PLATE TECTONICS ON STABILITY & PLUME GENERATING CAPACITY OF LLSVPS

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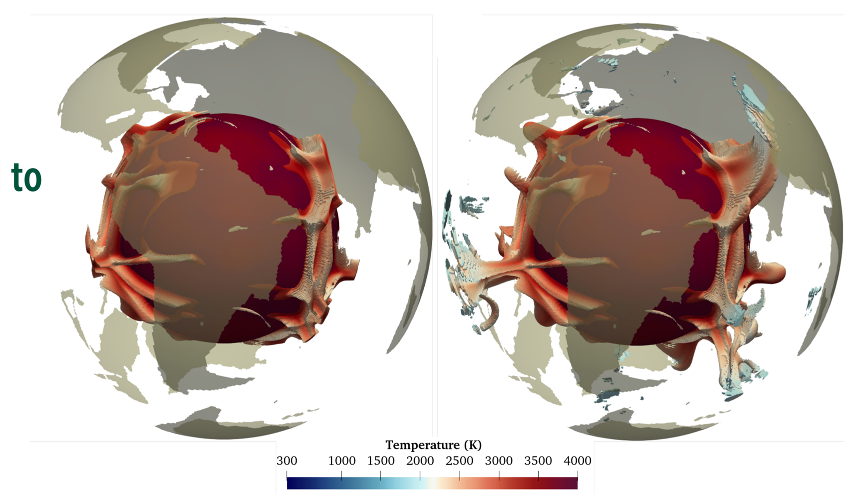
1 INTRODUCTION

- Relationship between Earth's surface and deep interior is fundamental to understand mantle dynamics
- Origins & evolution of LLSVPs are not well understood
- Different studies debate the long-term stability of LLSVPs, and the process which may control it
- We explore the relationship between plate tectonics, LLSVP stability, and plume generation

2 METHODS

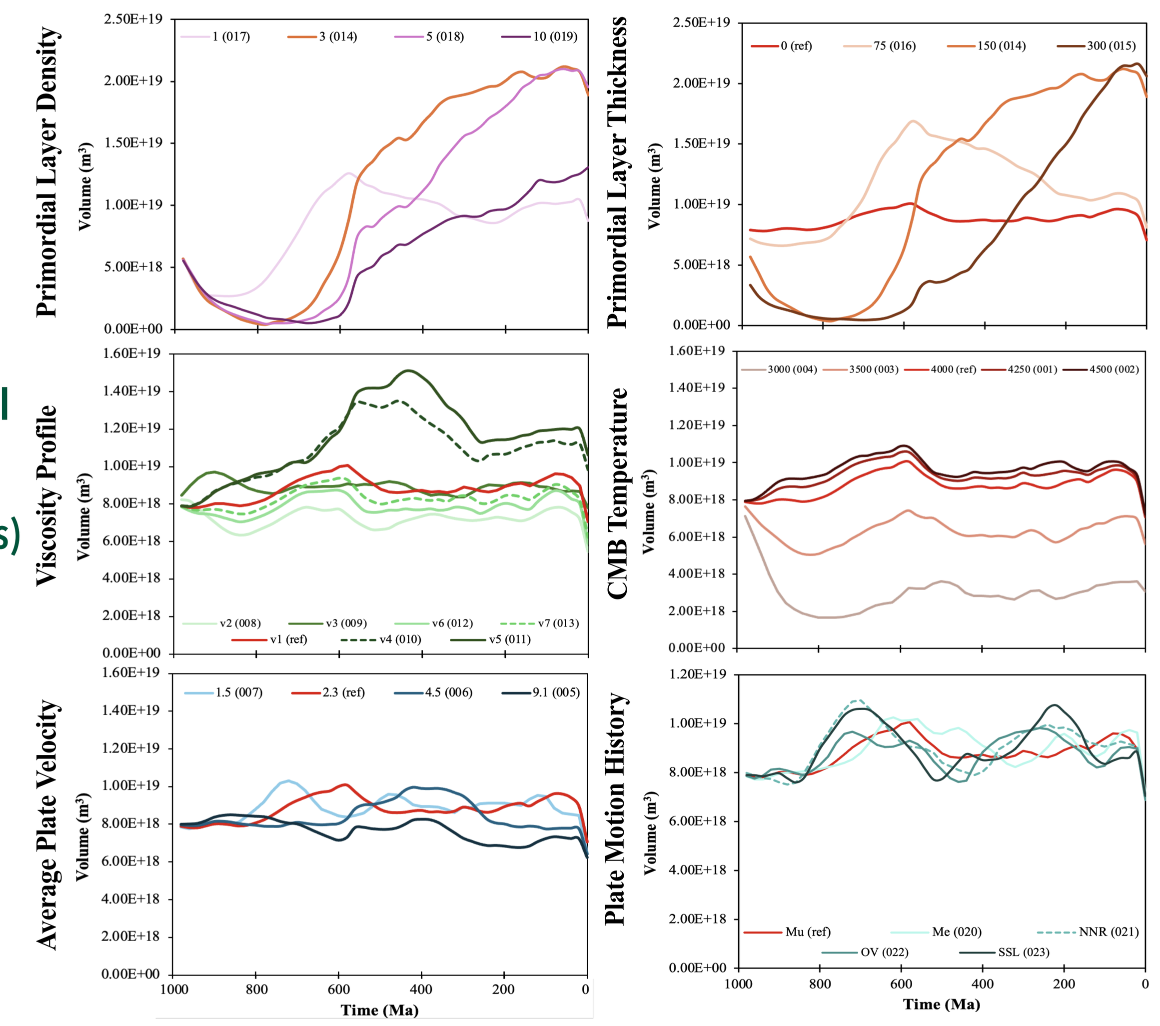
- We use 3D mantle circulation code, TERRA[1,2,3] to run 24 compressible simulations from 1000-0 Ma
- Across the suite of simulations we vary CMB temperature, primordial layer thickness and excess density, mantle viscosity, plate velocity, and implement different plate motion reconstructions at the surface[4,5,6]
- Particles store pressure, temperature, and composition data, (inc. recycled basalt) used to calculate seismic velocities[7]
- LLSVP-like material is defined by both a 200° K thermal anomaly and a -1.5% Vs anomaly (clipped to 800 km above CMB)

