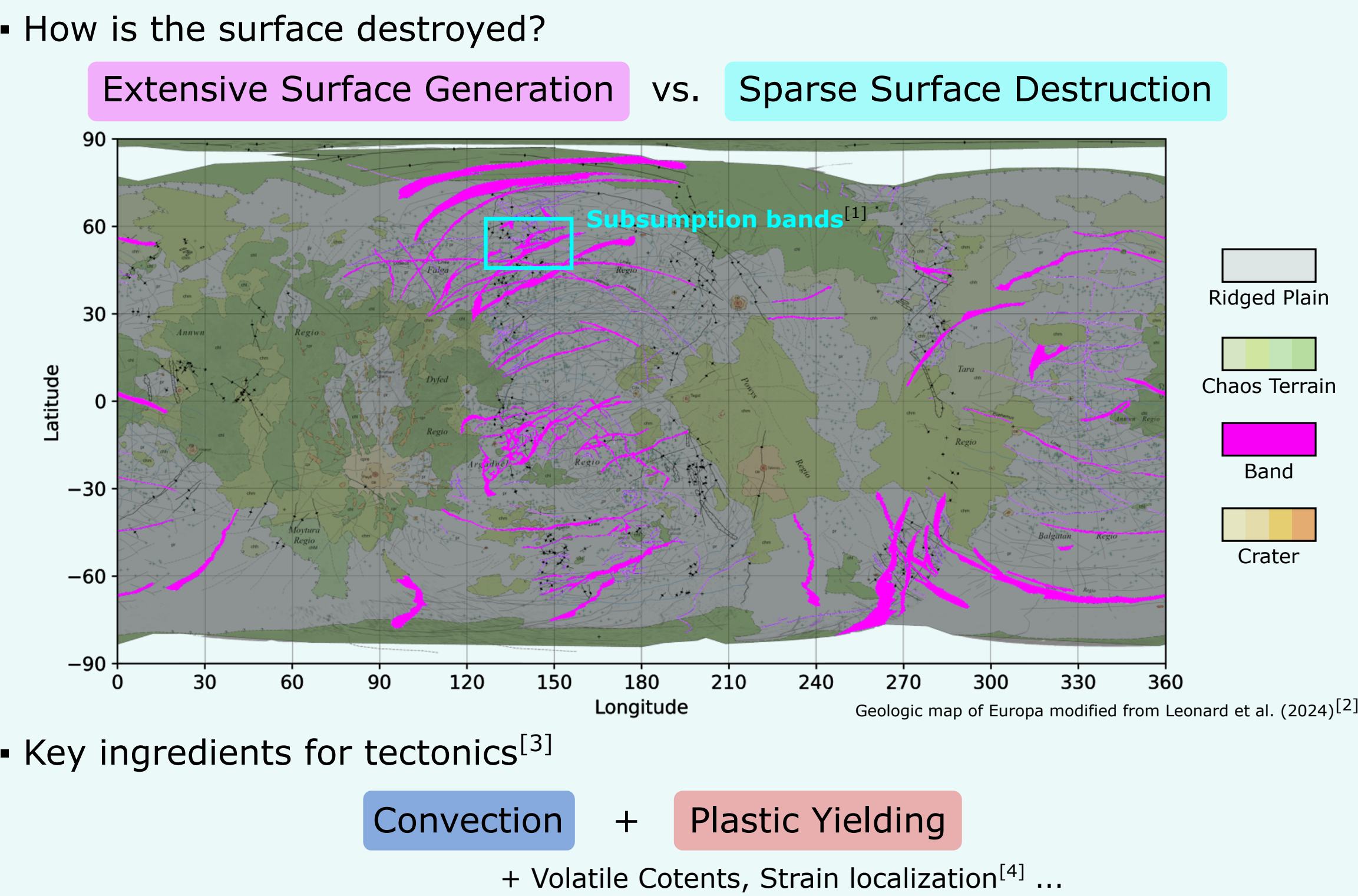


Cracking Europa's Shell: How Ice Thickness and Convection Drive Surface-Interior Dynamics

