Evolution of cratons in time-dependent mantle convection models

Mantle convection models using reconstructed plate velocities from 410 Ma till present day to investigate cratons' long term survival.

DI13B-0008

Jyotirmoy Paul*, Attreyee Ghosh
Centre for Earth Sciences, Indian Institute of Science, Bangalore 560012, Jyotirmoyp@iisc.ac.in

Origin of problem:

How did cratons survive for billions of years?
1. Due to their neutral compositional density? Or
2. Due to high viscosity?

Earlier findings from instantaneous study: (Paul et al., 2019)

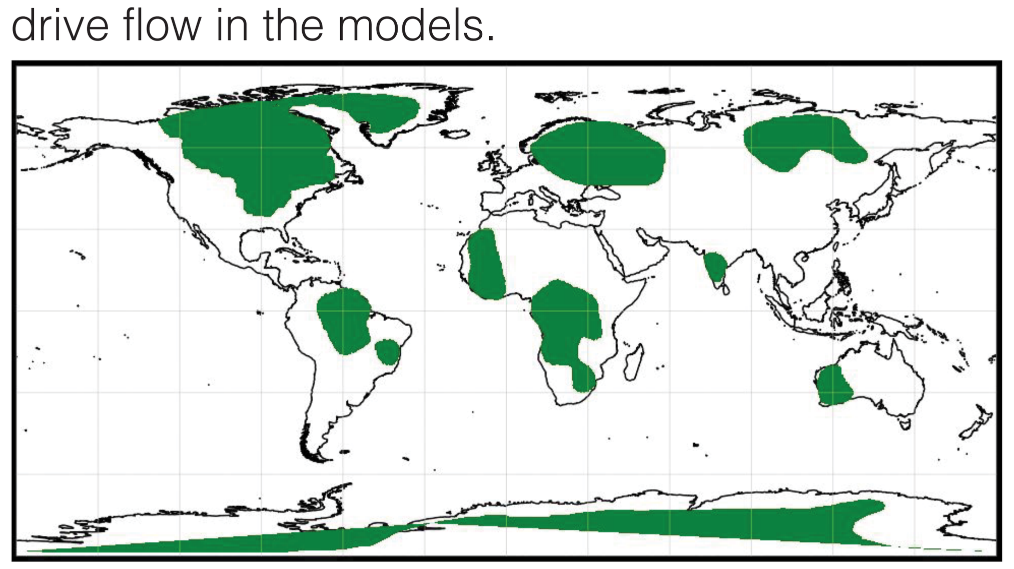
1. With increasing lithospheric thickness strain-rates at the base of the lithosphere decrease. This could potentially stabilize cratons.
2. Asthenosphere viscosity plays an important role in cratons' survival.

Goals of present study:

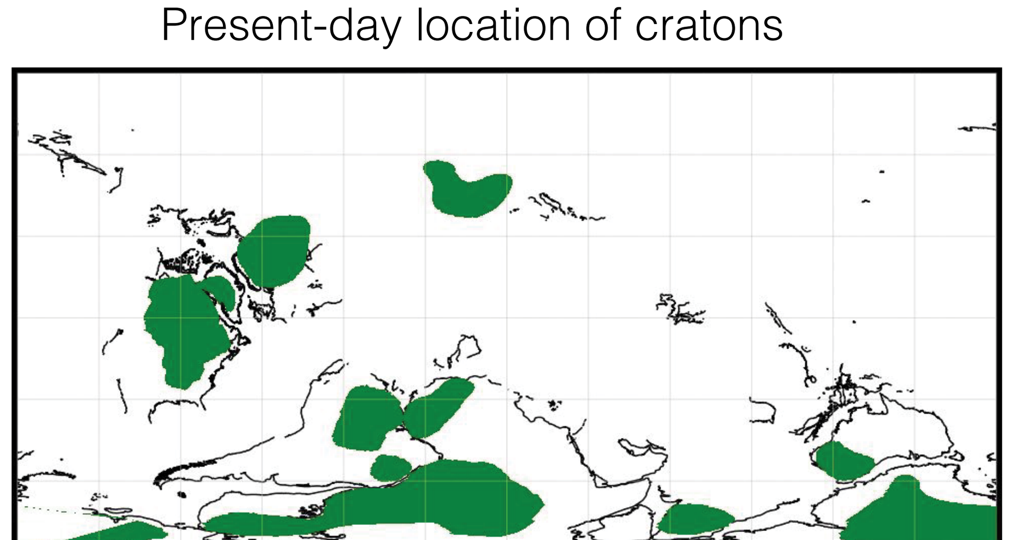
To estimate the viscosity of cratons and their surrounding asthenosphere that can support their long-term survival using time-dependent mantle convection models.

