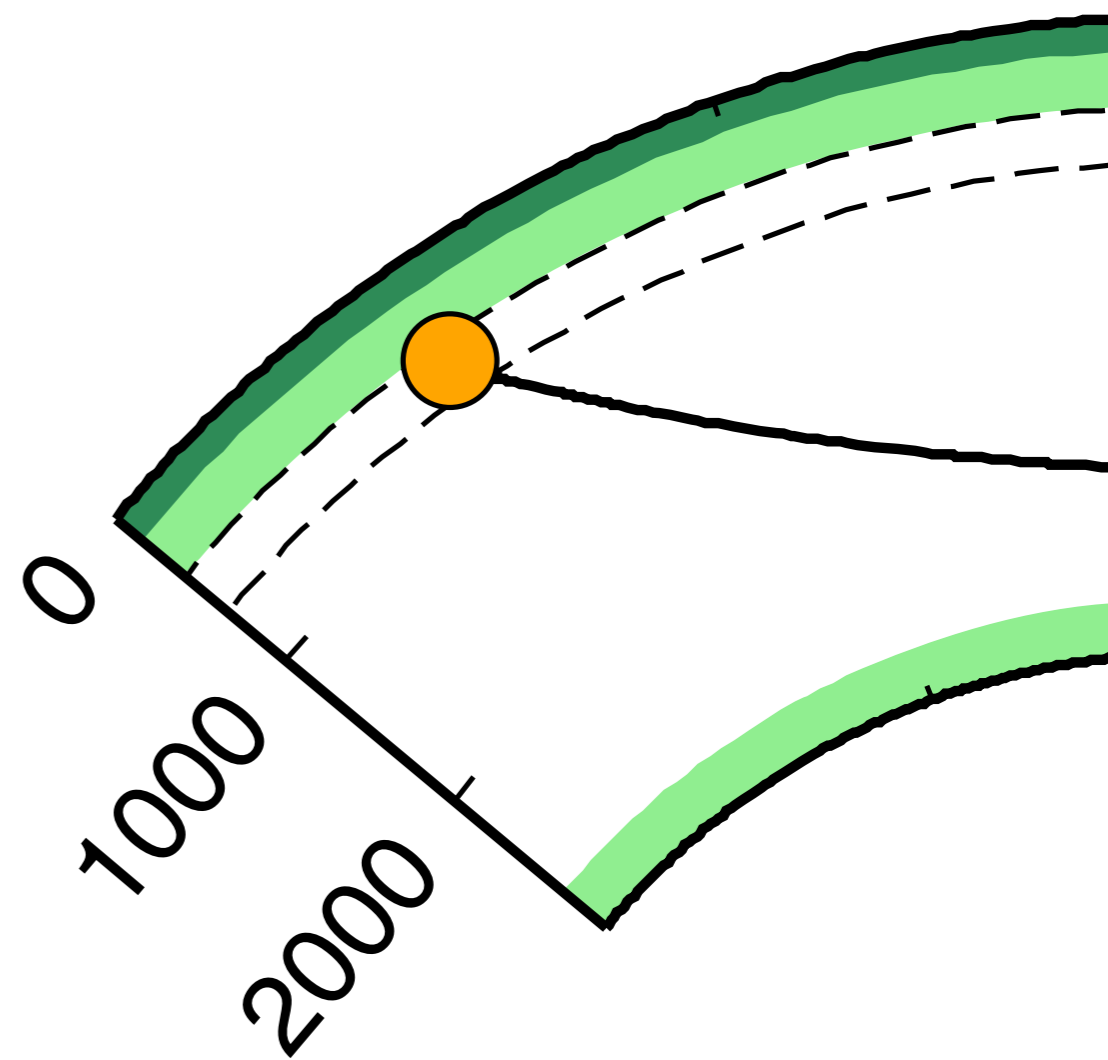
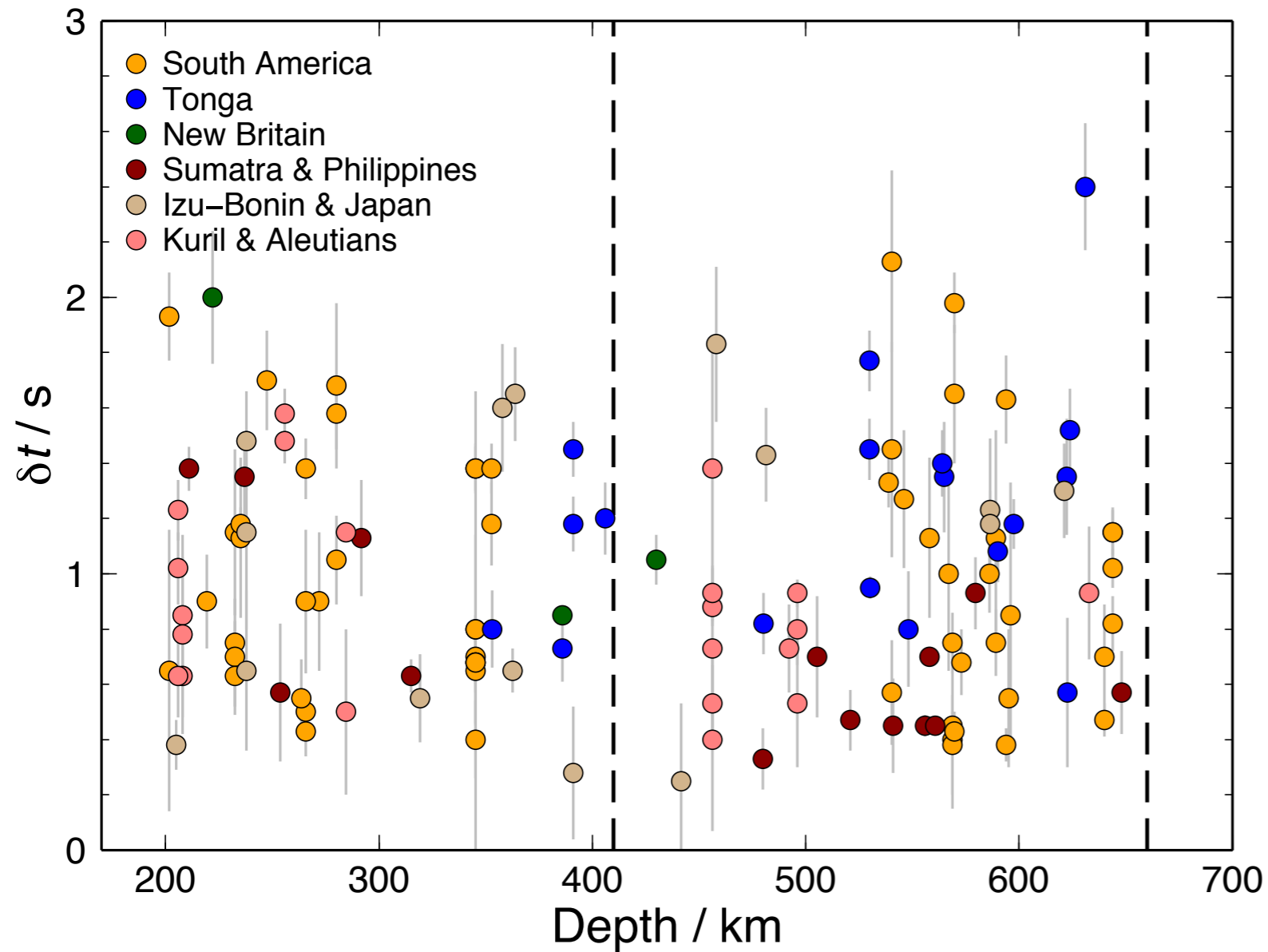
Results



Results

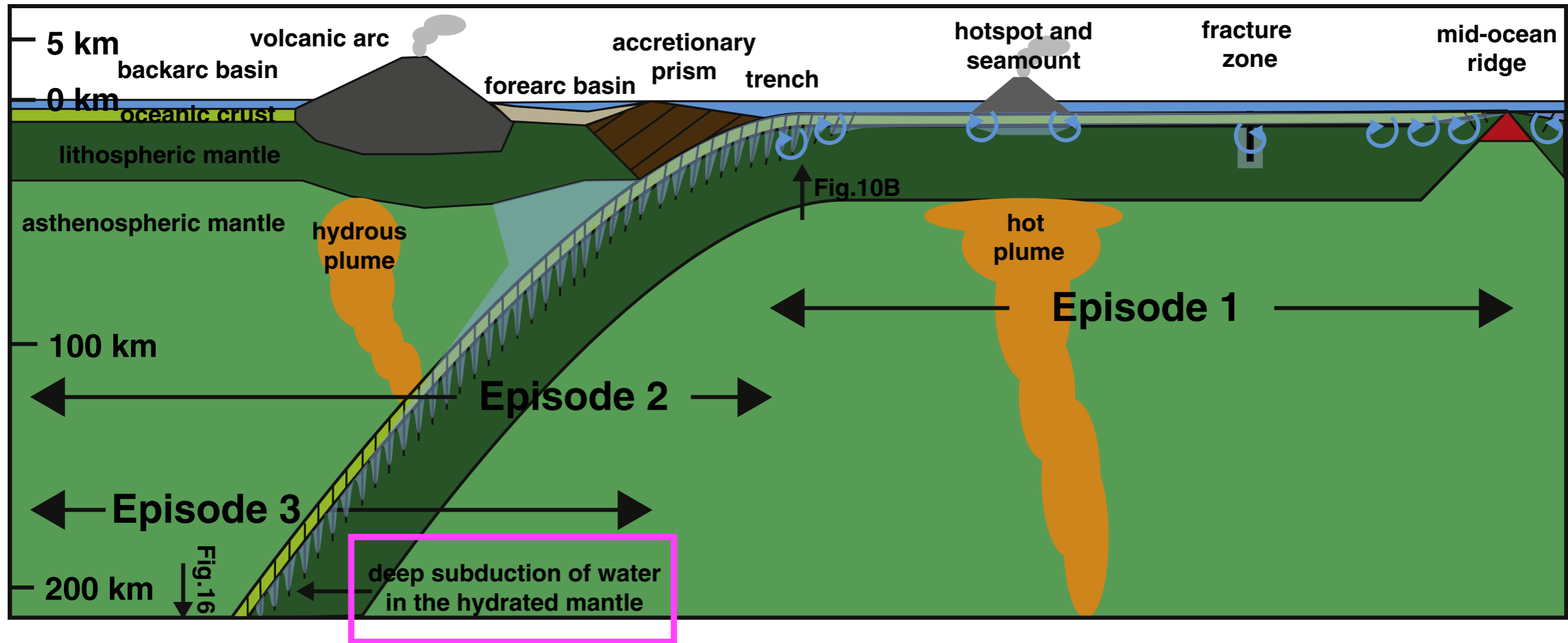


Results



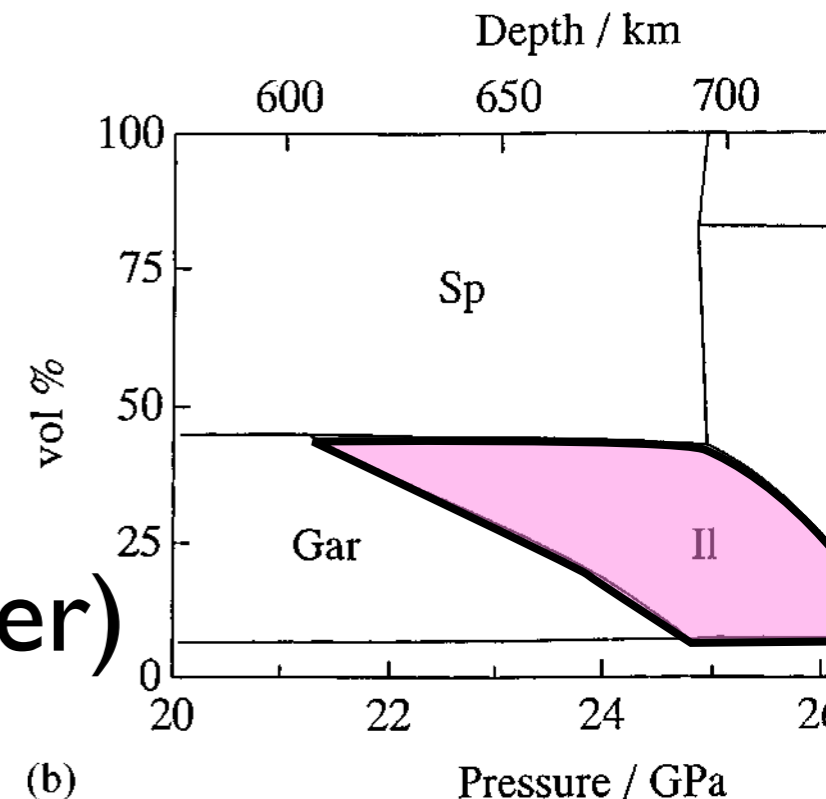
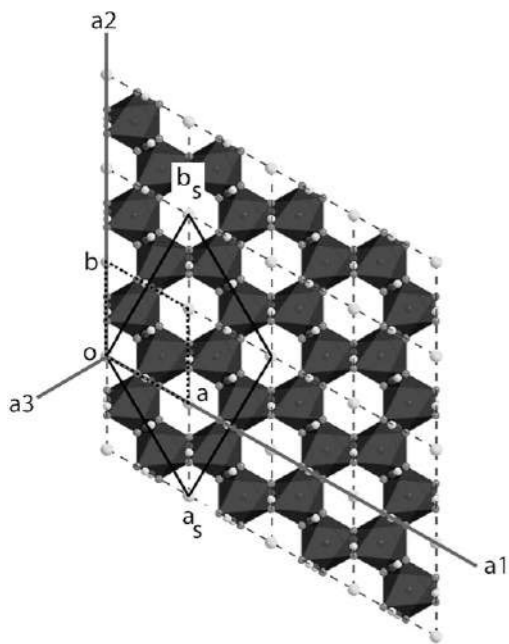
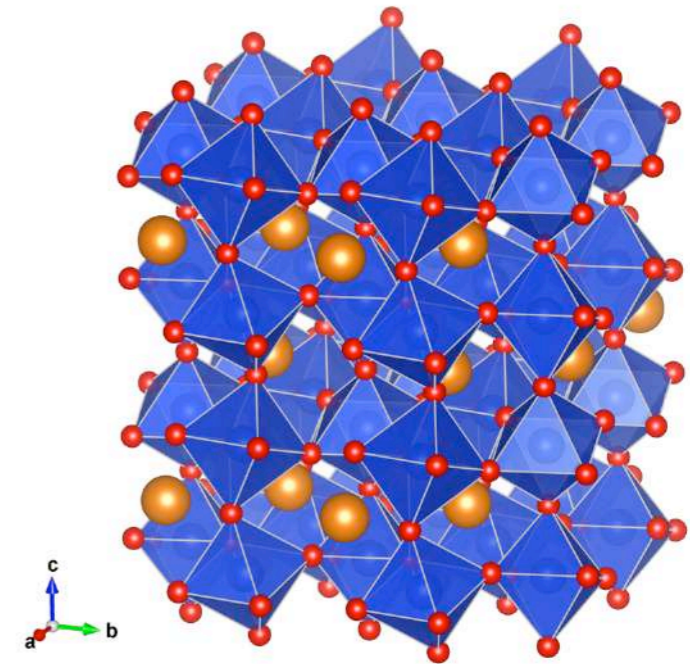
Transition zone near slabs is anisotropic

How did it get there?



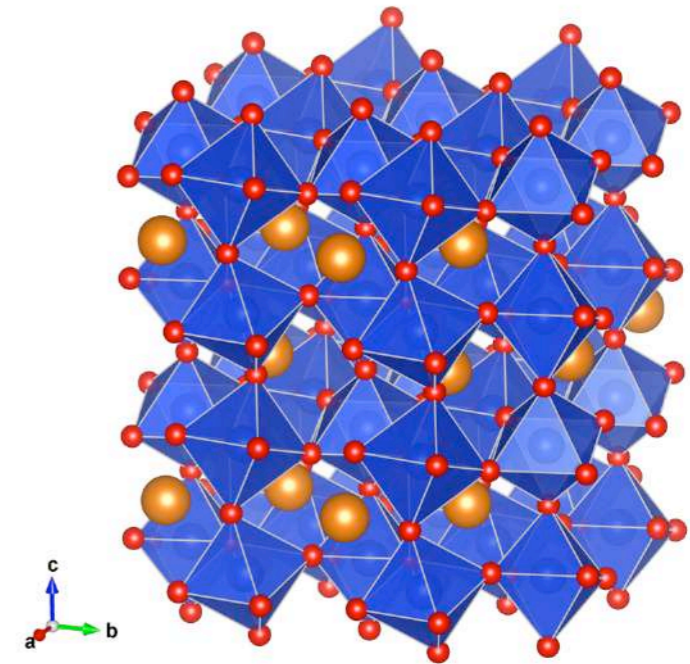
Some possible causes in lower TZ

- Ringwoodite
- Majorite
- Ca-perovskite
- Metastable olivine
- Bridgmanite in lower mantle
- DHMS: D, shyB
- Akimotoite (ilmenite form)
- Aligned inclusions (melt, other)

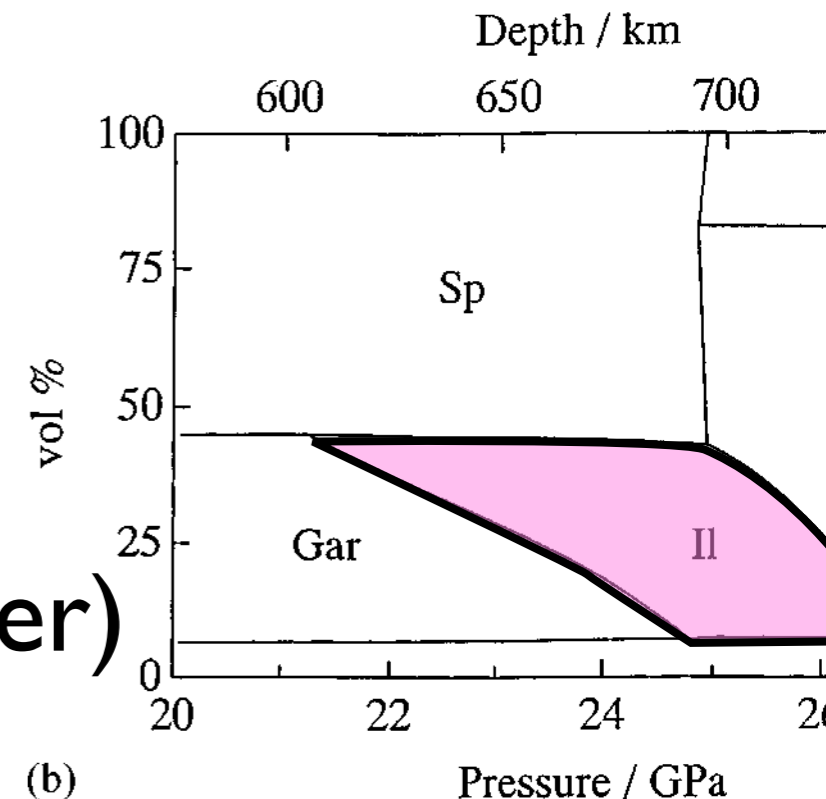
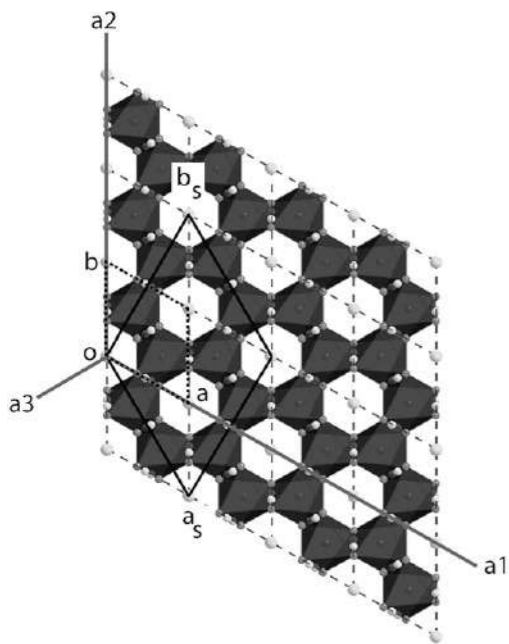


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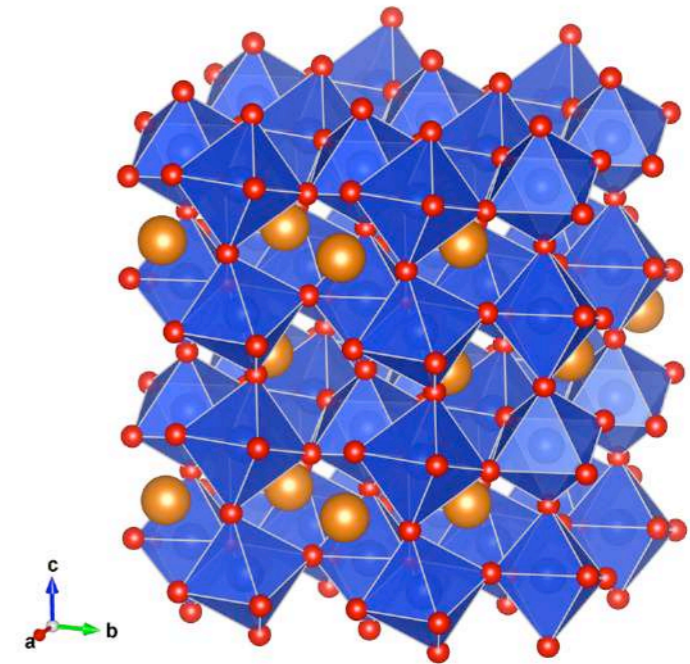


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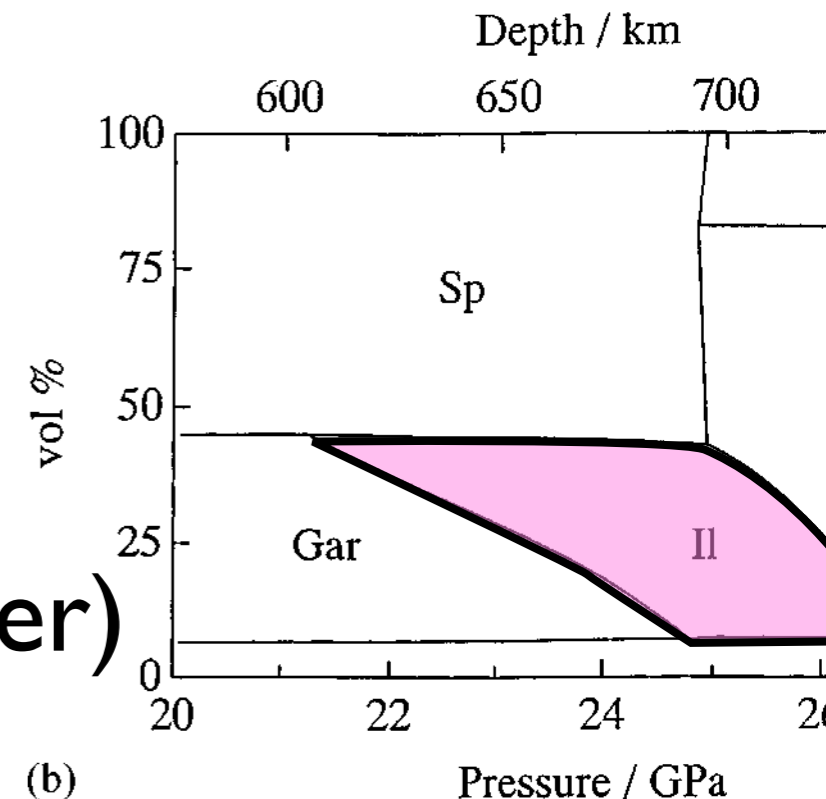
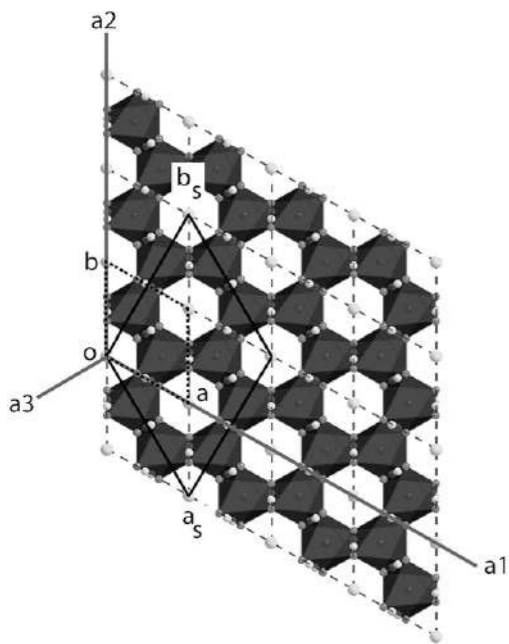


