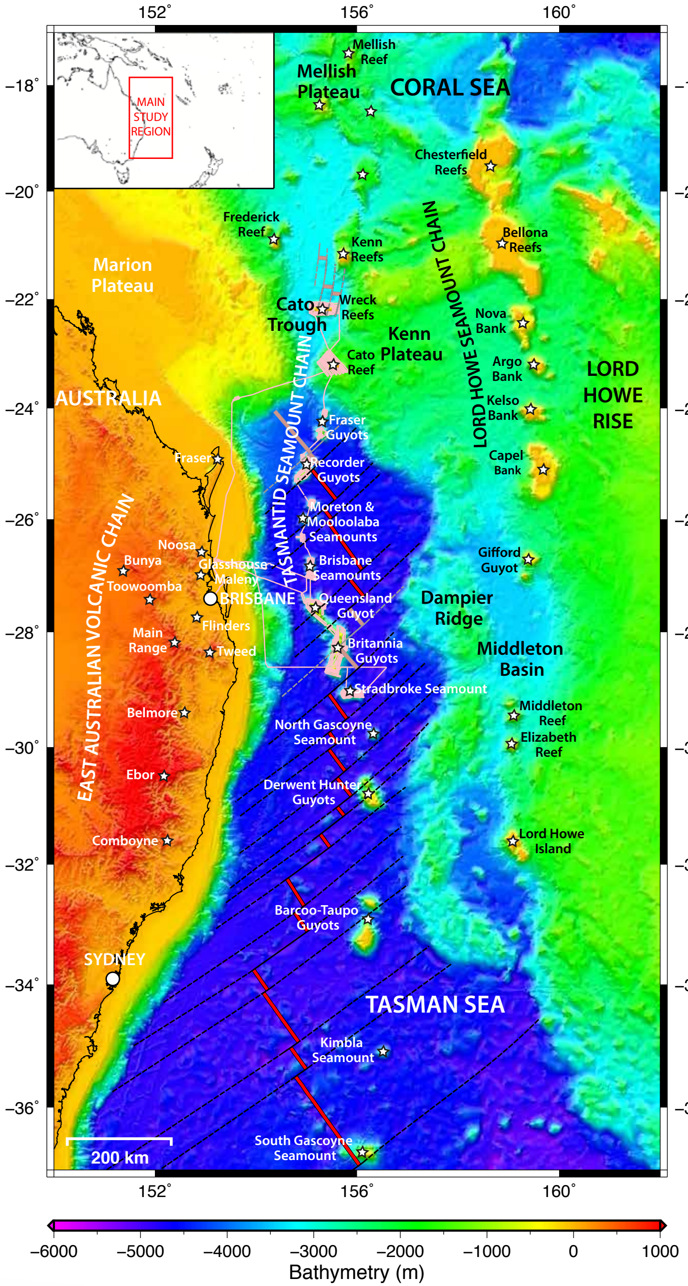

Tasman Sea Volcanism: 3 Parallel Hotspot Tracks

- Continental chain well dated and age-progressive
  - Commonly discussed as plume-related
- However, also two clear chains offshore
  - Much less studied
  - Some 1980s K-Ar ages show matching age progression
  - Two recent UK-Aus voyages

Richards et al., 2018, G-cubed

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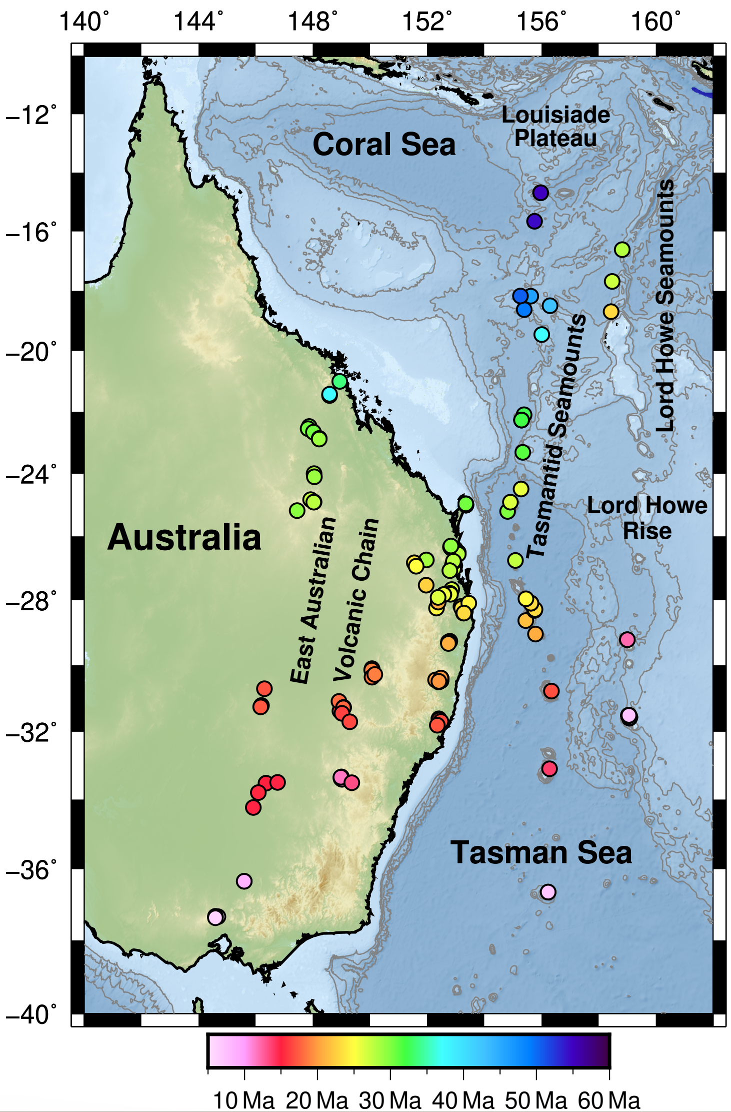
Tasmantid Chain Results



- Tasmantids chain is beautifully age-progressive
  - Starts at Louisiade Plateau: possible LIP?
    - Target of 2019 voyage
- All 3 chains have indistinguishable time-distance relationship

→ Probably not coincidence

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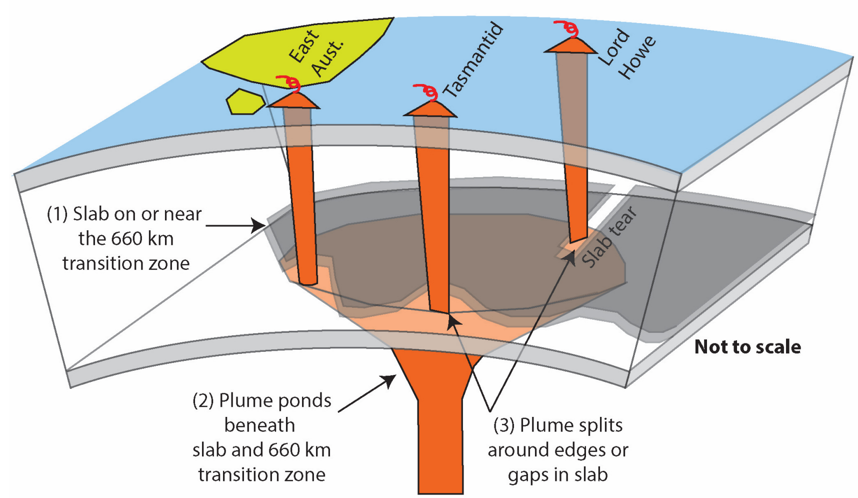
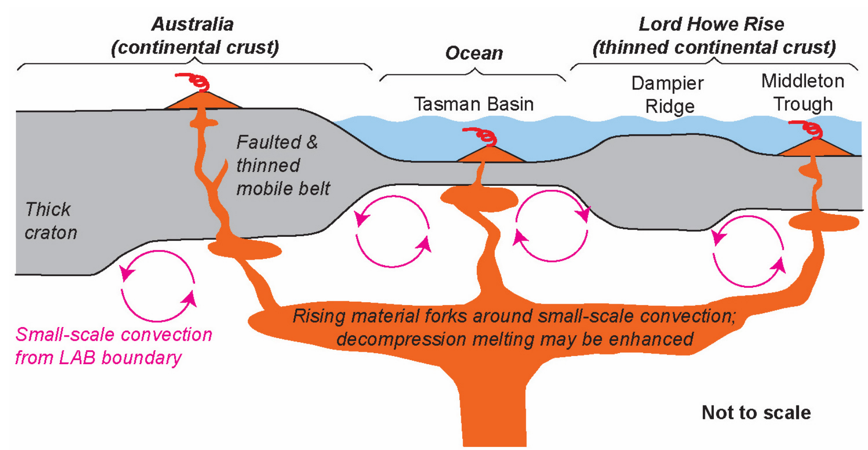
Possible Mechanisms

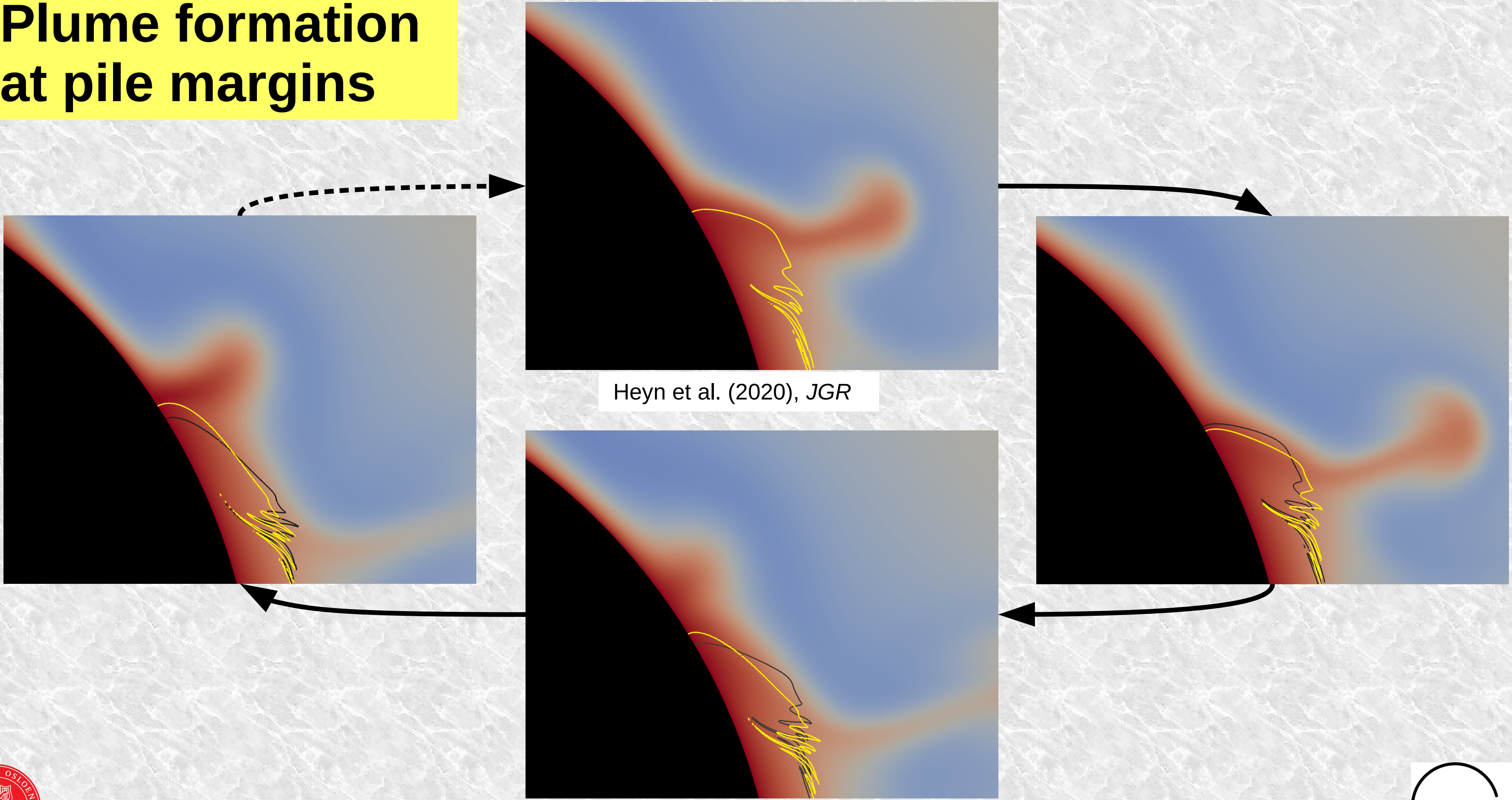
- Three closely spaced plumes?
  - Too close together – they'd merge in the lower mantle
- An upwelling sheet?
  - Not stable on 30 Ma timescale
- Area has long history of subduction and slabs imaged in transition zone
  - Could pond under slab and then split as finds different ways to get past
- LAB topography in the area is unusually complex – repeated bands of thick and thin lithosphere
  - Edge-driven eddies could split the rising plume material?





