MANTLE STRUCTURES BENEATH AN EVOLVING SUPERCONTINENT

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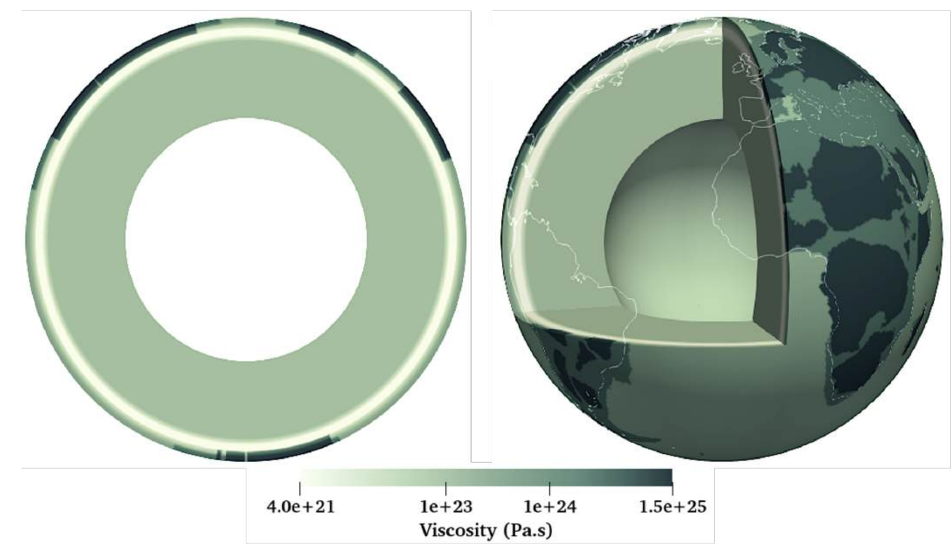
INTRODUCTION

- Supercontinents are one of the largest spatial & temporal processes on Earth
- Contribution of slab pull to plume push mechanisms of supercontinent breakup are often discussed
- We explore the interaction between slabs & plumes beneath supercontinent in response to different lithosphere structure
- Relative contribution of plume push may be affected by continental lithosphere thickness & viscosity

METHODS

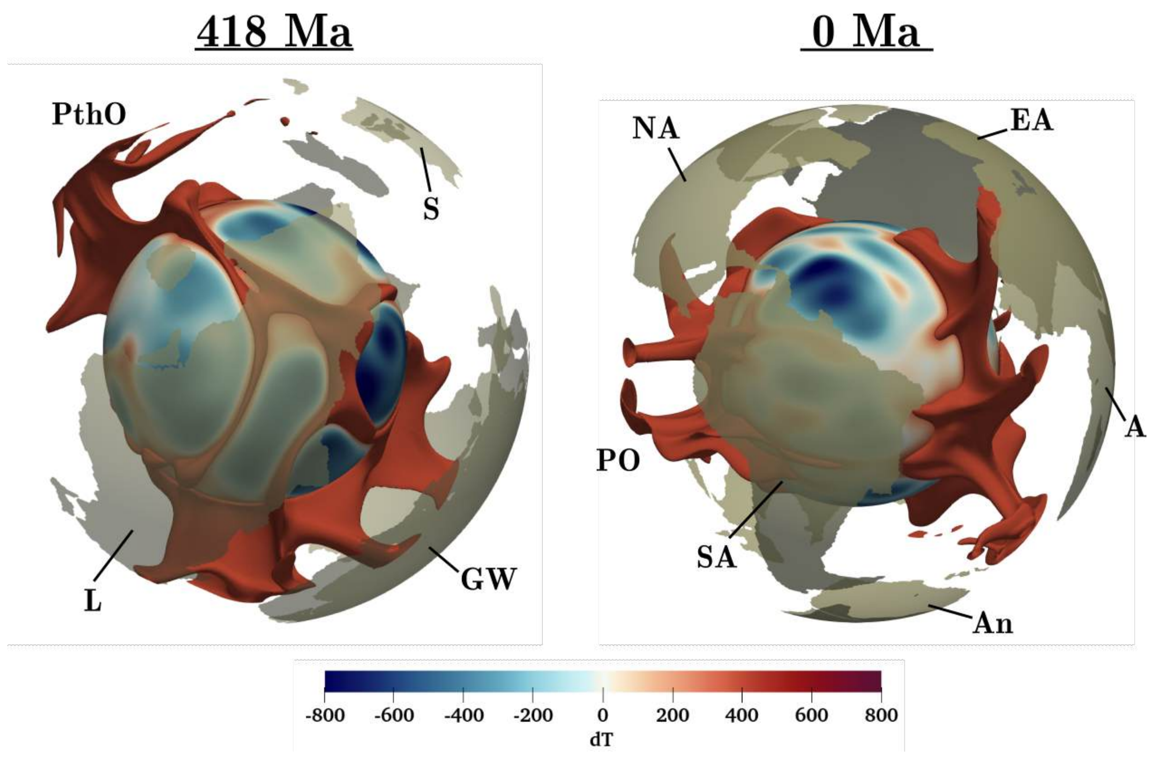
- Use 3D mantle circulation code, TERRA [1][2][3], to simulate supercontinent cycle from 500 Ma - present
- Apply plate motion history [4], with parameter to define continents, & cratons
- Vary thickness of continental lithosphere between 90-180 km, and vary viscosity between 1 x 10^{23} - 1 x 10^{25} Pa s