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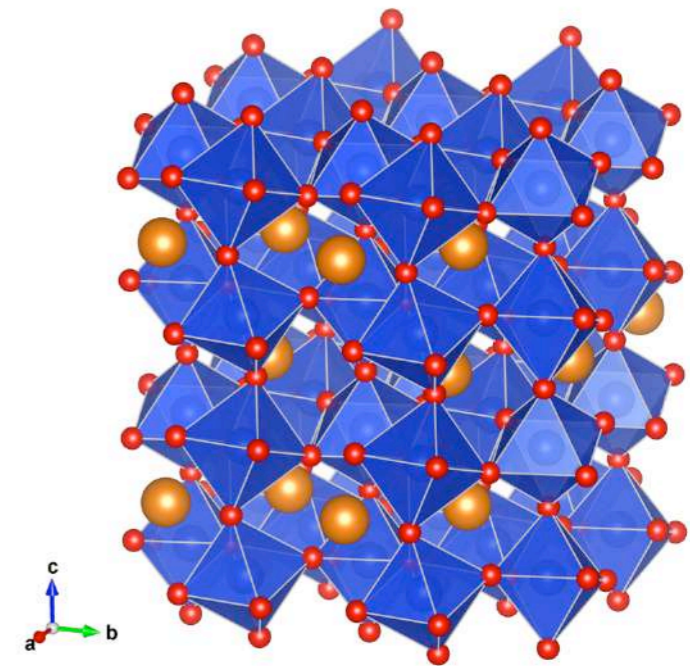


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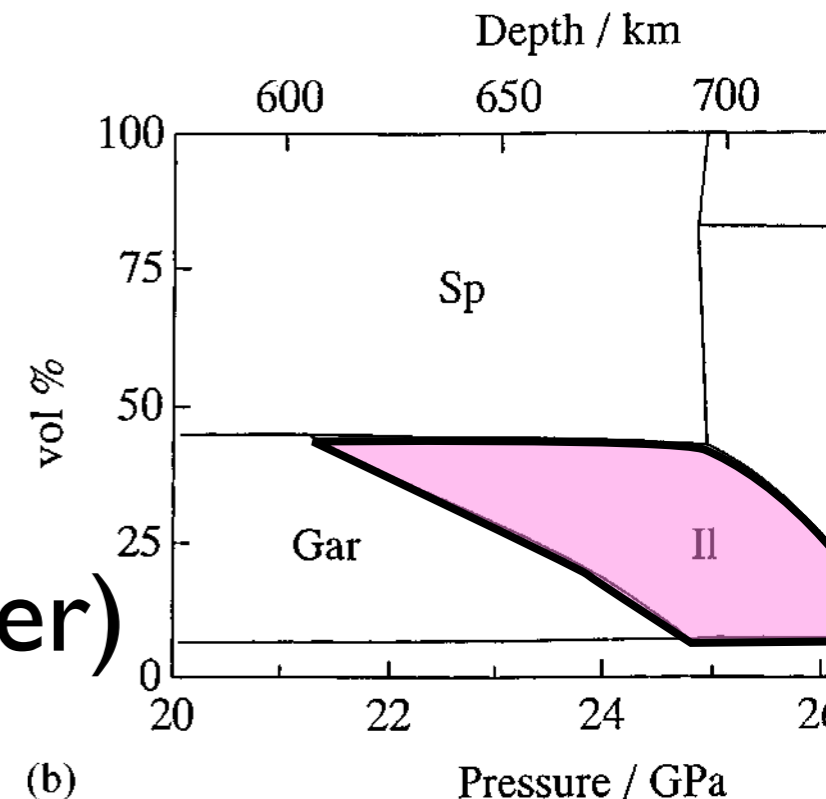
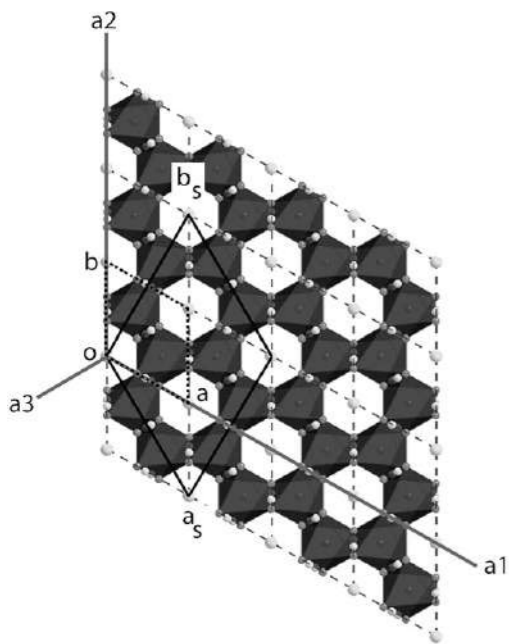
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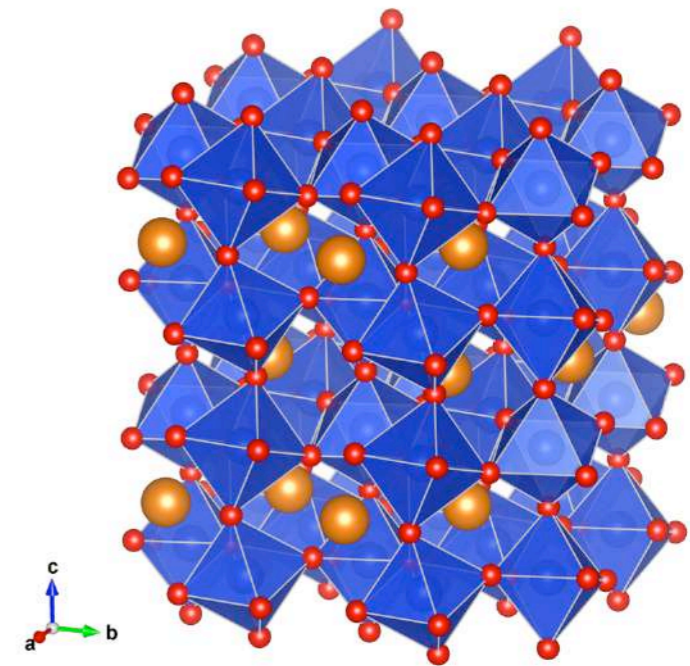
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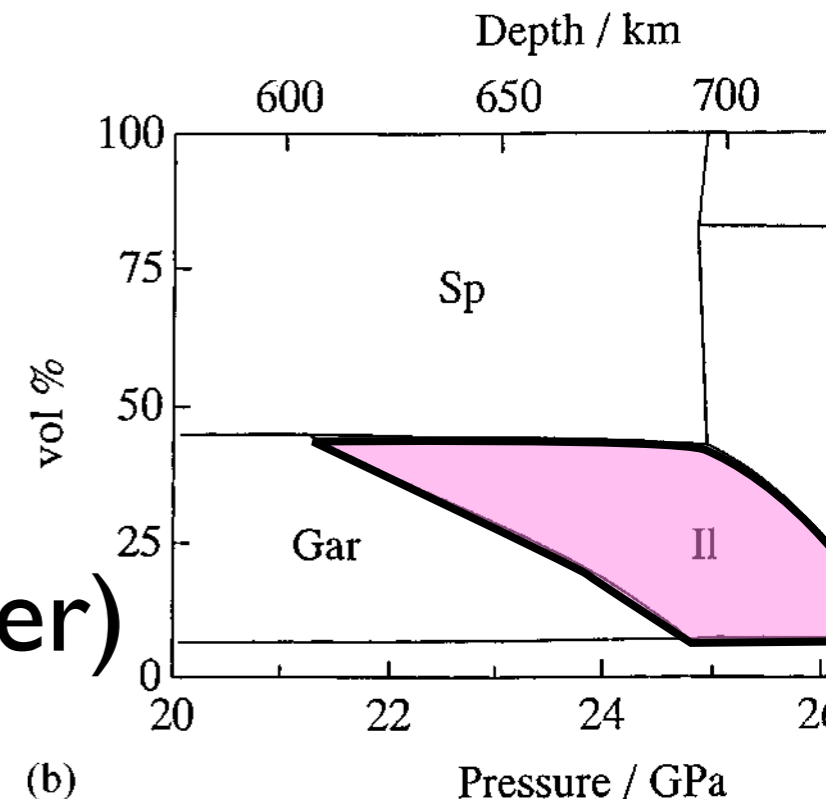
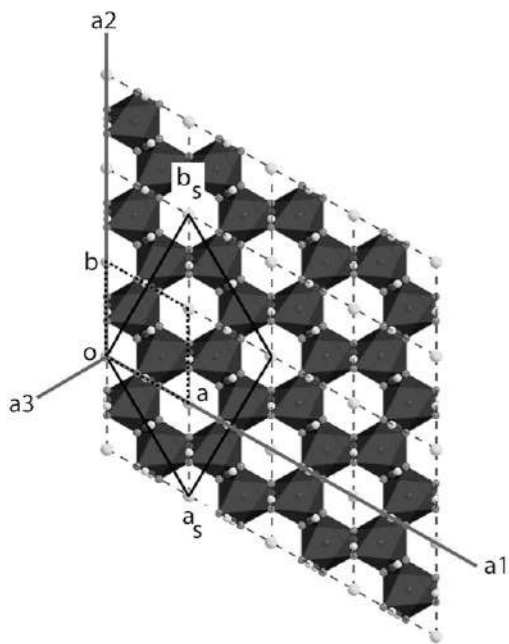
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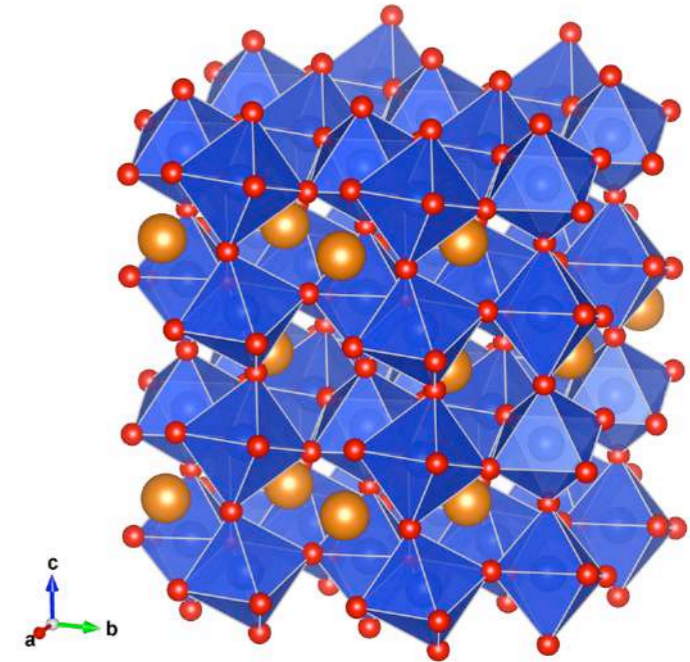


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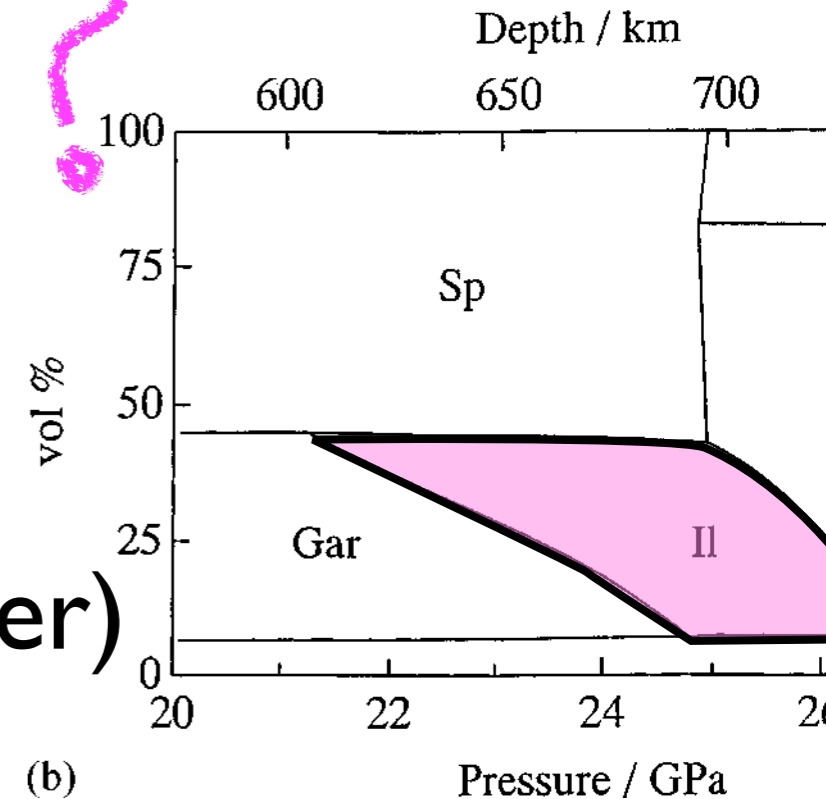
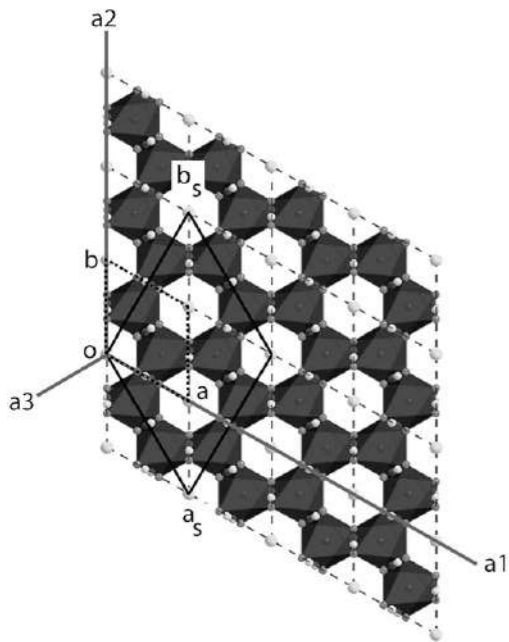


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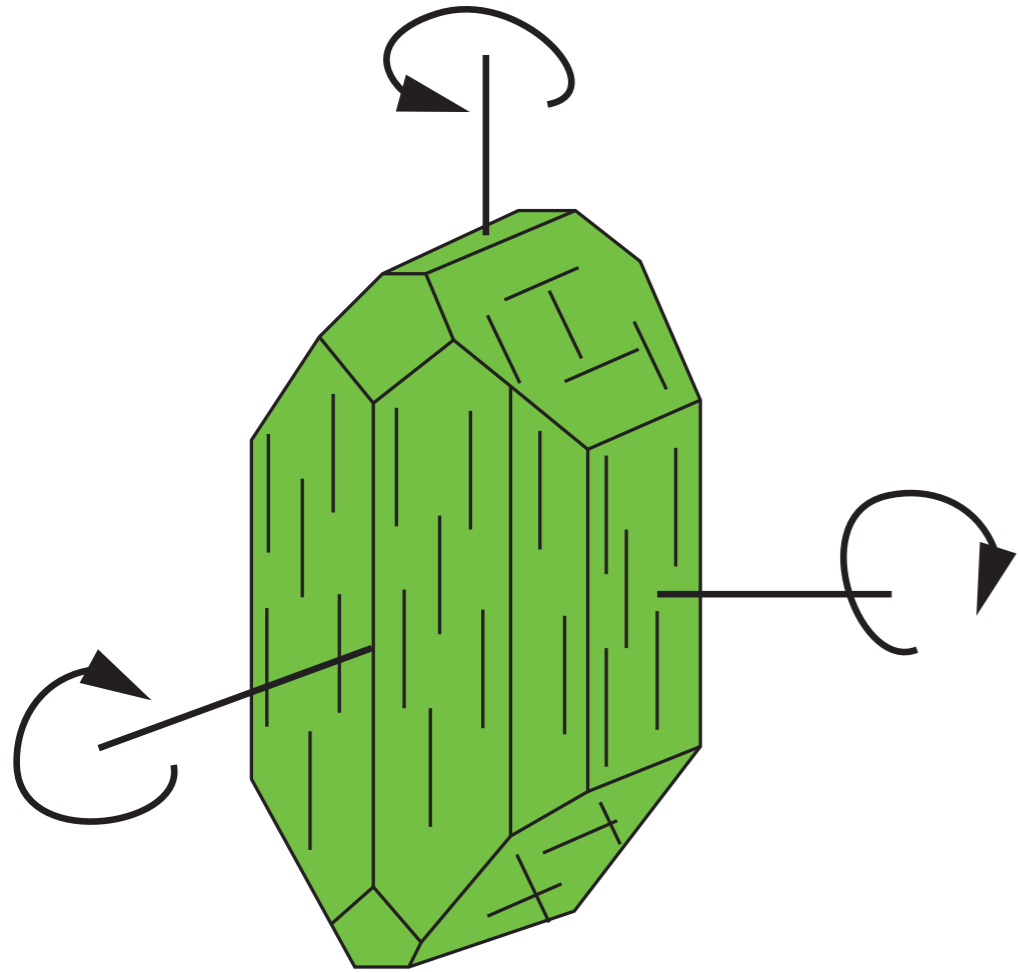
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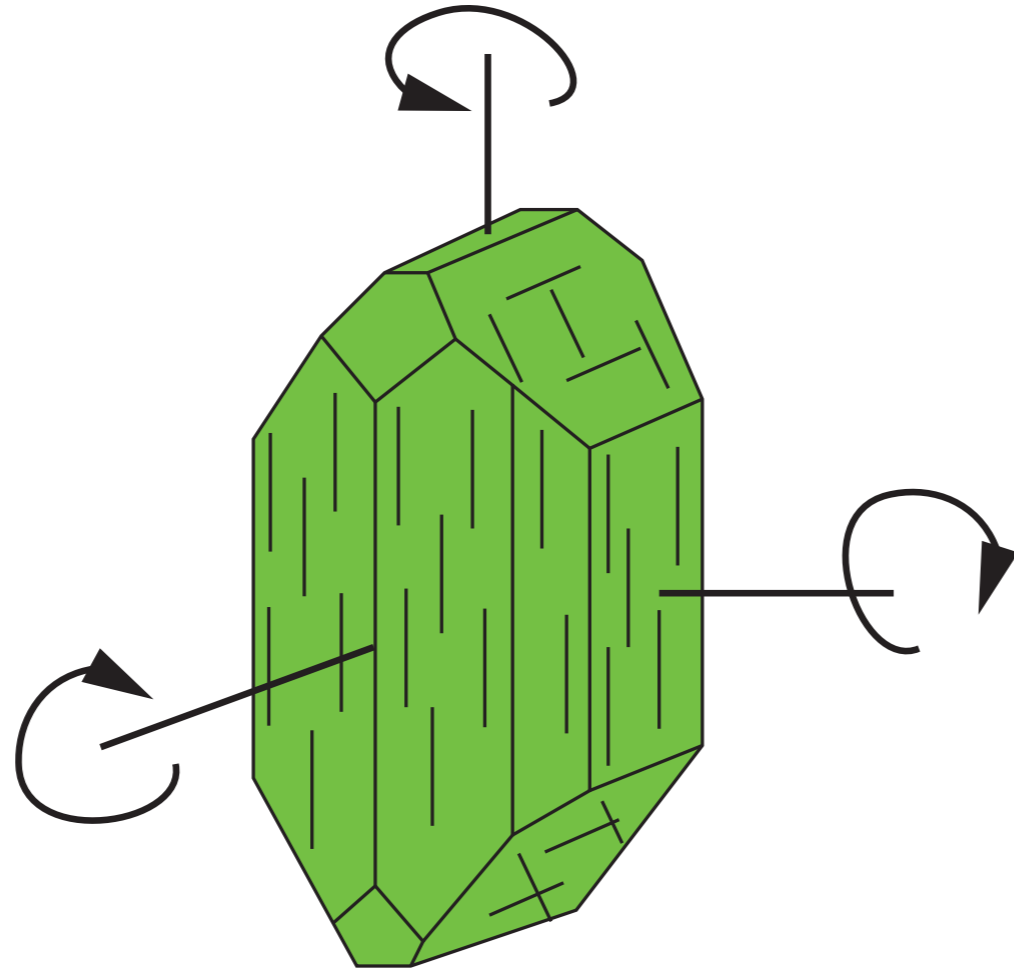
Test causes of anisotropy: Inversions



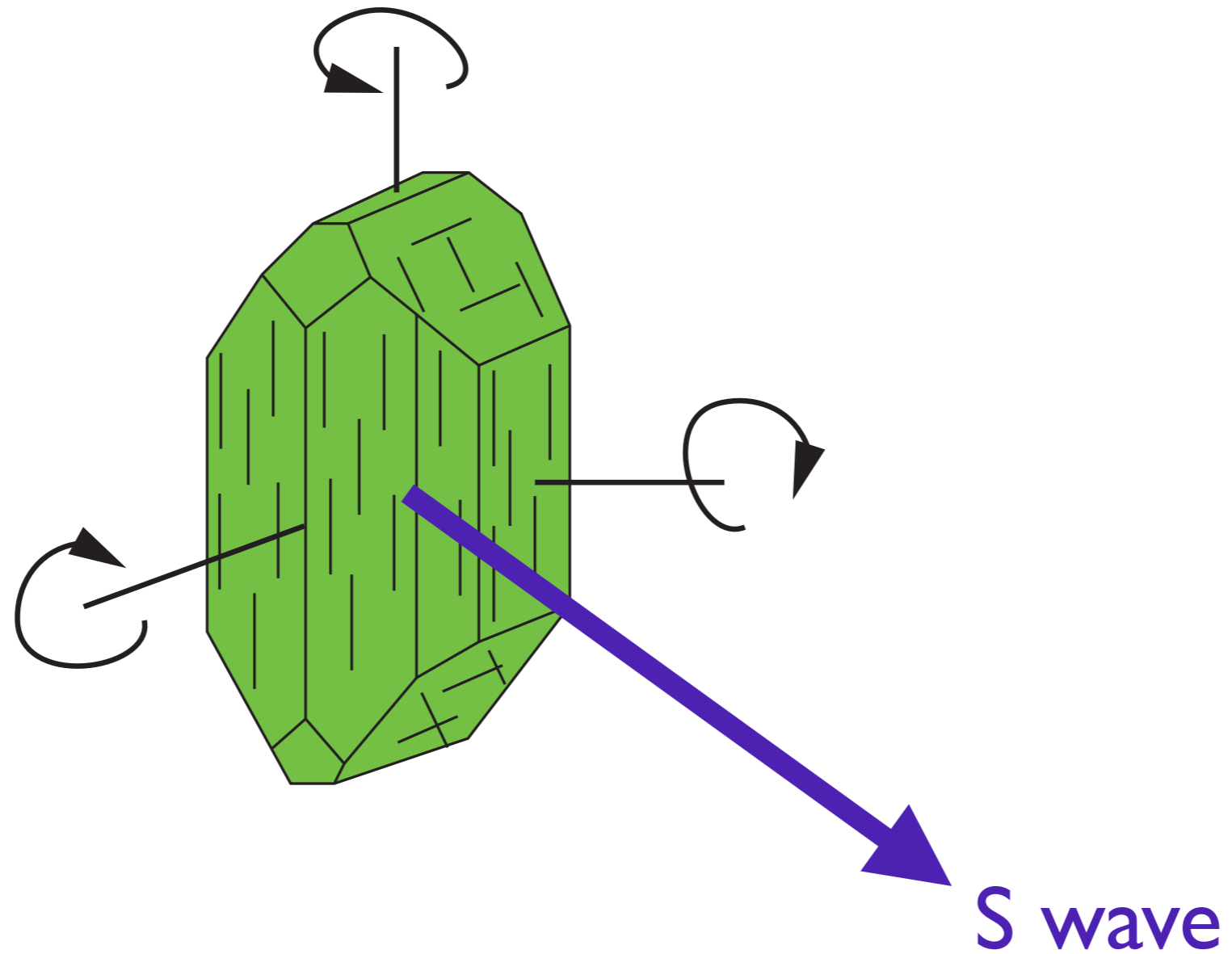
Elastic constants for:

- ‘transverse isotropy’
- akimotoite (flattened)
- phase D (flattened)
- bridgmanite (sheared $\gamma = 1,2$)

