Mantle Phase Changes under Dynamic Stress

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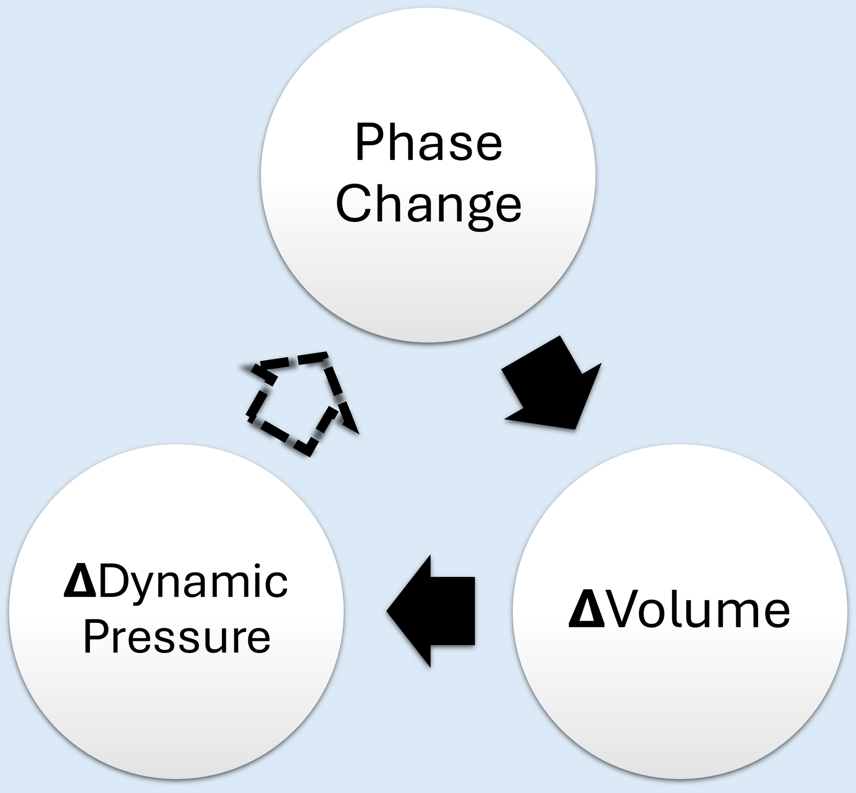
⇐ Problem ⇒