L. M. Kalnins, lara.kalnins@ed.ac.uk

Plume formation at pile margins

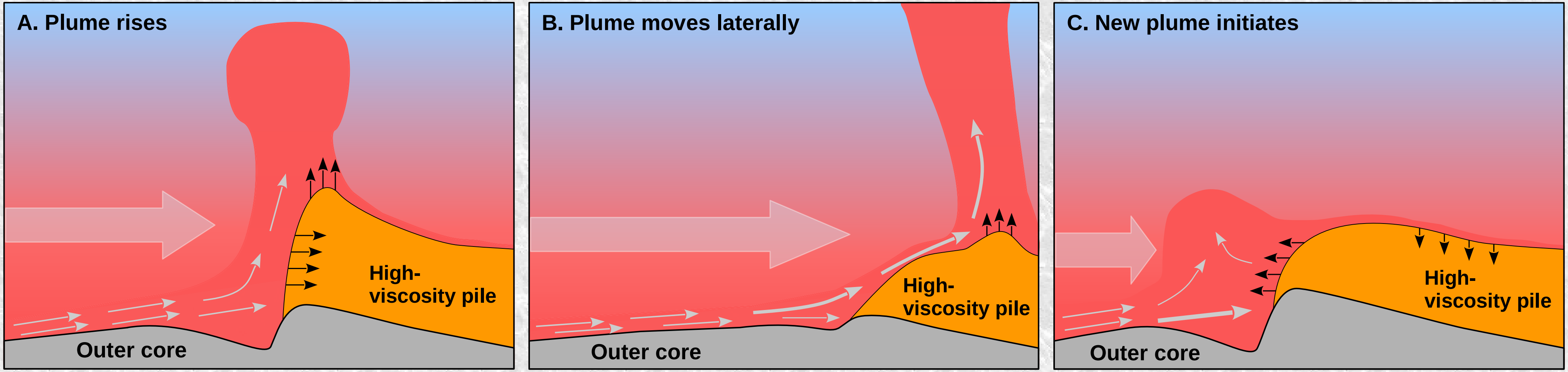


Heyn et al. (2020), *JGR*

Björn Heyn, Clinton Conrad, Reidar Trønnes

b.h.heyn@geo.uio.no

CMB deformation related to viscosity contrasts and plume formation



Heyn et al. (2020), *EPSL*

Towards a robust characterisation of mantle flow using the SOLA method

Federica Restelli[1]
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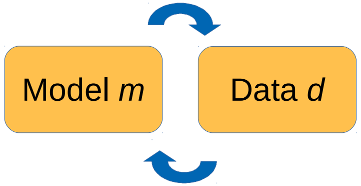
Dr Paula Koelemeijer[1]

Dr Christophe Zaroli[2]

[1]Department of Earth Sciences – Royal Holloway University of London
[2]École et Observatoire des Sciences de la Terre – Université de Strasbourg

Seismic tomography → solution of an inverse problem



A robust physical interpretation requires unbiased amplitudes and uncertainties!

SOLA *(Subtractive Optimally Localised Averages)* **method**

	DLS	SOLA
Non-unique solution	Ad hoc regularisation	Averaging
Data coverage	Influenced	Little influenced
Amplitudes	Potentially biased	Constrained to be unbiased
Uncertainties	Expensive	Efficient

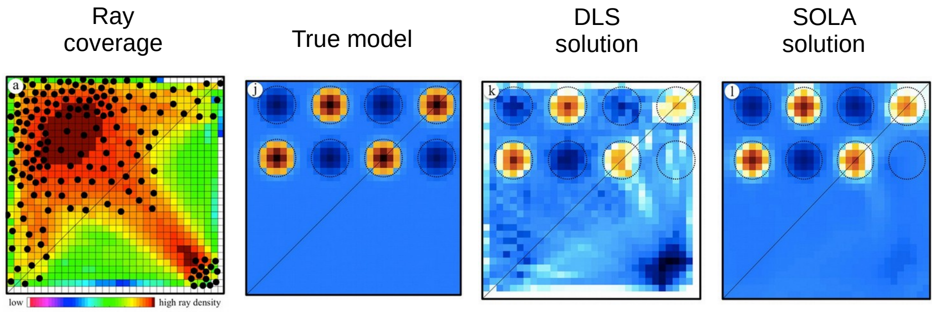


Figure 1: Toy problem to illustrate the local bias effect

Method applied to observations of **normal modes:**

global data coverage and sensitive to V_S and V_P anisotropy

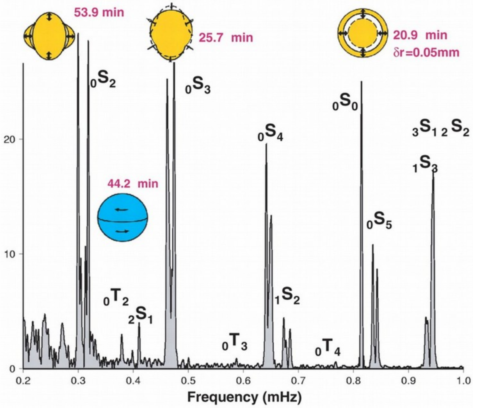


Figure 2: Amplitude spectrum from the 2004 Sumatra earthquake

Focus on **seismic anisotropy** ➡ More direct information on **mantle flow**

Acknowledgements:
Federica Restelli is funded by a Royal Society grant (RGF\EA\181029) and gratefully acknowledges their support.
Source of the figures:
Figure 1: Zaroli, C., Koelemeijer, P., & Lambotte, S. (2017). Toward seeing the Earth's interior through unbiased tomographic lenses. Geophysical Research Letters, 44(22), 11-399.
Figure 2: Park, J., Song, T. R. A., Tromp, J., Okal, E., Stein, S., Roult, G., ... & Berger, J. (2005). Earth's free oscillations excited by the 26 December 2004 Sumatra-Andaman earthquake. Science, 308(5725), 1139-1144.

Reconstructing western North America using lower mantle slabs

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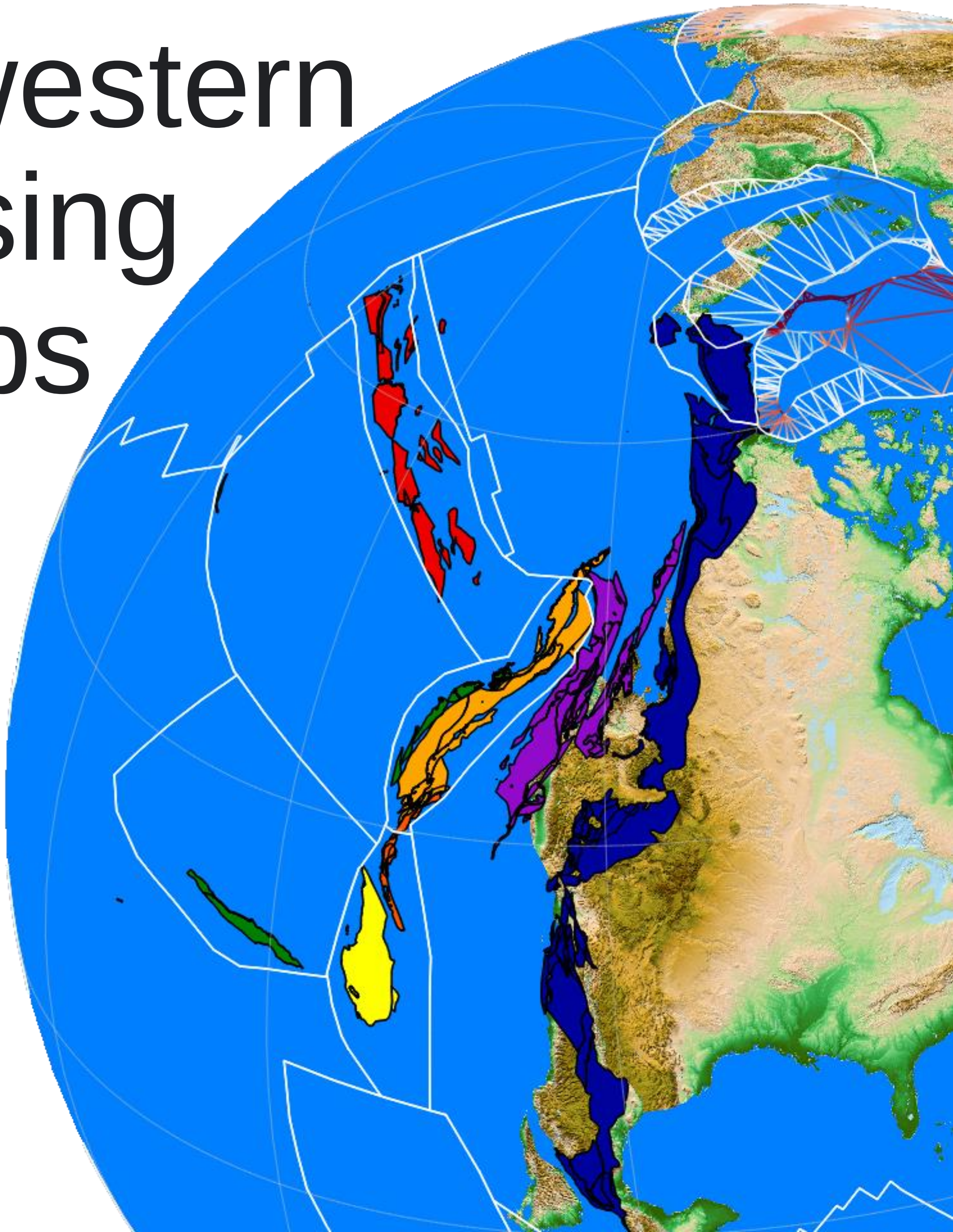
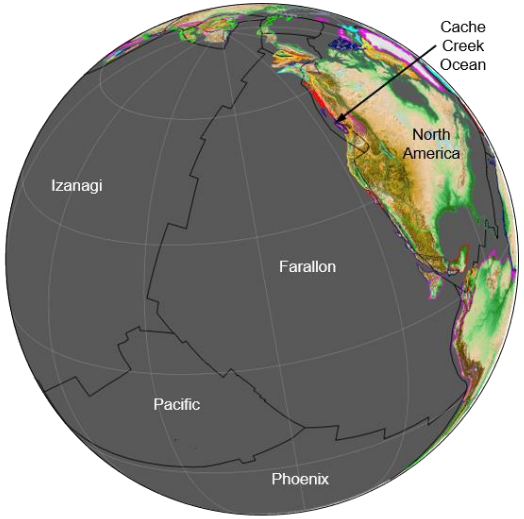
<u>Co-authors</u>: Karin Sigloch, Mitch Mihalynuk, Maria Seton, Martha Henderson, Kasra Hosseini, Afsaneh Mohammadzaheri, Stephen Johnston, Dietmar Müller



