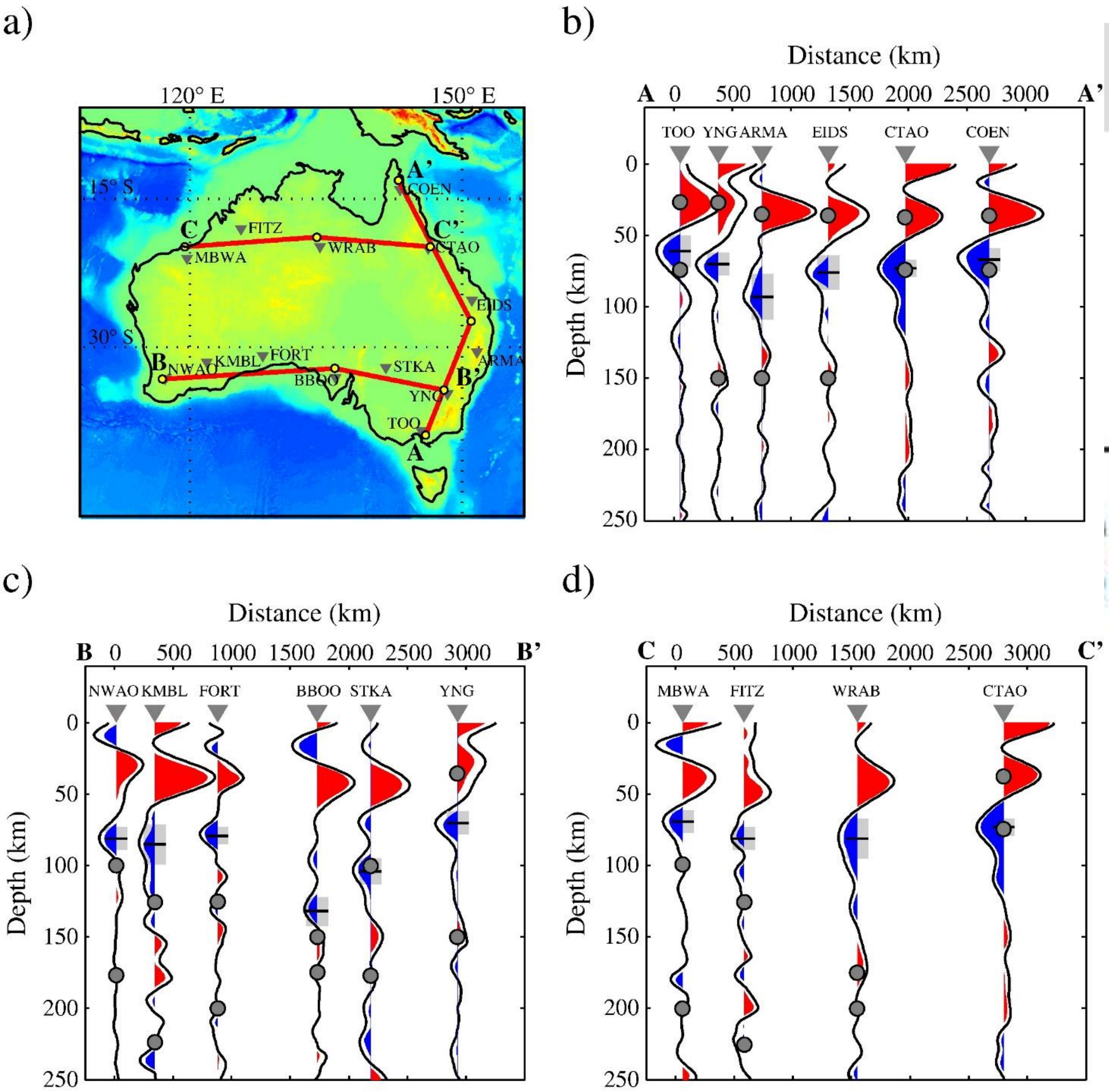
Effect of Weak Mid-lithospheric Discontinuities on the Survival of Cratons

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

Motivation

- Investigating the long-term survival of cratons
- Very small strain-rates at the base of thick cratons (Paul et al., GJI, 2019)
- Constraining the relative viscosity of cratons and asthenosphere that allow them to survive for a long time (Paul and Ghosh, EPSL, in Press)
- What role does MLD play in the survival of cratons?