Scan QR code for input parameters & investigation parameter space



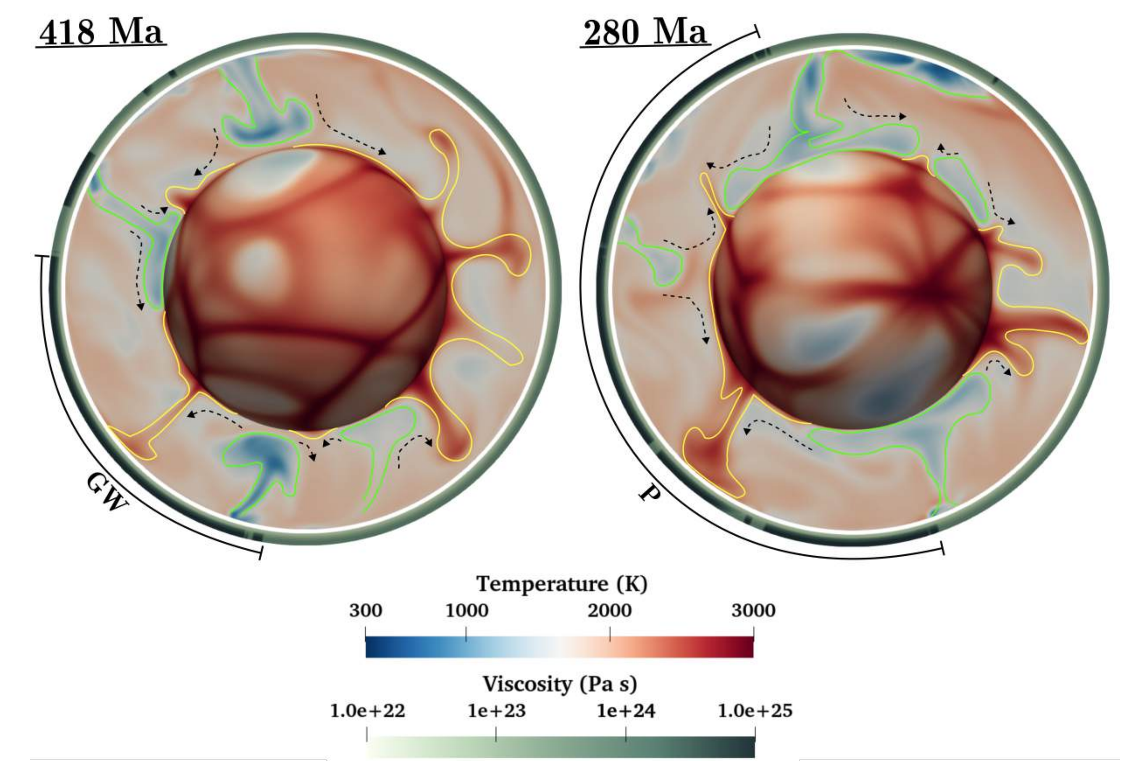
Map: Points on TERRA grid coloured by oceans, continents & cratons
3D: Cross section and spherical visualisation of viscosity field for model 011