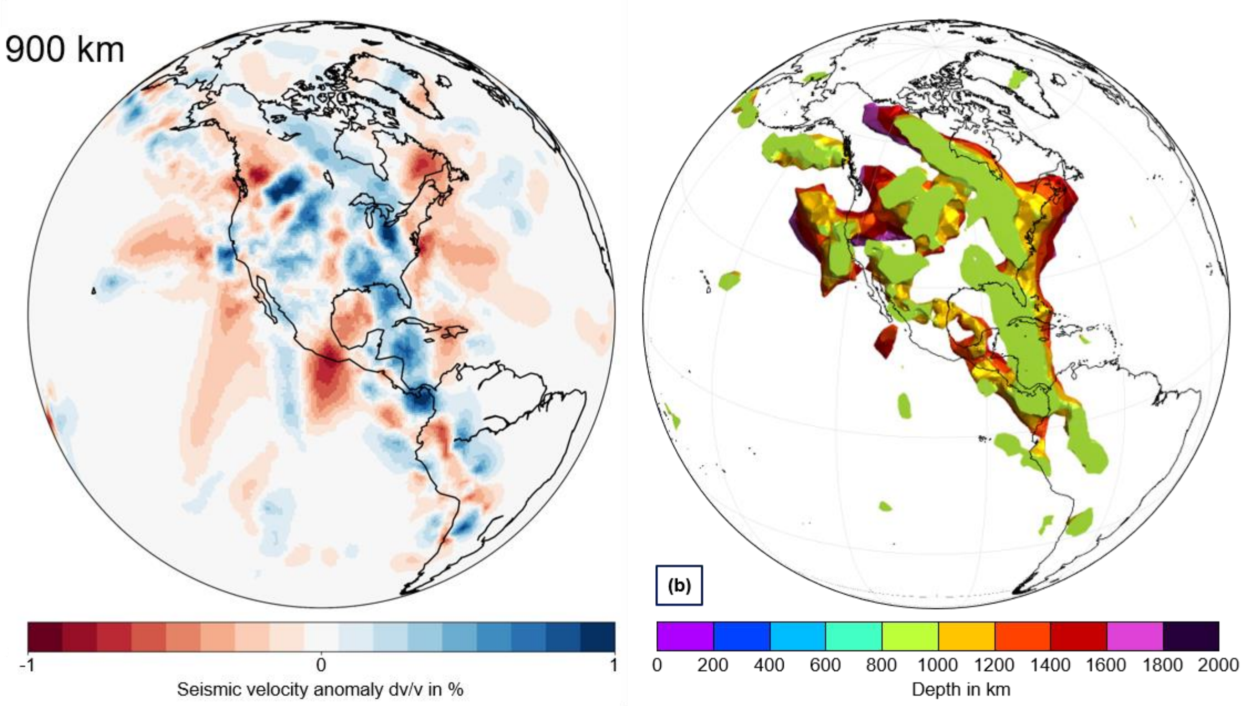
Tomotectonic Analysis

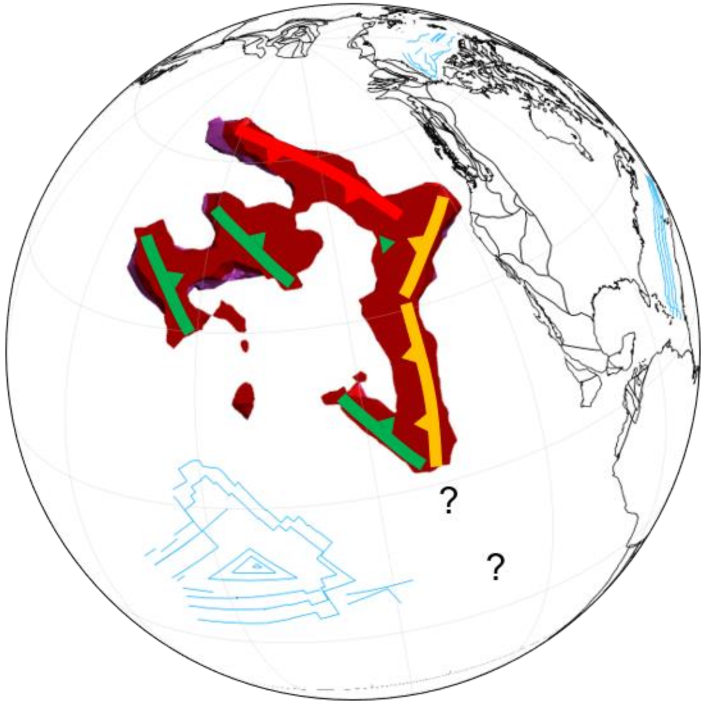
Previous Reconstructions

Engebretson et al., 1985, GSA Special Paper



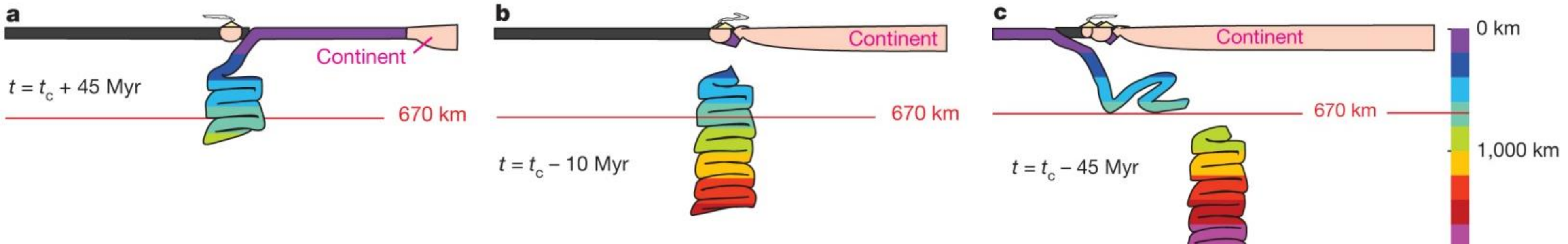
Shephard et al., 2013, Earth Science Reviews



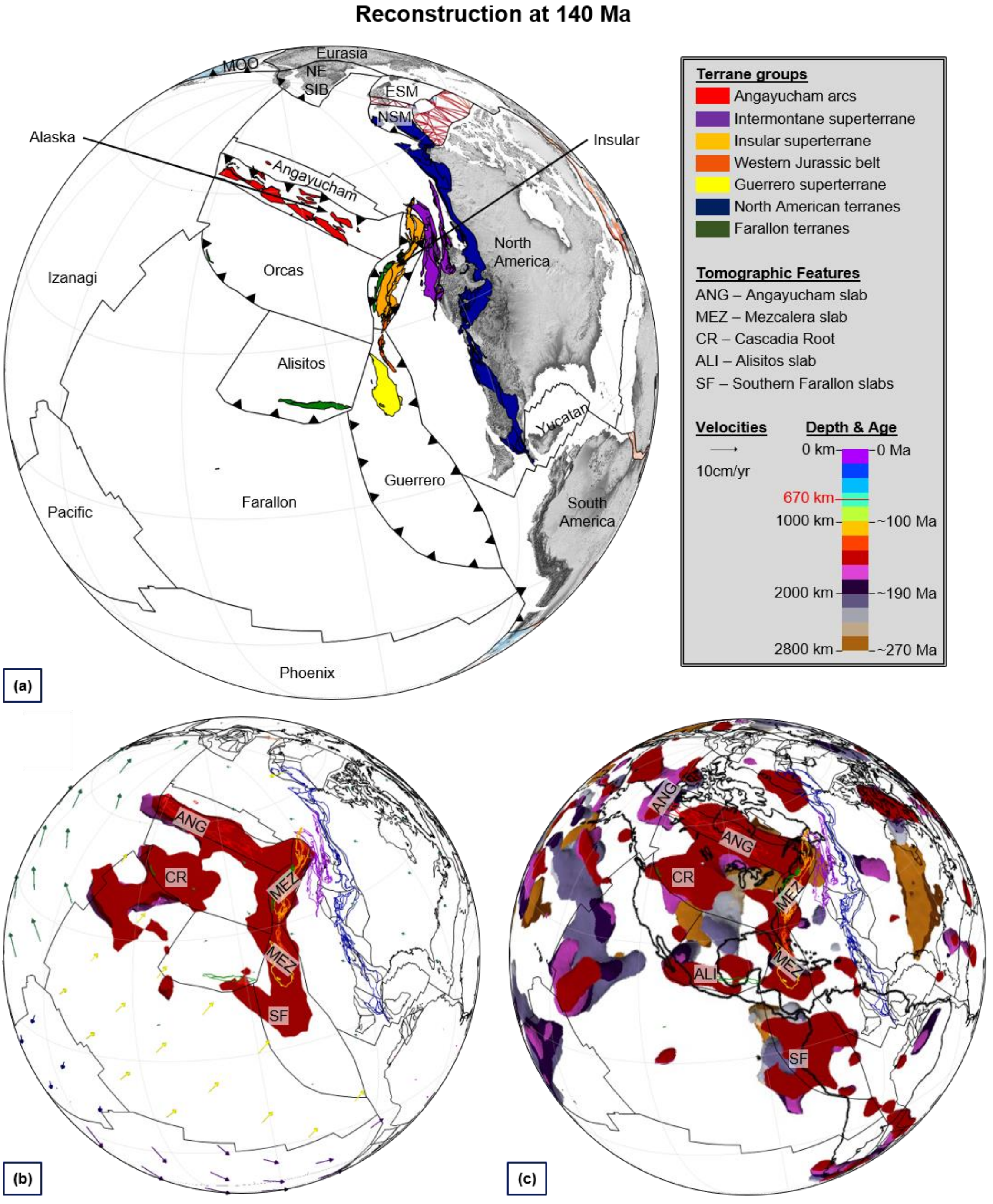


Sigloch & Mihalynuk, 2017, GSA Bulletin; Clennett et al., 2020, G-Cubed

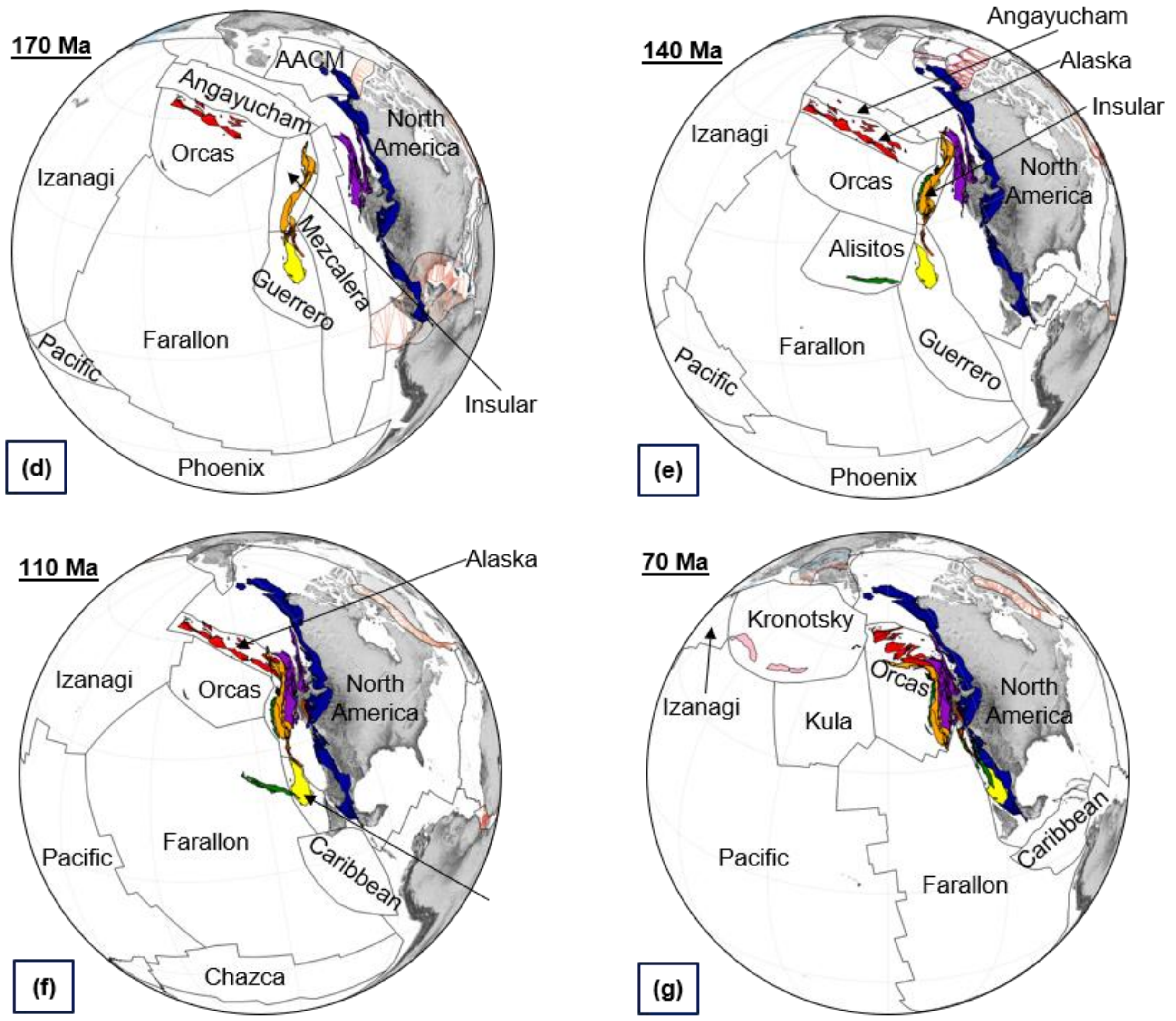
Slabs and arcs at stationary trenches



Sigloch & Mihalynuk, 2013, Nature



Clennett et al., 2020, G-Cubed



Clennett et al., 2020, G-Cubed

Conclusions

- Detailed, quantitative plate model that more accurately reconciles geophysical and geological evidence.
- Tomotectonic method can be used to further constrain palaeogeographic reconstructions in other regions.

