Detachment fault growth modulated by brittle softening and ductile flow at magma-poor slow spreading oceanic ridges

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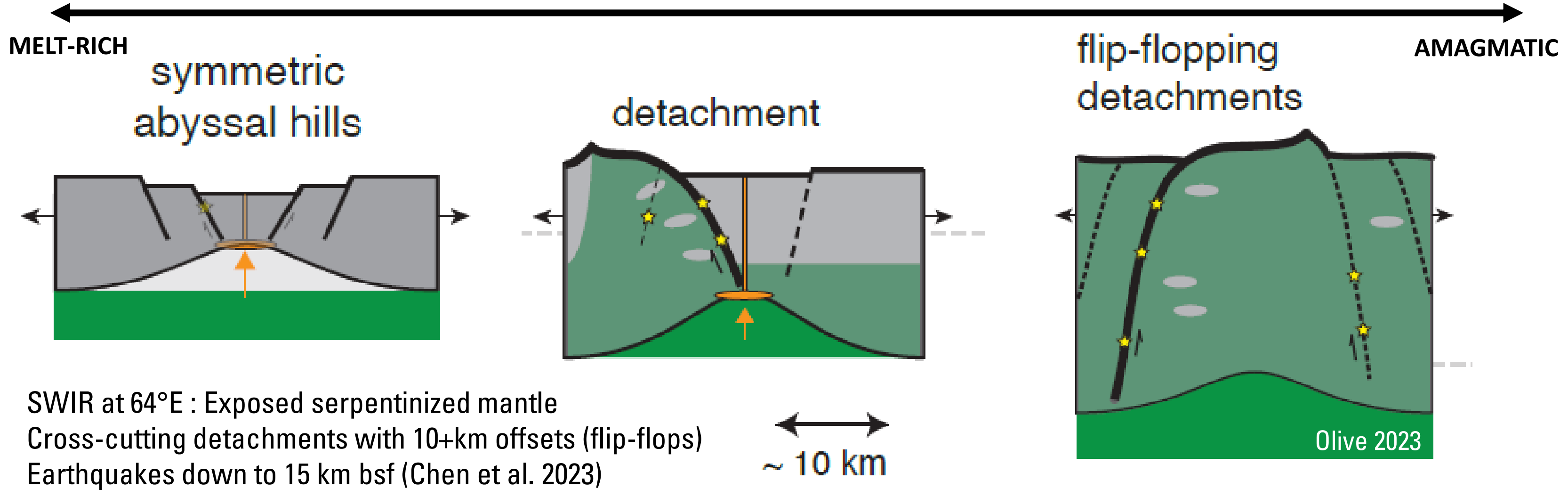
1. INTRODUCTION

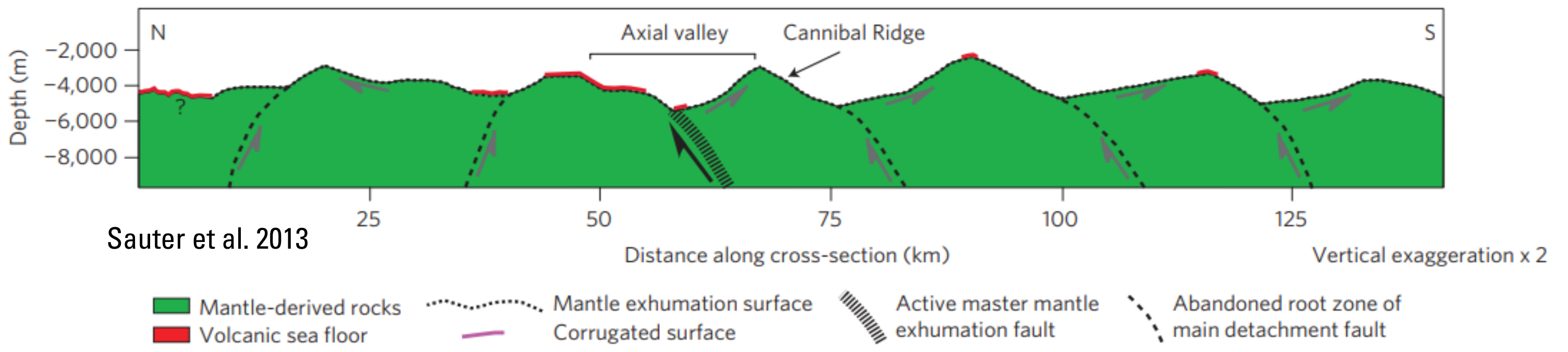
Slow spreading ridges have spatially variable :

- **Partitioning** between **faulting** and **magma intrusions**
- **Variable** thickness (strength) of axial oceanic lithosphere

Here we **focus** on the **melt-poor endmember : quasi amagmatic ultraslow spreading segments,** e.g., the **SWIR at 64°E**



SWIR at 64°E : Exposed serpentinized mantle
Cross-cutting detachments with 10+km offsets (flip-flops)
Earthquakes down to 15 km bsf (Chen et al. 2023)