Are cratons homogeneous?



Are these MLDs weak or strong? (Karato and Perk, 2015, Liao and Gerya, 2014)

Do they have any effect on craton destabilization?

Example:
North China Craton

(Ford et al., 2010)

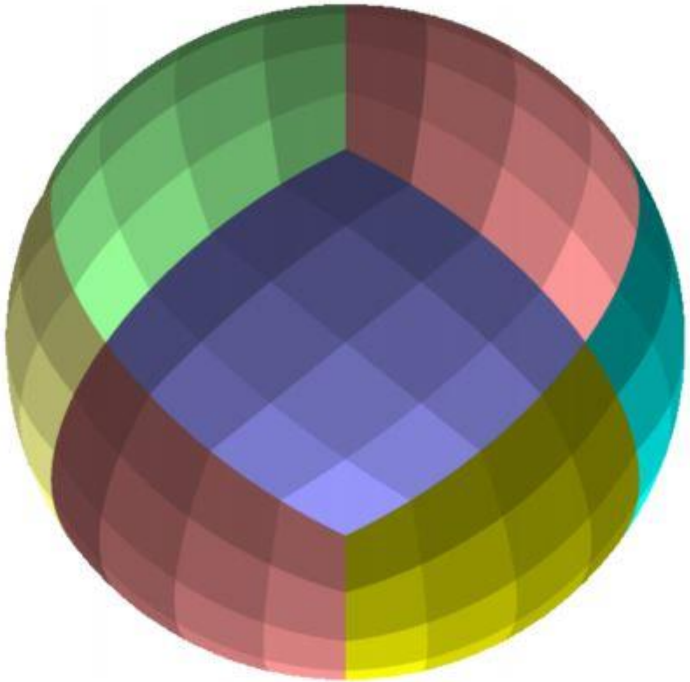
Goals of the present work

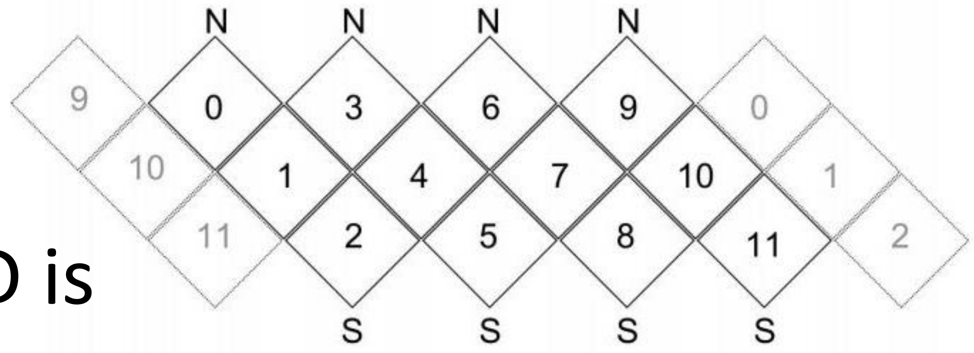
1. Developing 3-D full spherical earth-like mantle convection models to investigate the effect of MLDs in cratons' survival