Preliminary petrographic study of ultramafic xenoliths from Fresnillo, Zacatecas (Mesa Central, México)

Scarlett Jesybet Montoya-Rivera [a], Vanessa Colás- Gines [b], María Guadalupe Dávalos-Elizondo [c], José Jorge Aranda-Gómez [d], Augusto Antonio Rodríguez-Diaz [e]

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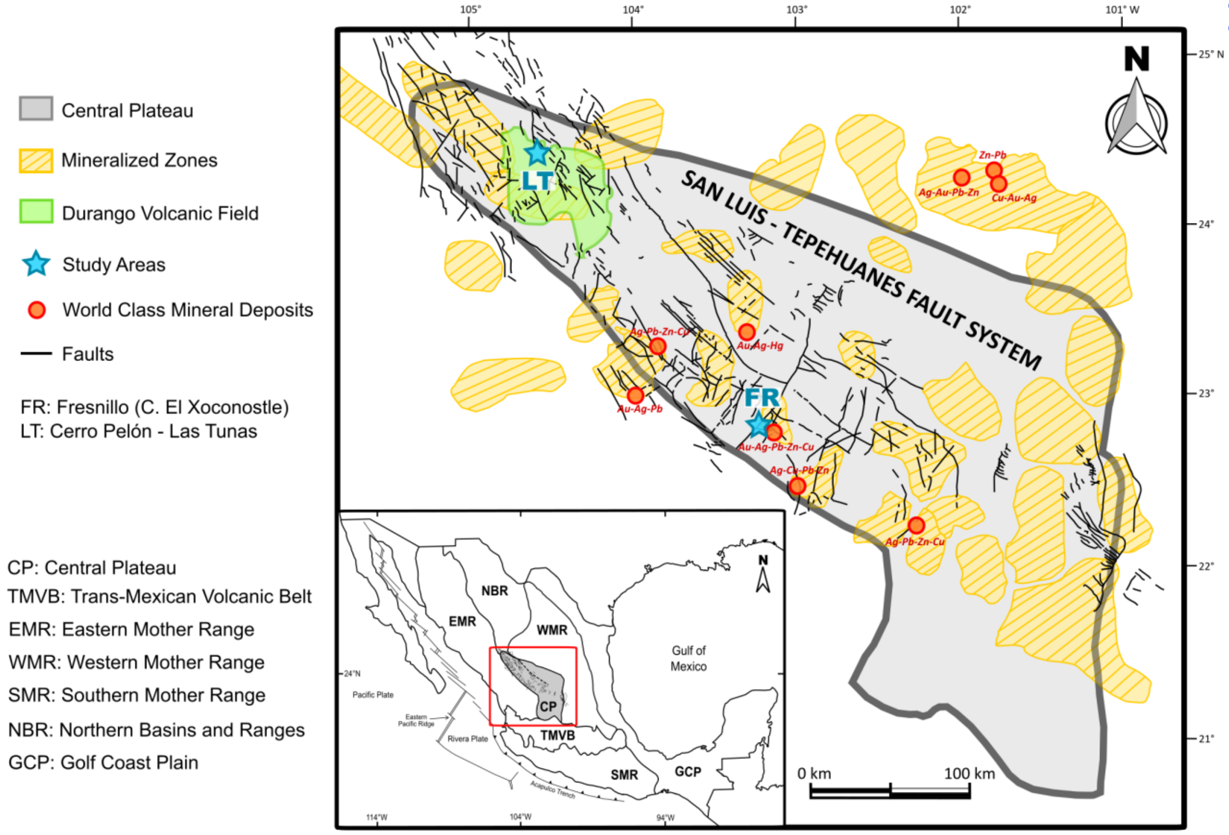
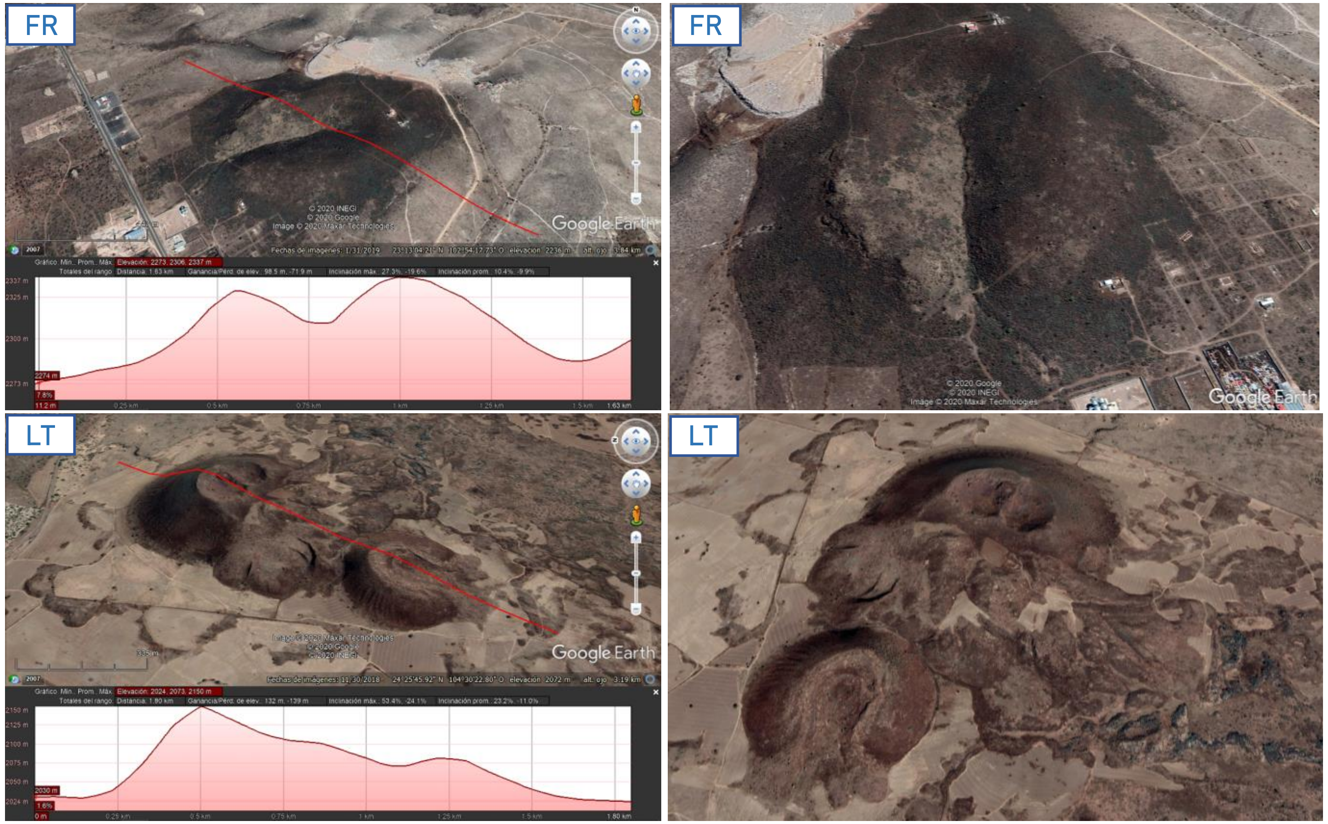
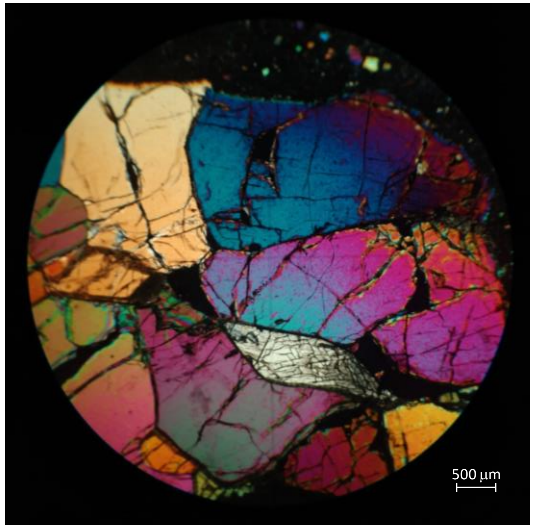
b Instituto de Geología, Universidad Nacional Autónoma de México, Ciudad Universitaria, 04510, Ciudad de México, México.
c Facultad de Ciencias, Departamento de Ciencias de la Tierra, Universidad Nacional Autónoma de México, 04510, Ciudad de México, México.
d Centro de Geociencias, Universidad Nacional Autónoma de México; Campus Juriquilla, Juriquilla, 76320, Querétaro, México.
e Instituto de Geofísica, Universidad Nacional Autónoma de México, Ciudad Universitaria, 04510 Ciudad de México, México.

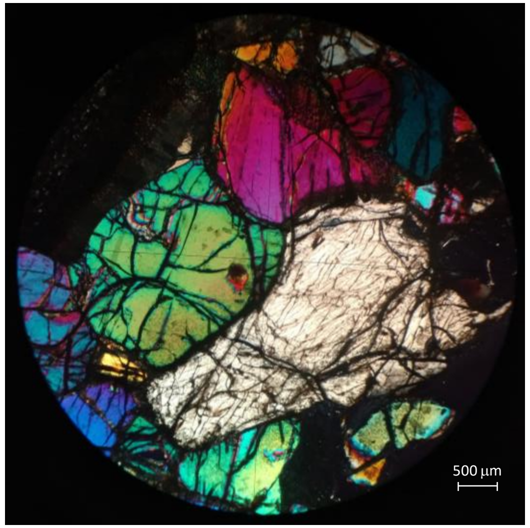


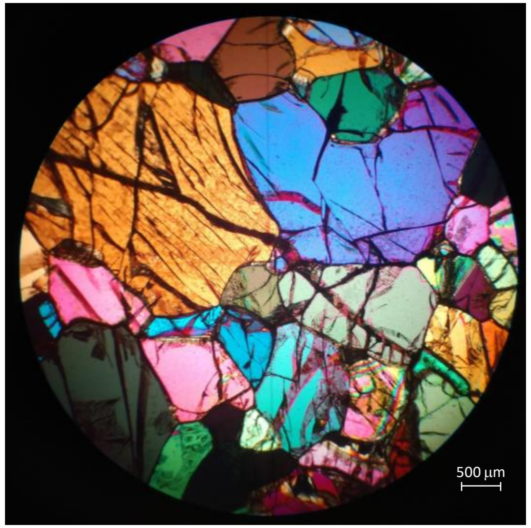


In Mexico, mafic alkali rock with xenoliths crop out in many isolated areas located along the northwestern margin of the Mesa Central (Central Mexico). The study areas are: 1) Cerro El Xoconostle volcano, near the city of Fresnillo (Zacatecas) and 2) Cerro Pelón-Cerro Las Tunas Complex in the Durango Volcanic Field.