Sauter et al. 2013

Lithosphere rheology conditions **detachment fault characteristics. It varies with melt supply and** can be **constrained** by studying abyssal **rock samples**

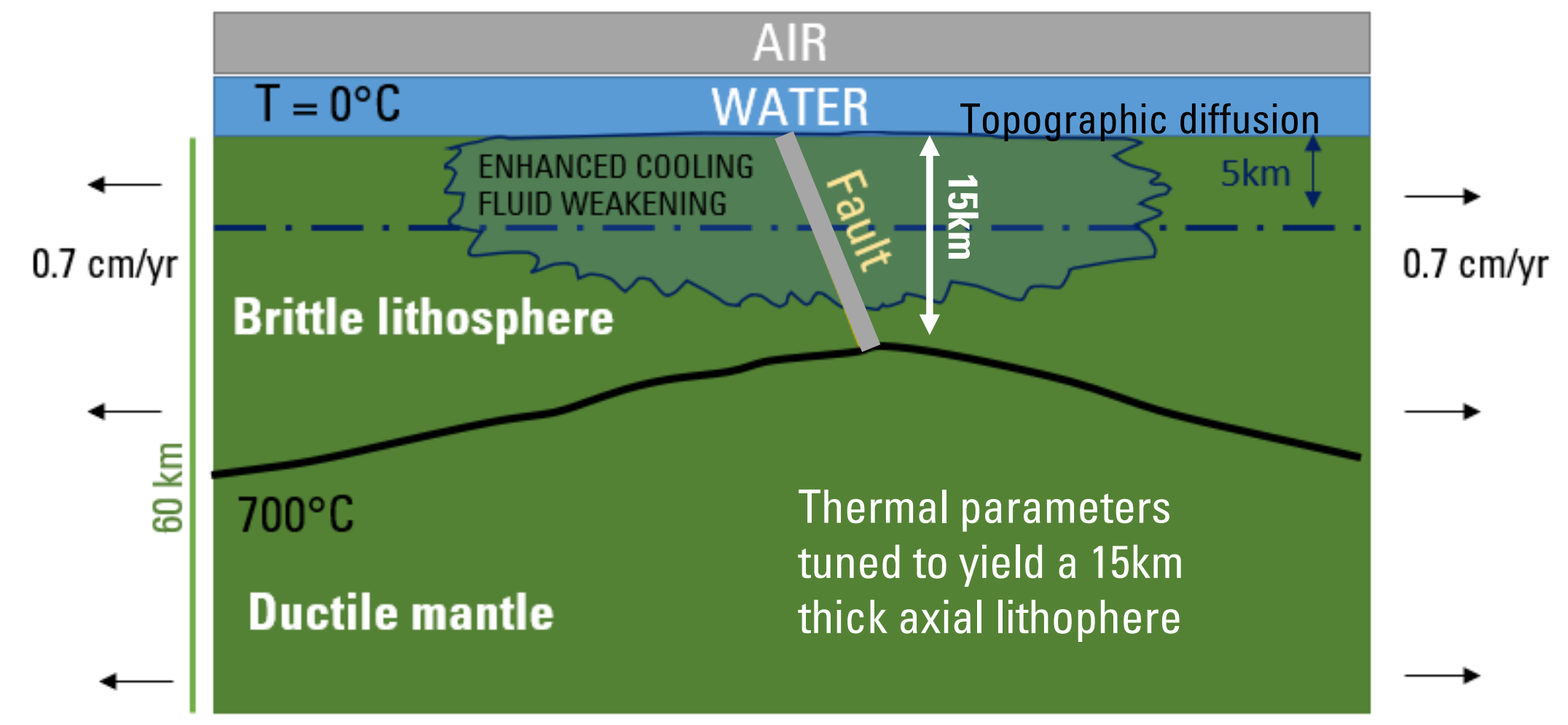
Here we explore the effect of key brittle and ductile rheological parameters on faulting styles in the ultraslow melt poor endmember.

2. MODELING APPROACH

Solving **conservation** of **momentum, mass & energy in a visco-elasto-plastic continuum** though time (Olive et al. 2016)

Self-consistent **temperature evolution**, with enhanced **hydrothermal cooling** on-axis and **off-axis aging**

Faults form spontaneously (Mohr-Coulomb criterion), **loose friction** and **cohesion** after **critical amount** of **slip**