2. Are MLDs really weak?

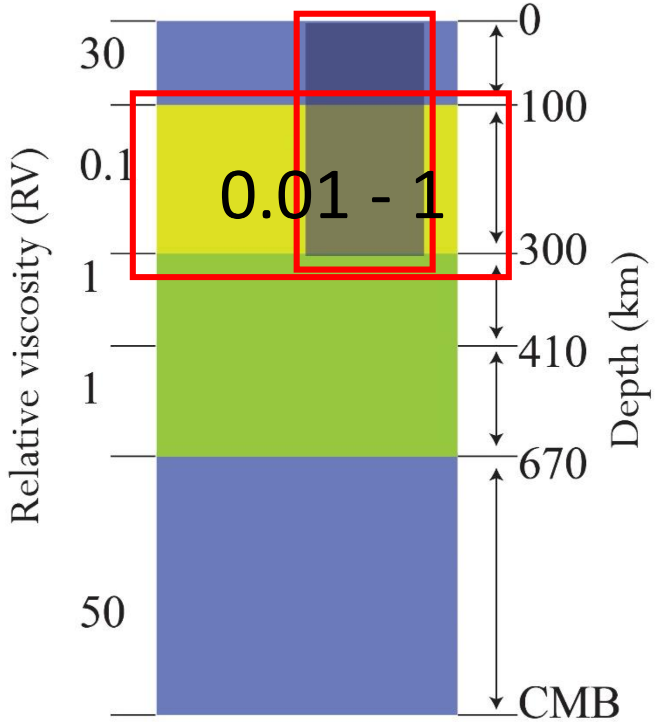
Methodology

1. FE code CitcomS to solve convection equations (Zhong et al., 2000).
2. Instantaneous mantle flow driven by density anomalies derived from tomography with free-slip boundary condition at the surface and at the CMB.
3. Both radial and lateral viscosity variations (temperature dependent viscosity) are applied
4. In between 80-160 km depth, a weak MLD is imposed under the cratons