OBJECTIVES





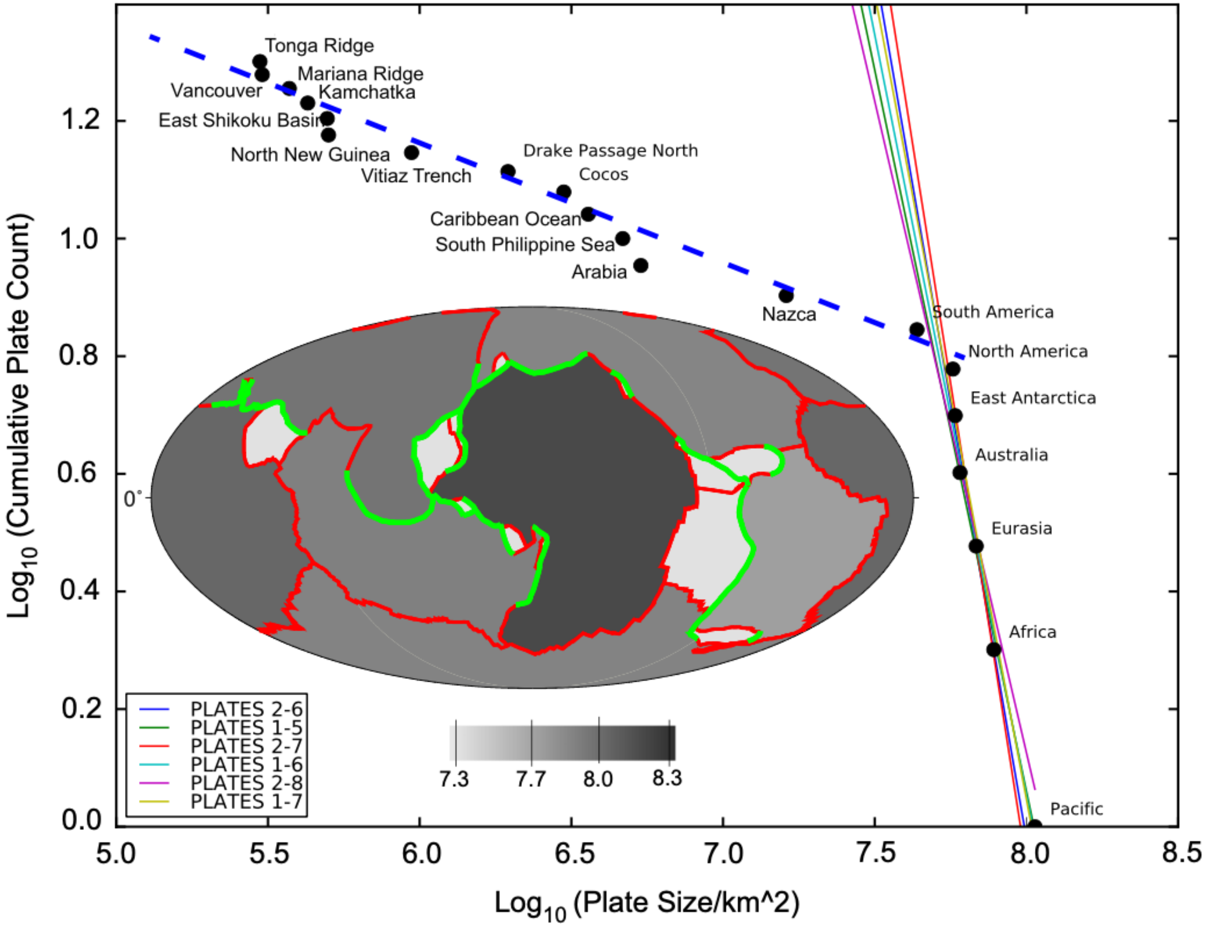


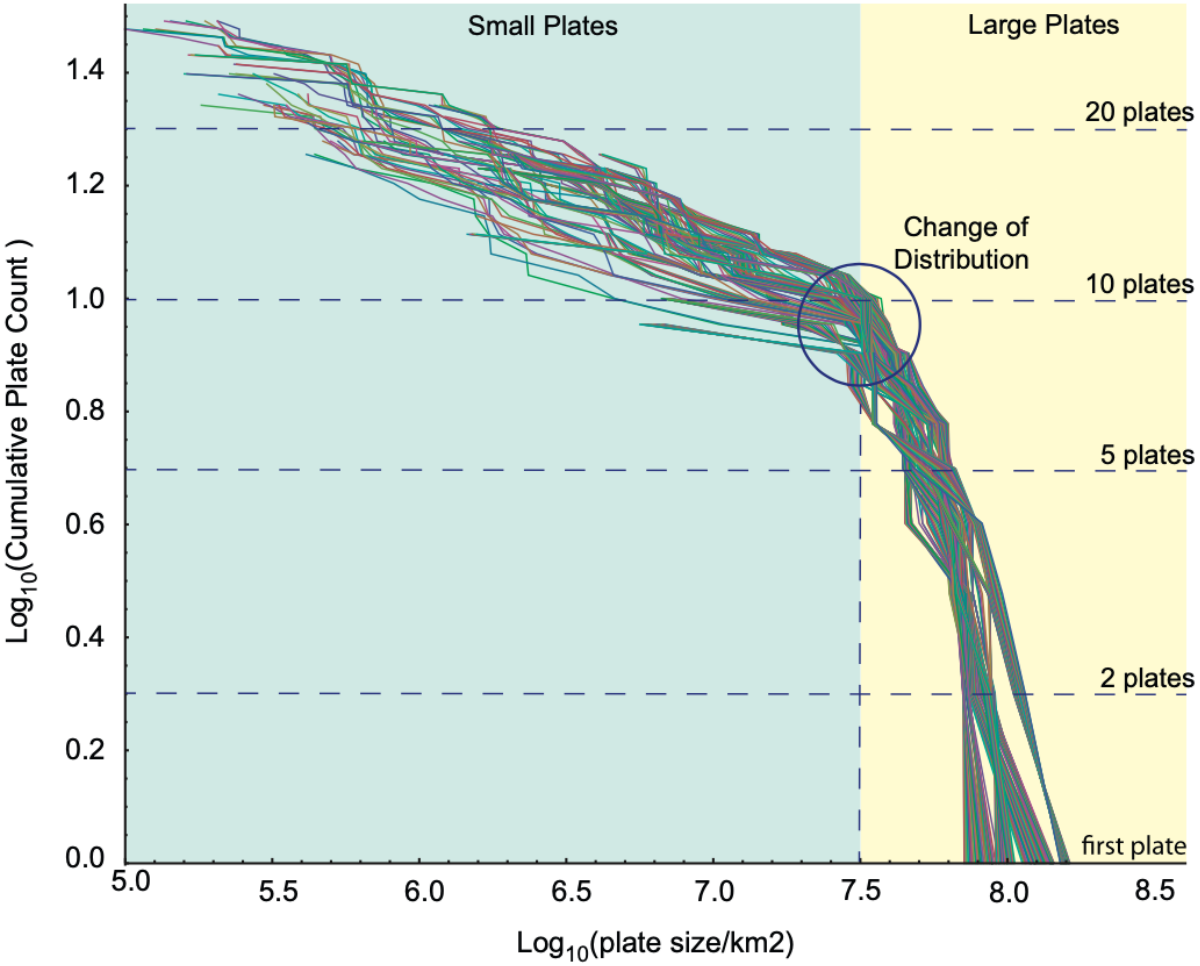
Characterize the possible metasomatic processes that have modified the Subcontinental Lithospheric Mantle located below the Central Plateau (Mesa Central), based on the petrology and mineral chemistry of ultramafic xenoliths collected at this location. These metasomatic processes can be registered in the chemical composition of silicates, as well as, oxides and sulfides in the lherzolites.

Identify the possible presence of sulphides with significant concentrations of noble metals in the ultramafic xenoliths. This might help to establish the concentration mechanisms of these metals and their possible relationship with the formation of mineral deposits in Central Mexico.

Earth's plates sizes are hierarchically organized

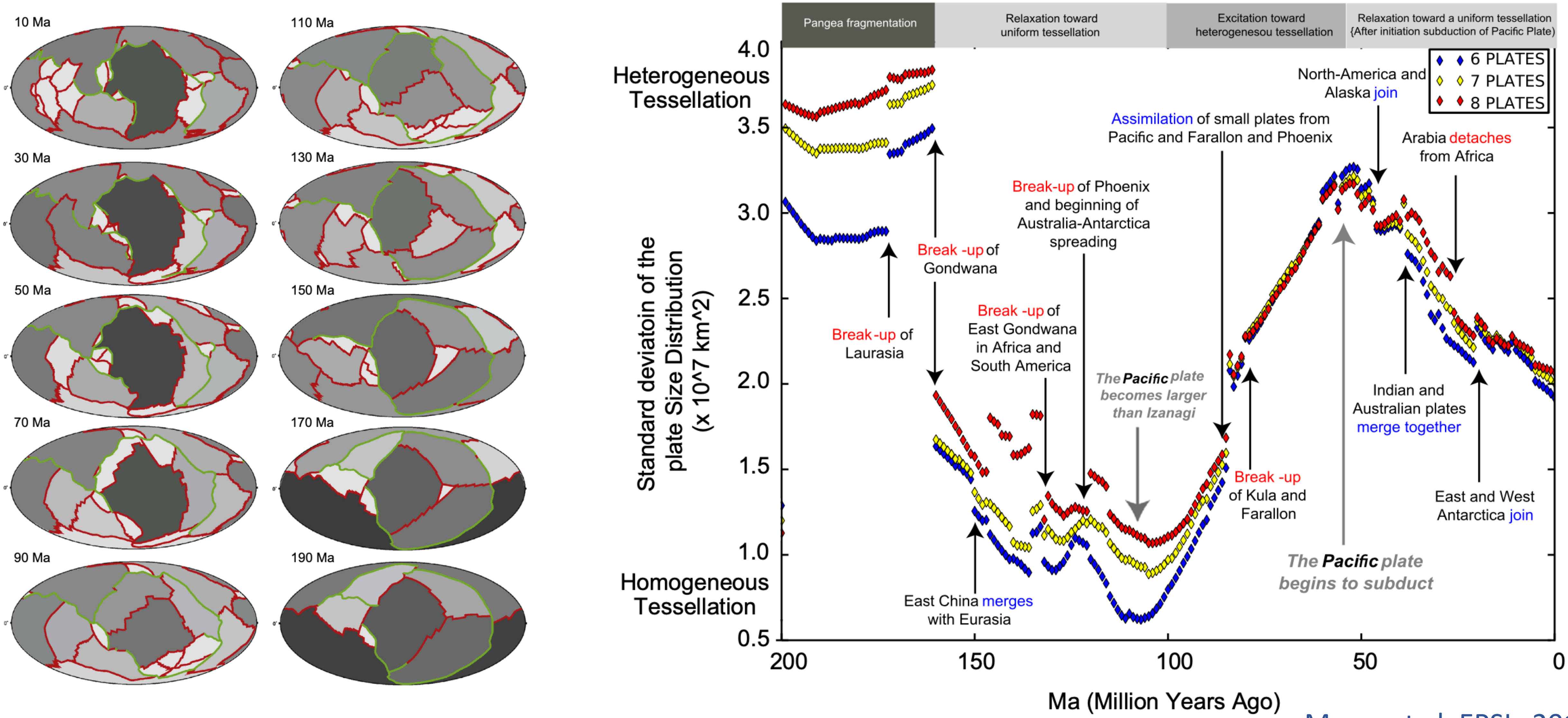
Gabriele Morra, Department of Physics and School of Geosciences. University of Louisiana at Lafayette, USA