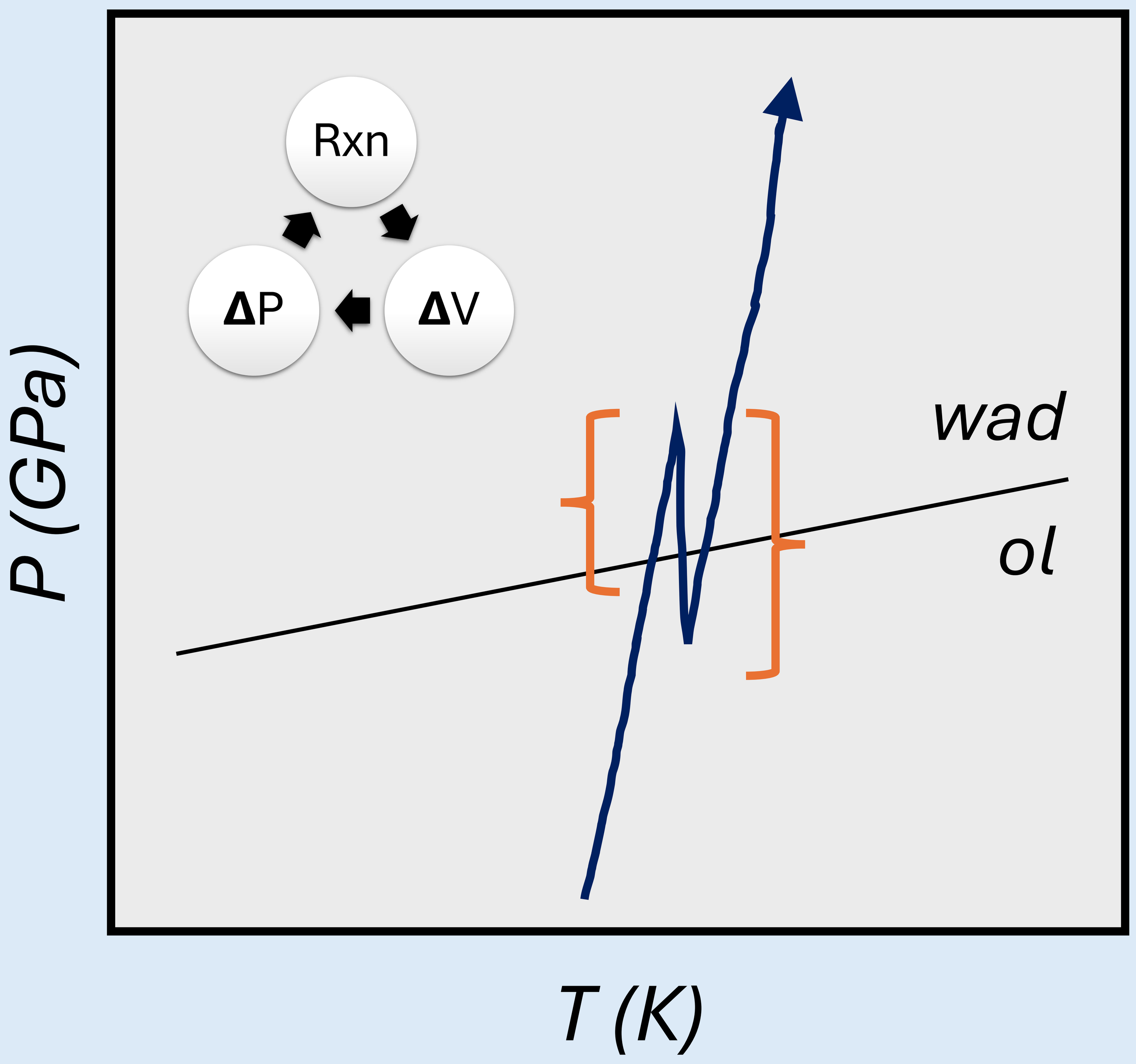
*The mantle is under **non-hydrostatic** stress, yet it is modeled with **hydrostatic** thermodynamics*

⇐ The Missing Link ⇒

Phase changes compress (or expand) the mantle and dynamic pressures arise



Geodynamic codes can simulate compressible mantle flow and thus include an important feedback between phase changes and volume (filled arrows). However, they neglect the missing link between dynamic pressure and phase changes (dashed arrow), which is essential for understanding mantle flow and seismic structure.



*Schematic illustration of the mantle adiabat as it crosses the olivine → wadsleyite phase transition. The olivine → wadsleyite transition compresses the mantle and the pressure decreases. The drop in pressure causes the reaction to reverse, which in turn causes an increase in volume and pressure. The orange brackets highlight the dynamics caused by the full Rxn–**ΔV**–**ΔP** feedback.*

