On the Significance of Weak Layers for Continental Subduction and Collision Processes

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INTRODUCTION

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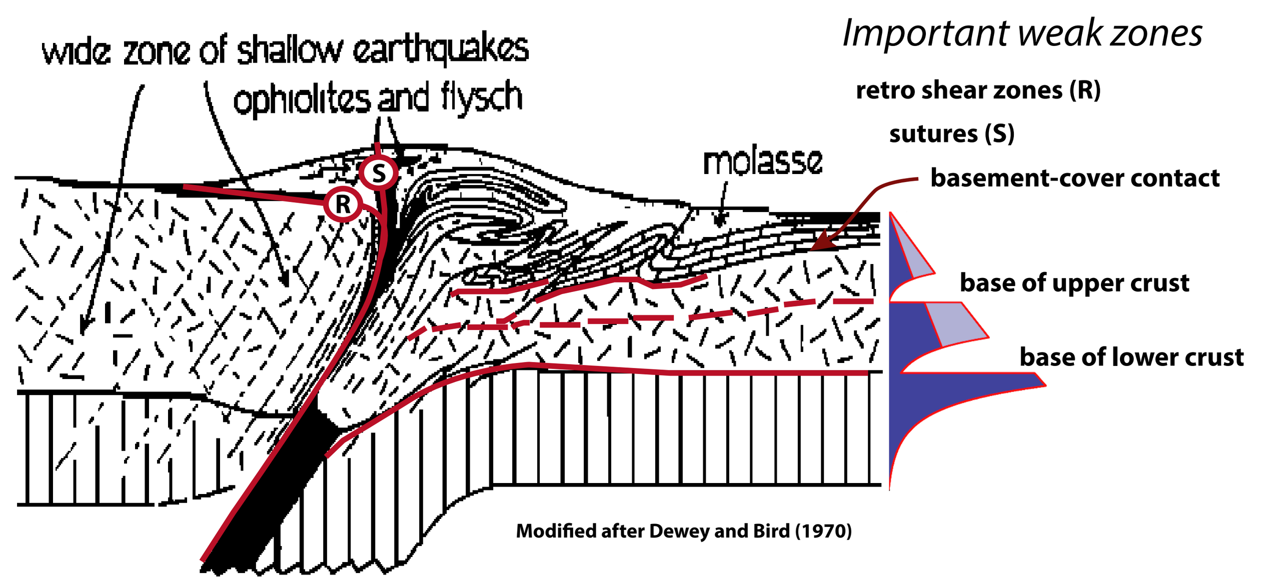
Over the last decades of research into mountain building processes, it became evident that the rheology of the plates involved in processes like continent-continent collision or subduction of continental lithosphere exerts a first order control on the resulting deformation geometries. Analogue and numerical modelling is used to investigate the role of weak, decoupling horizons and lateral strength contrasts in terms of collision dynamics and orogen geometries.

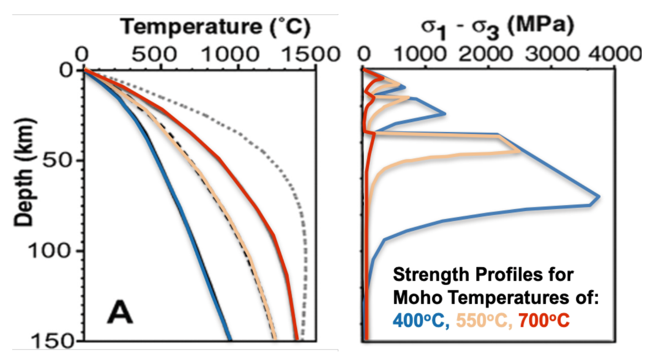
Our results show that differences in rheology of the crust across and along plate boundaries may lead to a variety of deformation patterns and mountain belt geometries and thus can be used as a proxy for inferring the rheological state of continents during collision.