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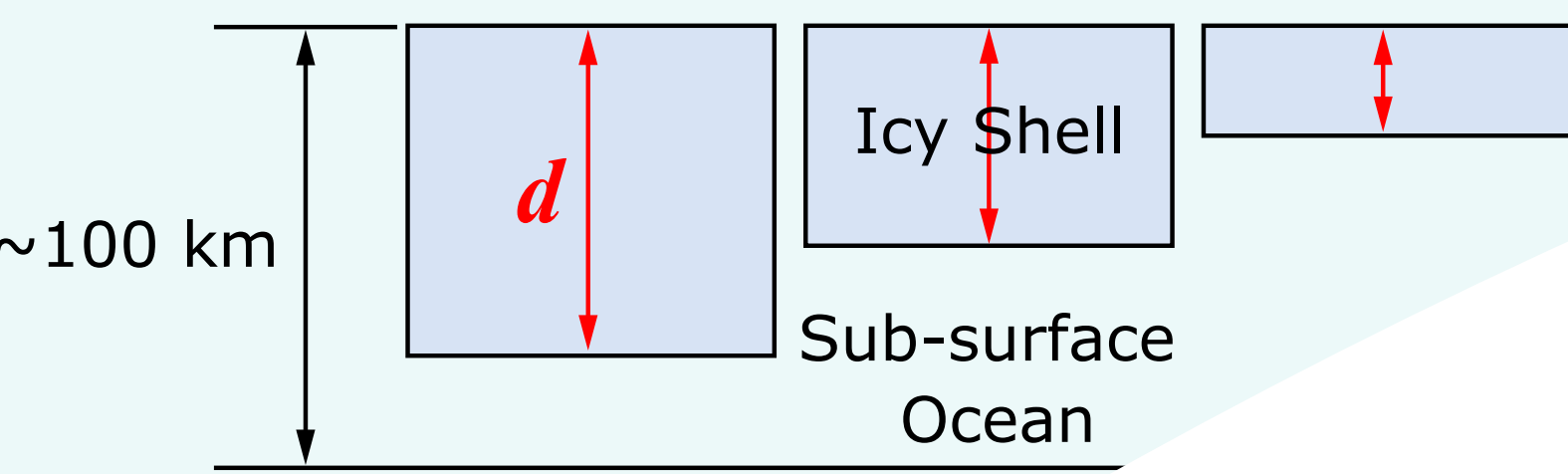