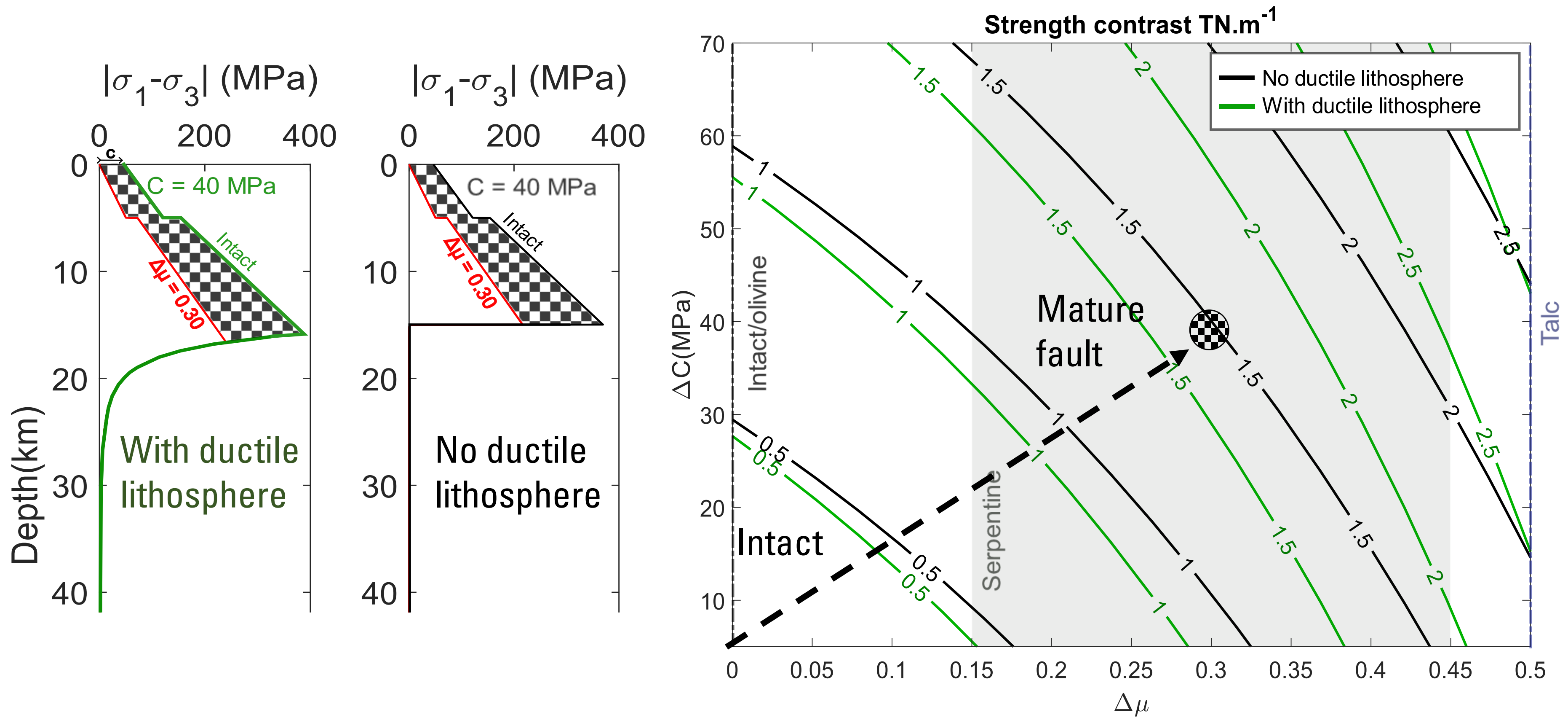


T ~1250°C (T model derived from half space cooling)

Parameters varied :

Friction/Cohesion contrast between **intact lithosphere** and **mature faults**

Presence or **absence** of a **ductile lower lithosphere** (dry olivine flow law, Hirth & Kohlstedt 2003)