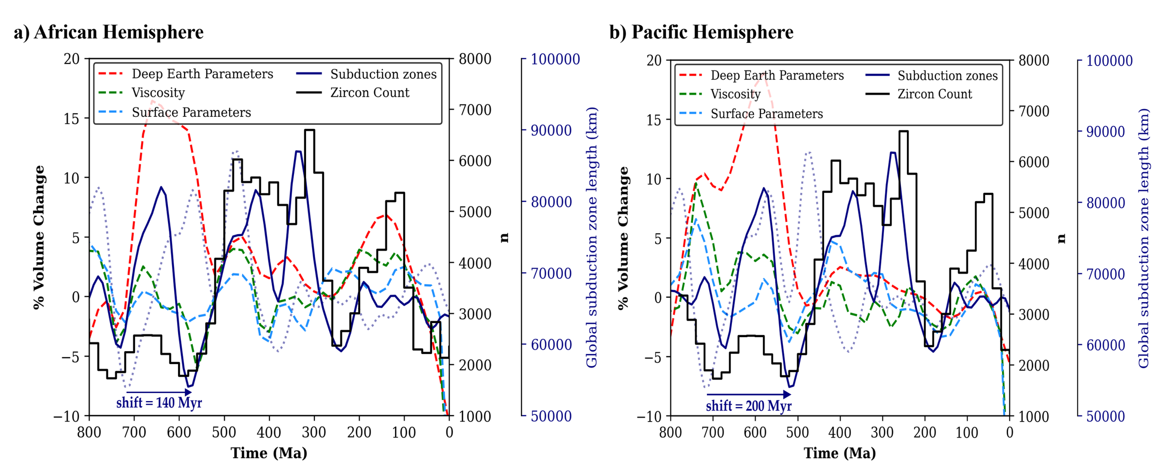
Full parameter space & initial conditions can be accessed by scanning the QR code