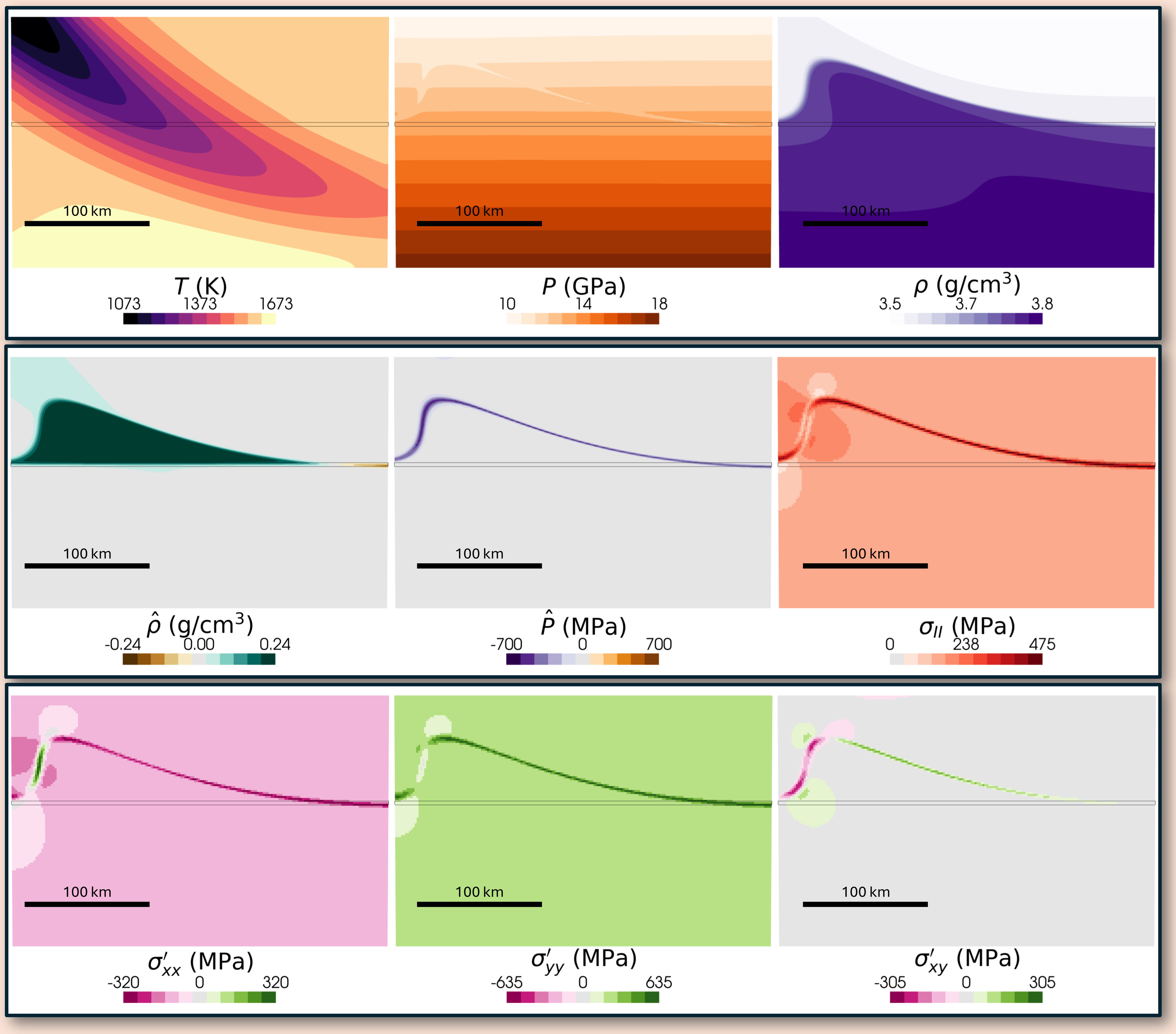
Question:

Can the missing feedback link explain observed displacements of seismic discontinuities?

⇐ The Effects of the Full Feedback ? ⇒

Observation:

Phase changes in compressible geodynamic simulations can generate dynamic pressures up to several hundred megapascal



*Compressible subduction model with a phase change (after 50 Ma of evolution). A simplified subducting slab is modeled by fixing a cold region at the top left boundary and prescribing a constant flow velocity directed towards the bottom-right boundary. Top row shows temperature **T**, pressure **P**, and density **ρ**. Middle row shows nonadiabatic density **ρ^**, nonadiabatic pressure **P^**, and the effective deviatoric stress **σ_II** . Bottom row shows different components of the deviatoric stress tensor **σ'**. The phase change occurs over a narrow depth interval (~ 2 km) and is dependent on **PT** only, but not on **P^** or **σ_II**. The sharp phase change causes the model to compress, and the stress field changes to conserve mass.*

Project Aims:

- *Implement the full feedback between phase changes and dynamic pressure in ASPECT*
- *Reconcile the full feedback simulations with observed displacements in seismic discontinuities*

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