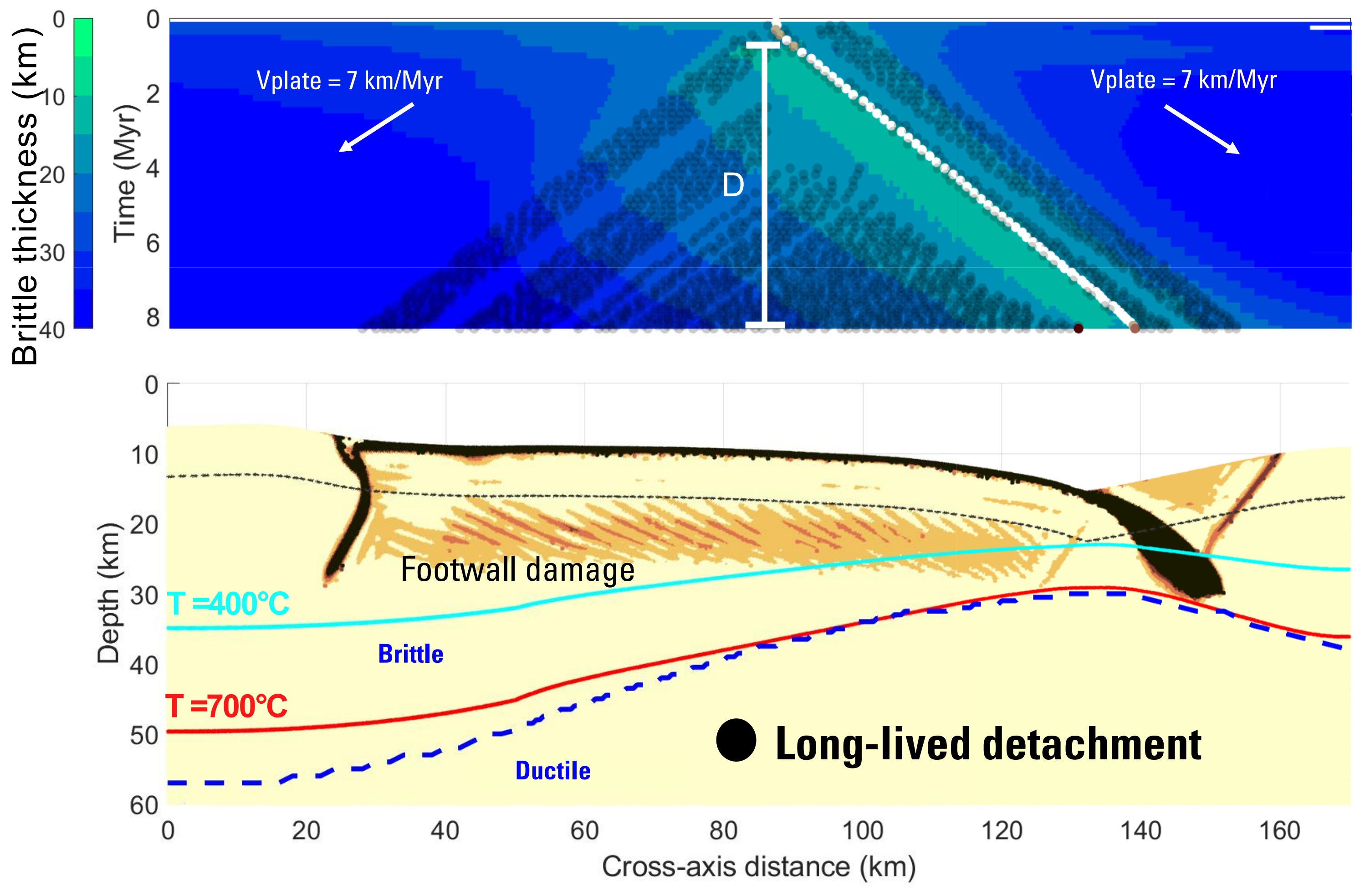


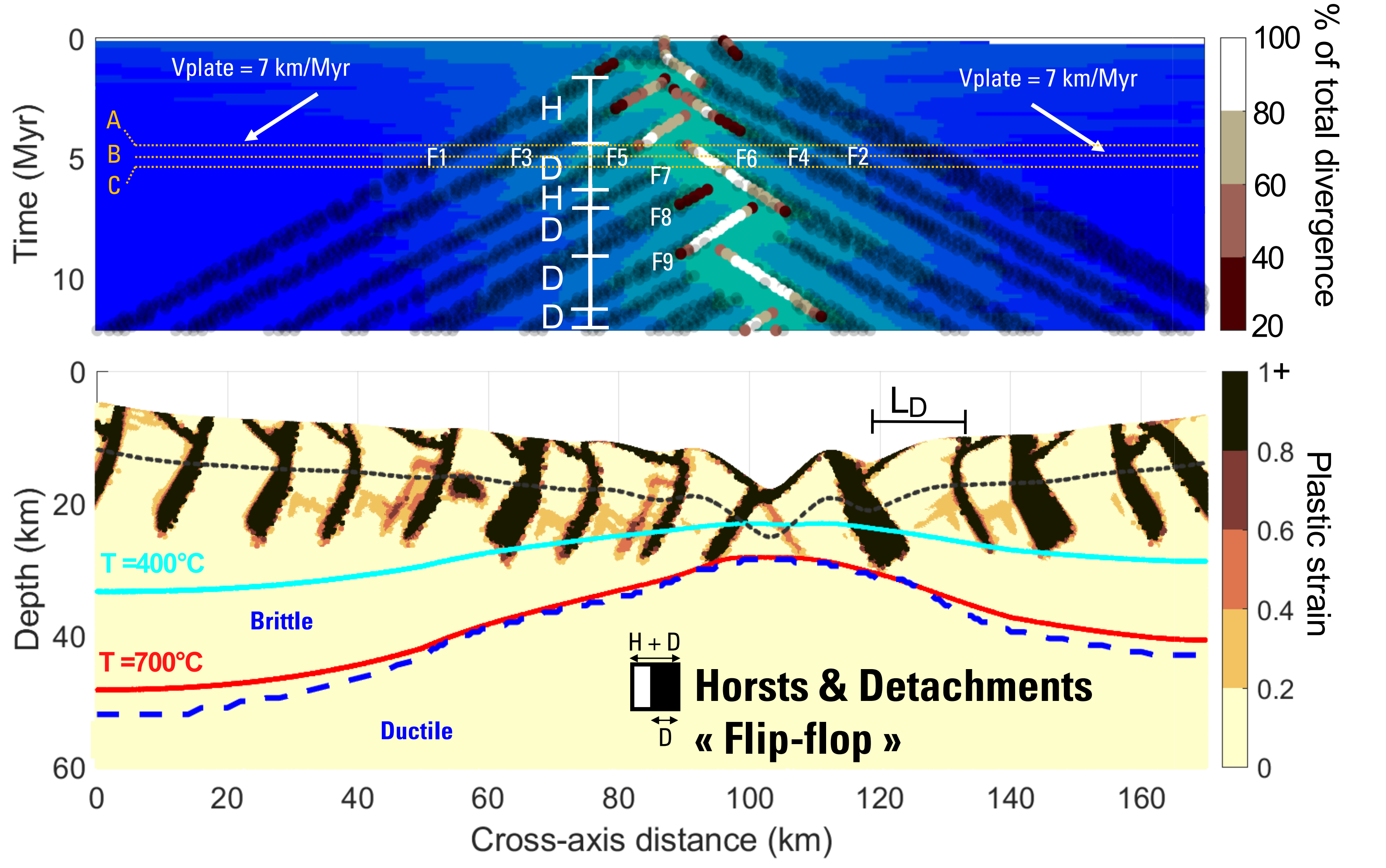
Each combination of friction loss and cohesion loss correspond to a **depth-integrated strength contrast** ▩ which we expect should **promote strain localization** (Lavier et al. 2000)