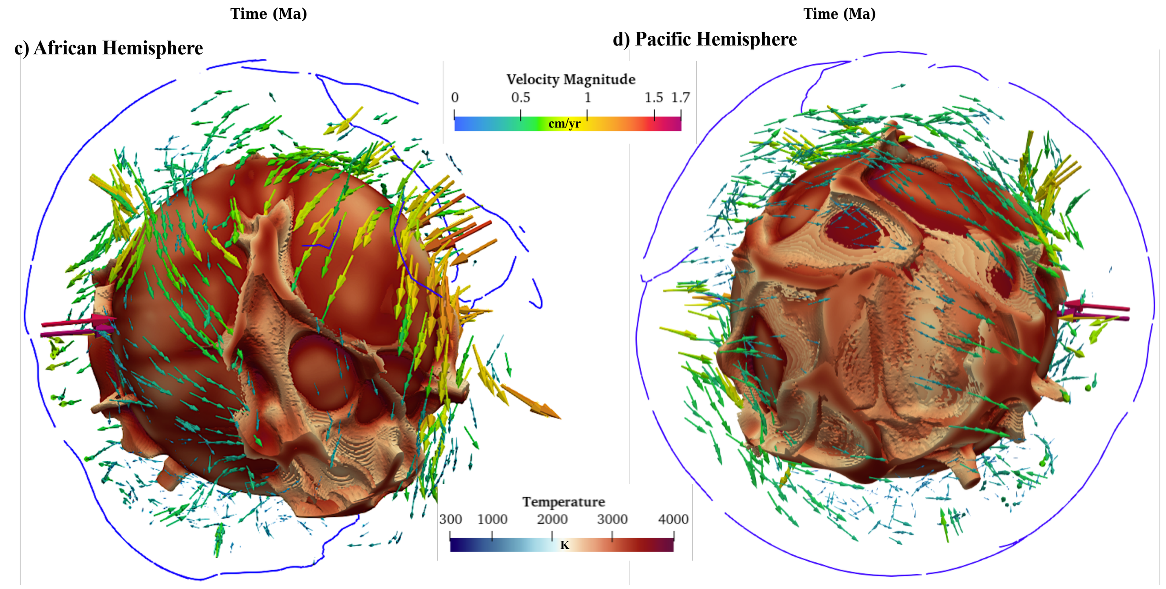


3 VOLUME STABILITY

- The volume of LLSVP-like material is not stable through time
- "Deep mantle parameters" (CMB temperature, primordial layer thickness and excess density) control volume of basal mantle structures (BMSs)
- "Surface parameters" (plate velocity and plate motion reconstruction) change timing of BMS accumulation or loss
- Suggests coupling between plate tectonics and modelled LLSVPs