PLUMES BENEATH ASSEMBLING SUPERCONTINENT



3D visualisation of reference model showing plume clusters. PthO - Panthalassic Ocean, S - Siberia, L - Laurentia, GW - Gondwana, NA - North America, EA - Eurasia, PO - Pacific Ocean, SA - South America, An - Antarctica, A - Africa

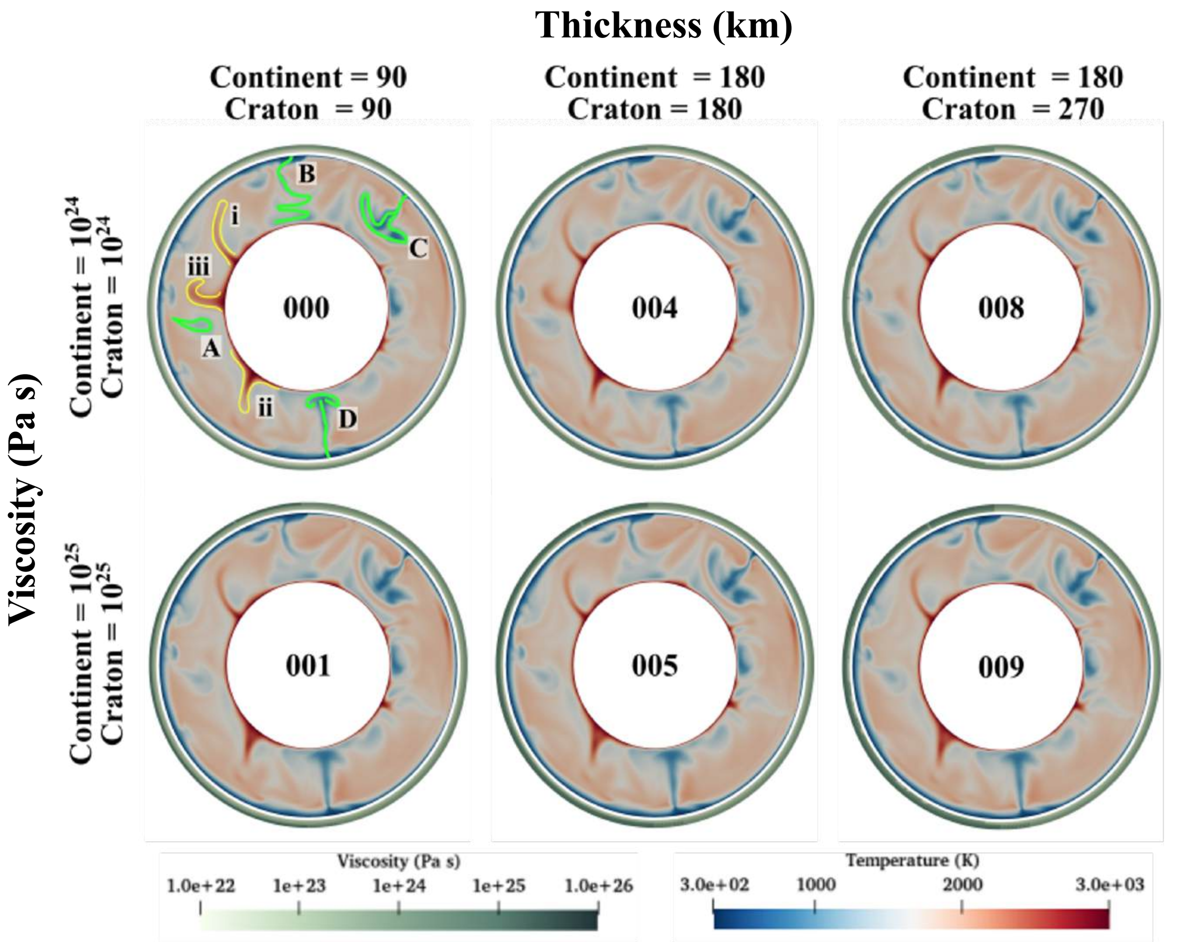
- Plumes develop into 2 antipodal clusters
- At 480 Ma, clusters beneath Gondwana & Panthalassic Ocean
- Plumes are mobile across simulations
- At 0 Ma, clusters beneath Africa & Pacific (related to LLSVPs?)