3. FAULTING REGIMES CONTROLLED BY STRENGTH CONTRASTS

Large brittle strength contrast (**Δμ** = 0.3, **ΔC** = 40 MPa), **ductile lithosphere**

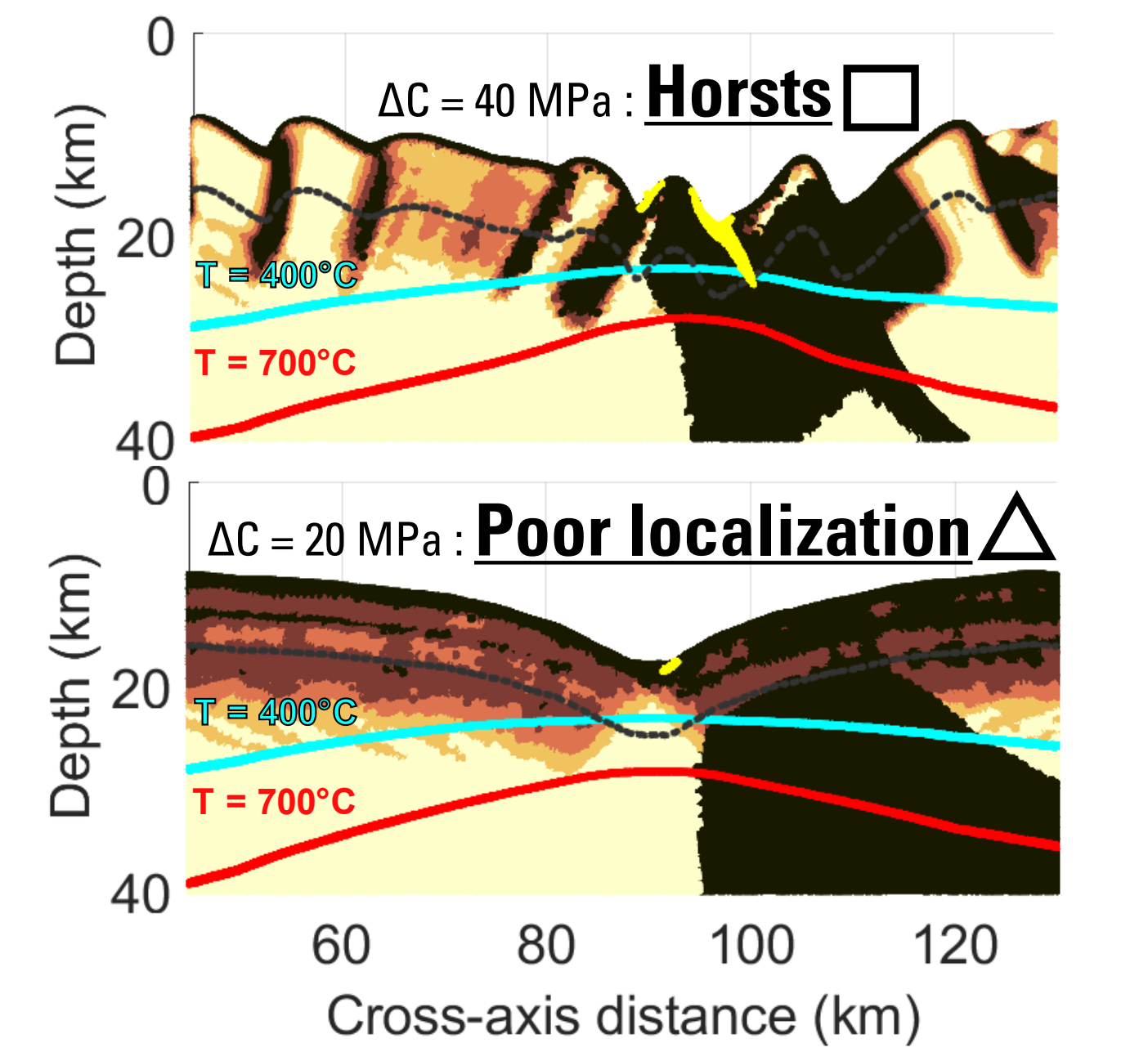
Moderate brittle strength contrast (**Δμ** = 0.1, **ΔC** = 40 MPa), **ductile lithosphere**