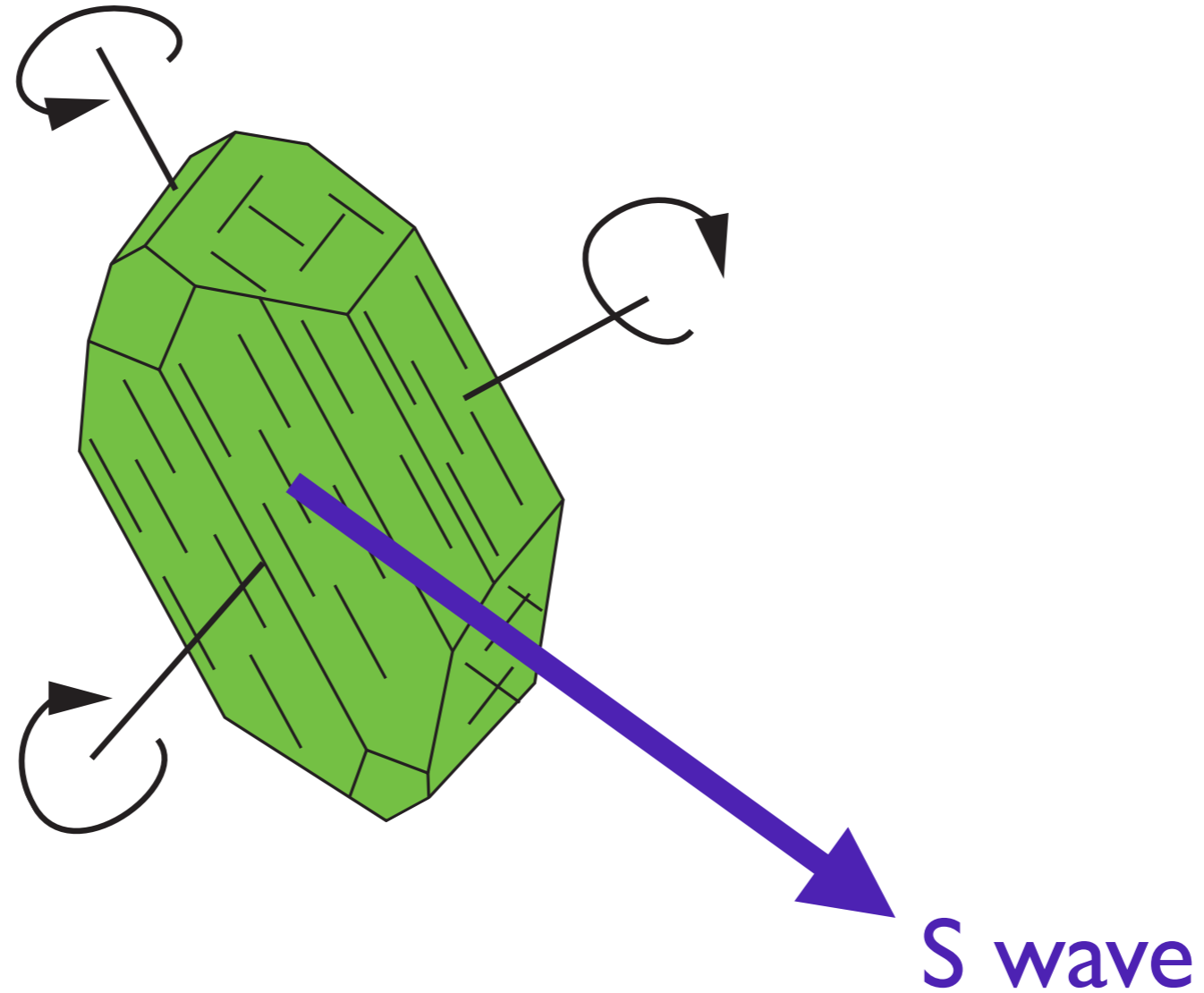
Test causes of anisotropy: Inversions



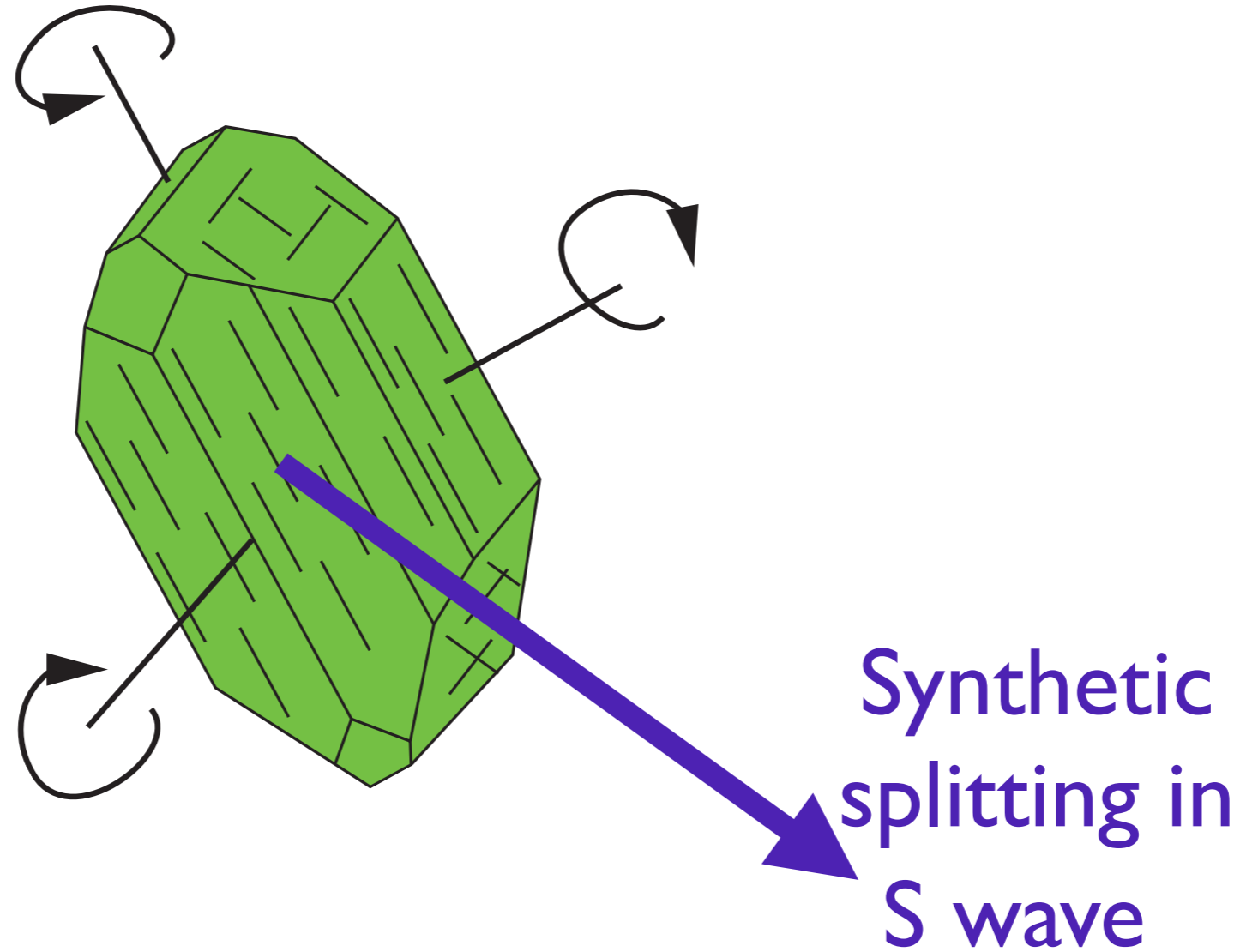
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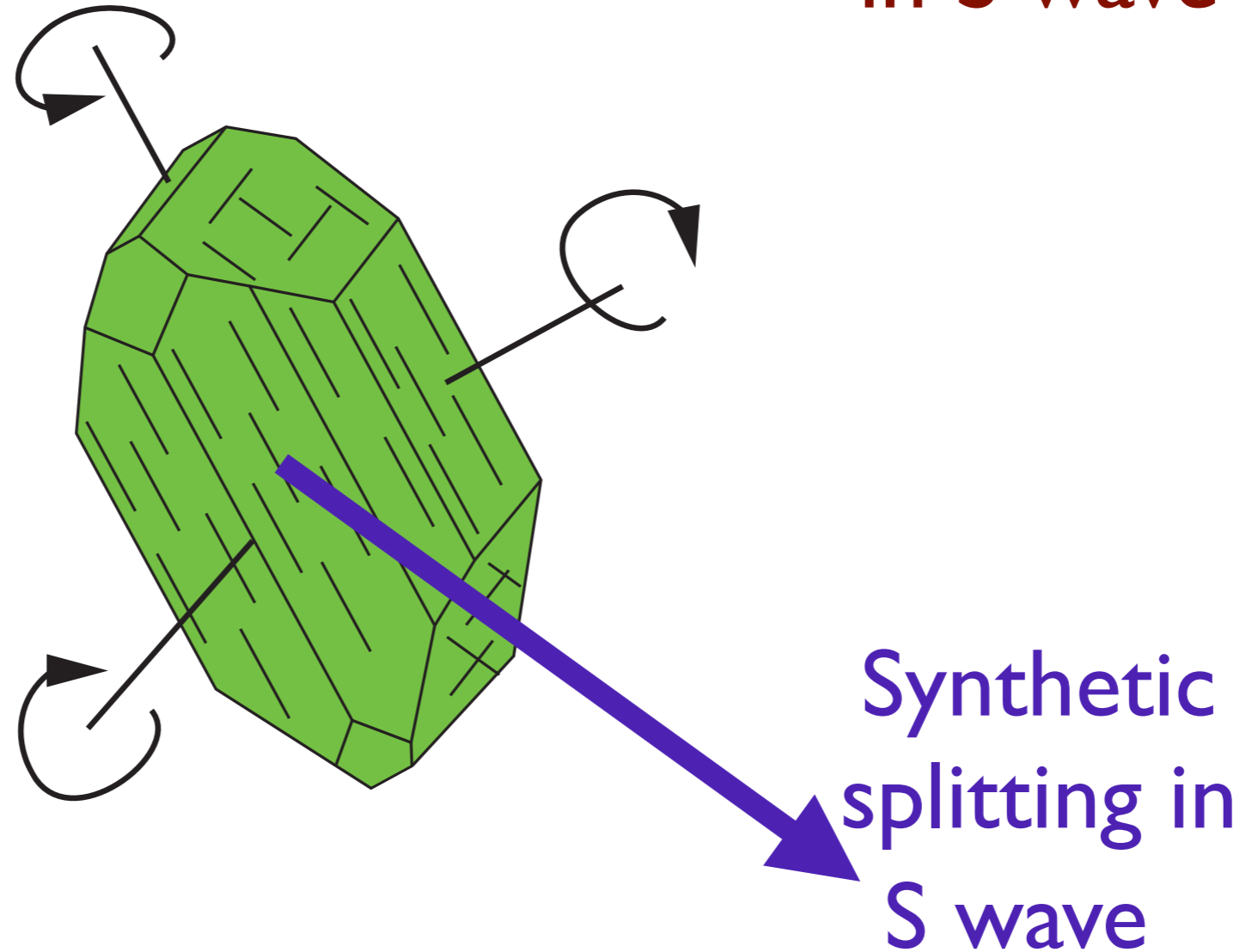


Test causes of anisotropy: Inversions

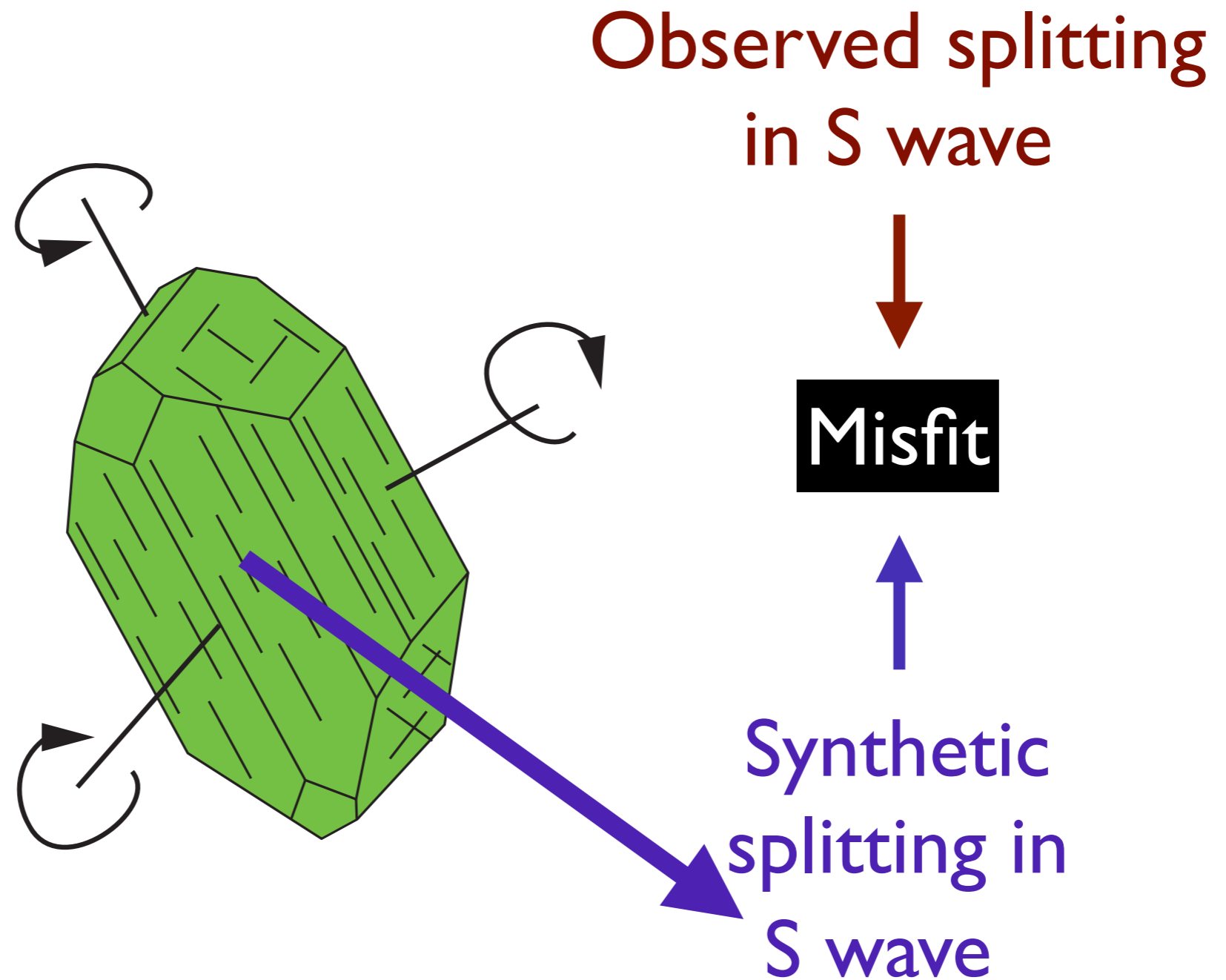


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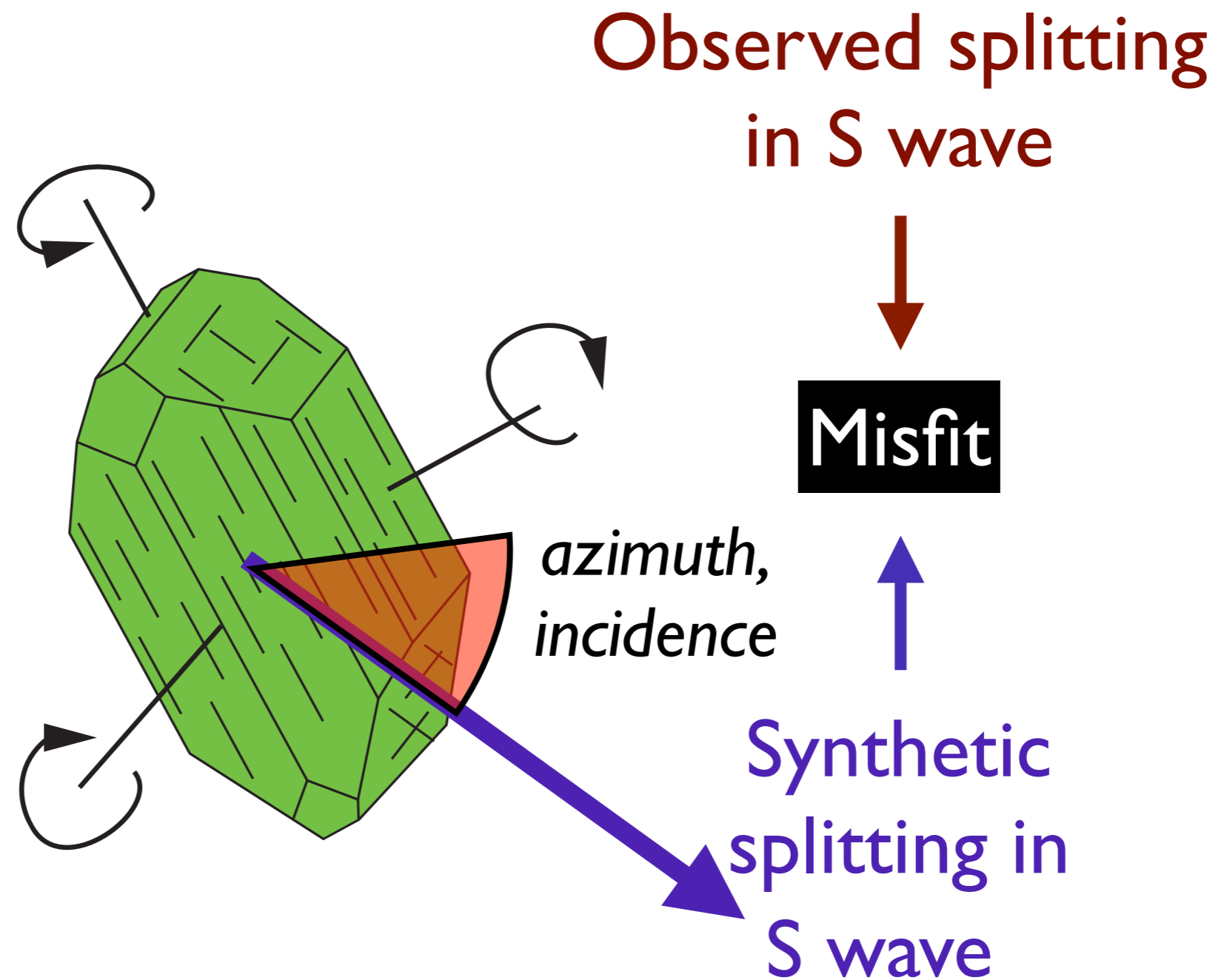
Observed splitting
in S wave



Test causes of anisotropy: Inversions

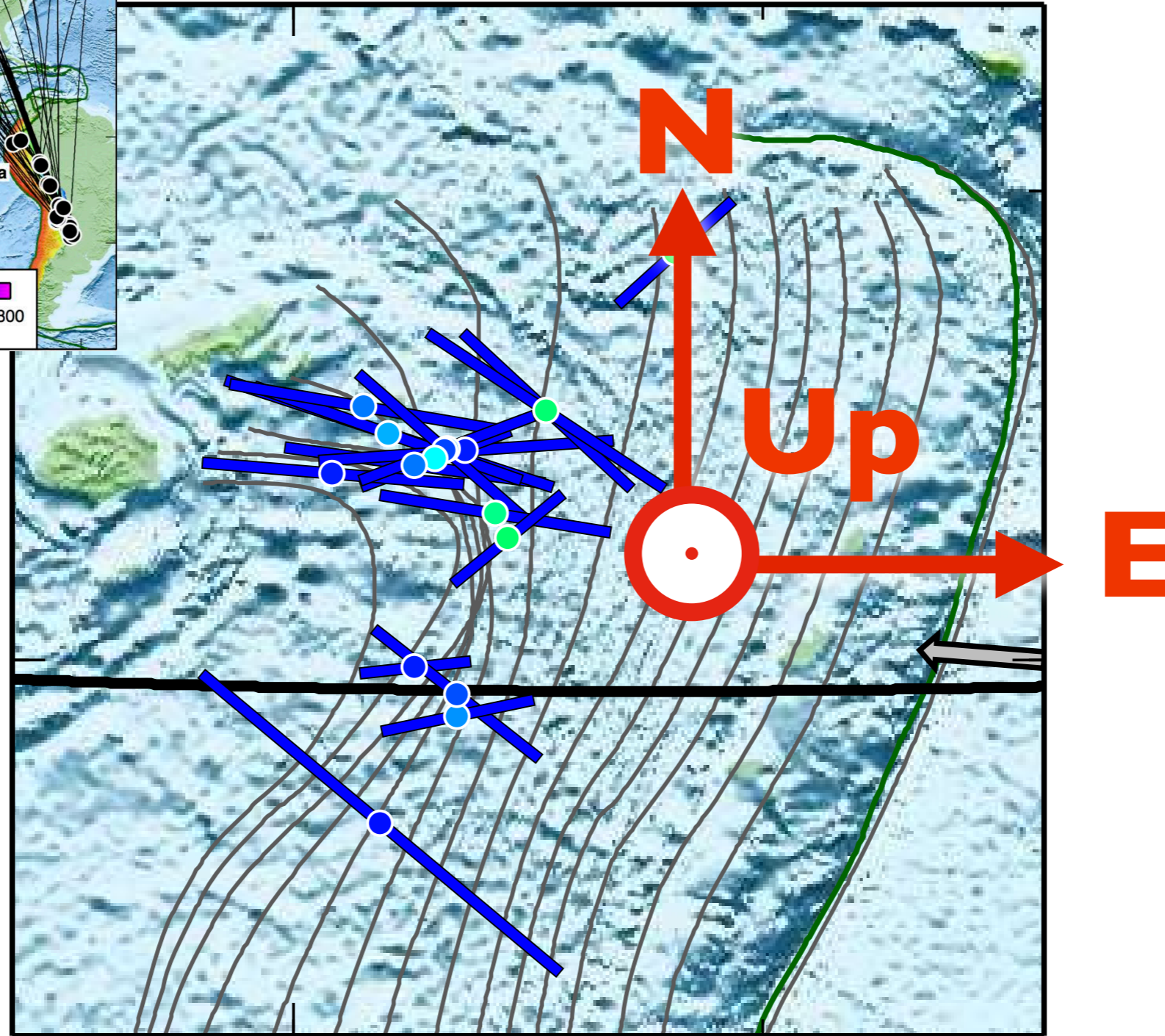
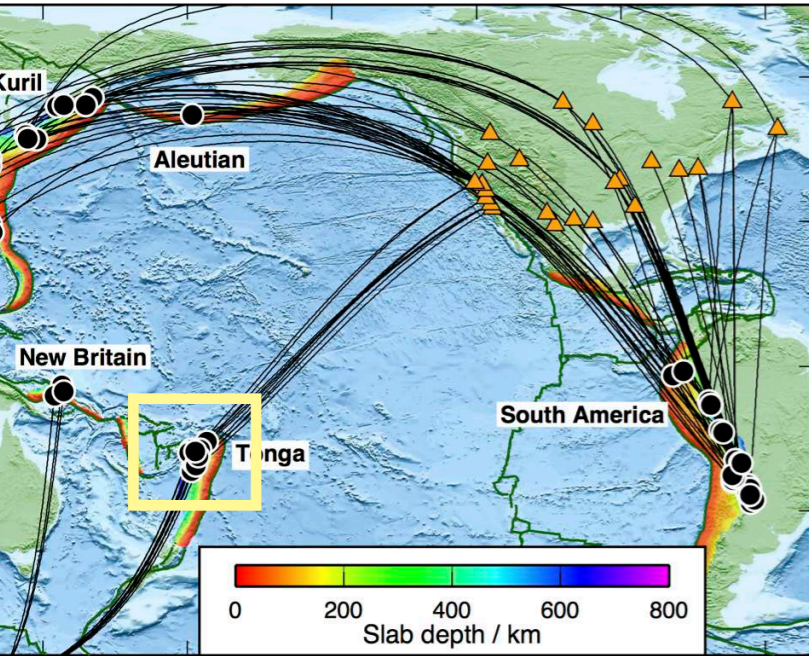