Slice through model with 180km thick continental lithosphere (viscosity = x100 oceanic lithosphere), showing the interaction between slabs (green outline) and plumes (yellow outline). GW = Gondwana, P = Pangaea

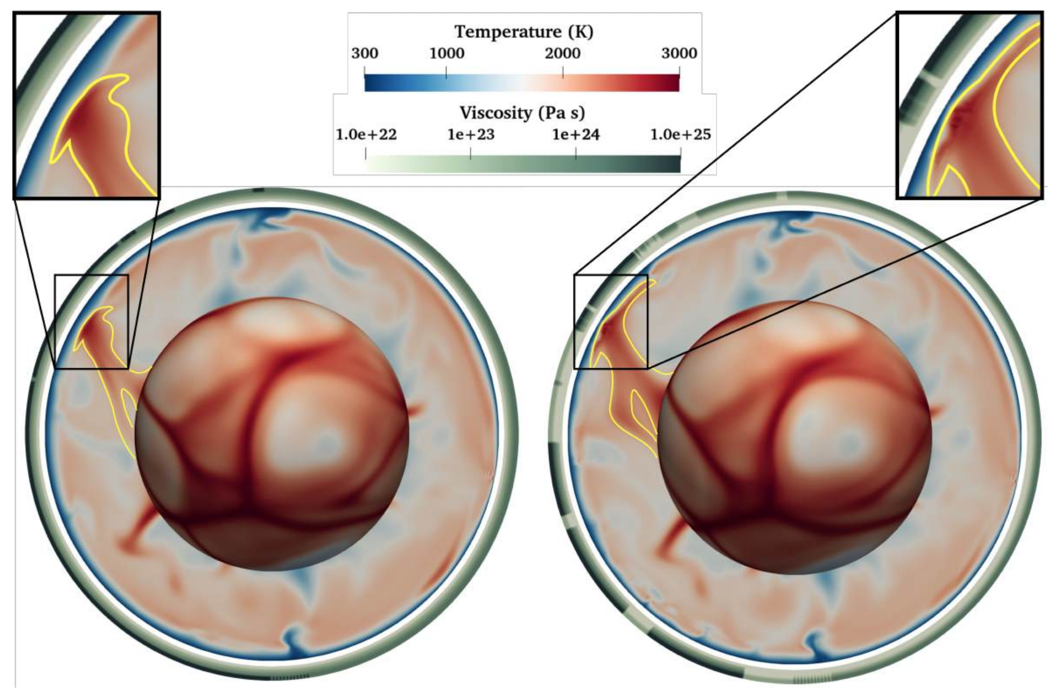
- Plumes initally develop as broad upwellings near CMB
- Downwelling slabs sweep hot upwelling material towards one central locus
- Plumes are swept beneath super-continent by exterior subduction zones

PLUME-SLAB INTERACTIONS WITH VARYING LITHOSPHERE STRUCTURE



2D slices through selected models at 280 Ma showing the temperature field and the viscosity field from 300-0 km depth. Left hemisphere = Pangaea, right hemisphere = Tethys Ocean

- Exterior slabs (B & D) push plumes beneath supercontinent
- Slab A and plume iii may interact as interior ocean closes
- When lithosphere is viscous (or very thick), slab sinks directly above evolving plume iii
- Plume signature is dampened out in these cases