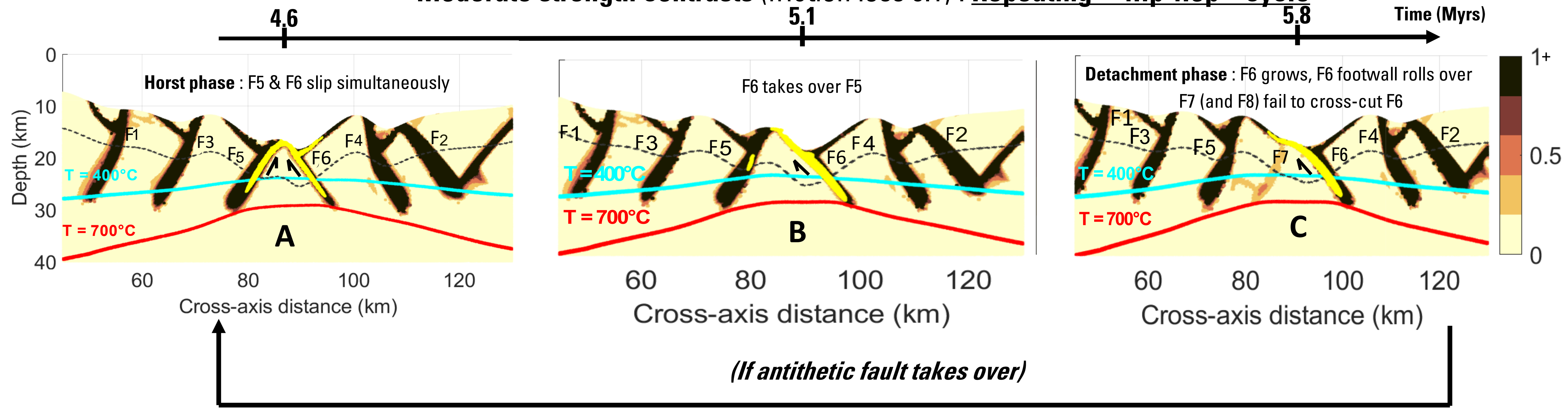


4. MODERATE STRENGTH CONTRASTS PROMOTE ANTITHETIC FAULTING

Very low strength contrasts (no friction loss)



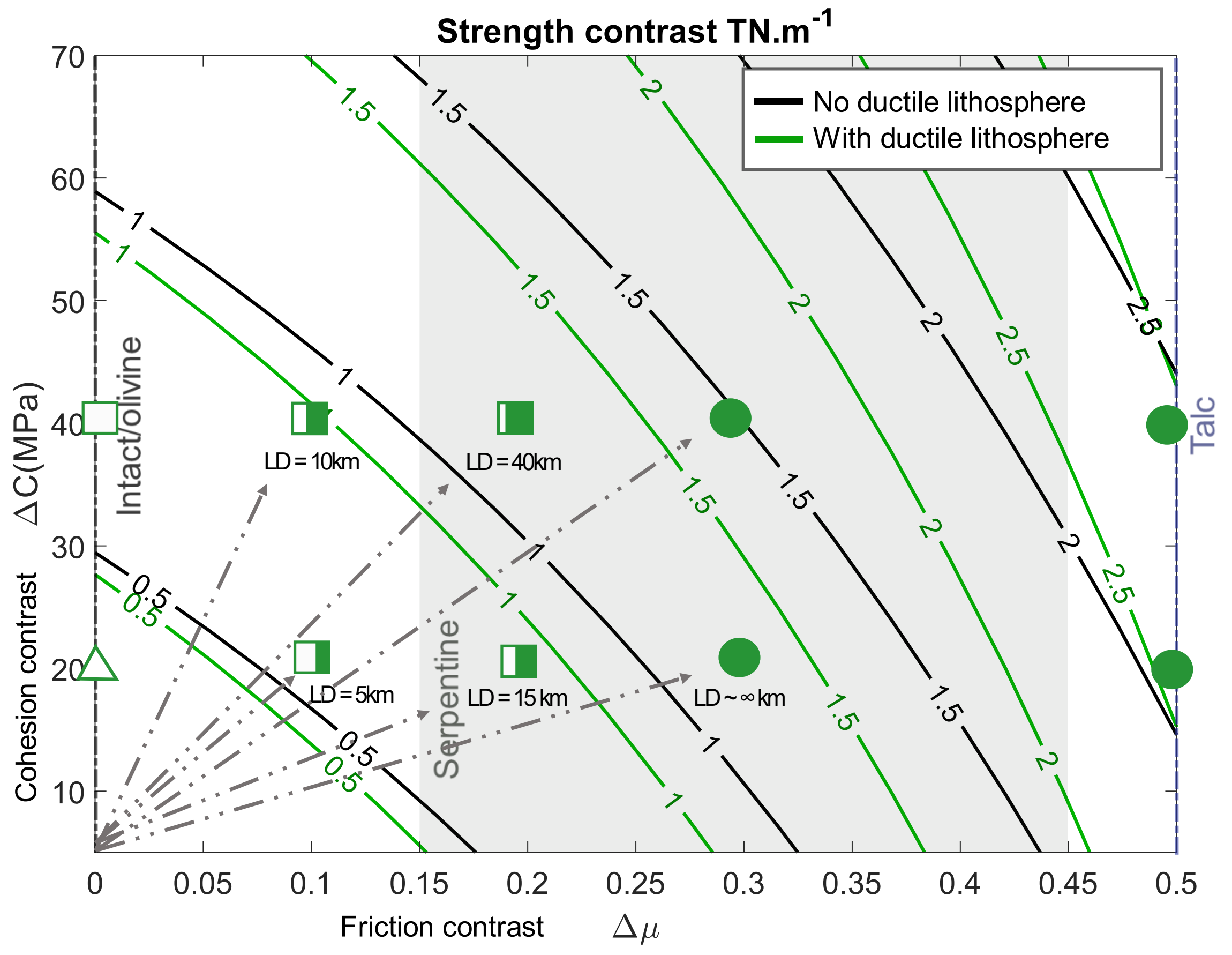
Moderate strength contrasts (friction loss 0.1) : **Repeating « flip-flop » cycle**