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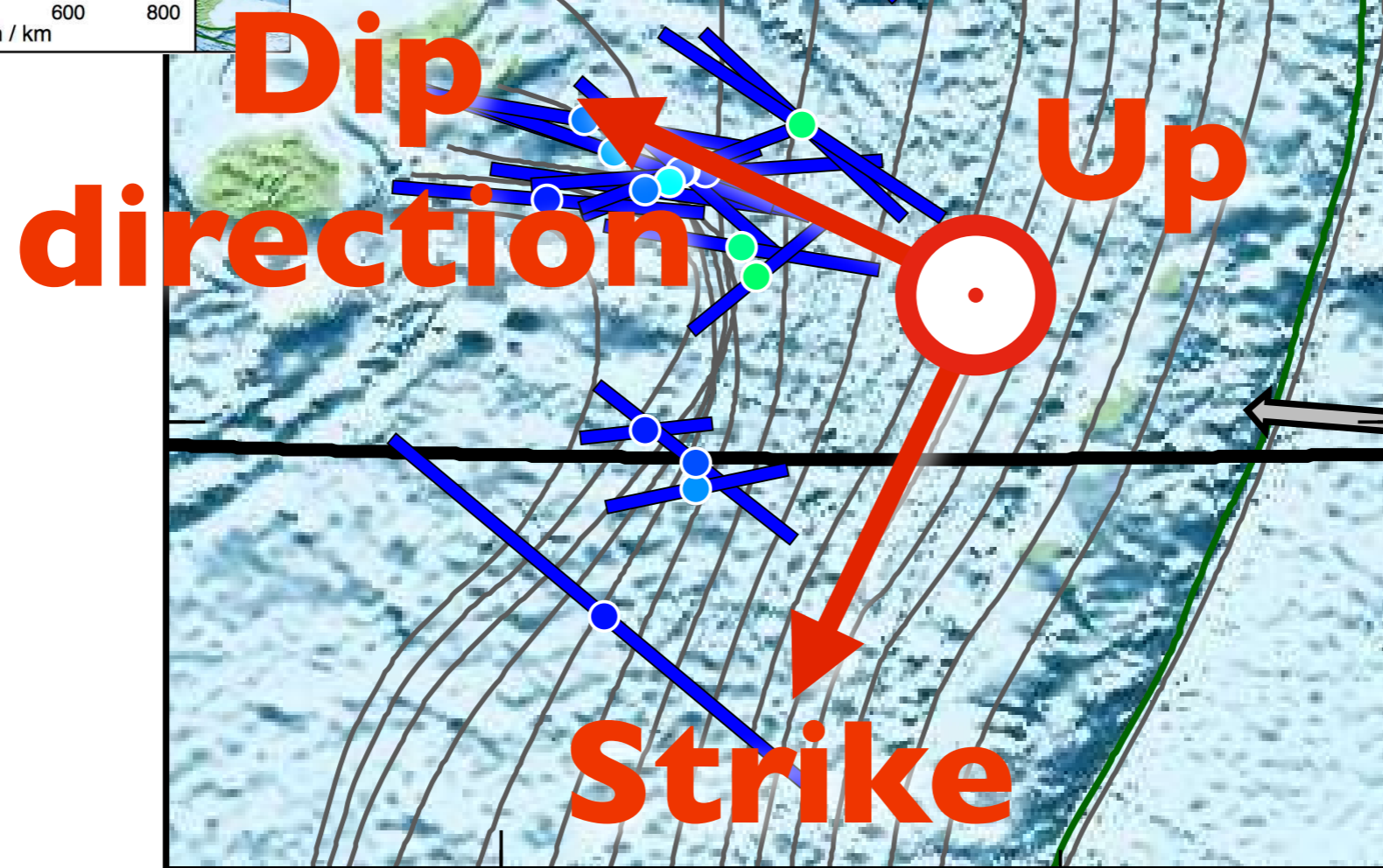
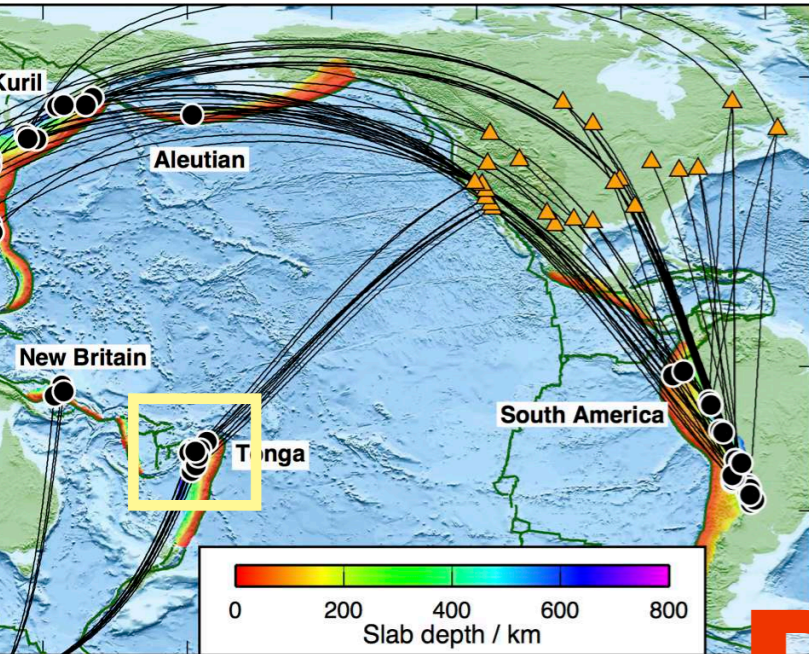
Reference frame

Tonga



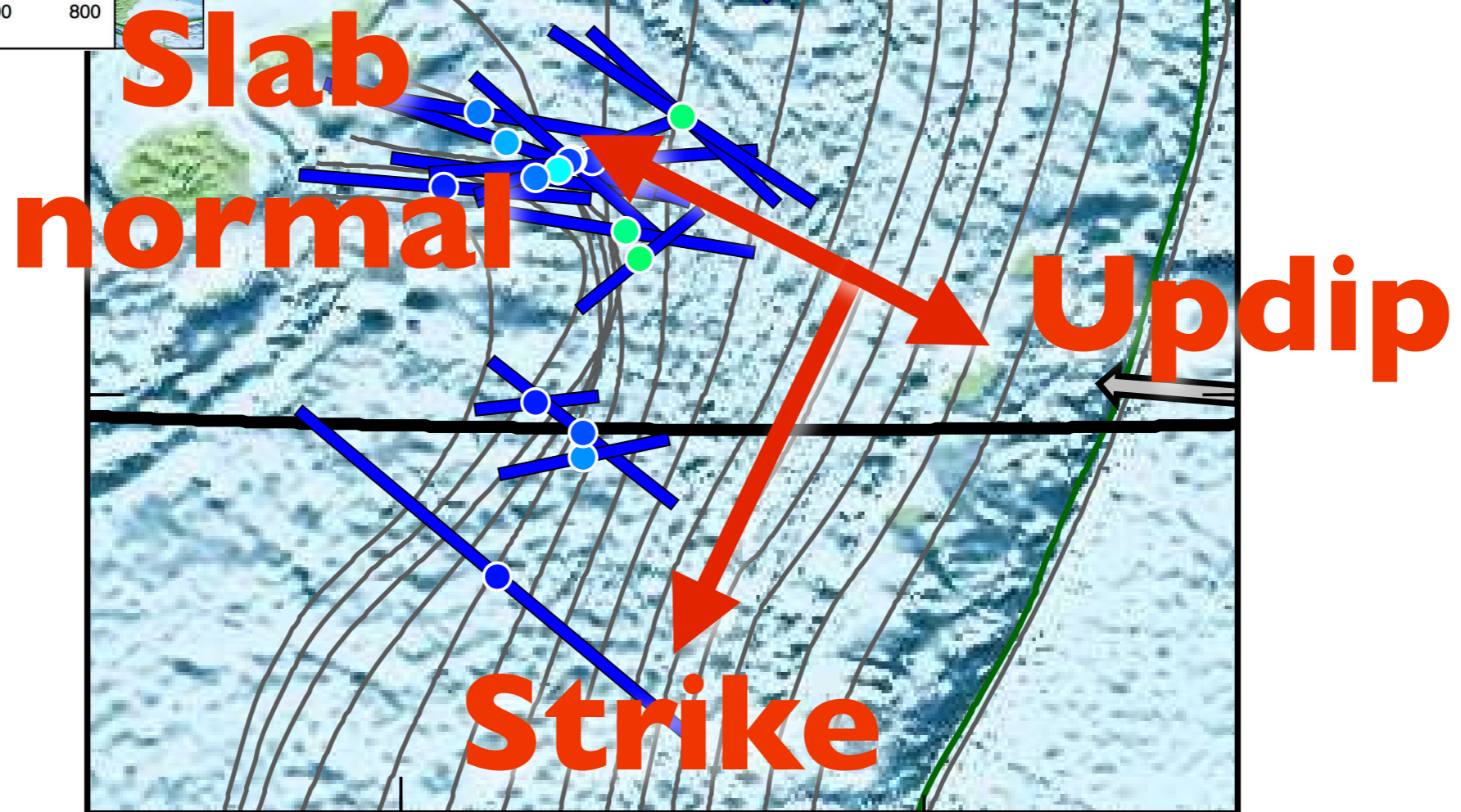
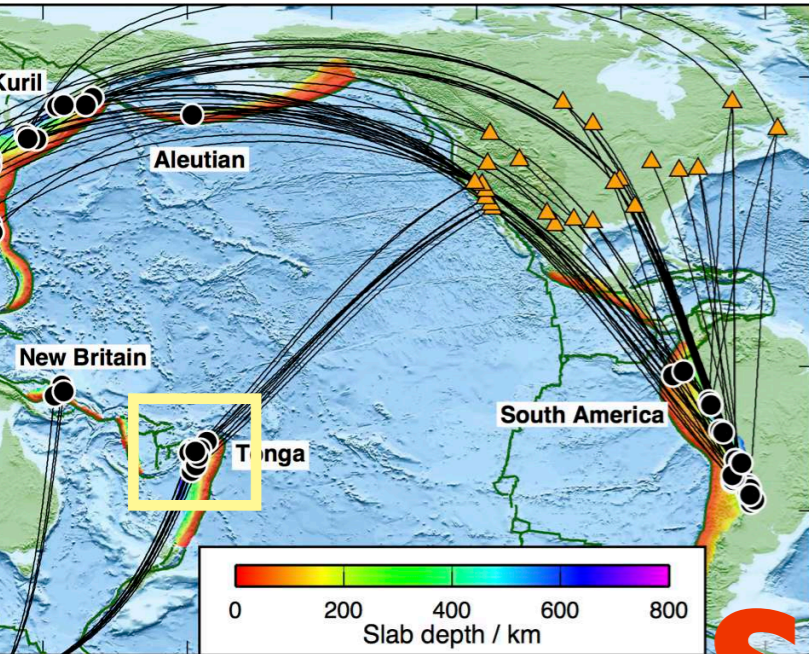
Reference frame