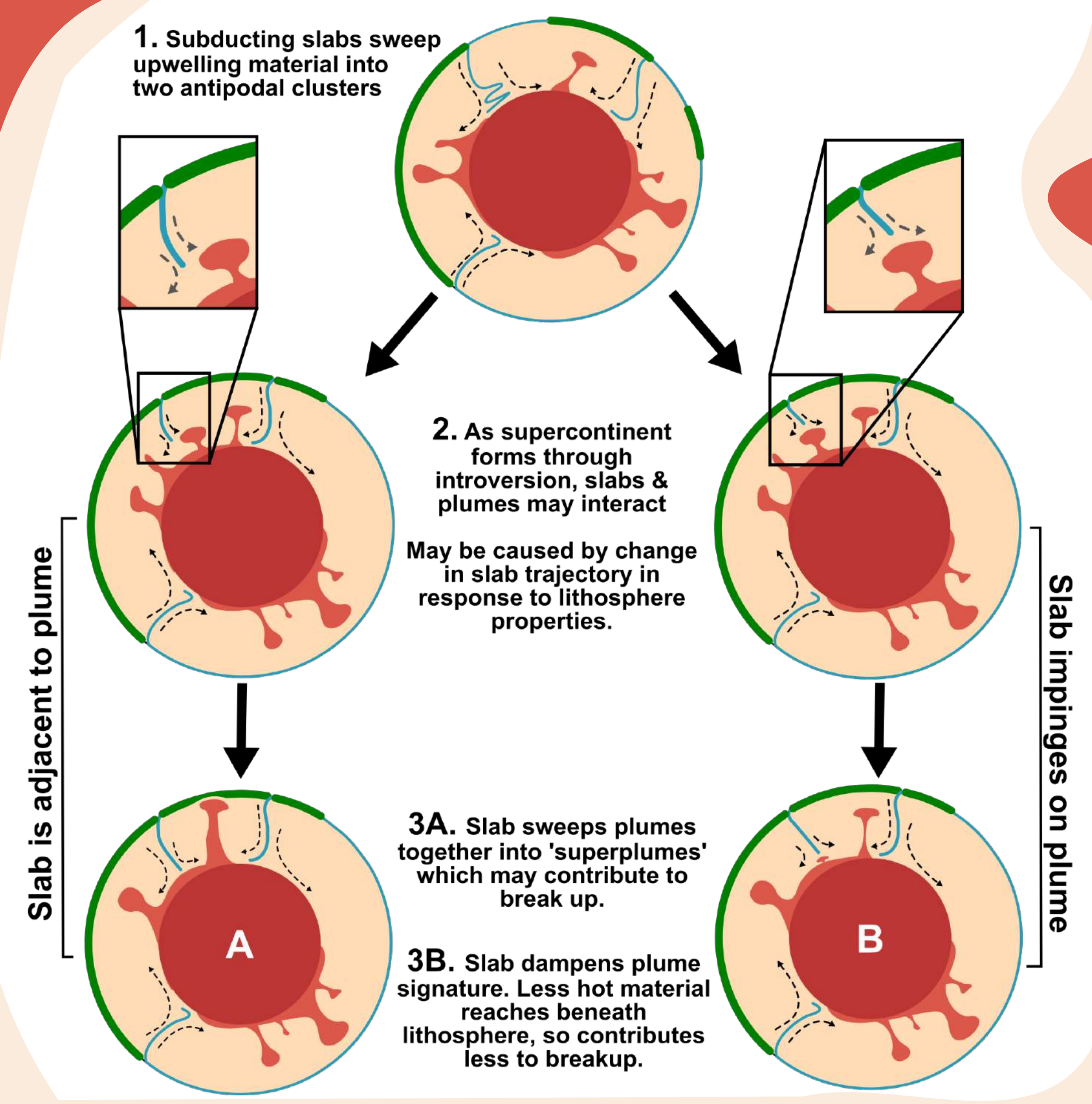
Evolution of 'superplume' at 177 Ma for model viscous continents and cratons (left) and weak, thick continents (right). Insets highlight the degreee of thinning of the thermal lithosphere

- When plume is not damepened out, it coalesces with plume i
- Larger plume thins the thermal lithosphere at time of supercontinent breakup
- Smaller plume (viscous continent models) cause less thinning and have smaller lateral extent

DISCUSSION

- Our models have demonstrated the close relationship between slabs and plumes in the mantle
- Any large continental landmass bound by subduction zones develops a sub-continental plume, regardless of lithosphere structure
- Lifespan and extent of evolving plume varies depending on it's proximity to descending slab
- Lithosphere thickness & viscosity are two factors which may affect slab dynamics, and therefore the interaction between slabs and plumes
- Lithosphere structure during super-continent assembly may affect the contribution of plume push forces during breakup

CONCLUSIONS



ACKNOWLEGEMENTS

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Plate geometries and plate motion reconstructions utilised GPlates software [5] and 3D visualisations and 2D slices were produced using Paraview [6].

Map projections were produced using terratools [7] and the Matplotlib package for Python [8].

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