Model input:

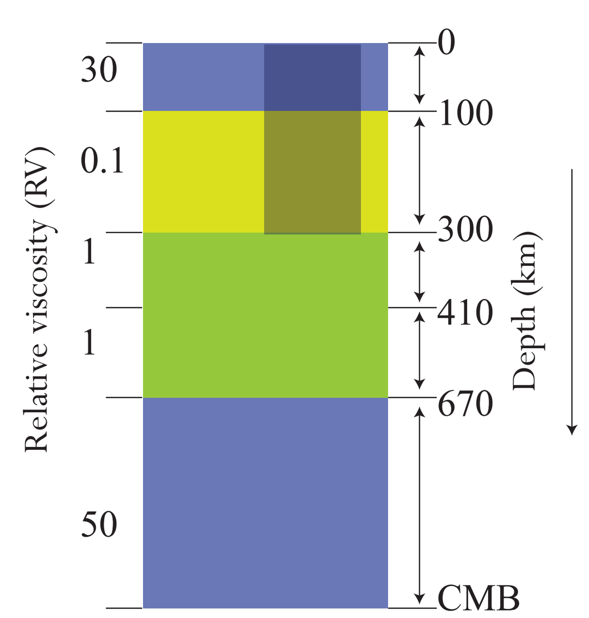
1. Radial viscosity variation and cratons of different viscosity implemented as tracers since 409 Ma.
2. Reconstructed plate velocity at every 1 Myr interval, from 409 to 0 Ma using GPlates (Matthews et al., 2016), as surface boundary condition to drive flow in the models.