Tonga

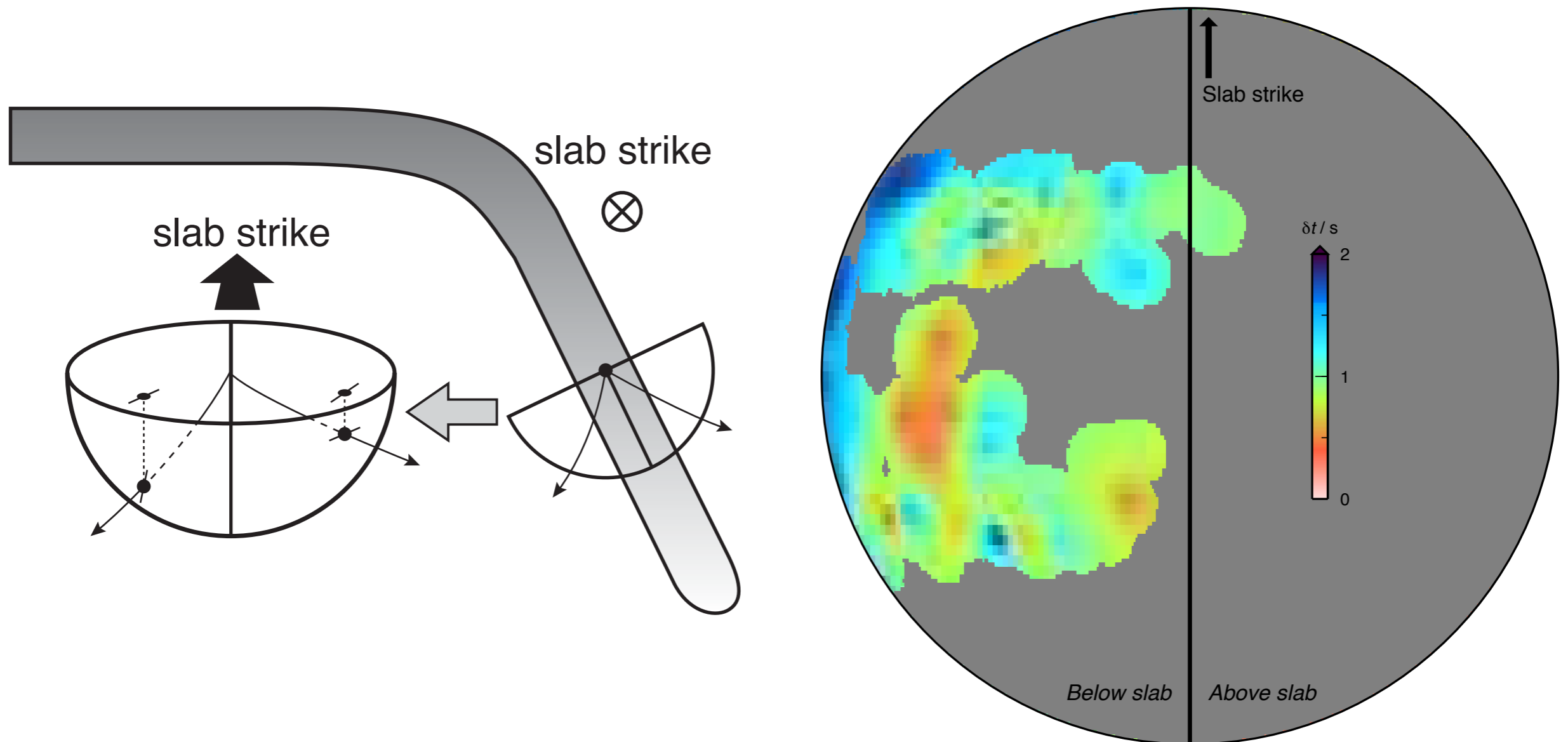


Reference frame

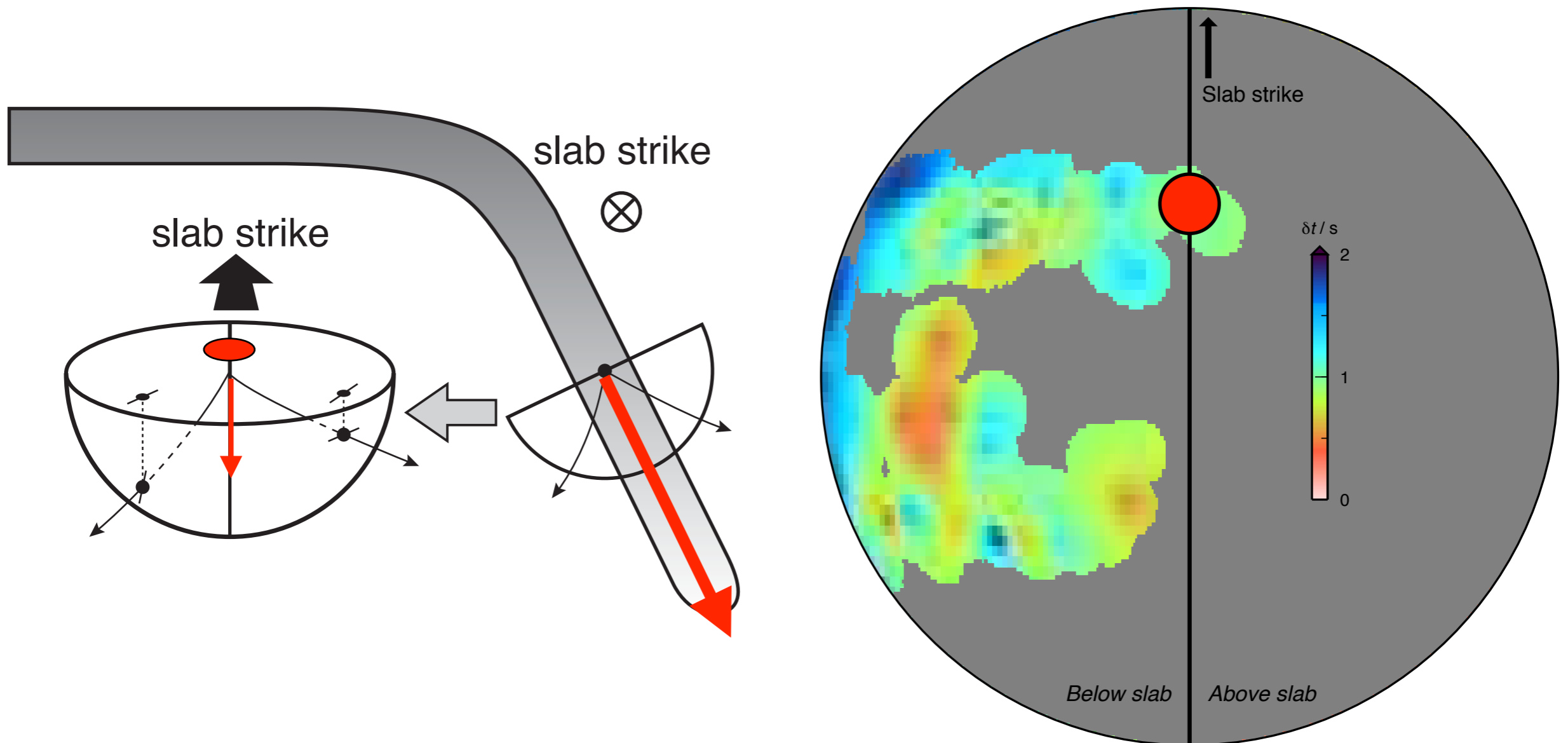
Tonga



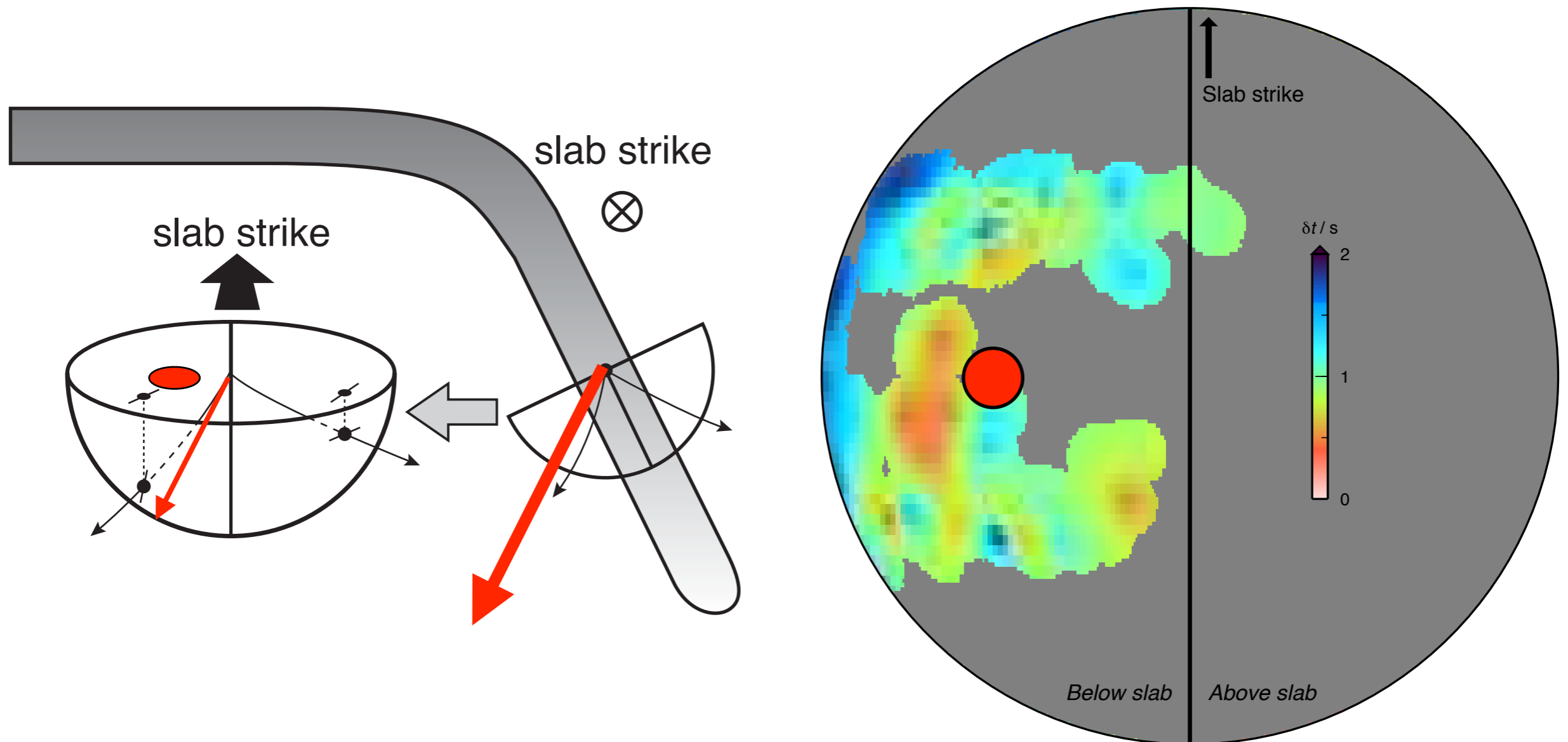
Slab processes



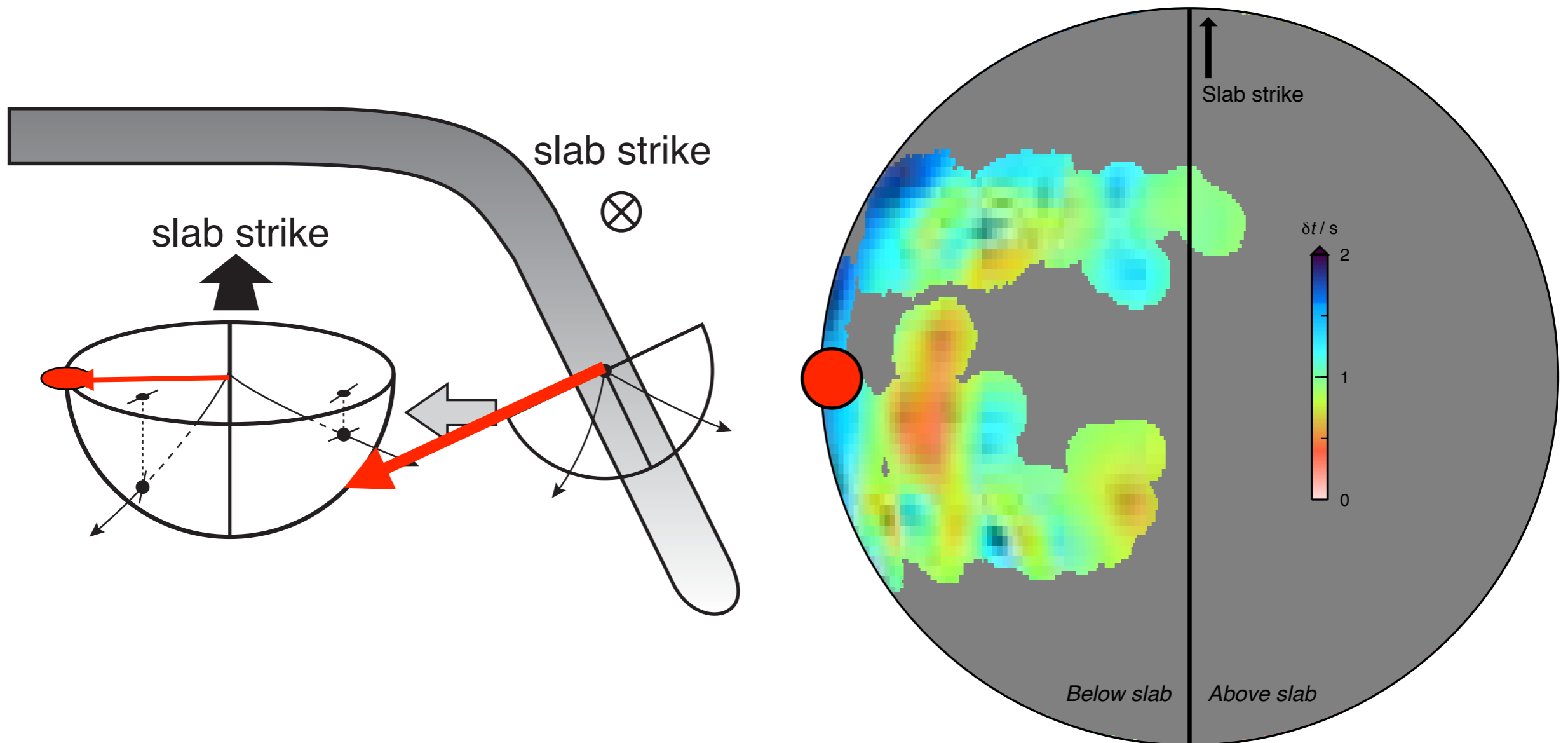
Slab processes



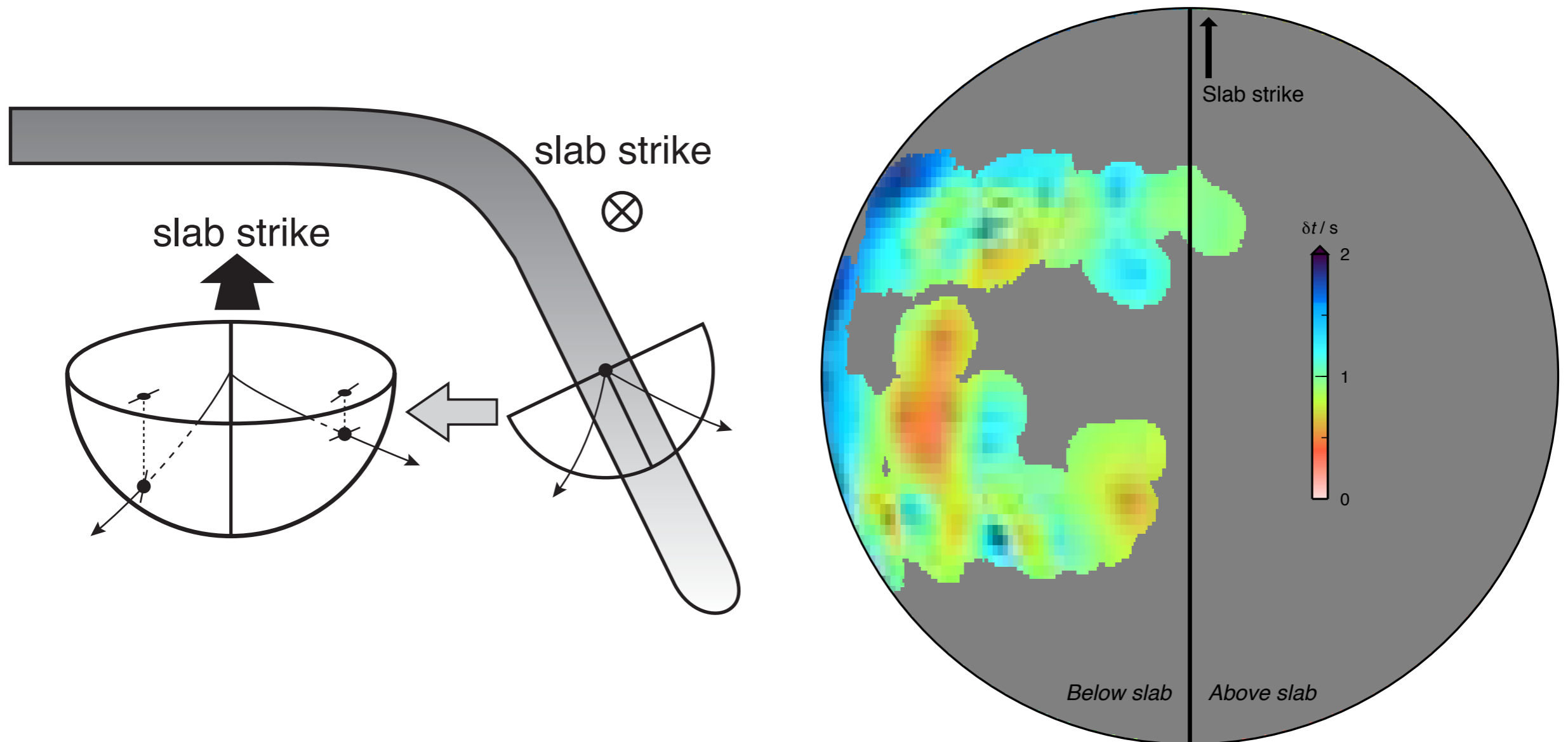
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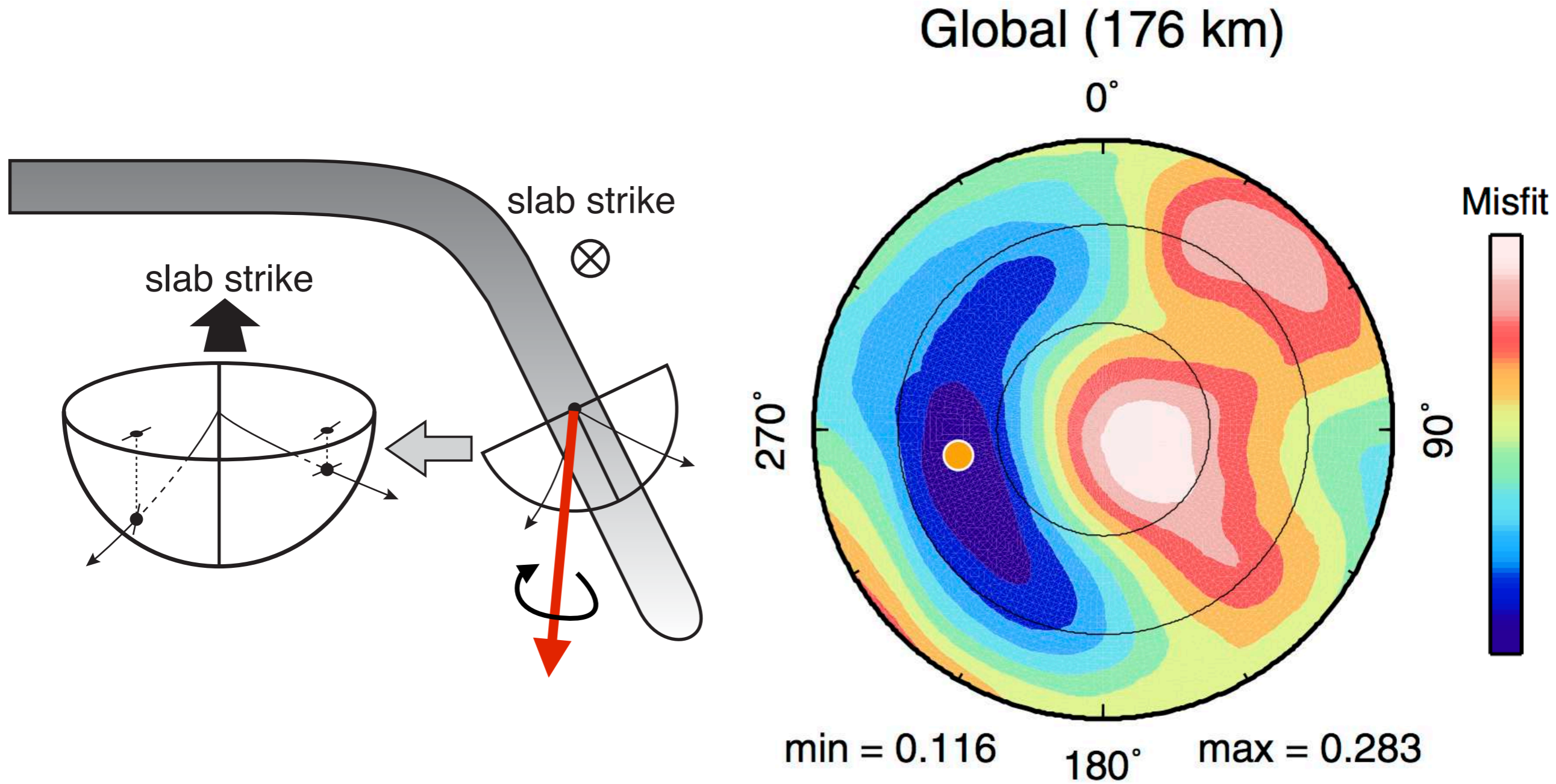
Slab processes



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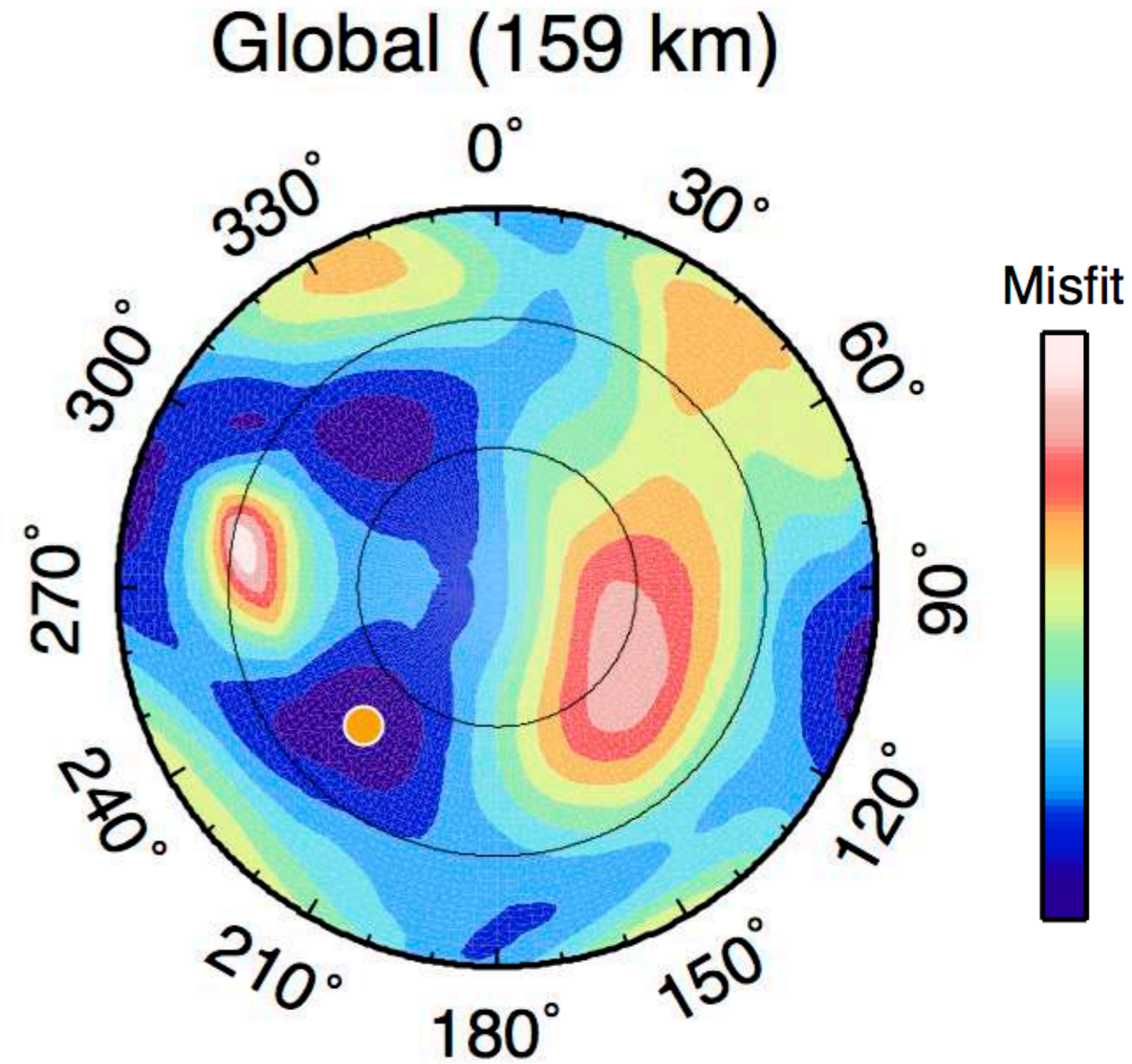
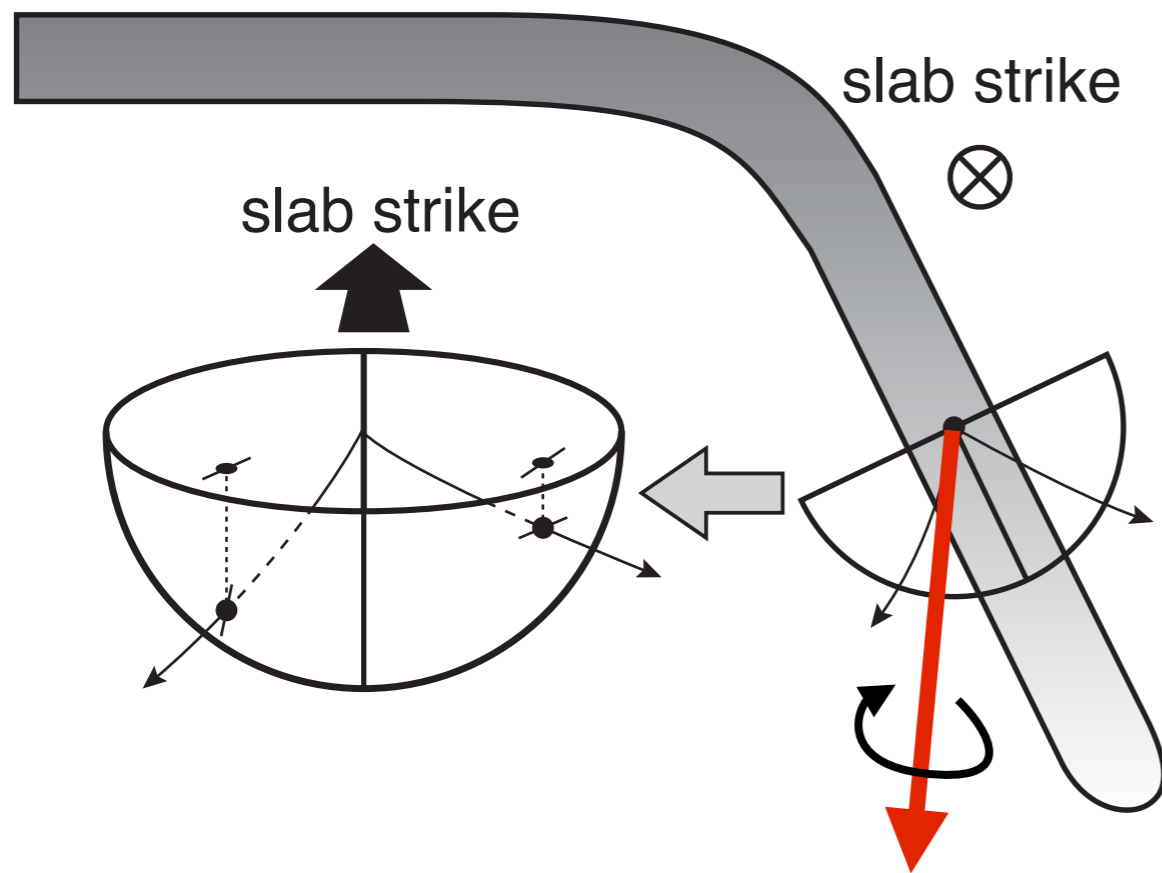


Fits to data



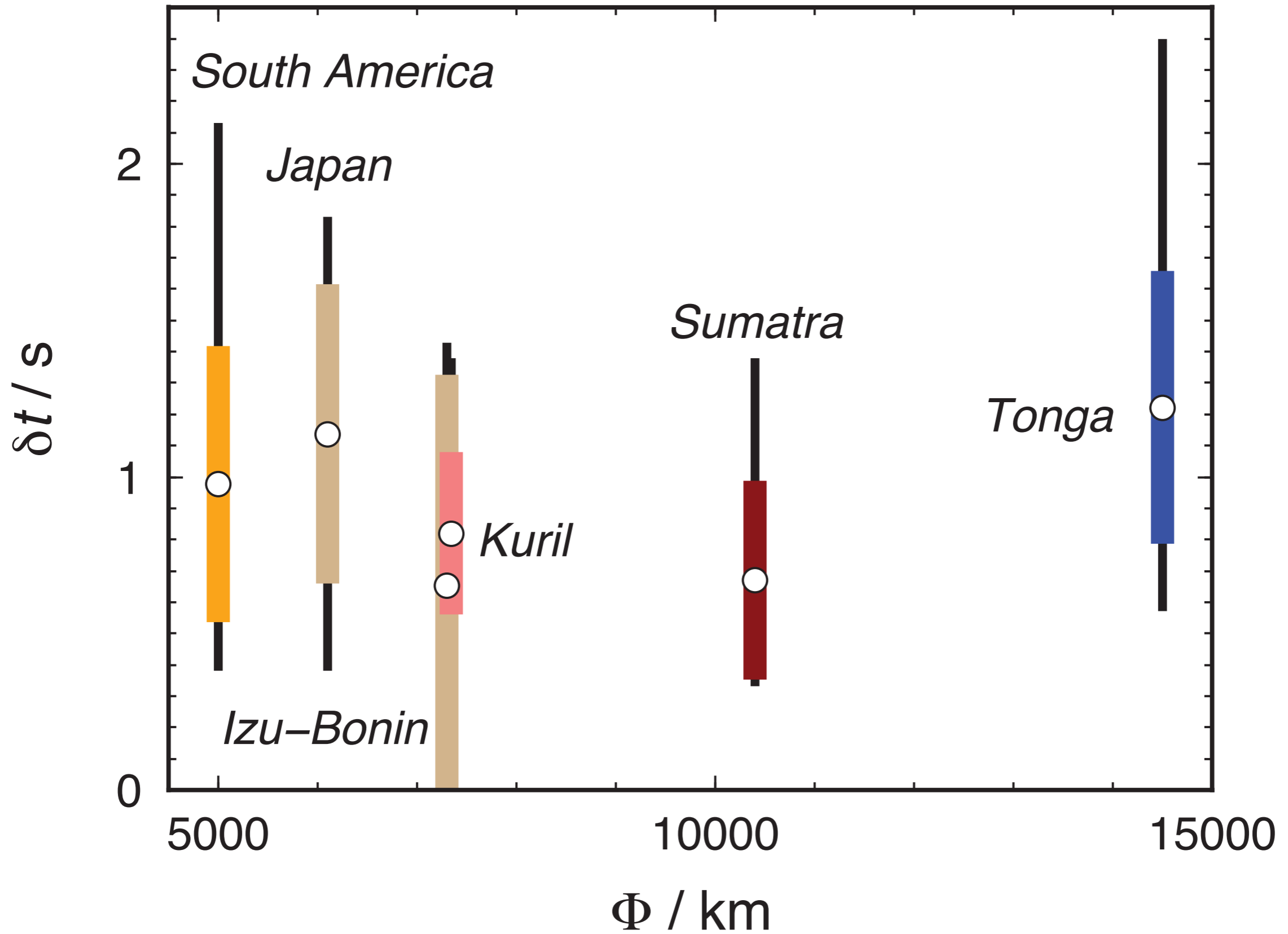
Transverse isotropy (elliptical)

Fits to data

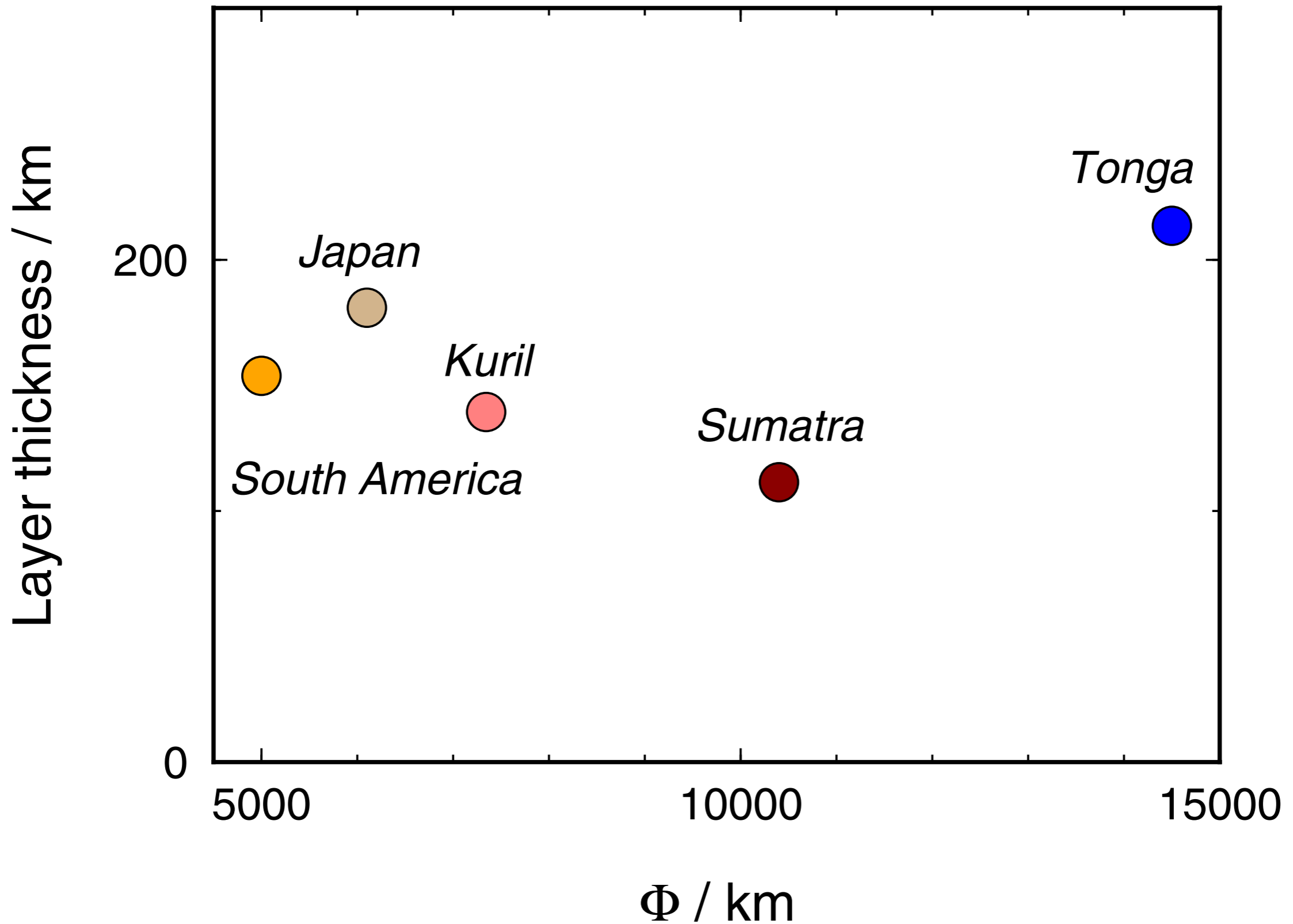


Layered structure (D, akimotoite or inclusions)