Morra et al, EPSL, 2013

Heterogeneous to homogeneous tessellation



Morra et al, EPSL, 2013

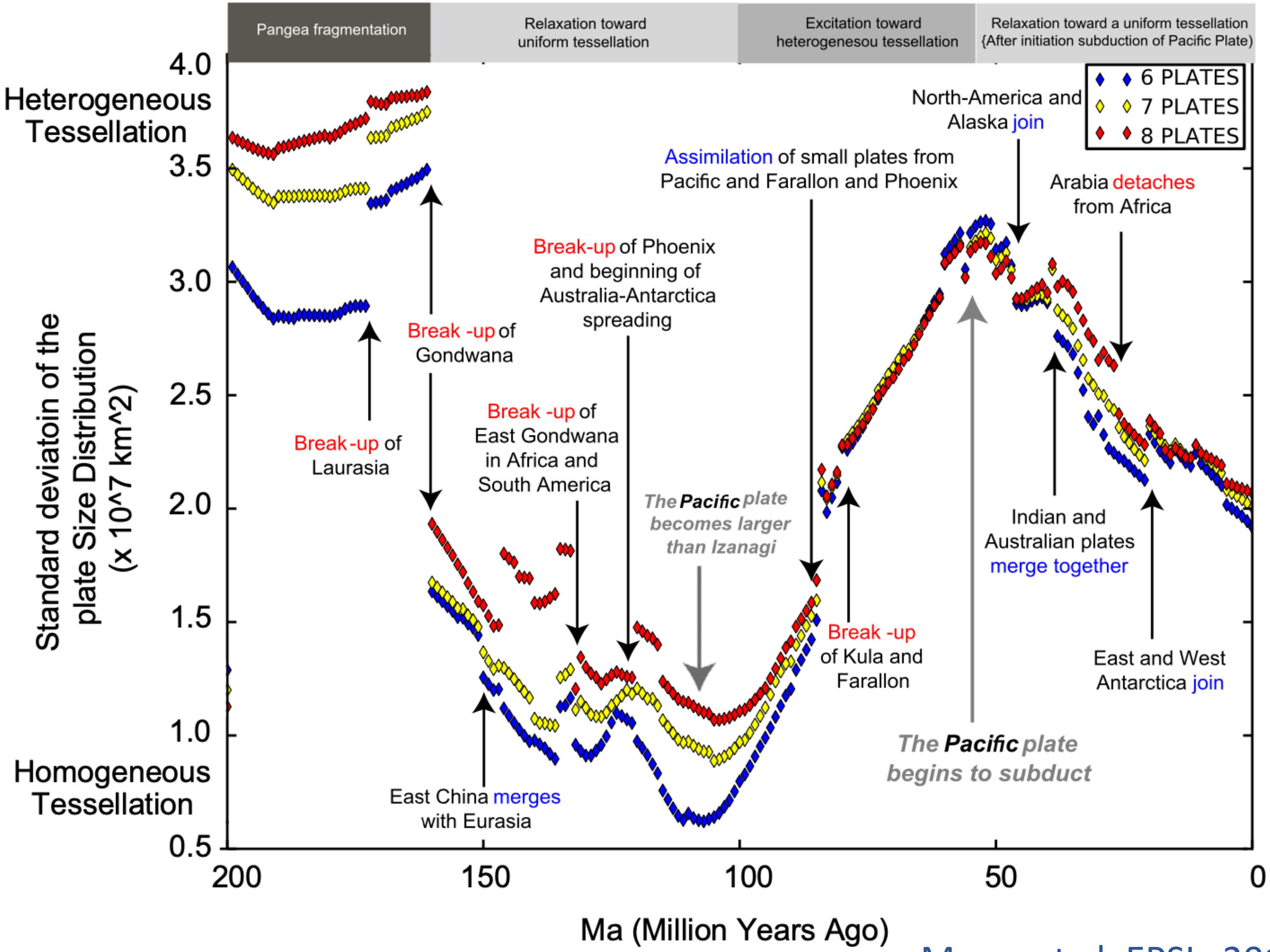
Driving Mechanism

- **Homogeneous tessellation:**

Whole mantle is **driven from the bottom or within**, as in Rayleigh-Benard convection, where surface tessellation is homogeneous.

- **Heterogeneous tessellation:**

Whole mantle convection **driven from the top by subduction** of the largest plates.

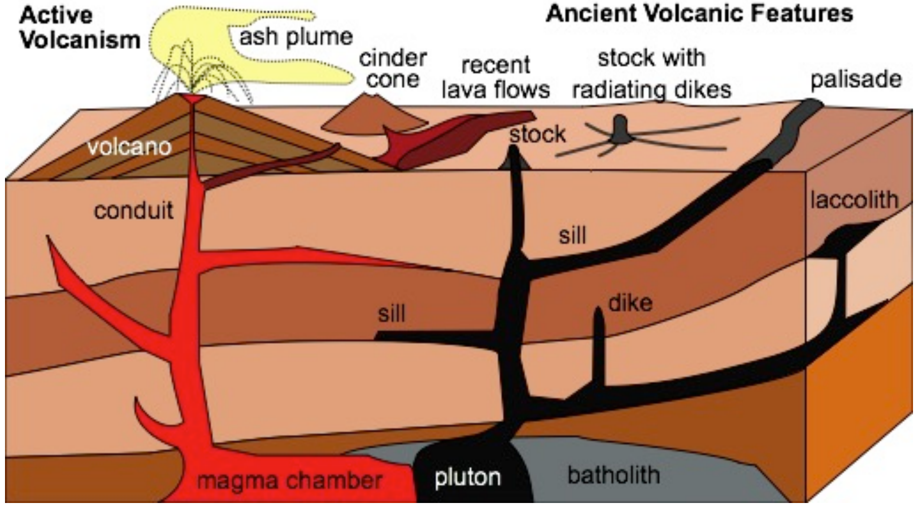


Morra et al, EPSL, 2013

Efficient cooling of rocky planets by intrusive magmatism

D. L. Lourenço [dlourenco@berkeley.edu][(1)], A. B. Rozel[(2)], M. D. Ballmer [(2,3)], T. Gerya [(2)], and P. J. Tackley [(2)]

(1) University of California, Berkeley, USA. (2) ETH Zürich, Switzerland. (3) University College London, UK

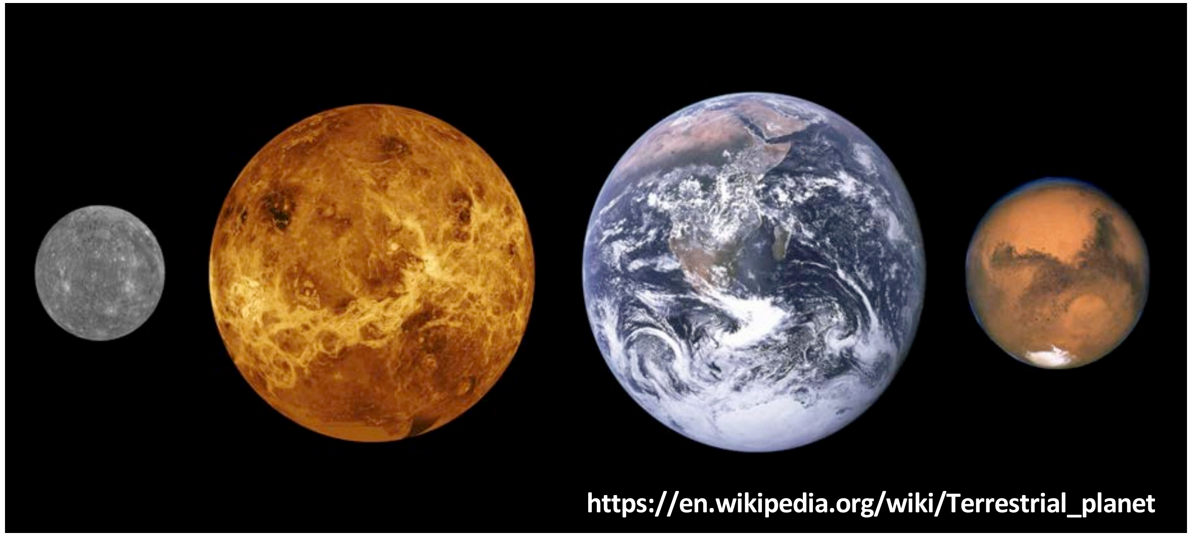


https://en.wikipedia.org/wiki/Intrusive_rock

ARTICLES
https://doi.org/10.1038/s41561-018-0094-8
nature geoscience

Efficient cooling of rocky planets by intrusive magmatism

Diogo L. Lourenço[1,2*], Antoine B. Rozel[1], Taras Gerya[1] and Paul J. Tackley[1]



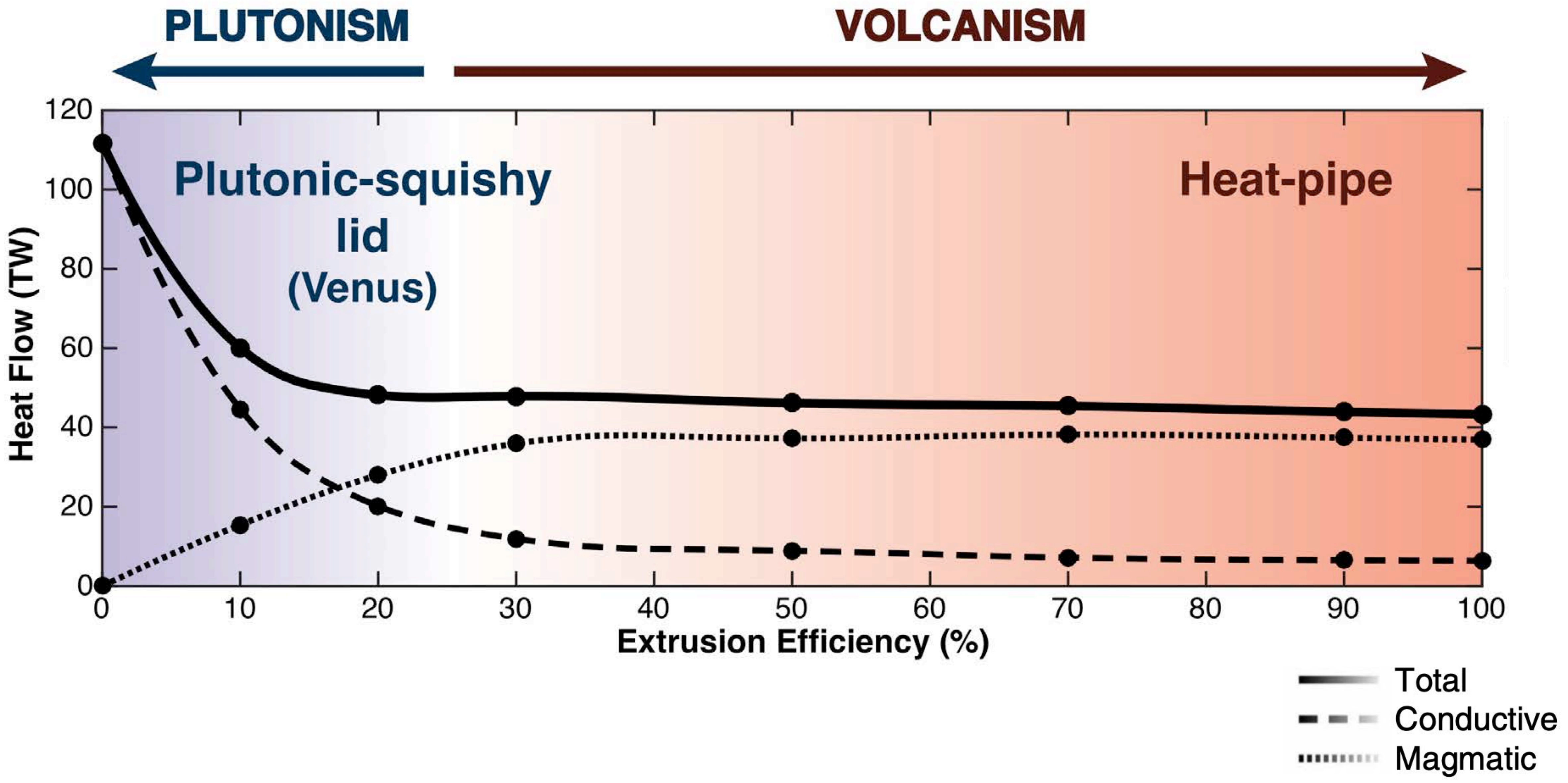
Geochemistry, Geophysics, Geosystems
AGU100 ADVANCING EARTH AND SPACE SCIENCE
RESEARCH ARTICLE
10.1029/2019GC008756

Plutonic-Squishy Lid: A New Global Tectonic Regime Generated by Intrusive Magmatism on Earth-Like Planets