Present-day location of cratons

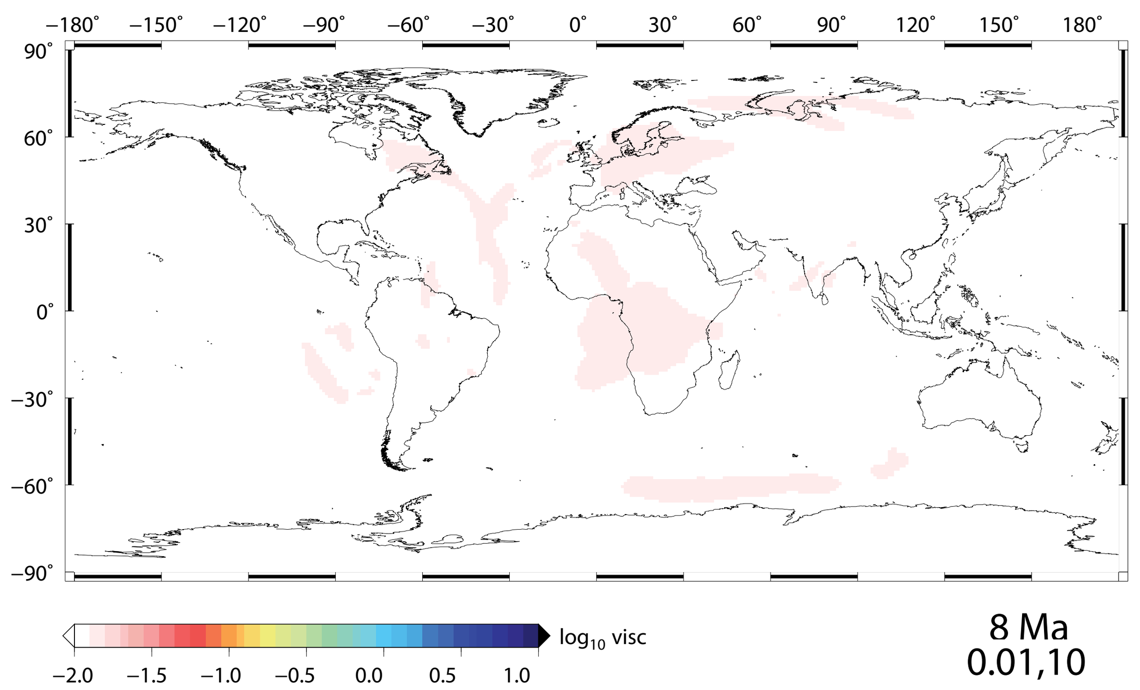


Reconstructed location of cratons at 409 Ma

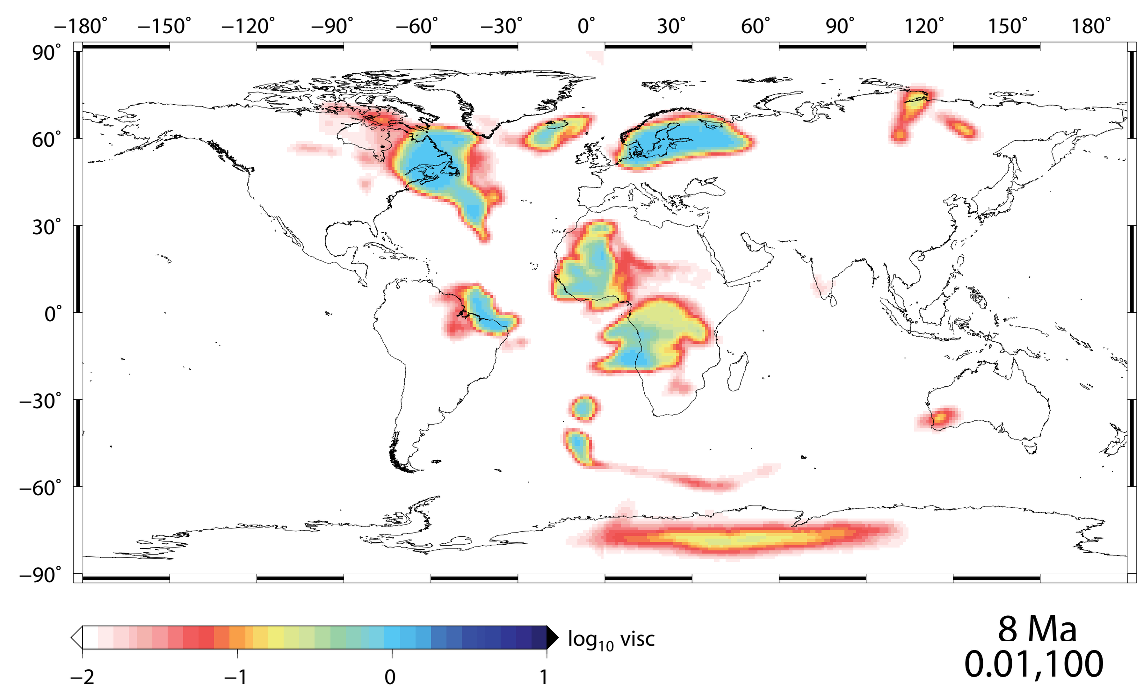


Radial viscosity structure of the mantle in the convection models. Reference upper mantle viscosity 10^{21} Pa-s