Thermal parameter

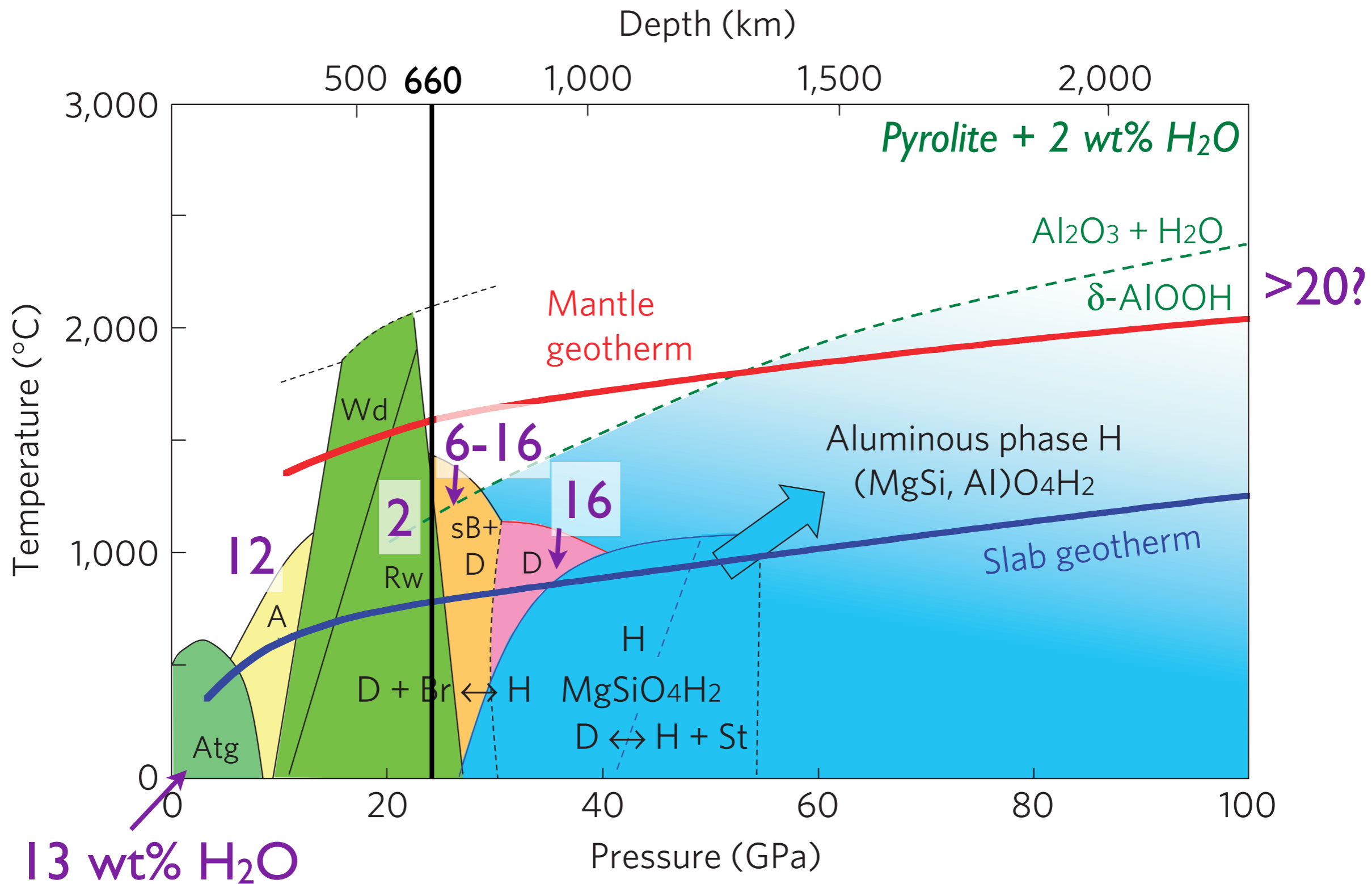


Thermal parameter

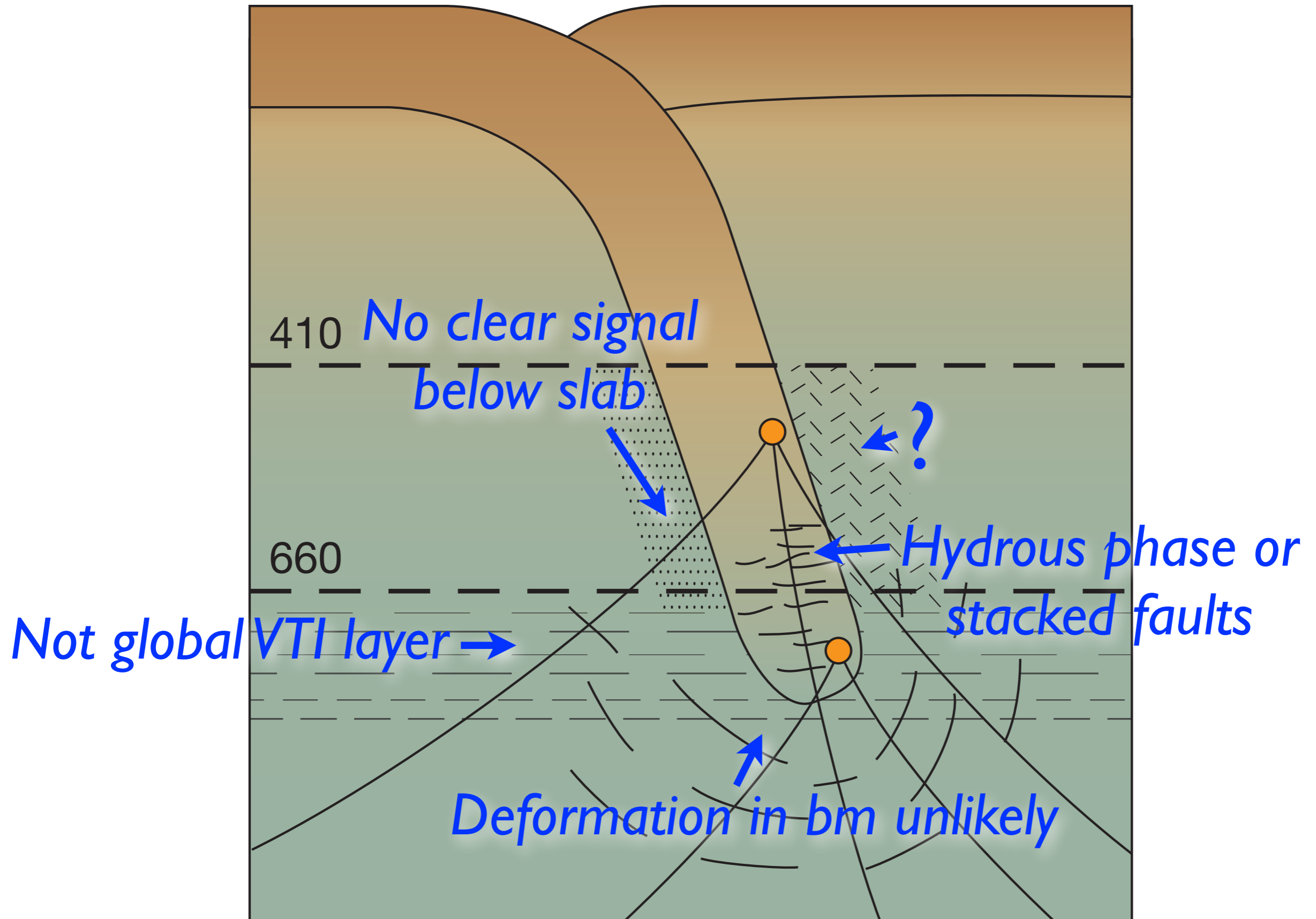


Nowacki et al., G^3 , 2015; Ben Ismail & Mainprice, Tectonophysics, 1998

Hydrous silicates (alphabet soup)



The transition zone: what causes the observations



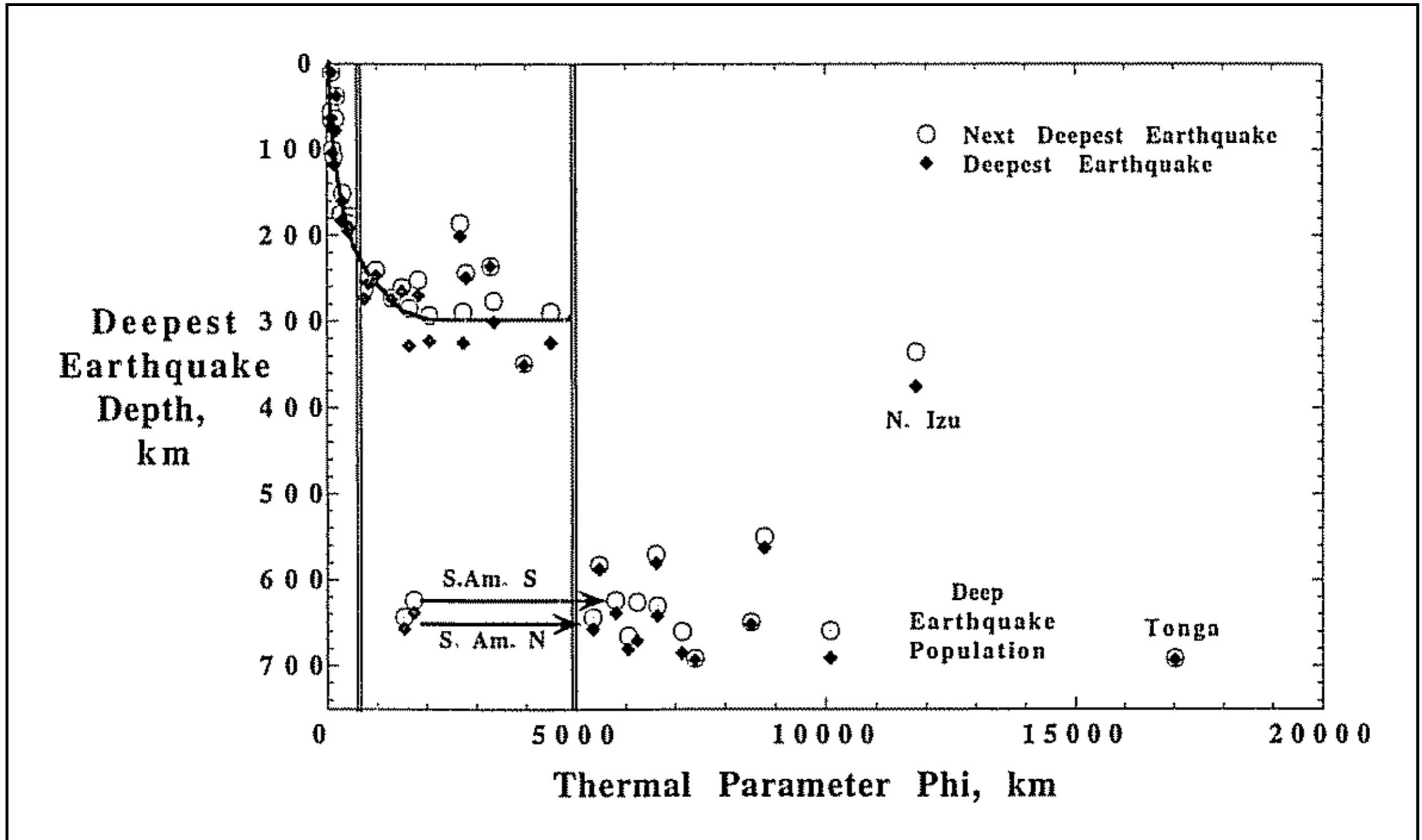
finni

*Deep earthquakes: observations,
experiments and explanations*

RAS discussion meeting
London, 10 May 2019

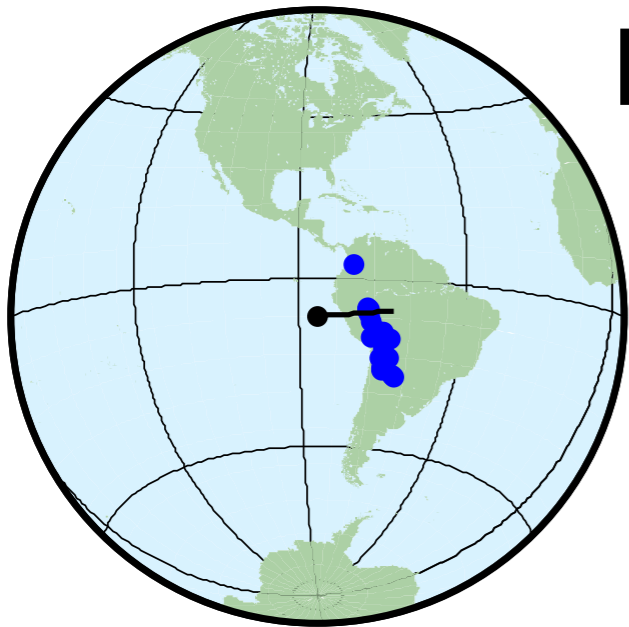
(Friday after UK-SEDI 2019 @ UCL)

Text

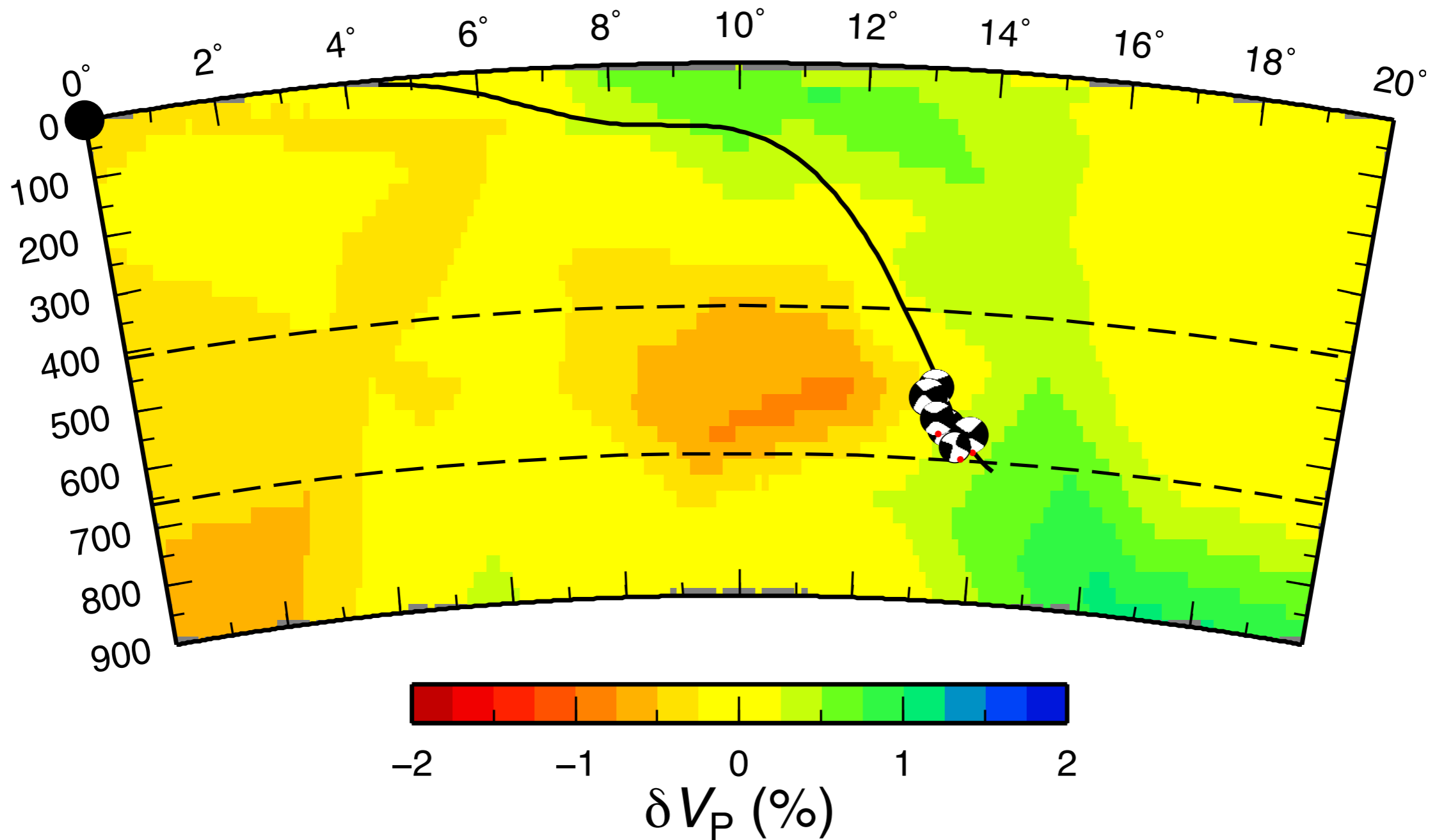


$$\Phi = a v \sin \theta, \text{ age } a, \text{ velocity } v, \text{ dip } \theta$$