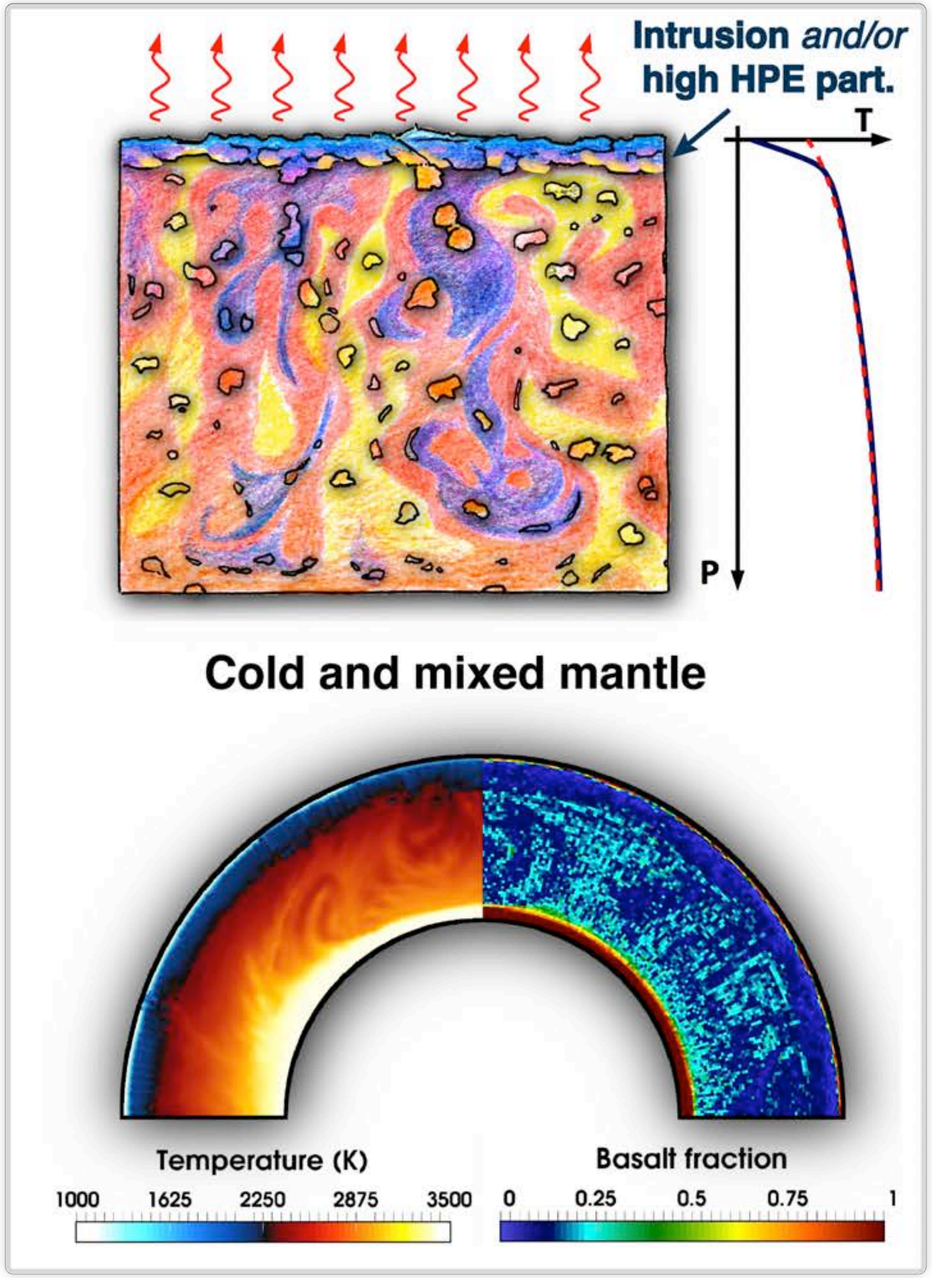
Diogo L. Lourenço[1,2,3], Antoine B. Rozel[1], Maxim D. Ballmer[1,4], and Paul J. Tackley[1]

[1]Institute of Geophysics, Department of Earth Sciences, ETH Zurich, Zurich, Switzerland, [2]Department of Earth and Planetary Sciences, University of California, Davis, CA, USA, [3]Department of Earth and Planetary Science, University of California Berkeley, Berkeley, CA, USA, [4]Department of Earth Sciences, University College London, London, UK

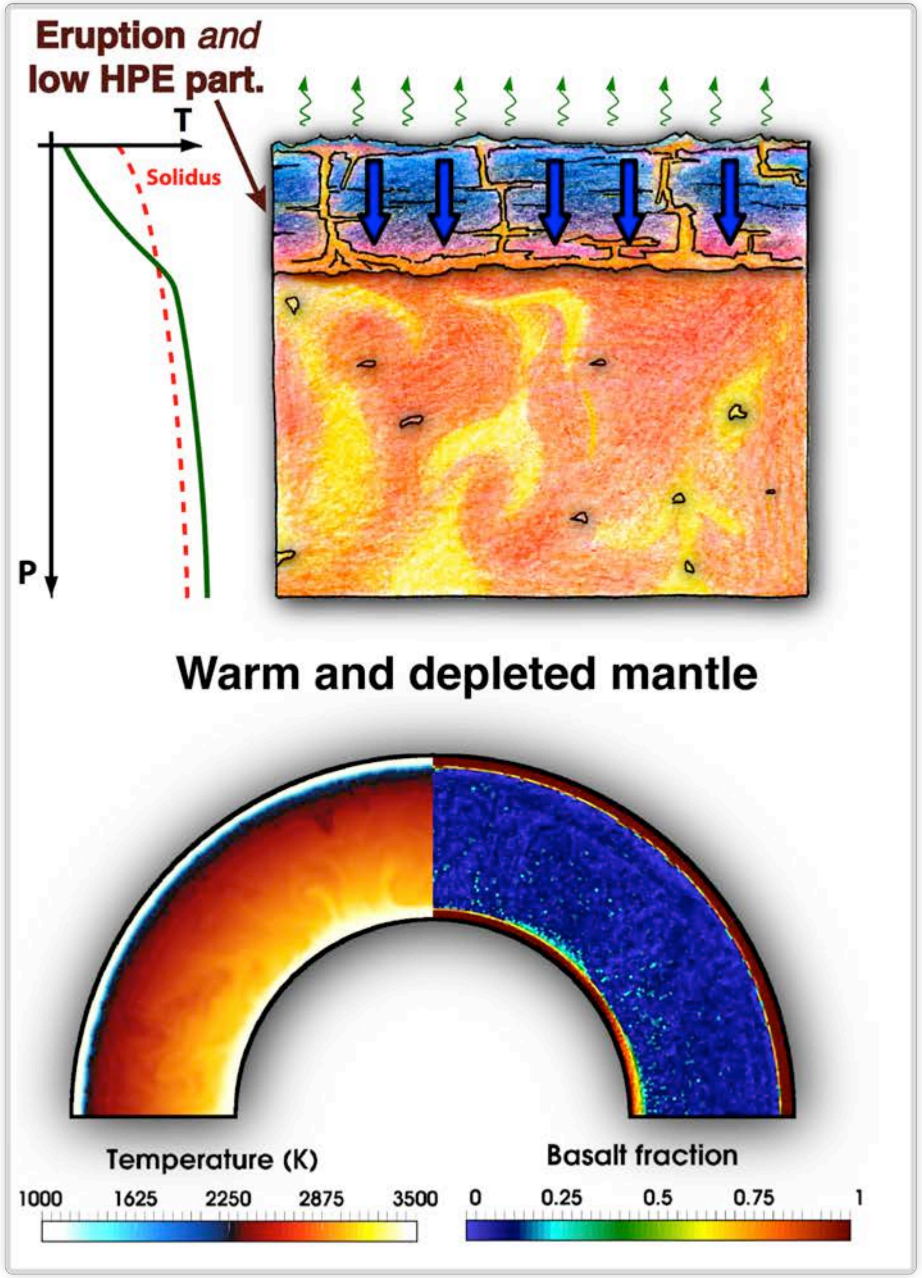
Key Points:
- High intrusion efficiencies lead to a new global tectonic regime, named plutonic-squishy lid
- The new regime is characterized by significant surface velocities, a thin lithosphere, and small plates
- The new regime has the potential to be applicable to the Archean Earth and Venus


PLUTONISM
VOLCANISM
Plutonic-squishy
lid
(Venus)
Heat-pipe
Heat Flow (TW)
120
100
80
60
40
20
0
0
10
20
30
40
50
60
70
80
90
100
Extrusion Efficiency (%)
Total
Conductive
Magmatic

High intrusion rates

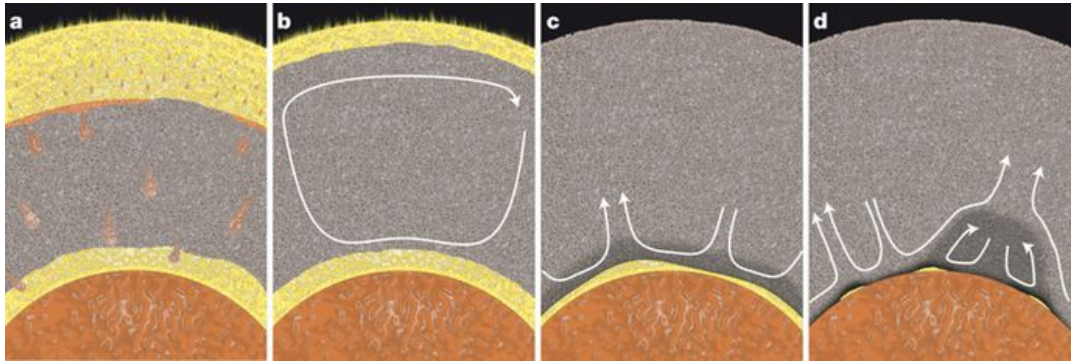


High extrusion rates



Deep mantle composition and early Earth surface mobility

Keely O'Farrell*(Univ. of Kentucky), Sean Trim (Univ. of Saskatchewan), & Sam Butler (Univ. of Saskatchewan)
Email: k.ofarrell@uky.edu

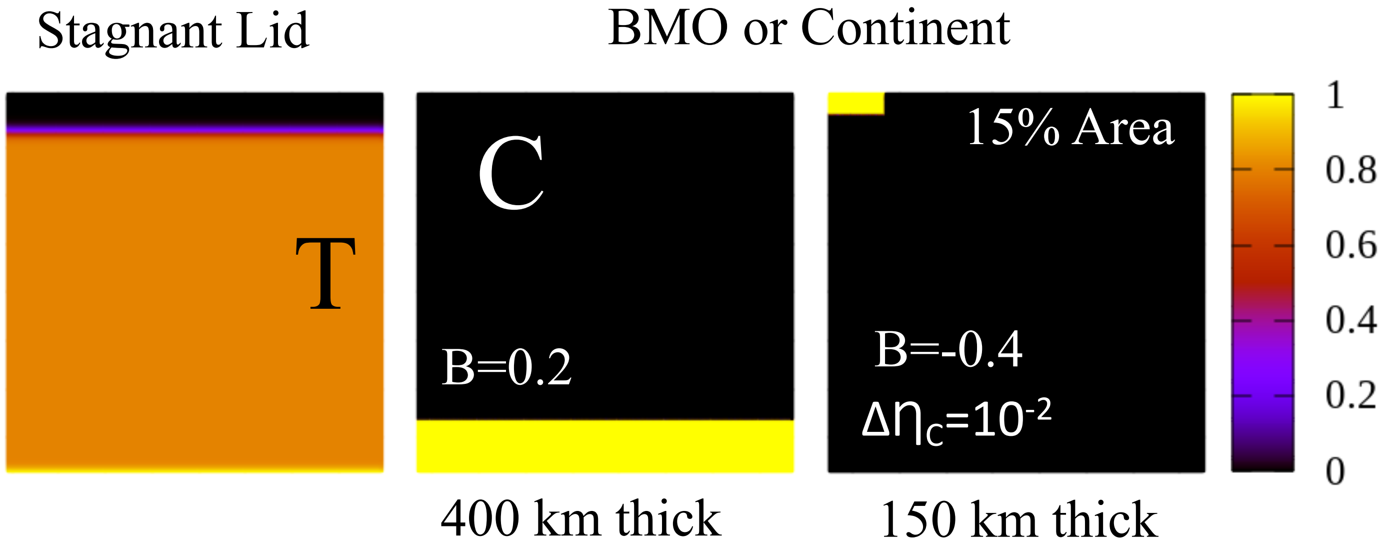


From Labrosse et al. (2007)