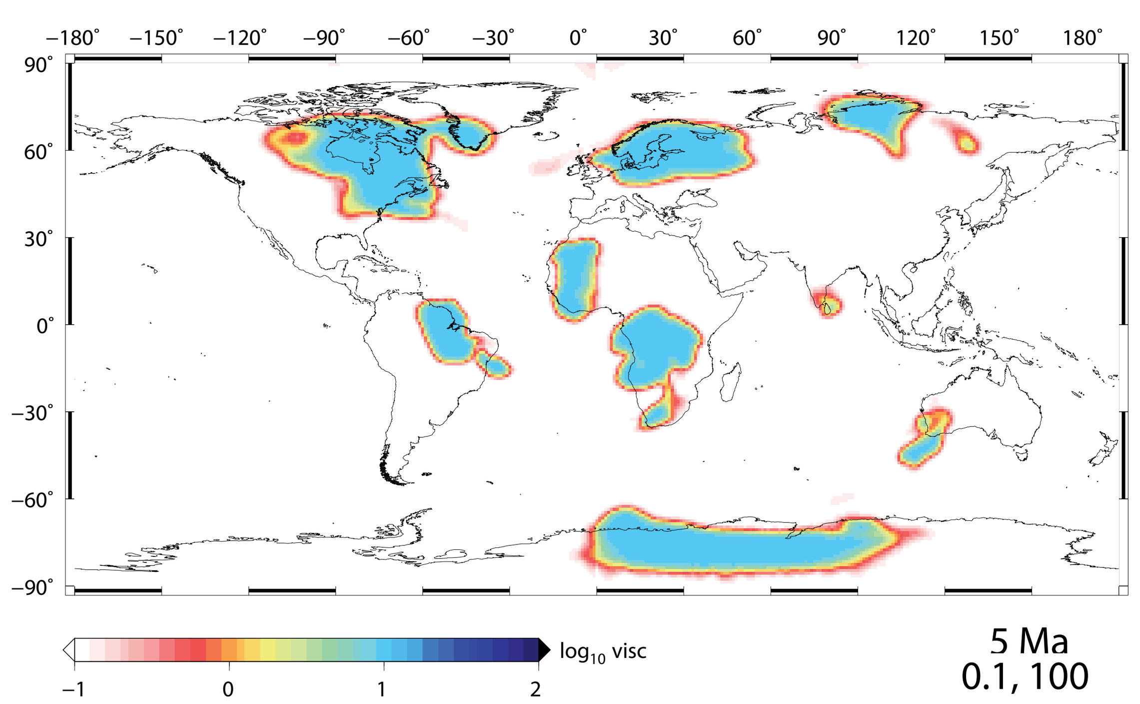
State of cratons after 400 Myrs predicted from models of different craton and asthenopshere viscosity



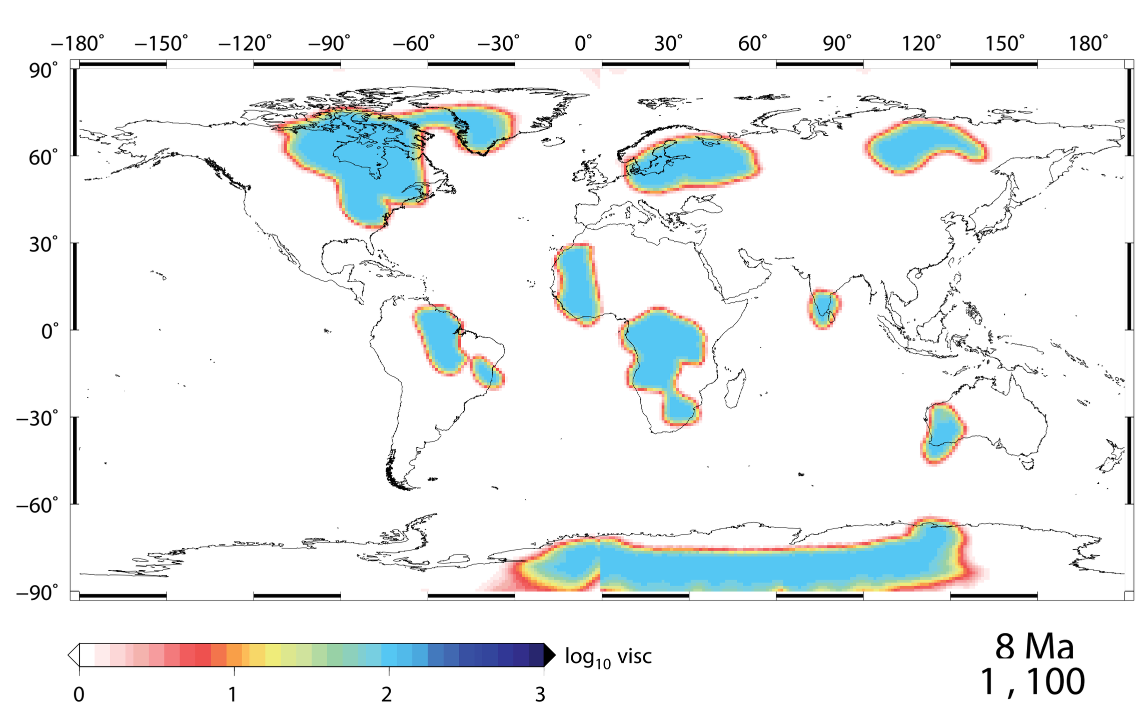
Weak case: Asthenosphere and craton viscosity are (0.01, 10) respectively. Cratons are destroyed