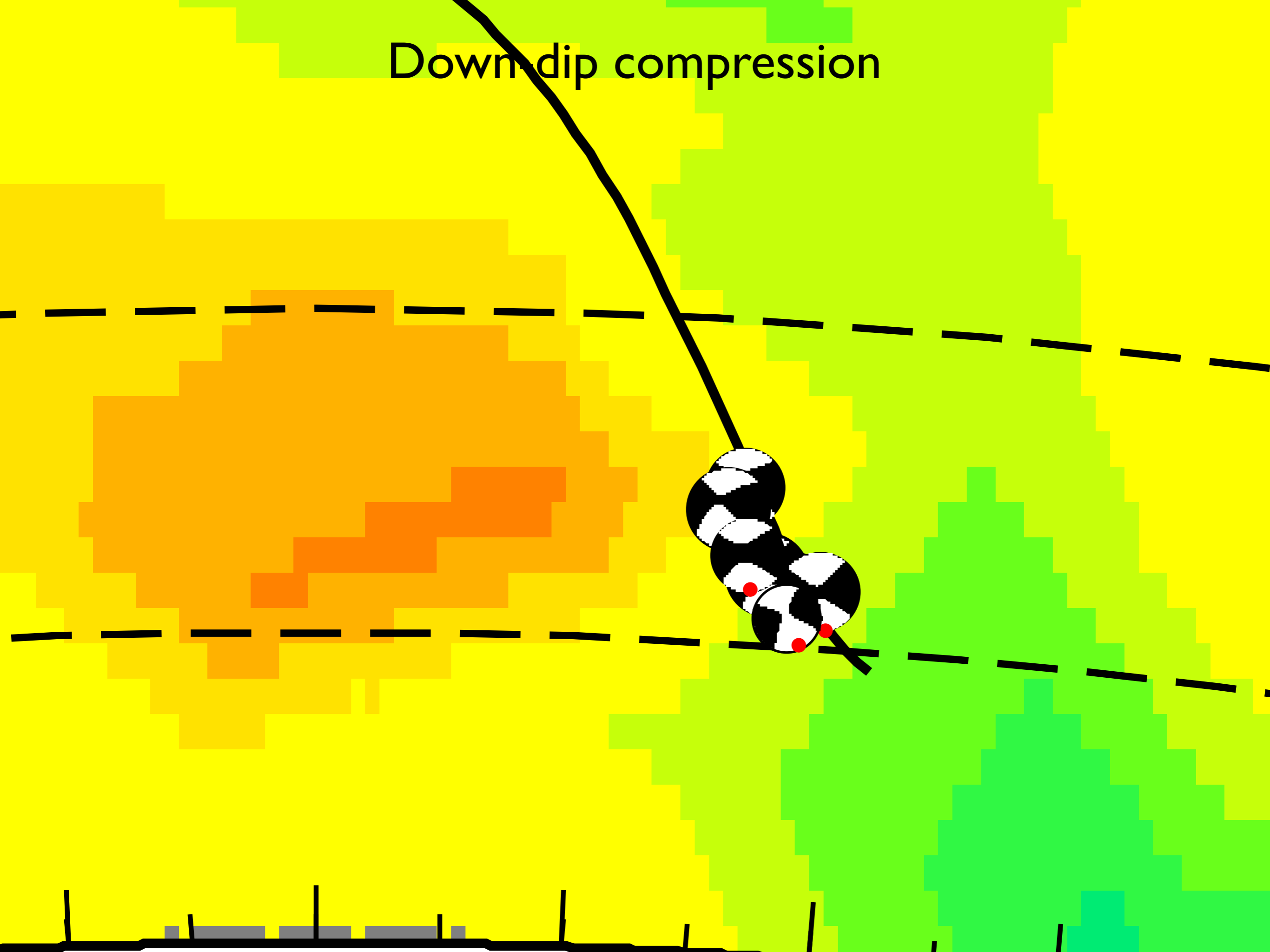
Down-dip compression



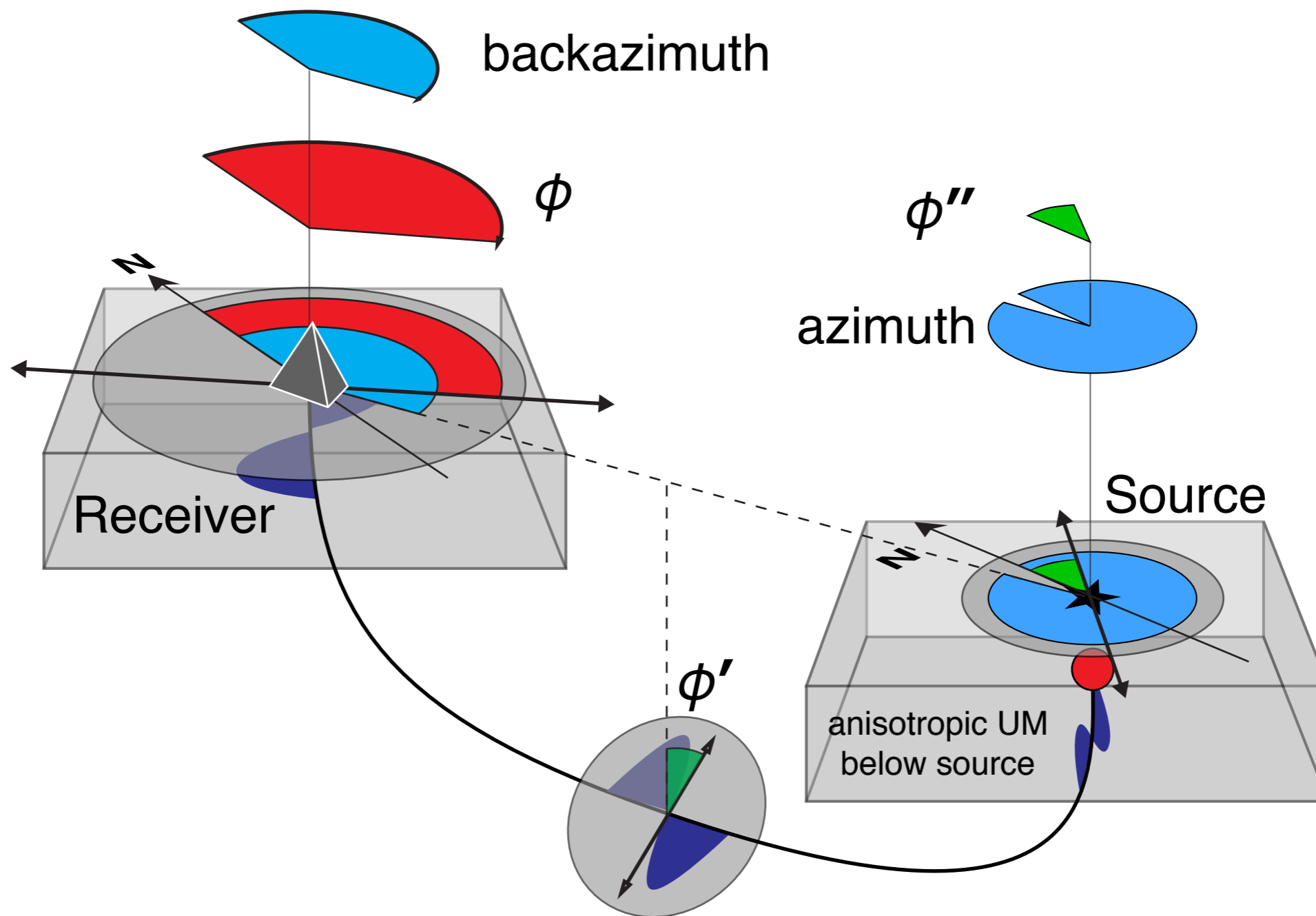
South America 1



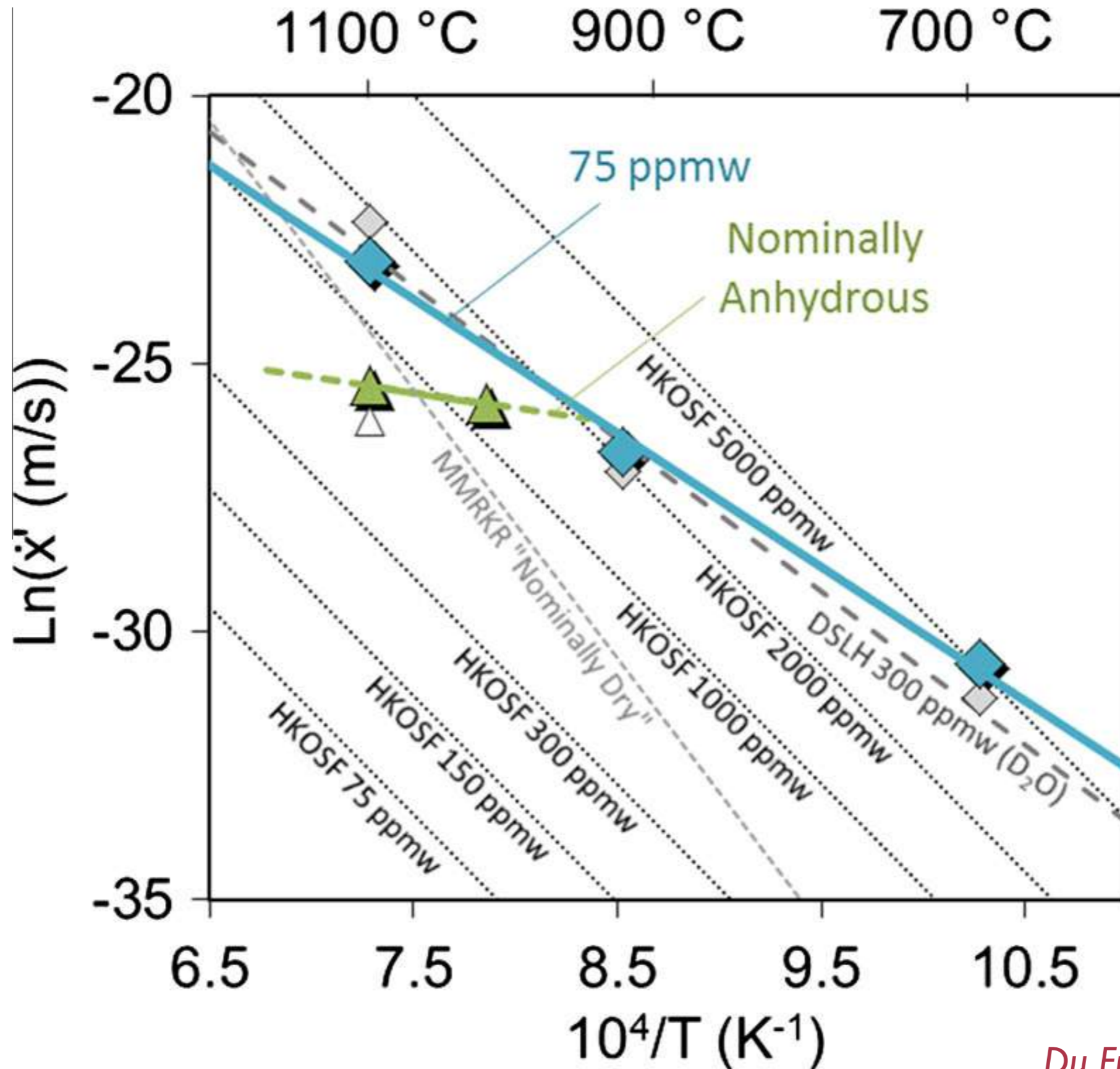
Down-dip compression



Fast orientations



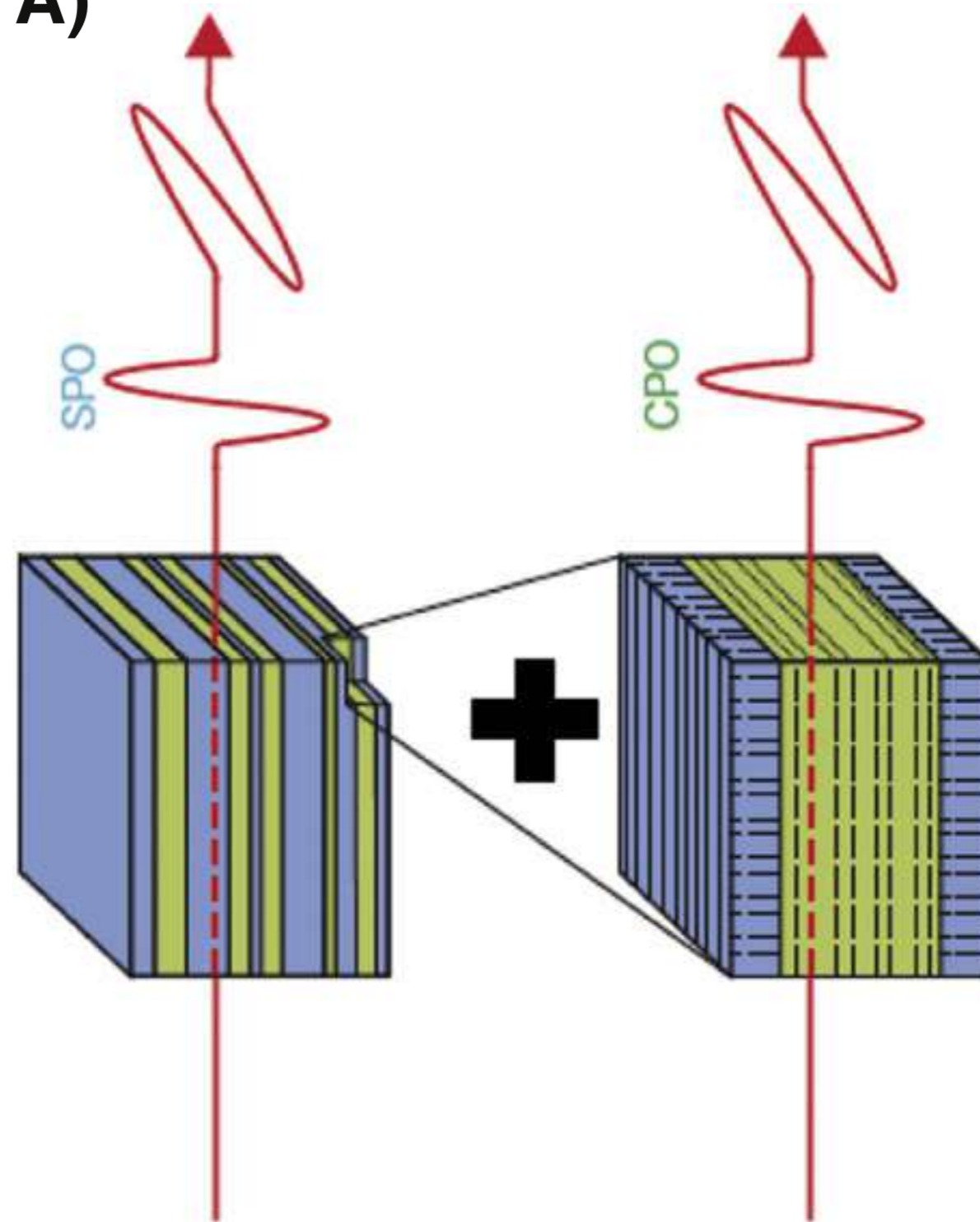
Metastable olivine? Not unless bone-dry



Size problem

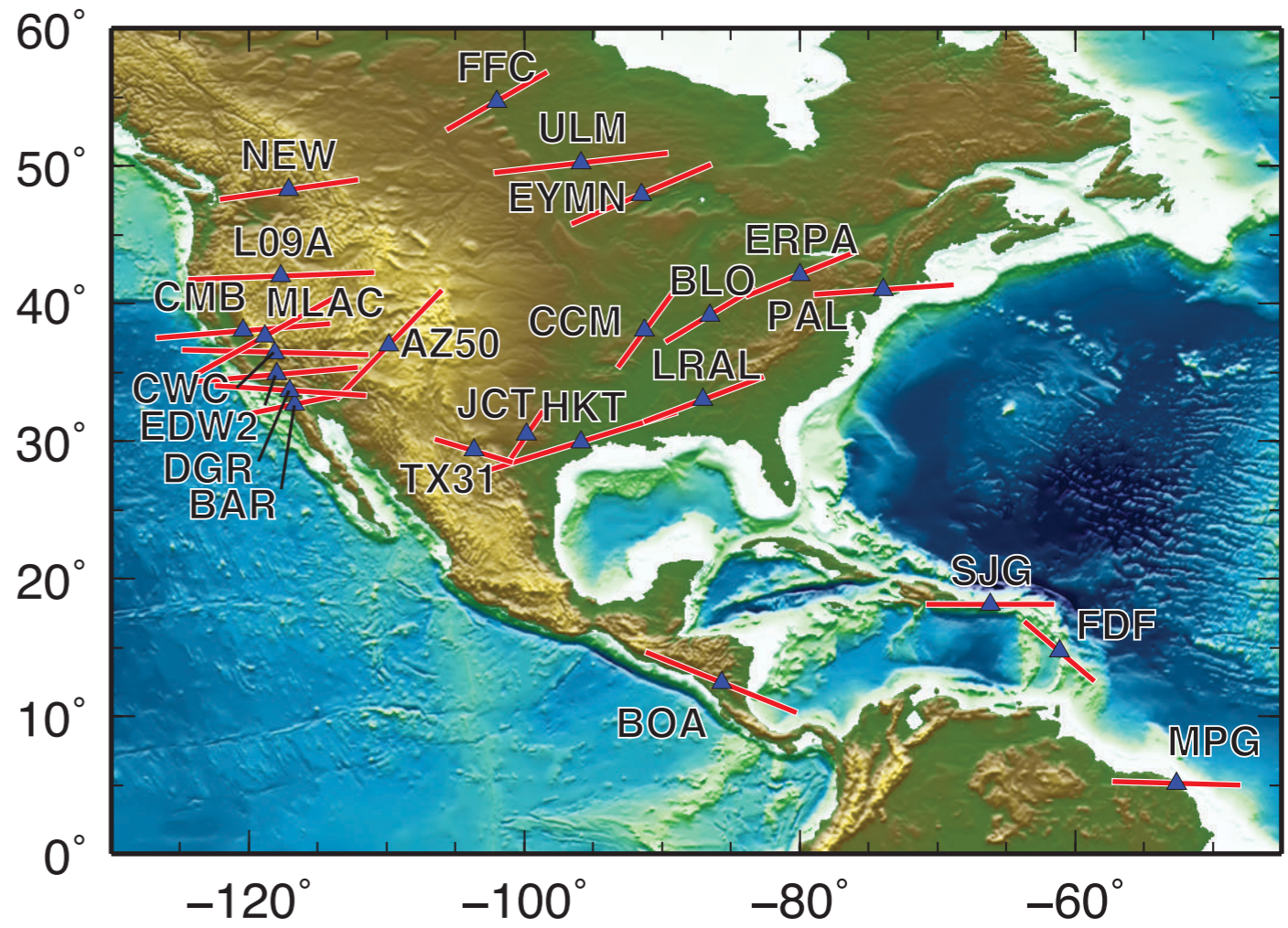
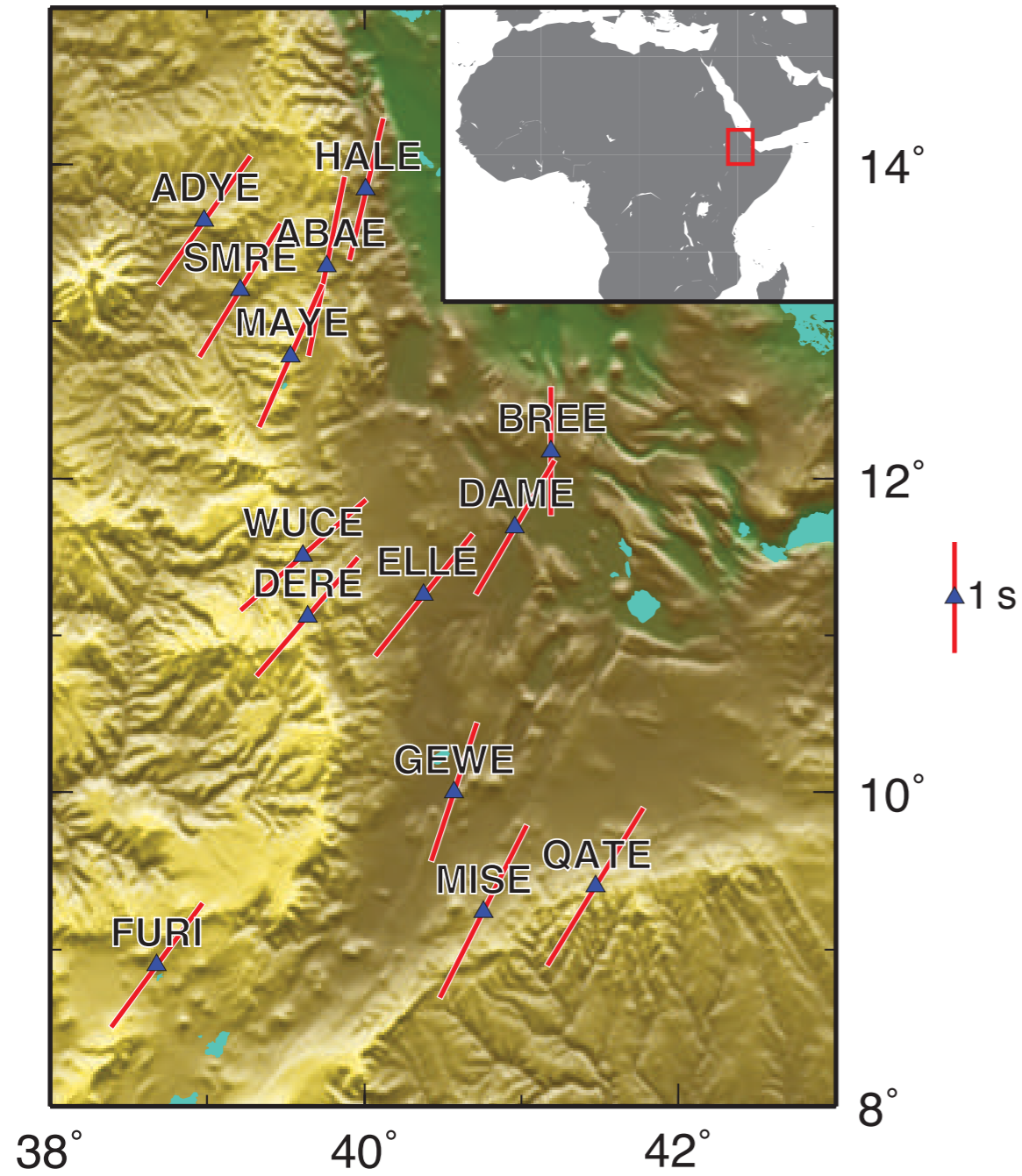
A)

Aligned faults
containing
hydrous phases



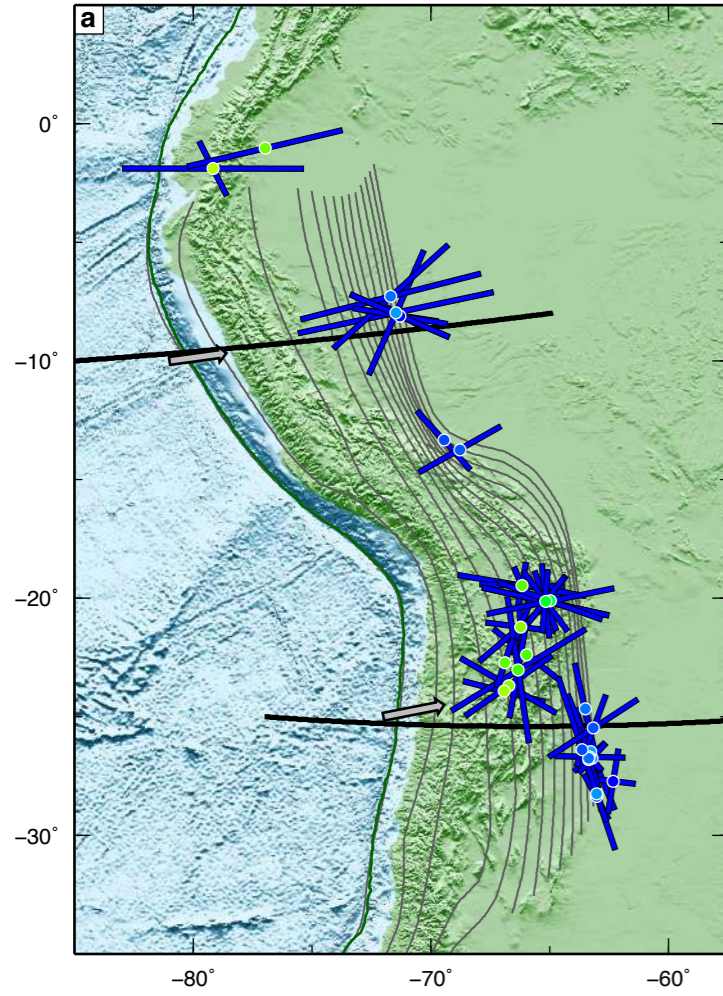
Alignment of
hydrous
minerals

Method

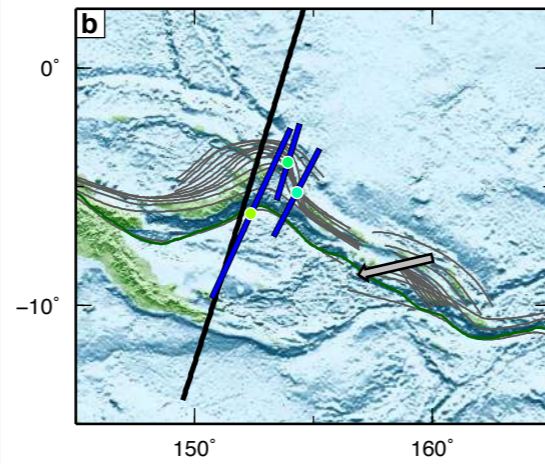


Results

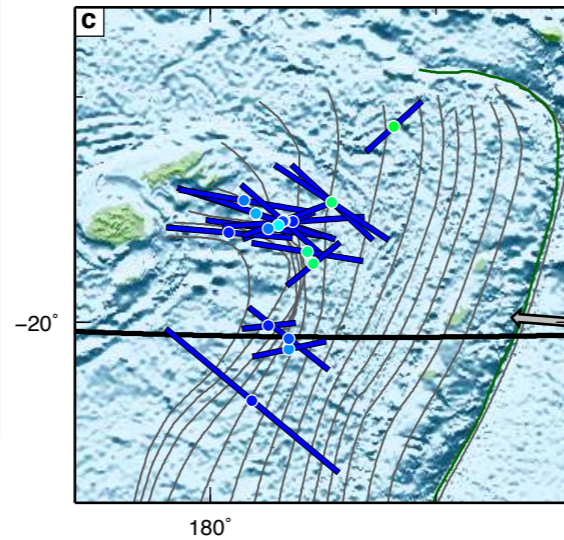
South America



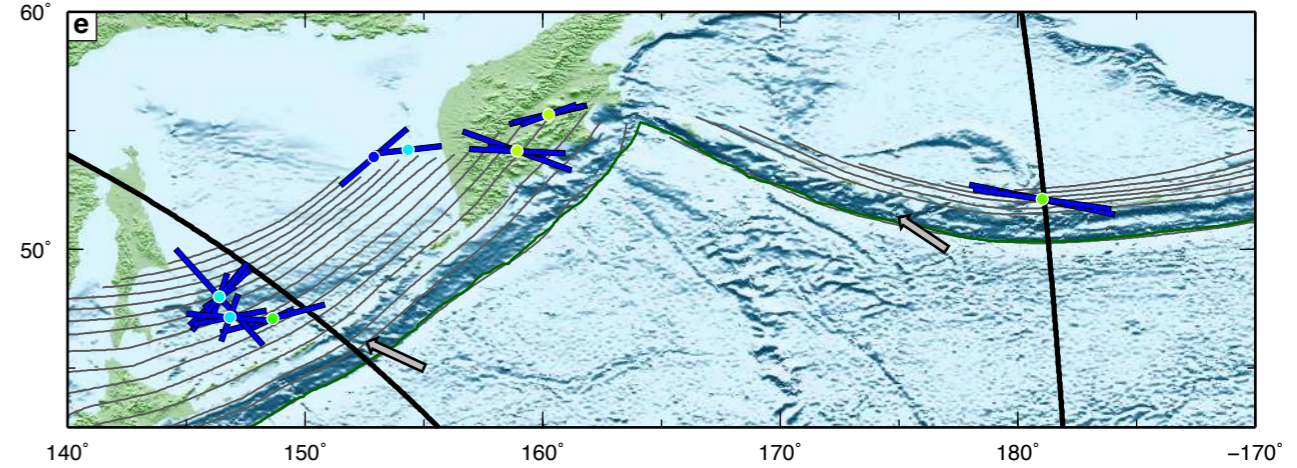
New Britain



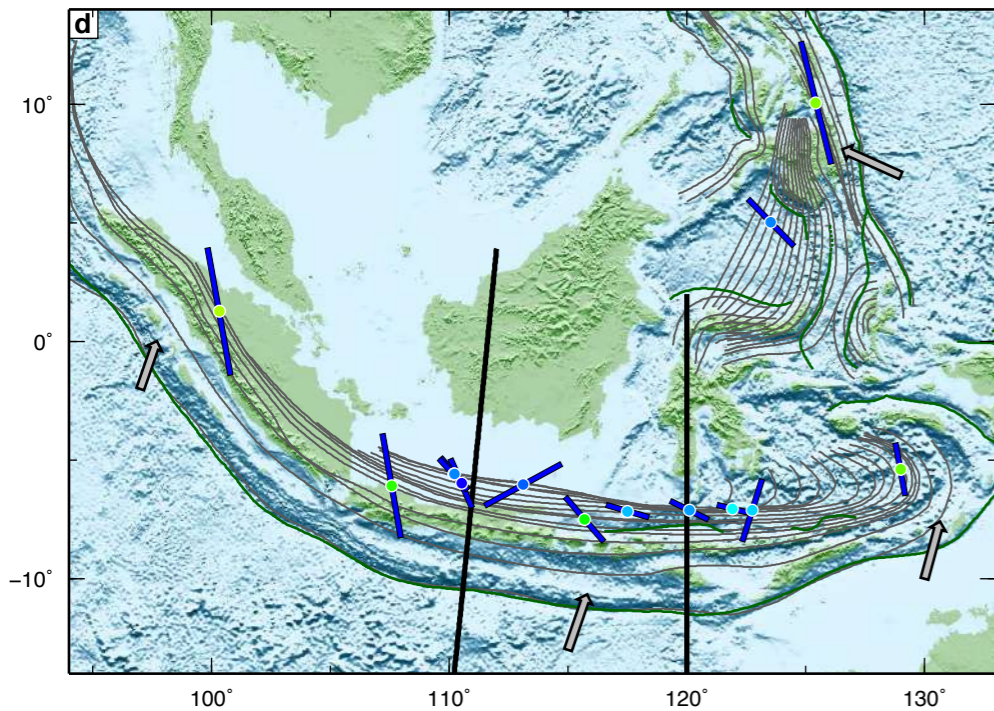
Tonga



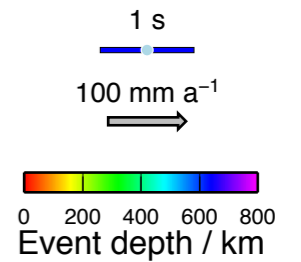
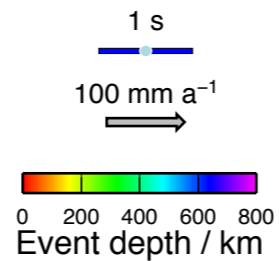
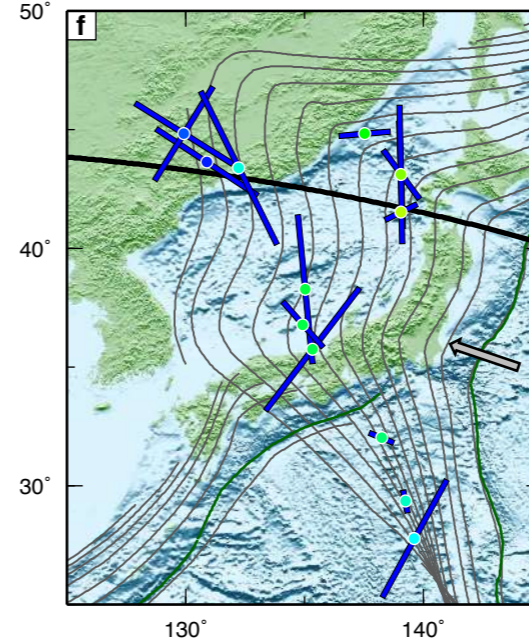
Kuril & Aleutians