Conceptual Model of Collision Zones

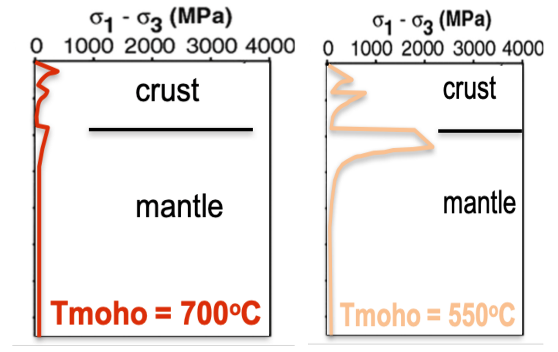


Modified after Dewey and Bird (1970)

Strength of Continental Lithosphere

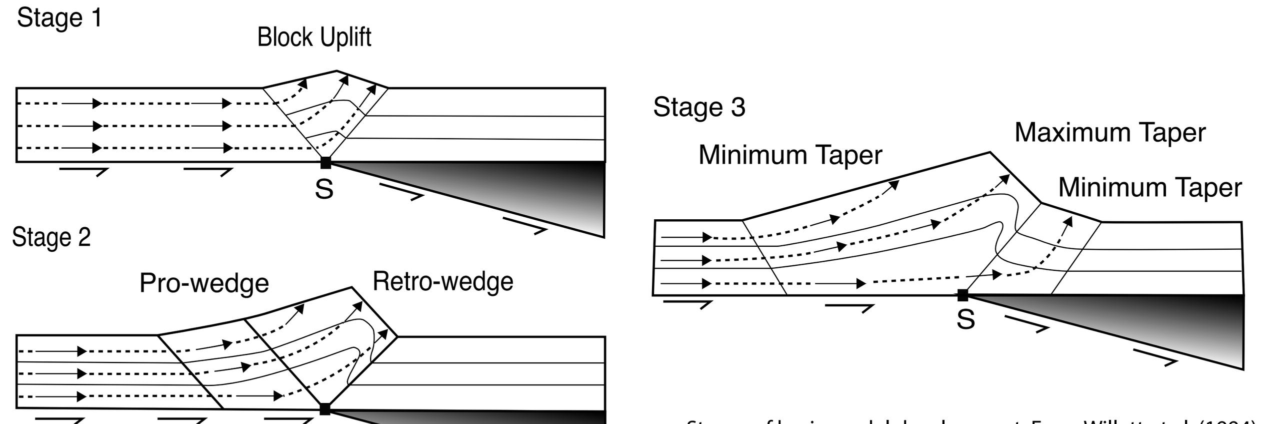


Coupled vs Decoupled Lithosphere



Modified after Toussaint et al. (2004)

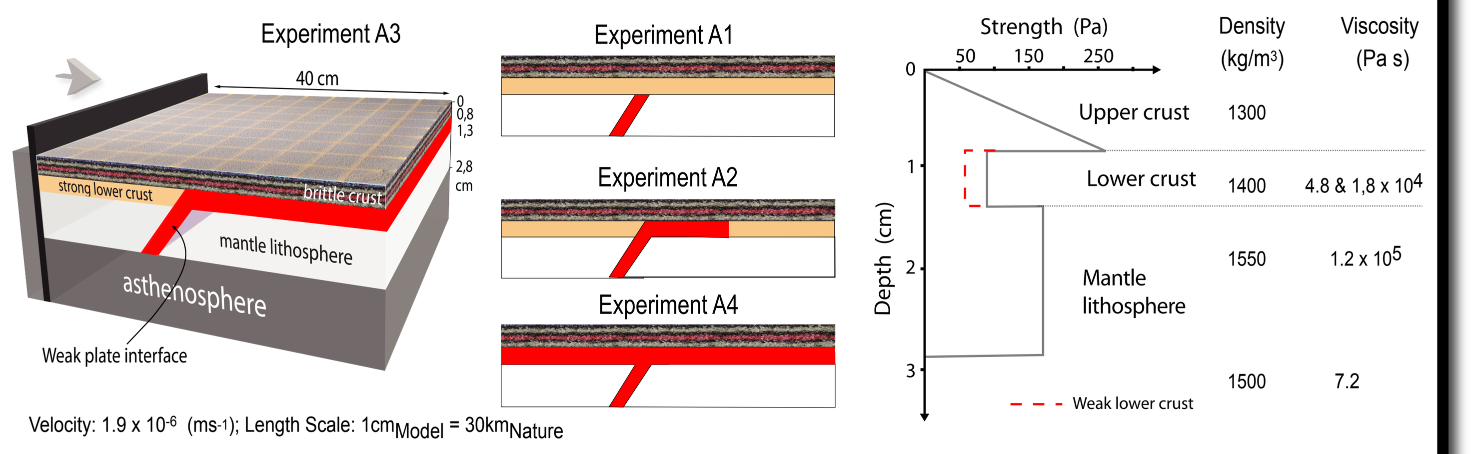
Numerical Model of Collision Zones



Stages of basic model development. From Willett et al. (1994).