Moderately weak case (0.01, 100) Cratons are significantly deformed



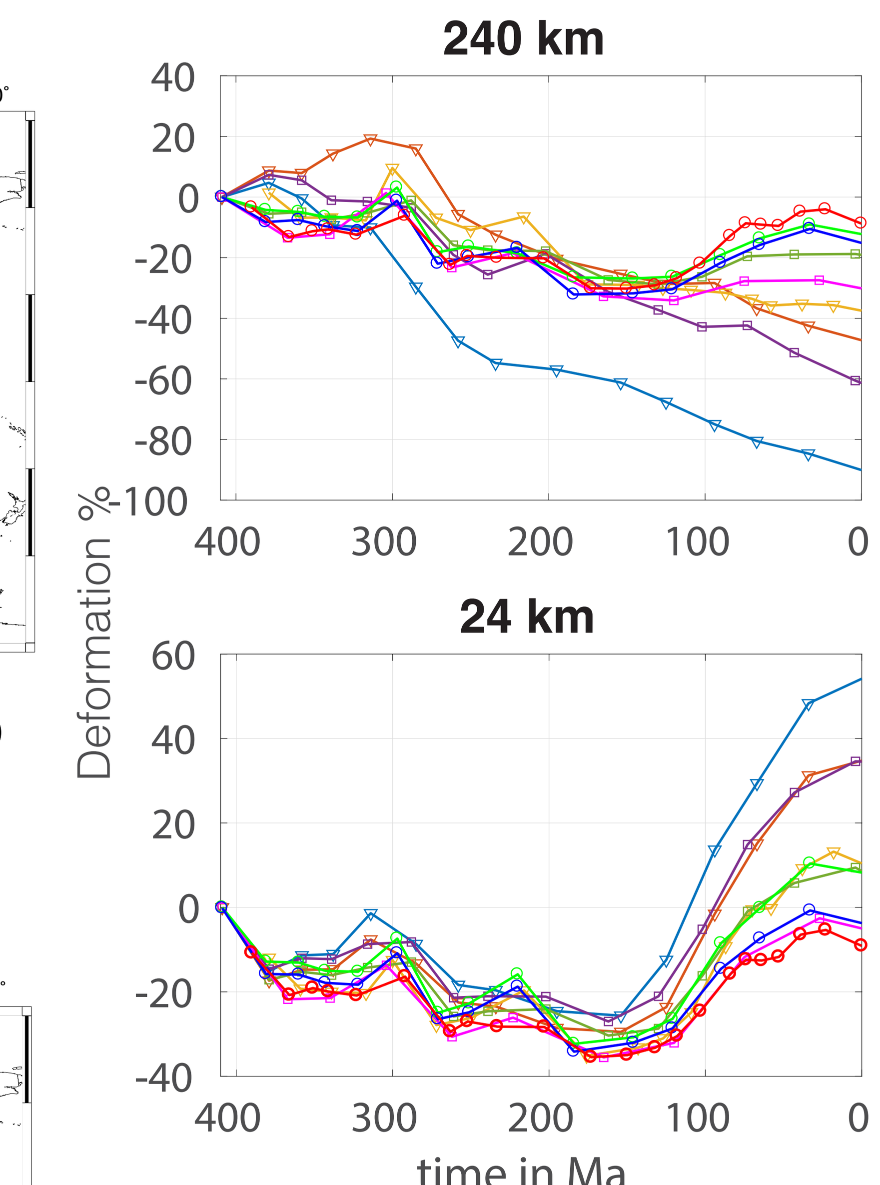
Moderately strong case (0.1, 100) Much less deformed cratons