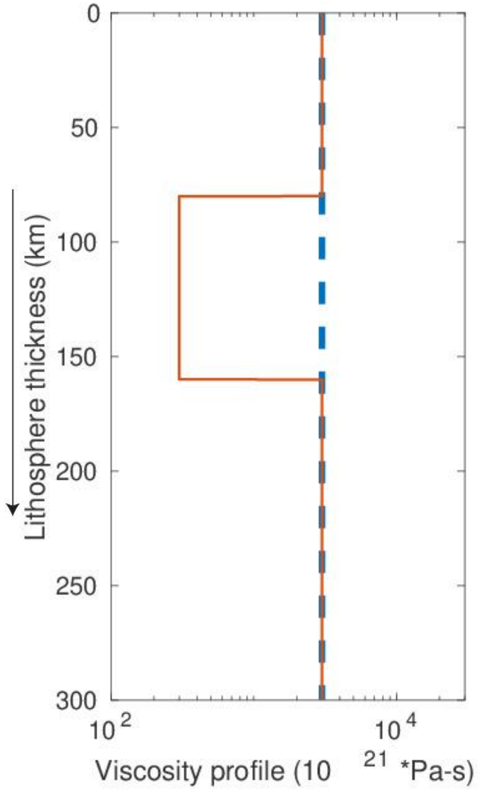


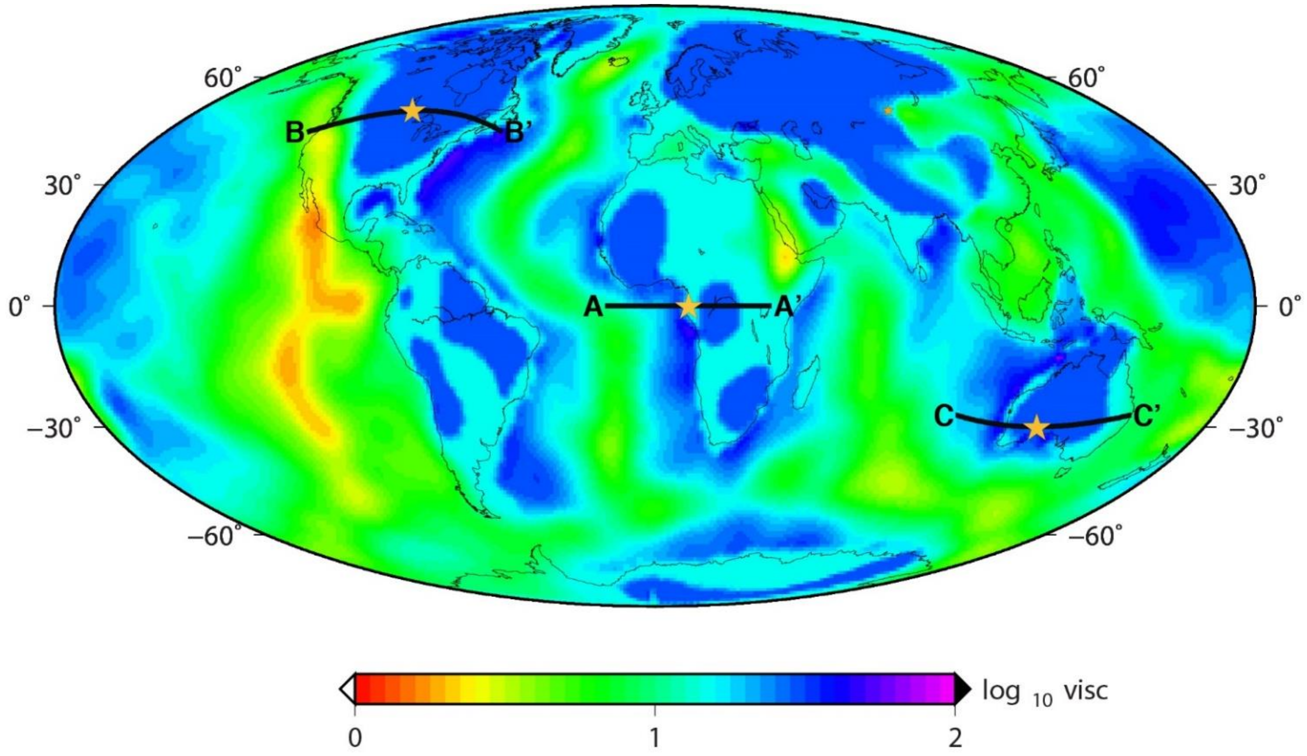


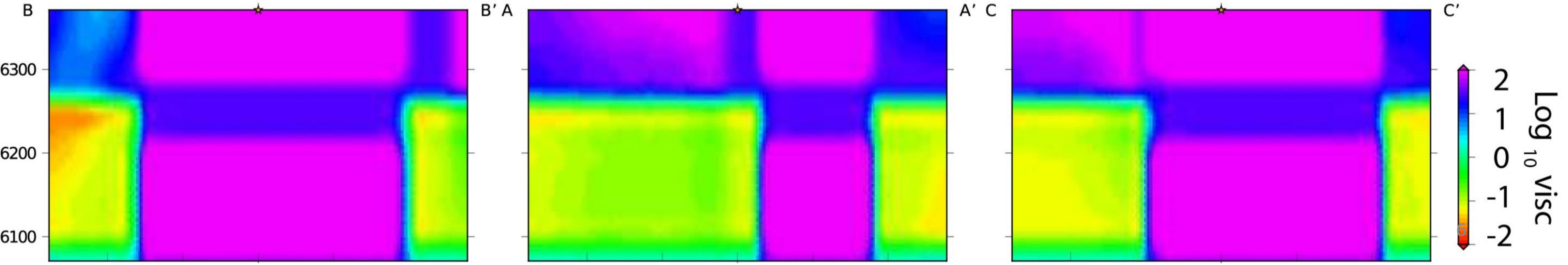