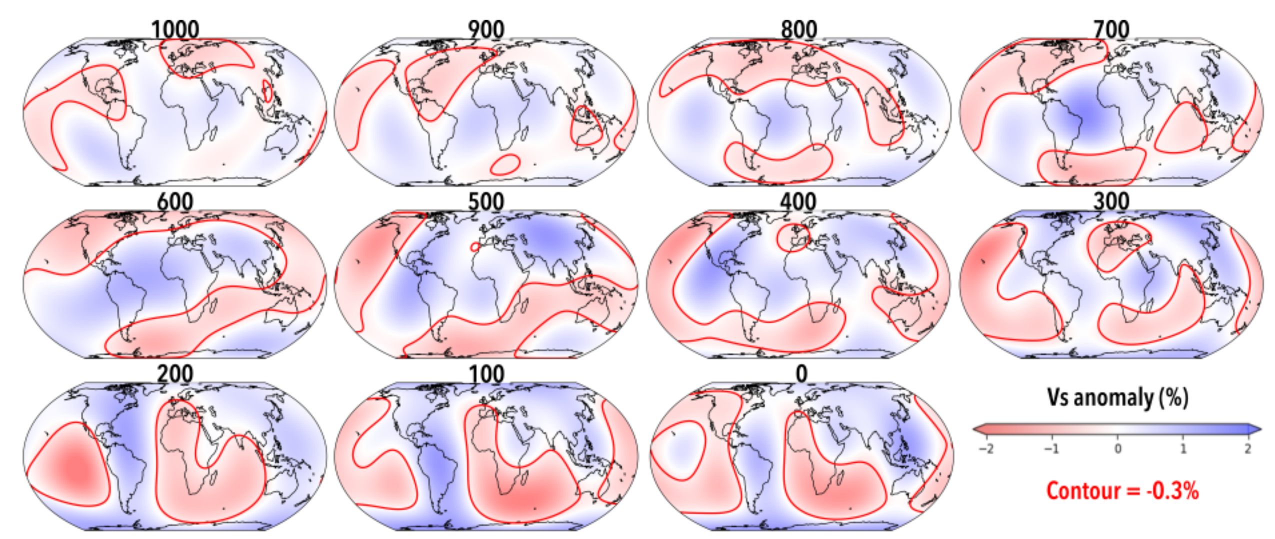




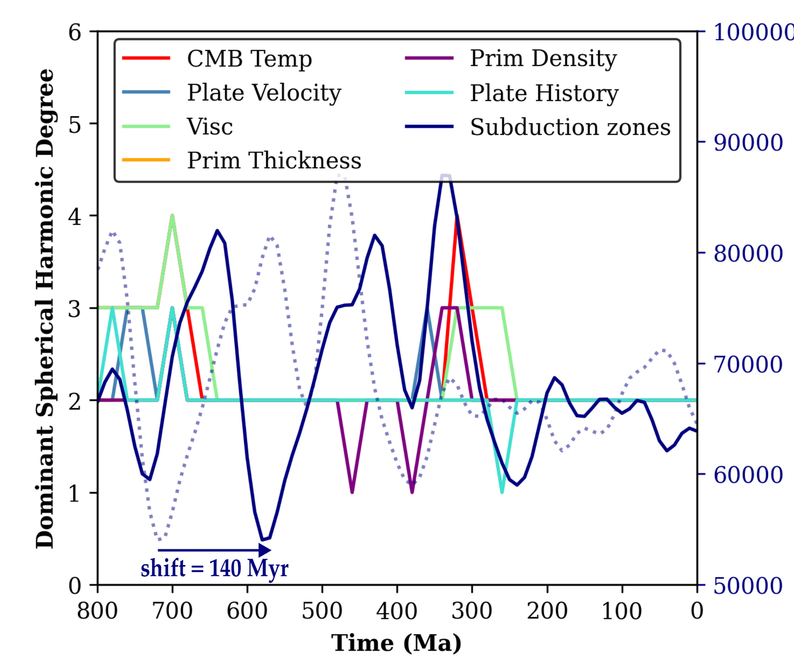
- Accumulation of material tied to global subduction zone length & super-continent assembly
- Slabs sweep material in lower mantle
- Circum-continental subduction sweeps material beneath the centre of supercontinent & antipodal ocean
- 60 Myr delay between LLSVP growth in African hemisphere compared to Pacific hemisphere
- Attributable to the greater distance between slabs and slower velocities beneath Pacific
- In these models, 2 distinct structures form in response to Pangaea assembly

4 LLSVP SHAPE

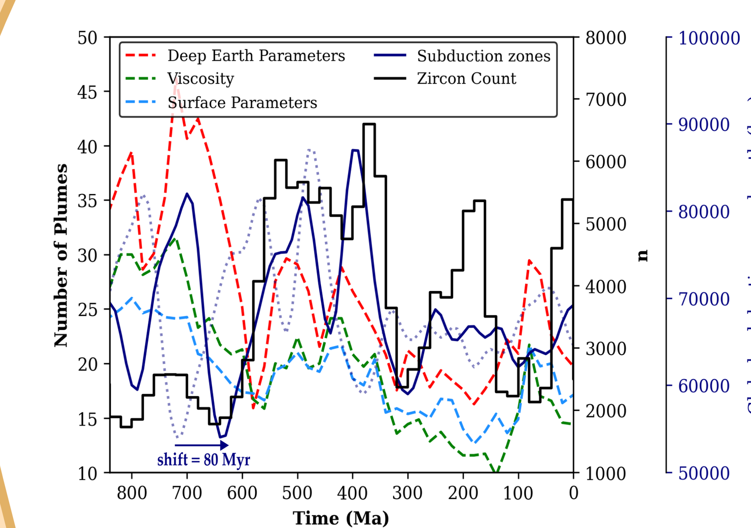
- BMSs are smoothed to max. degree 4 structure to analyse long wave-length evolution
- Shape of BMSs are not consistent through time across simulations
- BMSs begin to resemble present day morphology across most simulations between 300-200 Ma (and become more stable)
- Changes in shape across supercontinent cycle reflect two 'rearrangement events', linked to peak supercontinent assembly