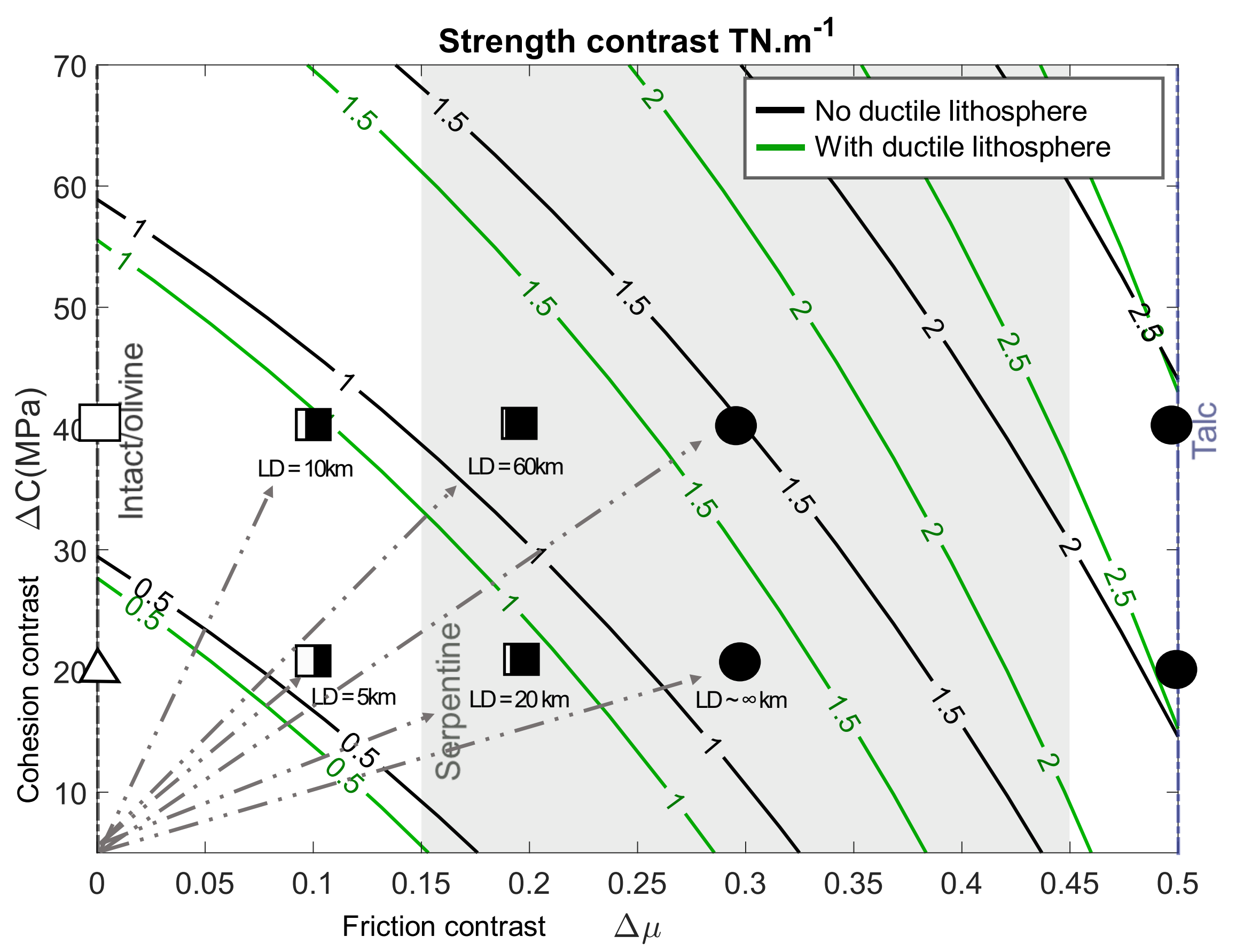


5. FAULTING REGIMES AND IMPACT OF THE DUCTILE LITHOSPHERE

Simulations with ductile lithosphere (green symbols)