1. Icy Shell Thickness for Ice Tectonics



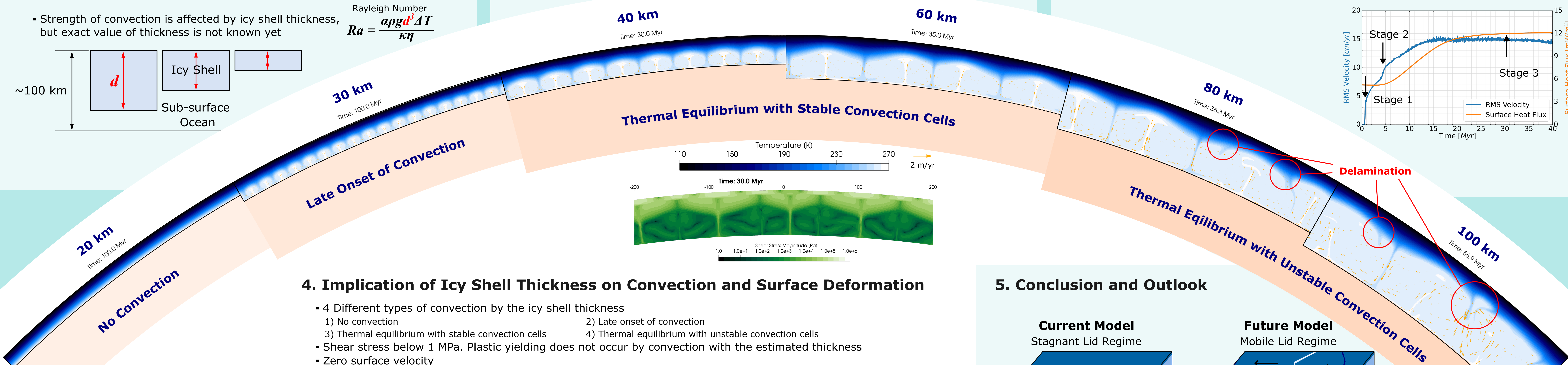
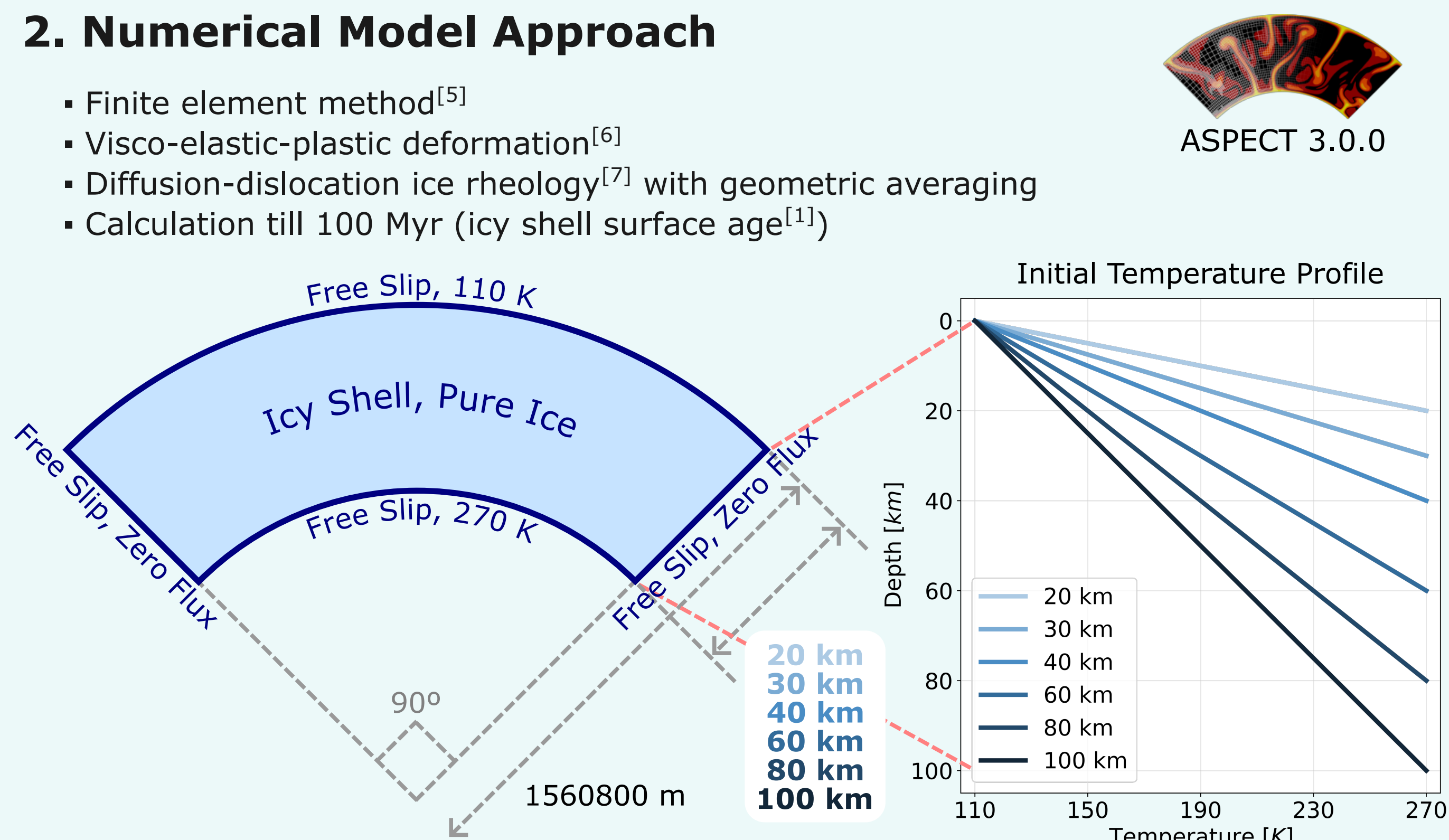
Strength of convection is affected by icy shell thickness, but exact value of thickness is not known yet