- More subduction leads to disruption of degree 2 structure
- Slabs at new subduction zones disrupts degree 2 structure (~140 Myr delay)
- Tends back to degree 2 structure as subduction zones stabilise
- In these simulations, subduction zones have been relatively stable since the assembly of Pangaea

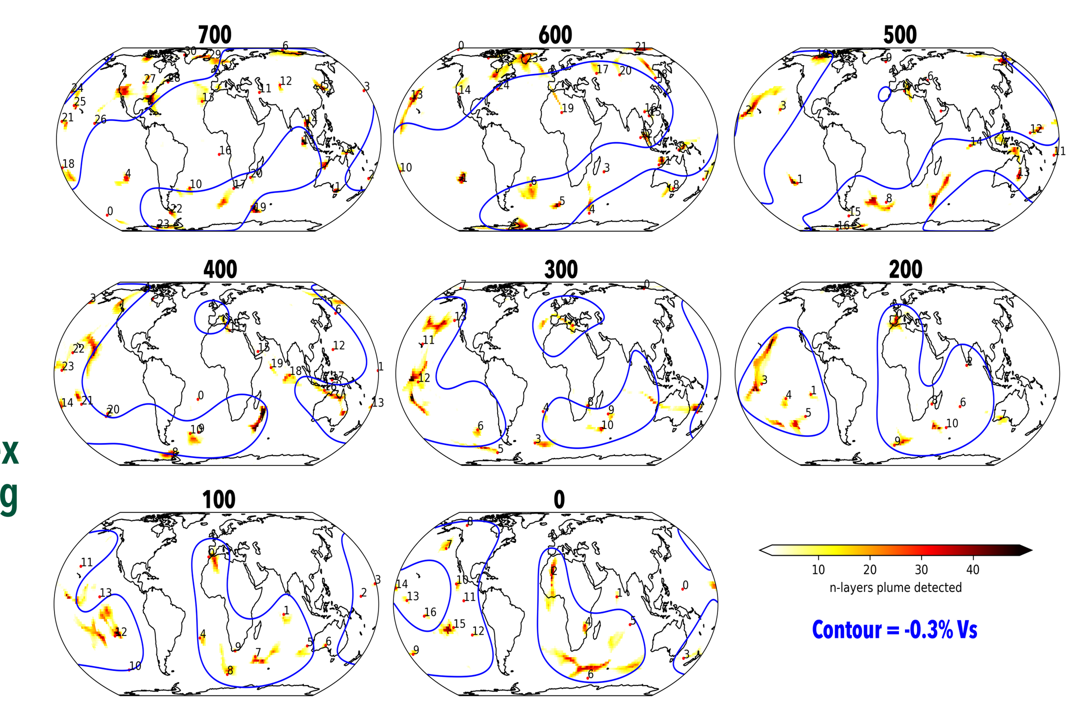


5 PLUME GENERATION



- Plumes detected by K-means clustering between 300-2500 km
- Across all simulations, peaks in plume generation occur ~ 700Ma, and between 550-350 Ma
- Plumes begin to rise before accumulating volume or changing dominant spherical harmonic degree
- Converging flows induce upwellings before the BMS have time to move signficantly