Viscosity structure



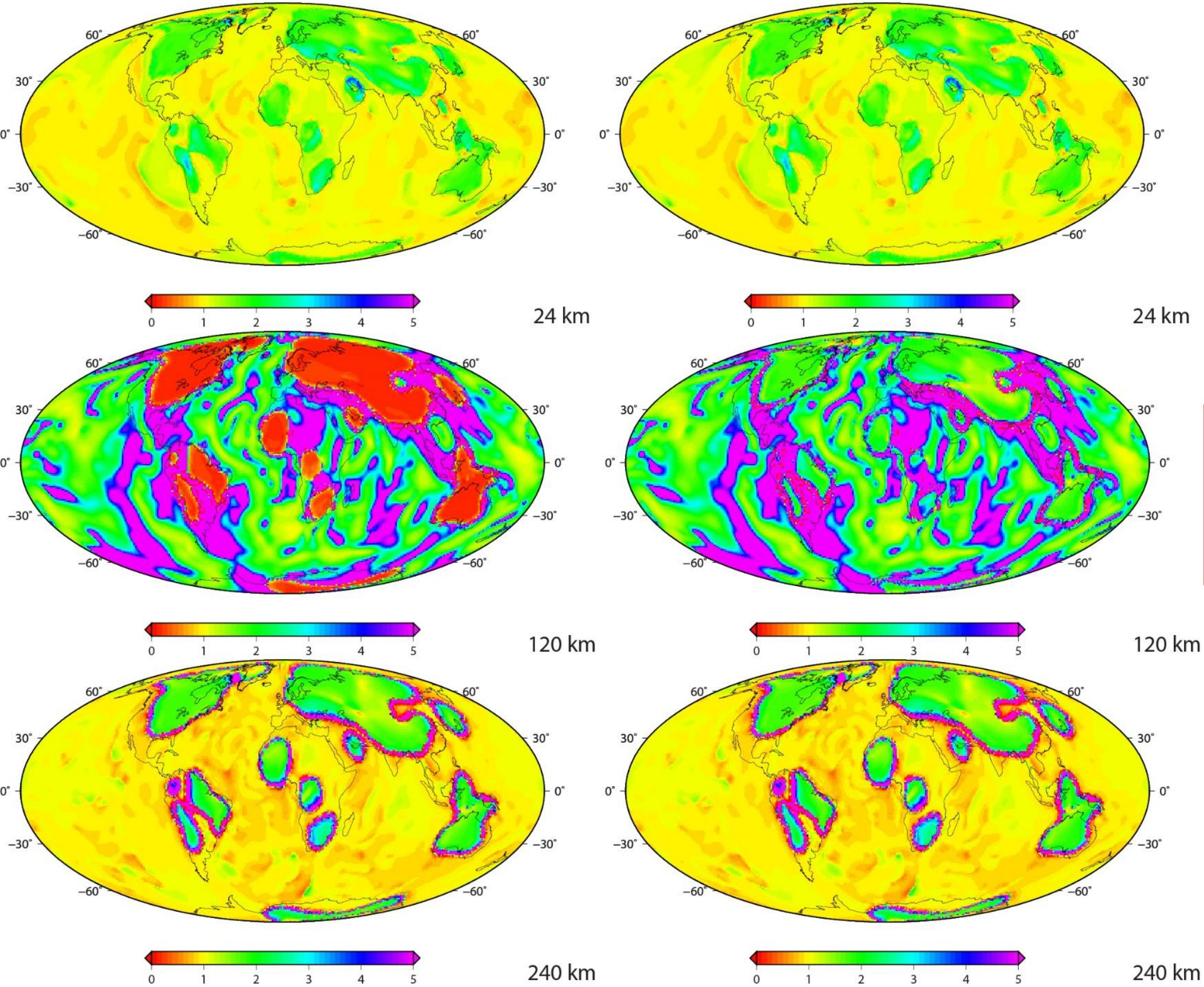
(Paul et al., GJI, 2019)