Simulations without ductile lithosphere (black symbols)





Regime transitions may correspond to **thresholds in strength contrast** between mature faults and intact lithosphere

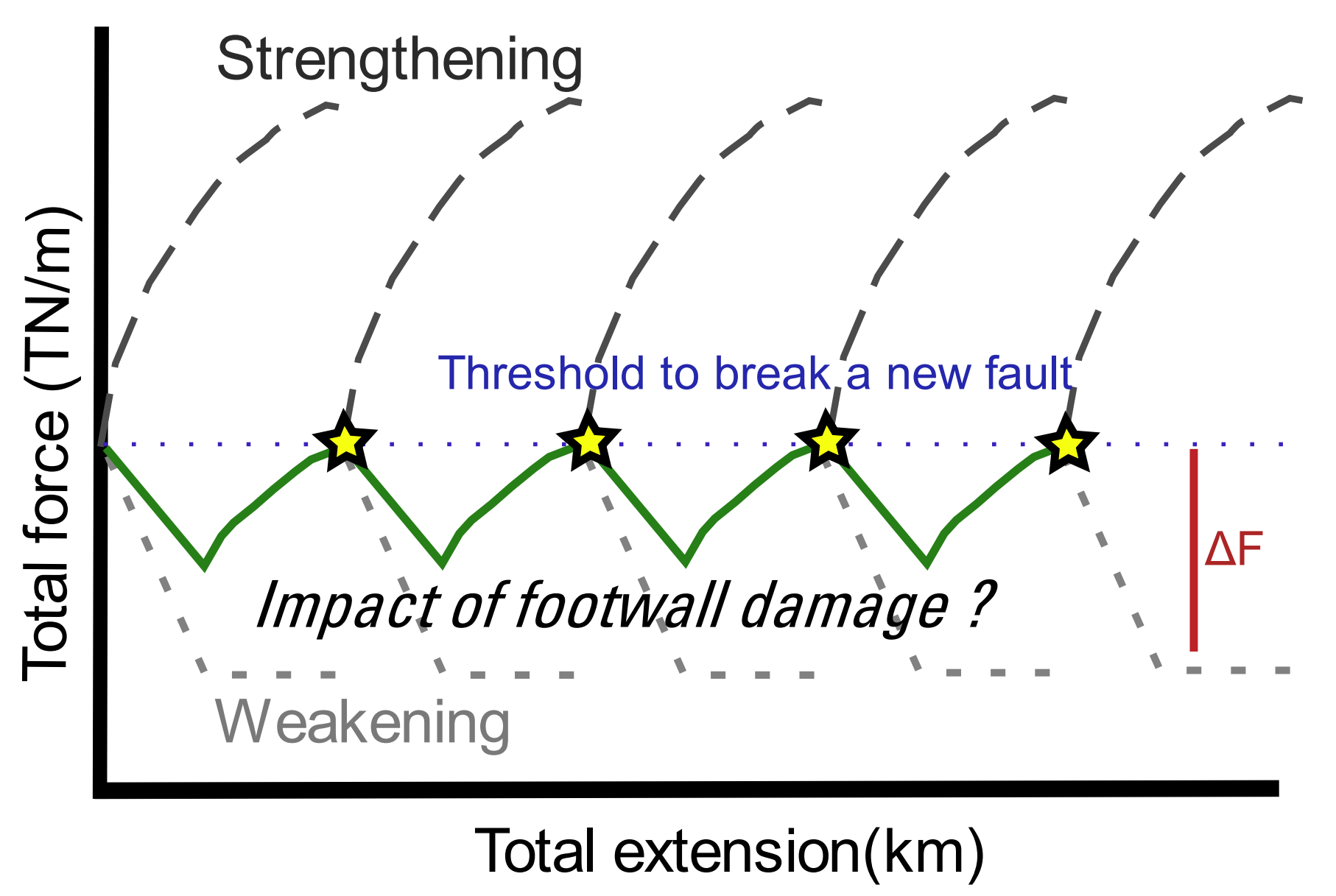
Moderate influence of the **ductile lithosphere** on **regime transition**

6. CONCLUSIONS

Flip-flopping favored by **moderate fault weakening,** consistent with **high-end estimates of serpentine strength**

Limited influence of **ductile** lower **lithosphere**

Alternative mechanism for **flip-flopping** : **horst-detachment cycles** instead of cross-cutting detachments



Future challenge : upscale mineral strength to fault strength