Early Earth mantle much hotter
Possibility of basal magma ocean

Primordial layer may contain a high concentration of radiogenic element, patches of low viscosity melt or metals

Primordial layer has one of the following:
- Increased internal heating (H=20)
- Decreased viscosity ($\Delta\eta_C$=10)
- Increased conductivity (k=2)

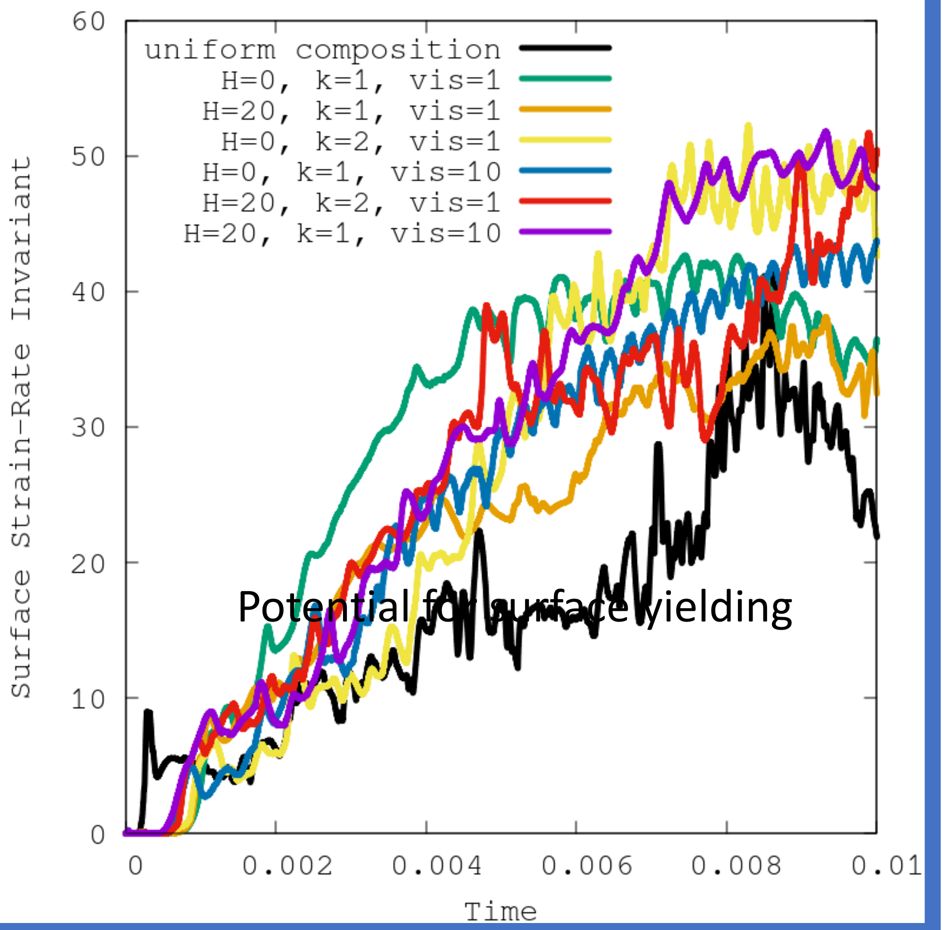


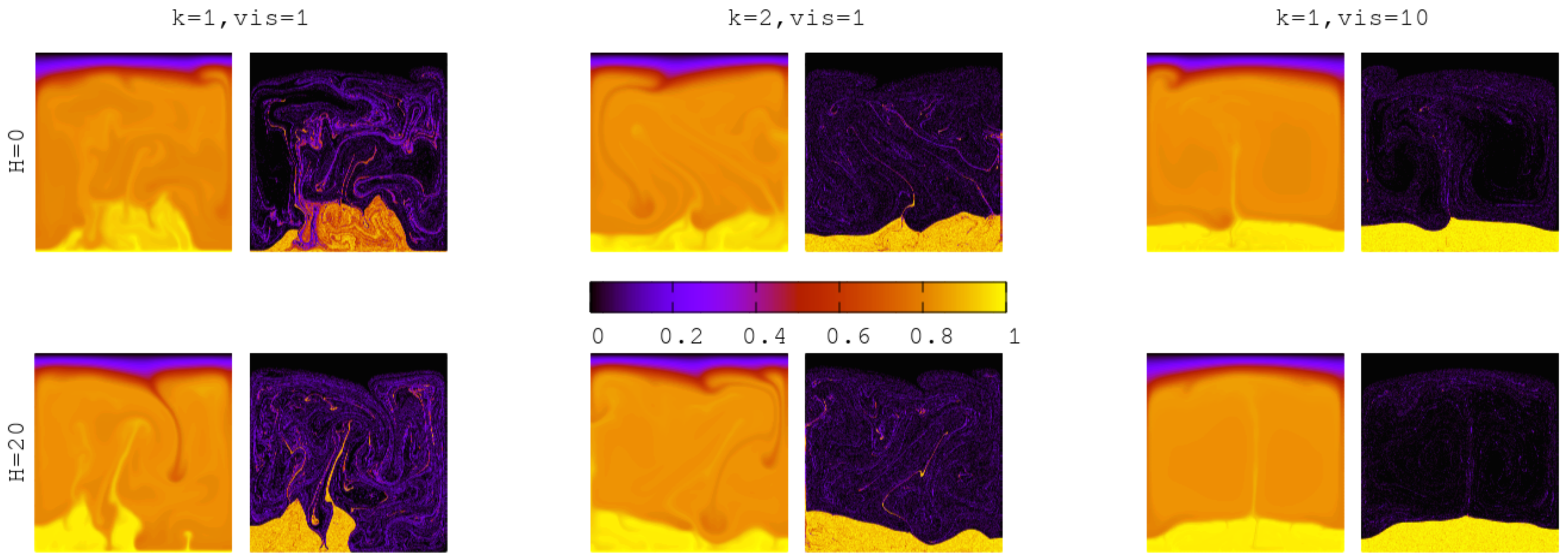
Primordial composition affects the onset time of surface mobility in the early Earth

Surface mobility increases in the presence a primordial layer or continent

Newtonian Rheology

K. O’Farrell (k.ofarrell@uky.edu),
S. Trim, & S. Butler



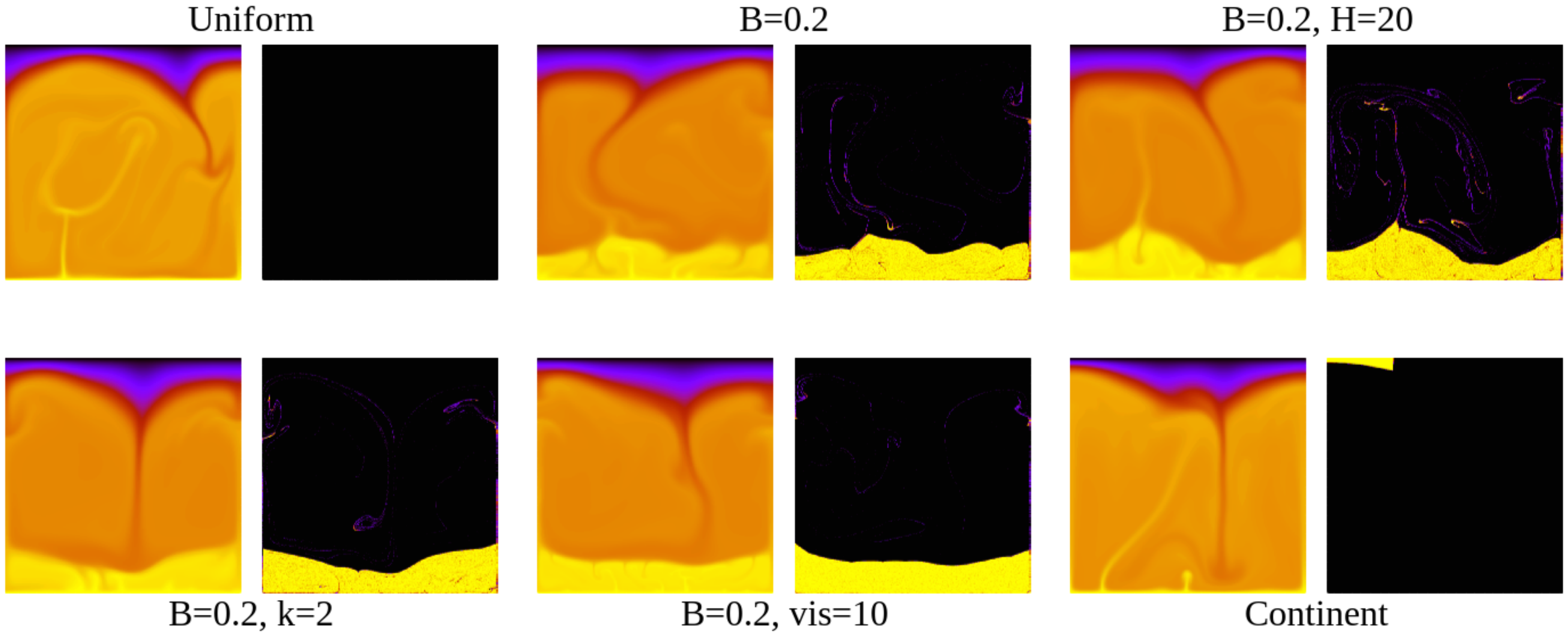


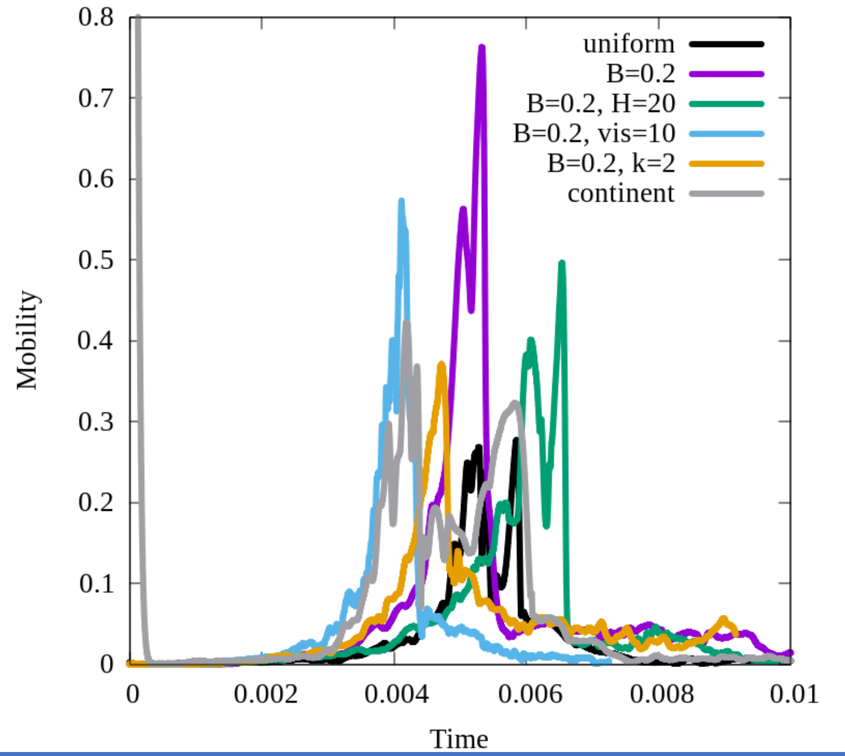
- ↓ viscosity or ↑ conductivity in layer flattens basal topography

- 2nd invariant of the strain-rate tensor is an indicator of the potential for surface yielding
- The presence of a primordial layer increases the likelihood of surface yielding

Non-Newtonian rheology

K. O'Farrell (k.ofarrell@uky.edu), S. Trim, & S. Butler





- ↑ layer conductivity or ↓ viscosity promotes basal coverage
- Strong downwellings from the overturn of the initial stagnant lid hinder basal coverage

- Episodic-lid convection
- Compositional features increase peak lithosphere mobility
- Onset time of lithosphere mobility affected by primordial composition

CONCLUSIONS

Primordial composition affects the onset time of surface mobility in the early Earth

Surface mobility increases with a primordial layer or continent