Second invariant of stress and strain-rates

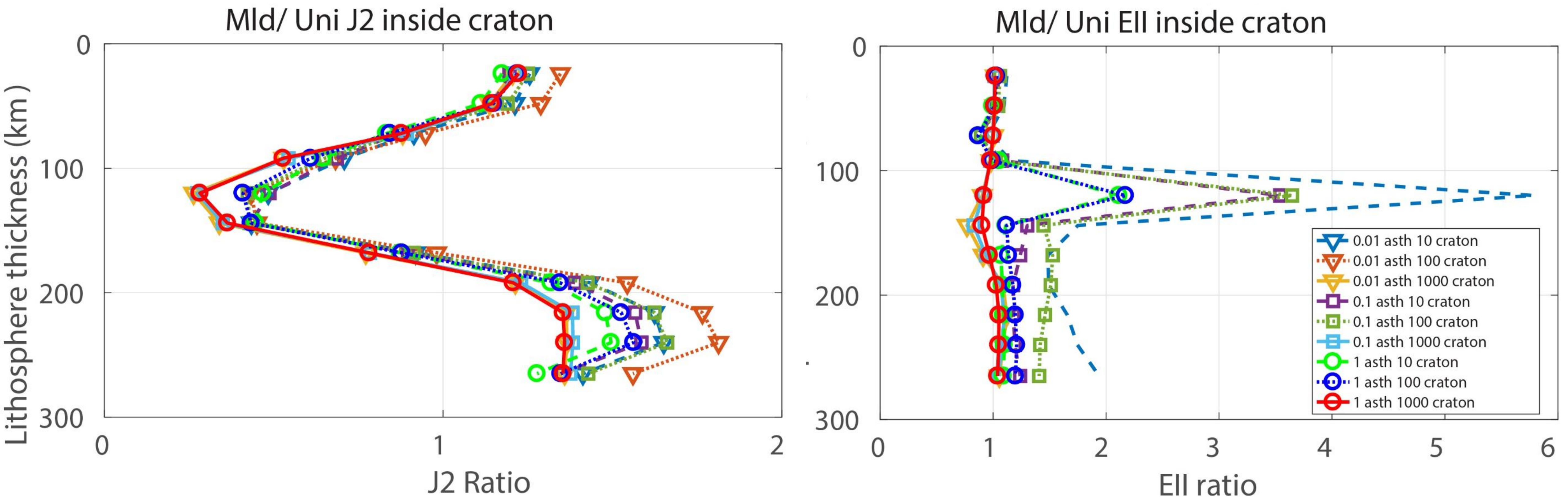


Example case:
100 times viscous craton,
Asthenosphere 10^{20} Pa-s
MLD is 10 times weaker
than the craton

Left : $J2_{mld}$ / $J2_{uniform}$
Right : EII_{mld} / $EII_{uniform}$

Stress and strain-rate magnitudes behave differently within MLD layer and change globally, even if MLDs are locally placed.