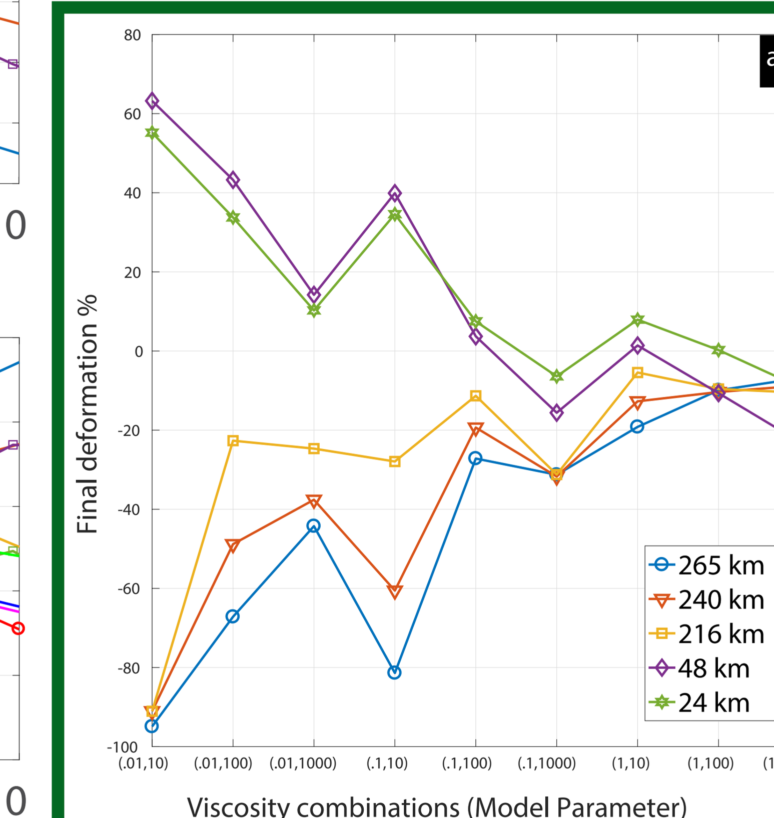
Strong case (1, 100) No visible deformation of cratons

Cratons need to be 100 times more viscous compared to their surroundings and asthenosphere needs to be at least 10^{20} Pa-s to support long term stability.

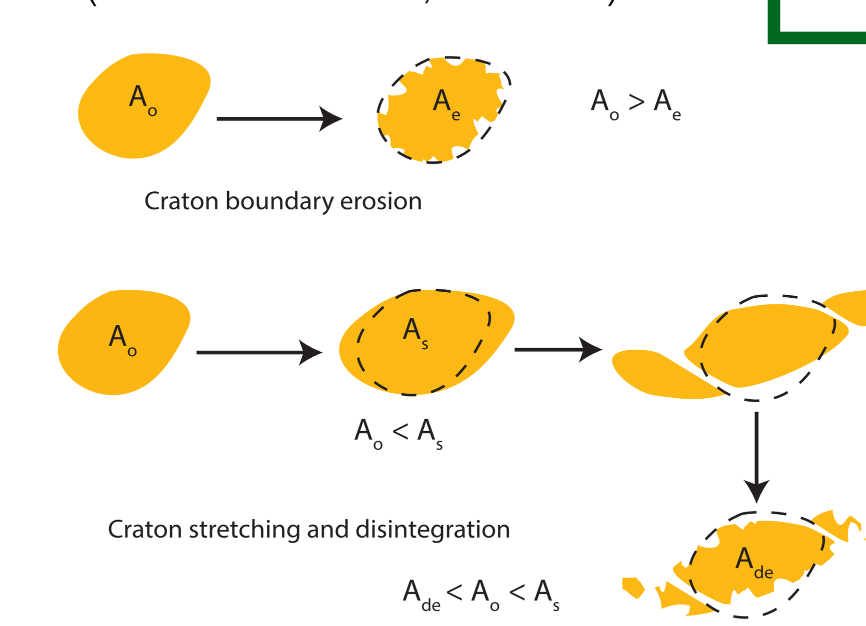
Deformation % of cratonic areas with time



(Paul and Ghosh, in Press)



Final stage of deformation at different depths



Deformation mechanism of cratons

1. erosion
2. stretching
3. disintegration

Animations

Paper

Supported by:
Tata Trust Grant

Reference:
1. J. Paul, A. Ghosh, C. P. Conrad. Geophysical Journal International, 2019.
2. K. J. Matthews, K. T. Maloney, S. Zahirovic, S.E. Williams, M. Seton, R.D. Mueller. Global and Planetary Change. 2016.
3. J. Paul, A. Ghosh, Earth and Planetary Science Letters, in Press