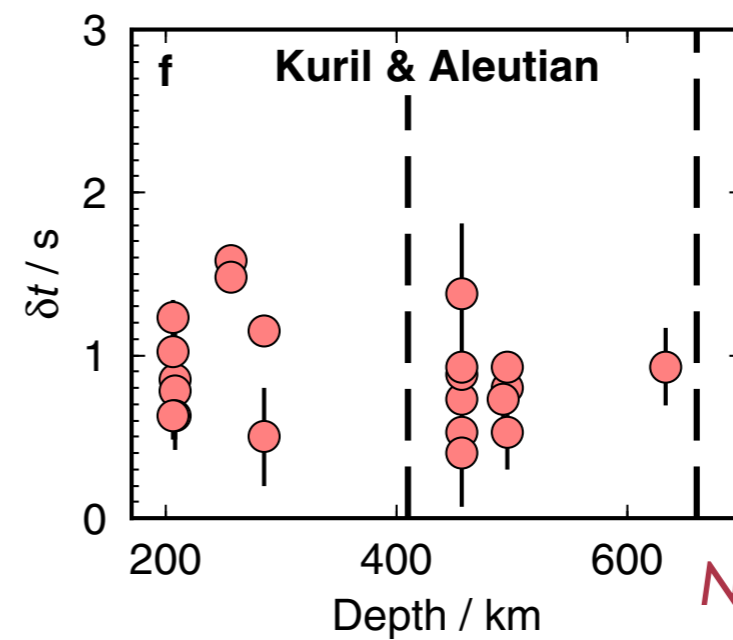
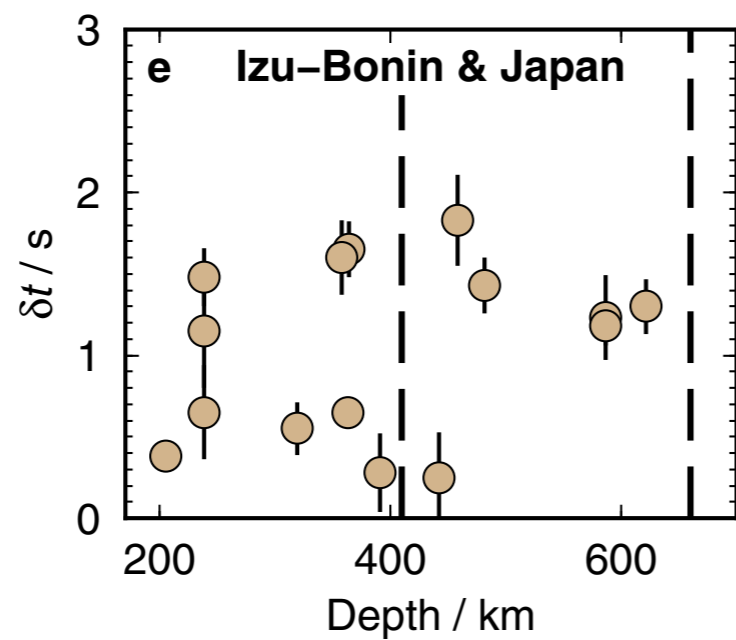
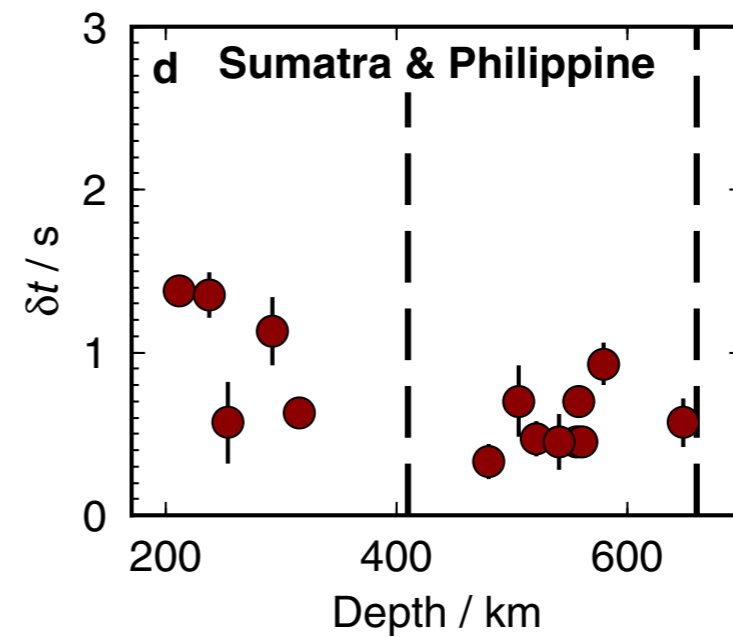
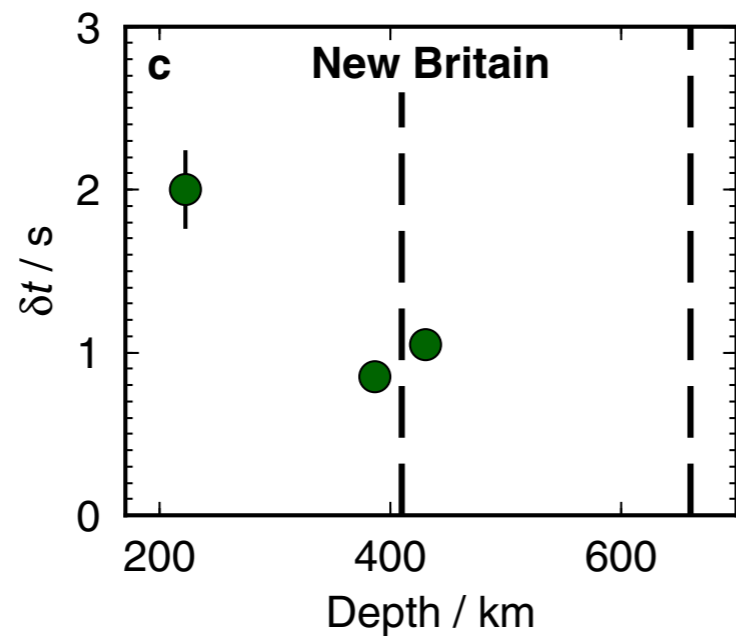
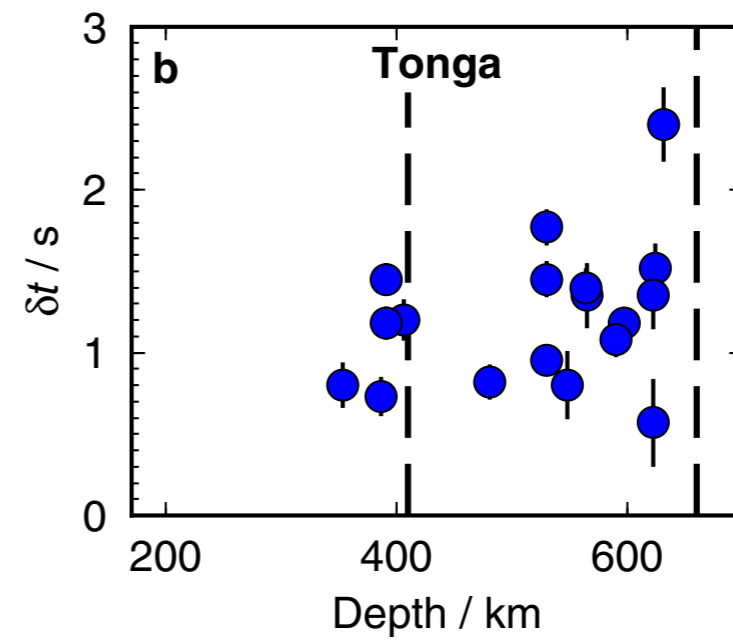
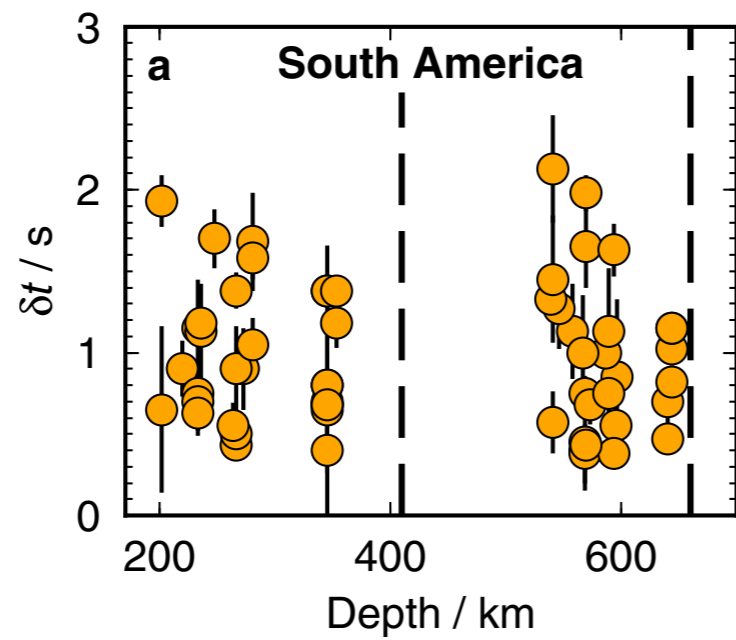


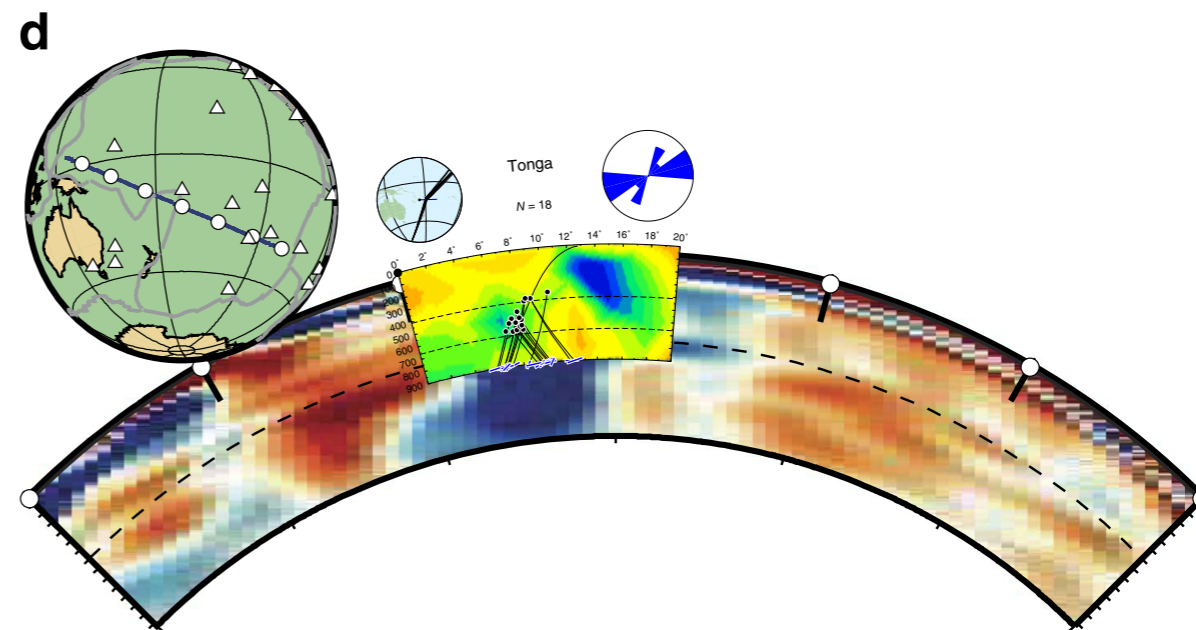
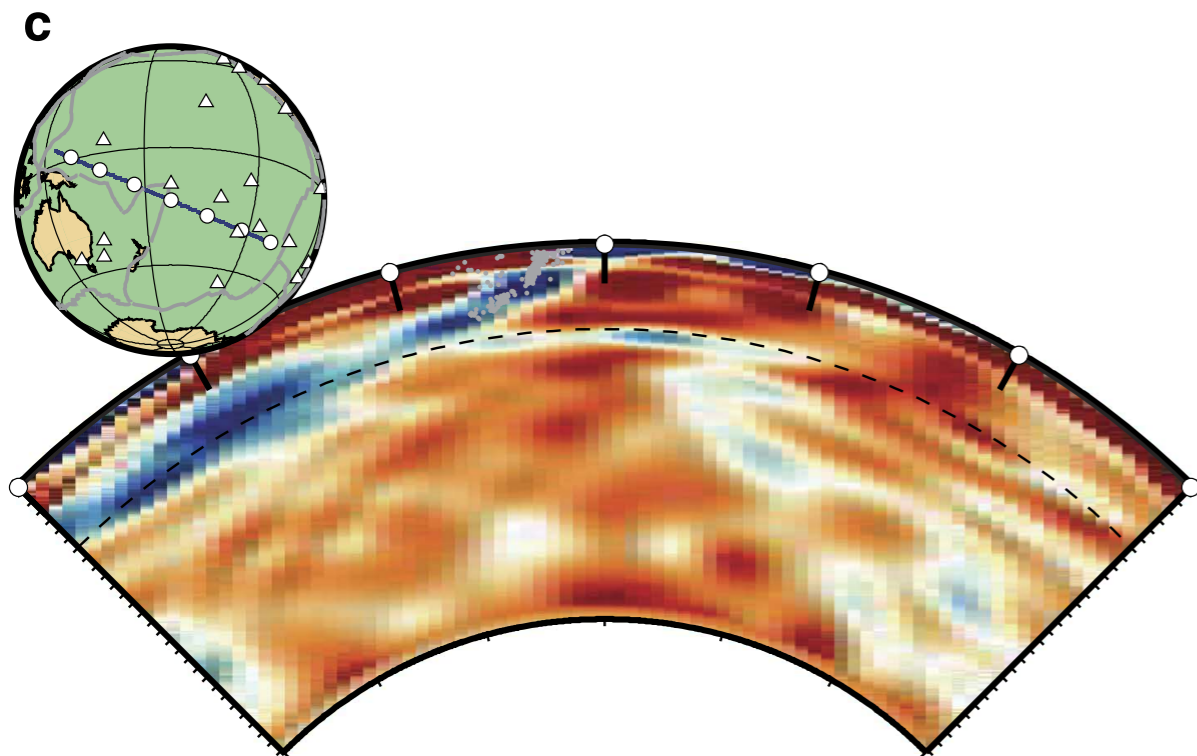
Sumatra & Philippines



Izu-Bonin & Japan







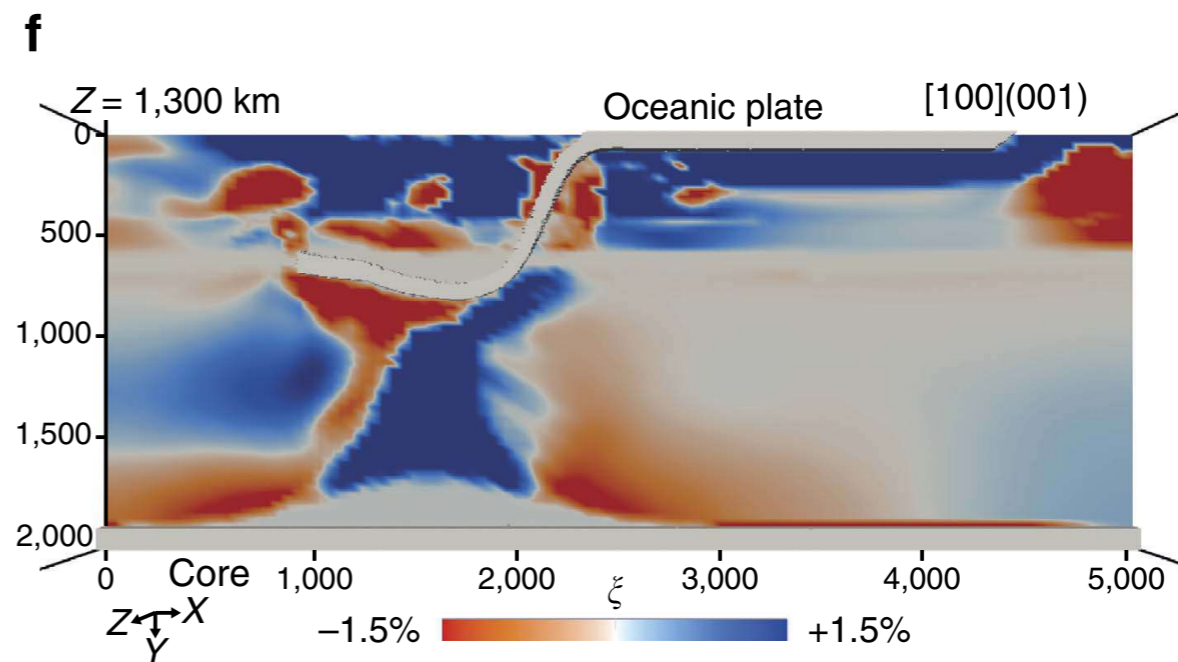
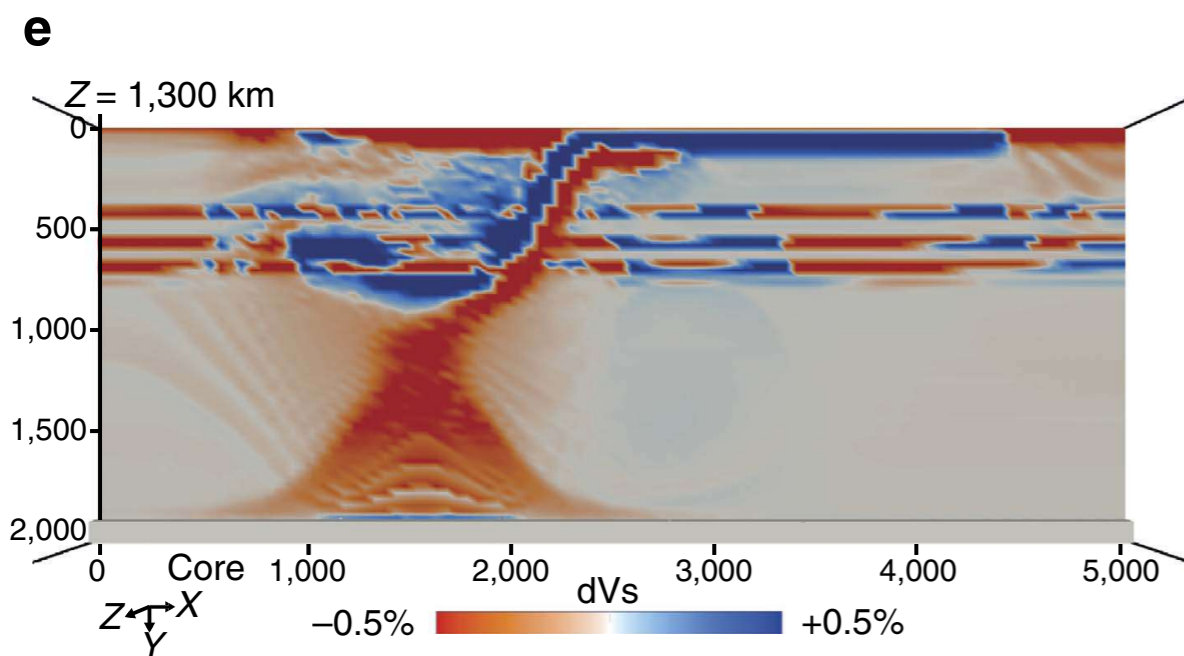
(faster SV)

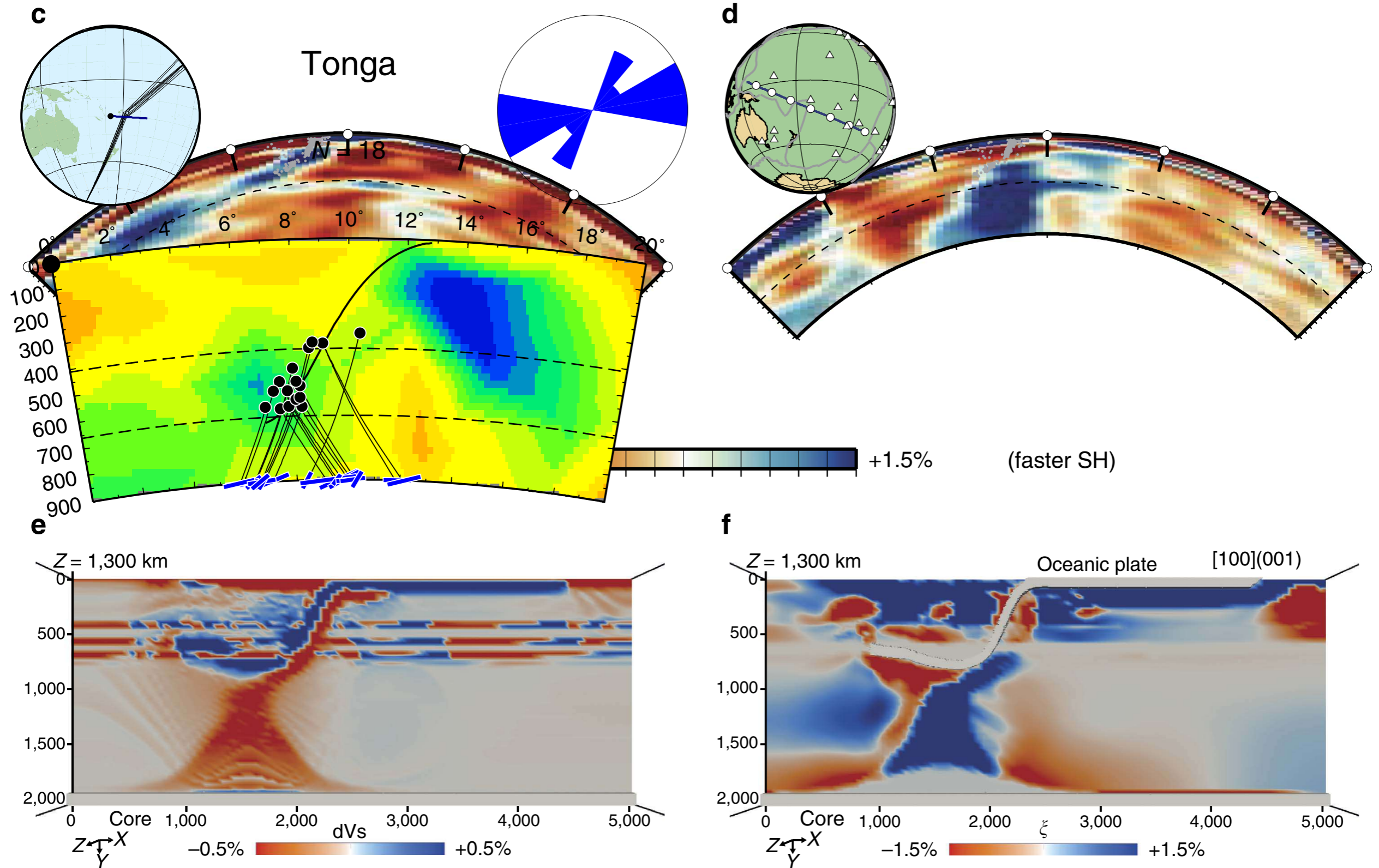
-1.5%



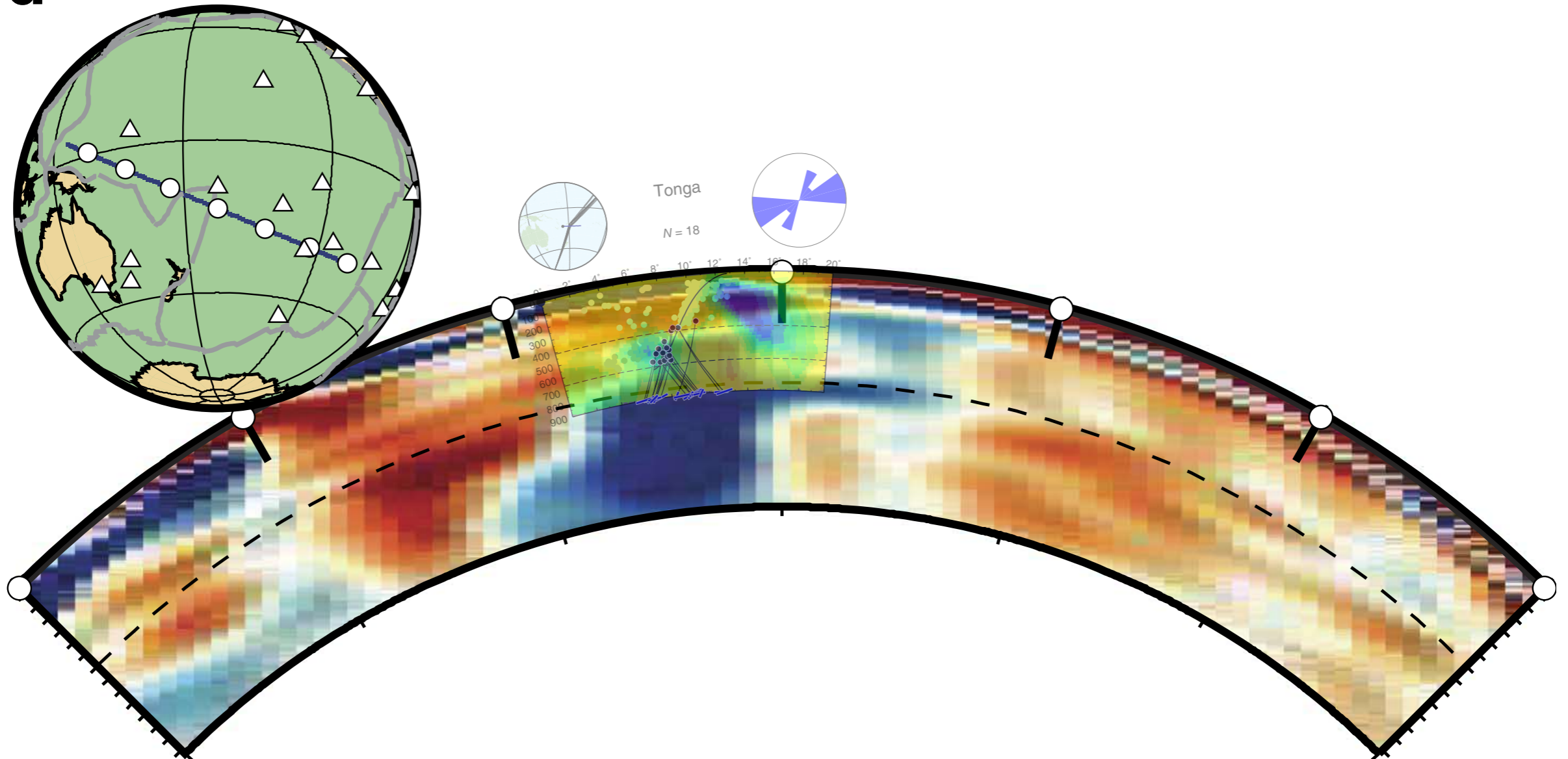
+1.5%

(faster SH)





d



+1.5%

(faster SH) *Chang et al., 2016; Nowacki et al., 2015*