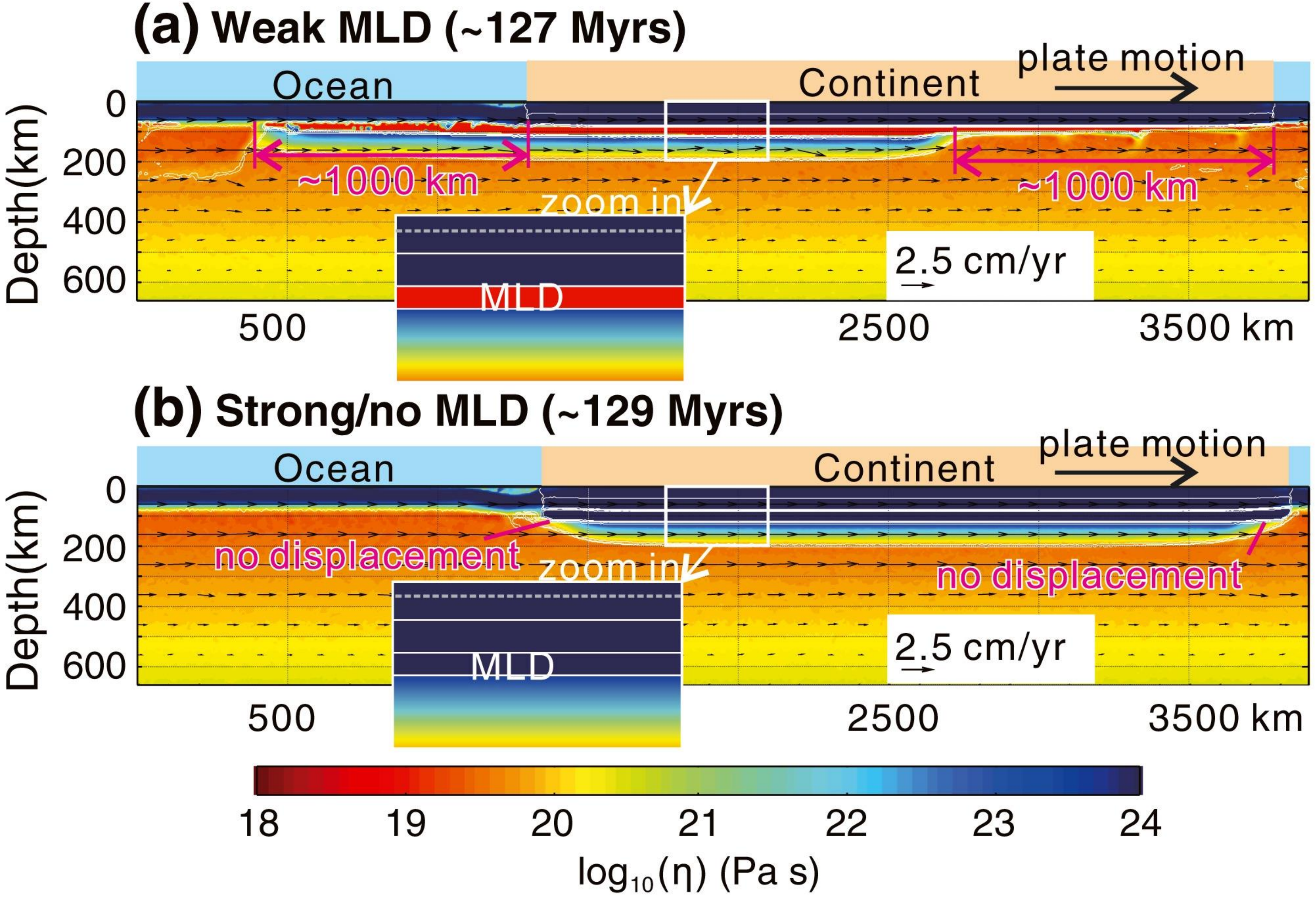
Variation of second invariants



Decrease in stress inside the craton in presence of MLD, but strain-rate increases ~2-3 times.

This can potentially promote delamination.