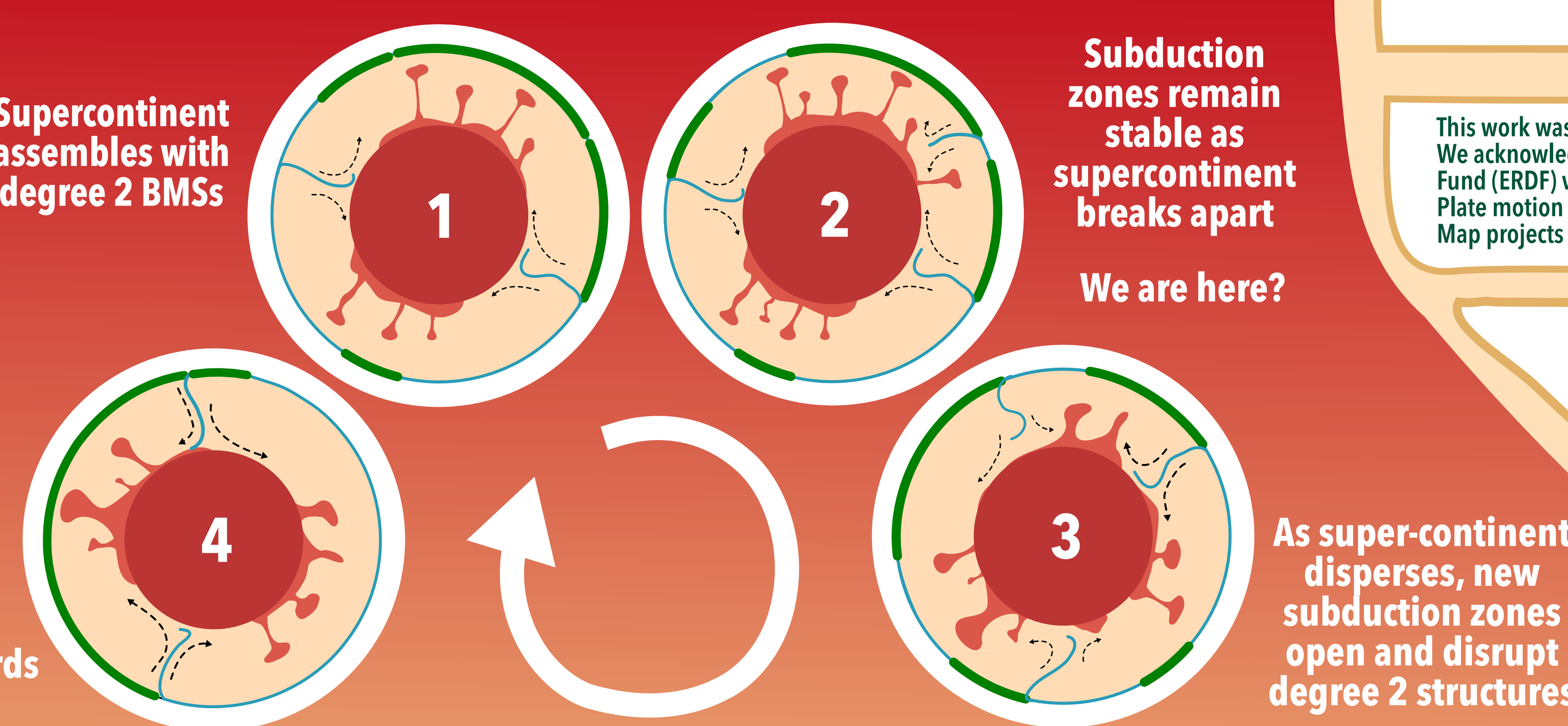
- Most plumes ascend above BMSs
- Evolve across BMSs, not just at the edges
- Plumes move away from BMSs during rearrangement
- Alludes to more complex deep mantle flow during these periods
- Highlights cyclical nature of upwellings & downwellings



6 DISCUSSION

- Evolutions of LLSVPs are closely related to subduction dynamics
- Percieved stability of LLSVPs may be associated with consistency in subduction zone location since formation of Pangaea
- Mantle experiences large-scale 'rearrangement events' tied with the initiation of new subduction zones
- Material is swept into antipodal clusters, plumes evolve, & volume of structures grows
- Once clusters are antipodal, they stabilise (timing is dependent on slab sinking rate)

7 CONCLUSIONS



Supercontinent assembles with degree 2 BMSs

Subduction zones remain stable as supercontinent breaks apart

We are here?

As super-continent disperses, new subduction zones open and disrupt degree 2 structures

Subduction zones stabilise, facilitating assembly of new supercontinent

BMSs swept back towards degree 2 structure

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Plate motion reconstructions utilised GPlates software [8] and 3D visualisations were produced using Paraview [9].
Map projects were produced using terratools[10] and the Matplotlib package for Python[11].

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