Rayleigh Number

$$Ra = \frac{apgd^3\Delta T}{\kappa\eta}$$


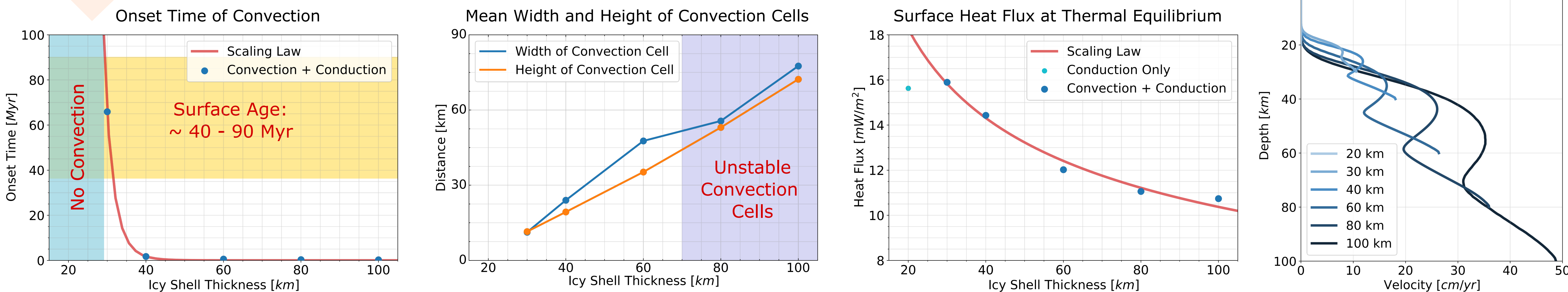
2. Numerical Model Approach

- Finite element method^[5]
- Visco-elastic-plastic deformation^[6]
- Diffusion-dislocation ice rheology^[7] with geometric averaging
- Calculation till 100 Myr (icy shell surface age^[1])



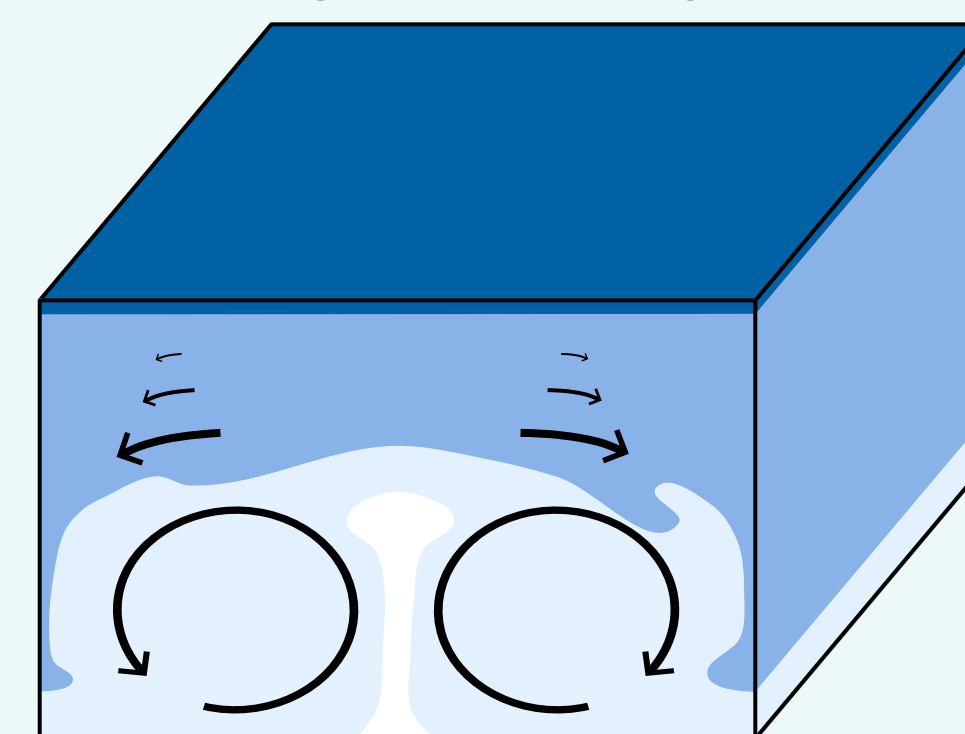
4. Implication of Icy Shell Thickness on Convection and Surface Deformation