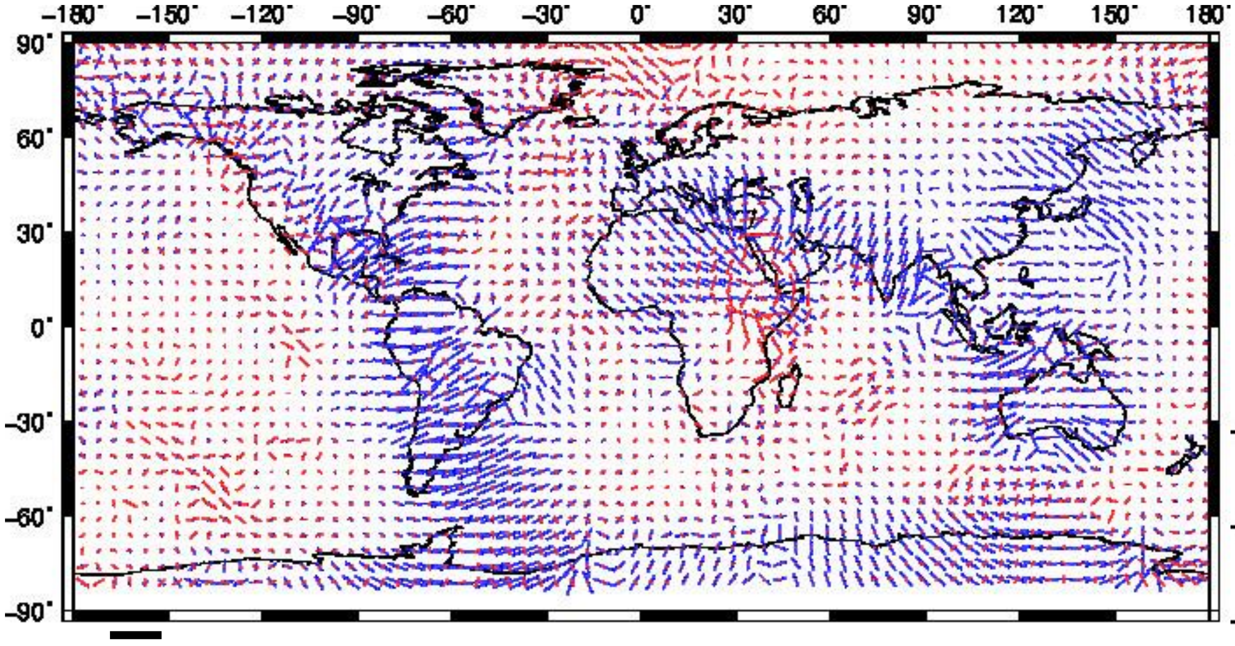
Earlier studies



In presence of a weak MLD, craton got delaminated, but no significant deformation at its base.

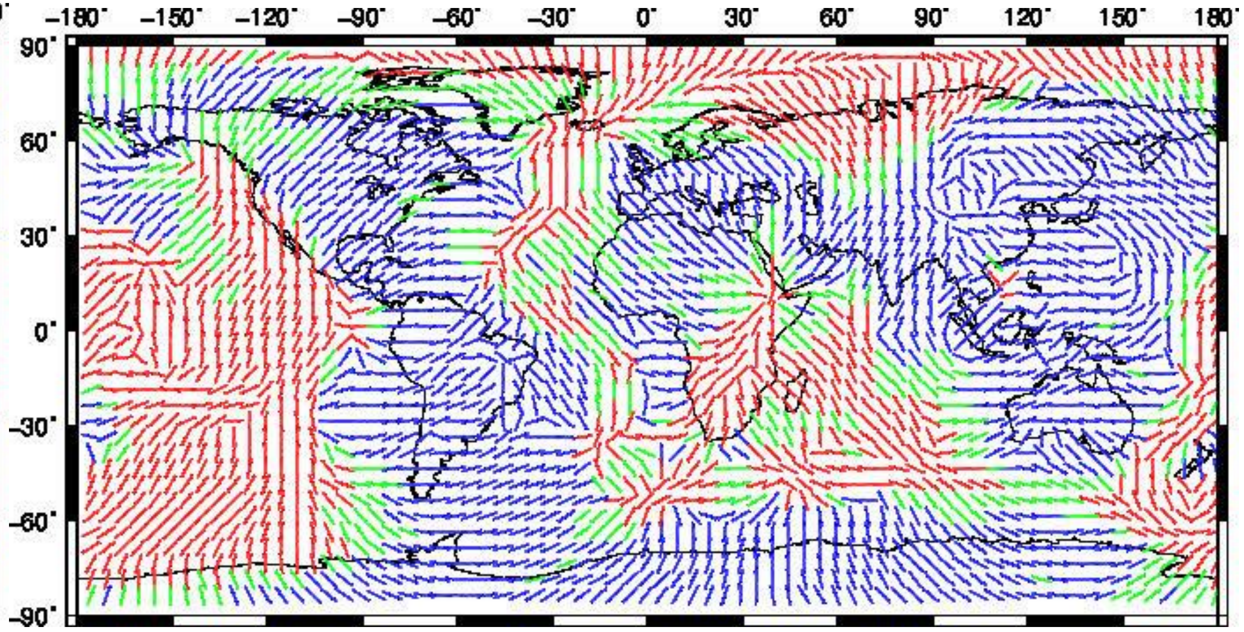
(Wang et al., 2017)

Predicted Sh_{max} from model having MLD



25 MPa

Red: extensional,
Blue: compressional



96 km

Red: extensional,
Blue: compressional,
Green: Strike slip

Work in progress: Compare with Sh_{max} from WSM and calculate misfit

Conclusion

- Weak MLDs can decrease the stress inside the cratons, but enhance strain-rates which can potentially promote delamination from the middle of the cratons.
- The presence of a weak MLD changes the global stress magnitudes, even though they are local features.

Future work

Poster no. DI13B-0008
Today, afternoon

- What happens in time-dependent cases?
- Can we constrain the viscosity of MLDs?
- How multiple MLDs affect stress and strain-rates inside cratons?