- 4 Different types of convection by the icy shell thickness
- 1) No convection
- 2) Late onset of convection
- 3) Thermal equilibrium with stable convection cells
- 4) Thermal equilibrium with unstable convection cells
- Shear stress below 1 MPa. Plastic yielding does not occur by convection with the estimated thickness
- Zero surface velocity
- Inverse relationship between surface heat flux and icy shell thickness



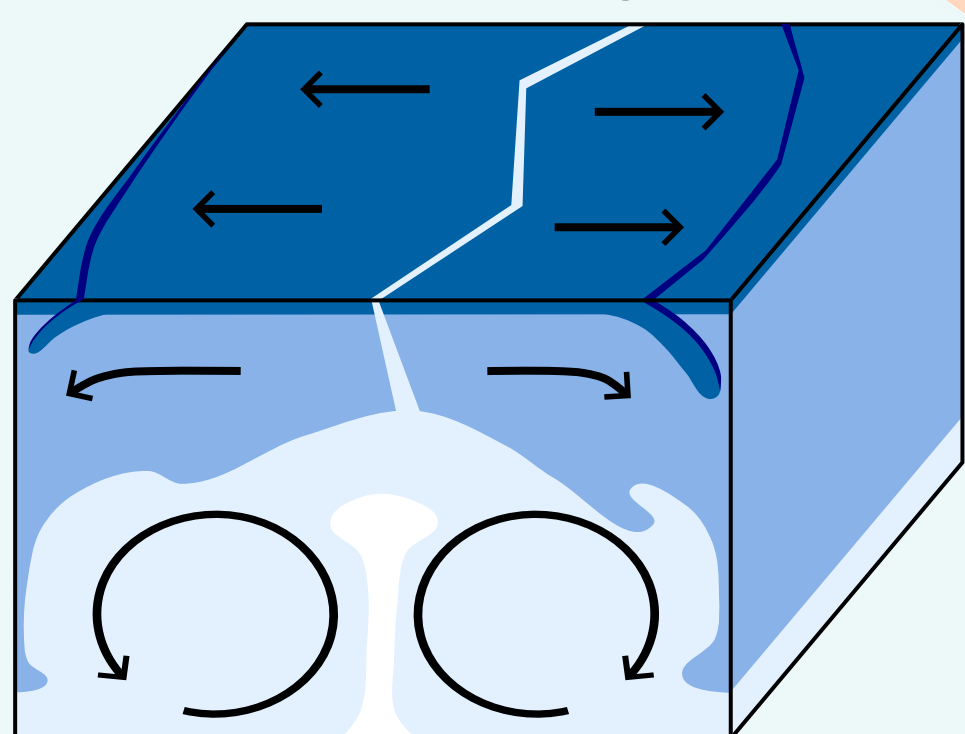
5. Conclusion and Outlook

Current Model
Stagnant Lid Regime



- Visco-elastic-plastic deformation
- Different types of convection with various icy shell thickness
- Plastic yielding cannot occur by known icy shell thickness range

Future Model
Mobile Lid Regime



- Grain-size dynamics^[7]
- Tidal heating and stress^[8]
- Weaker ice^[9]
- Strain localization^[10]
- Free surface deformation^[11]