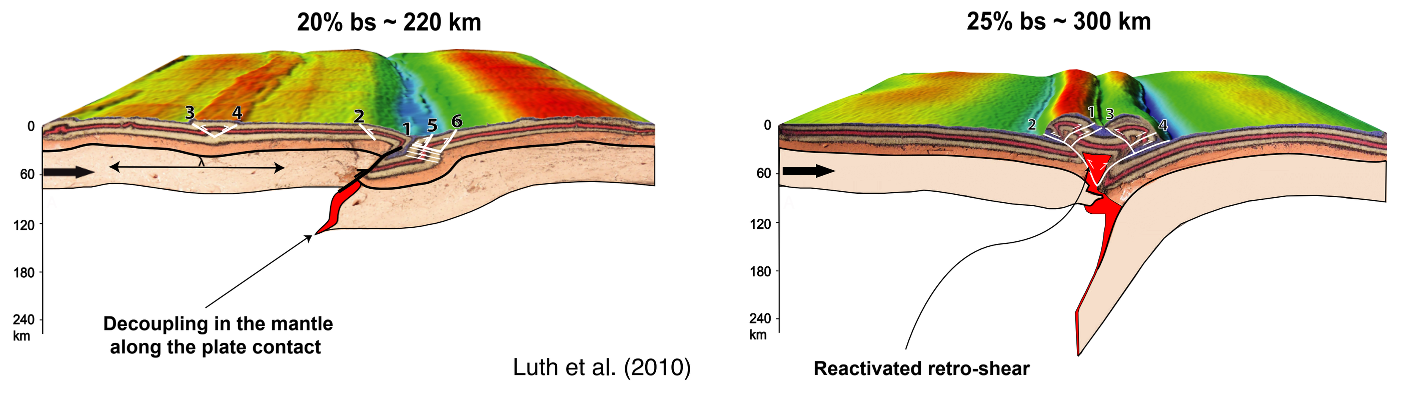
ANALOGUE MODELLING

EXPERIMENTS WITH DECOUPLING ZONES



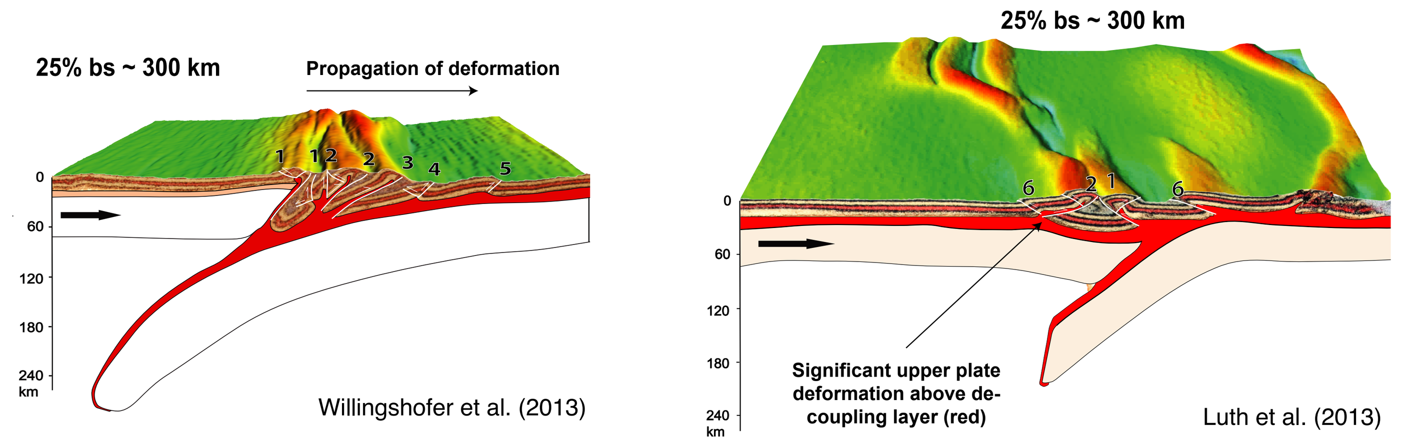
Velocity: 1.9×10^{-6} (ms-1); Length Scale: $1cm_{Model} = 30km_{Nature}$

Decoupling at the plate interface (A1, A2)



Luth et al. (2010)

Crust-mantle coupling on the upper and lower plates (A3, A4)

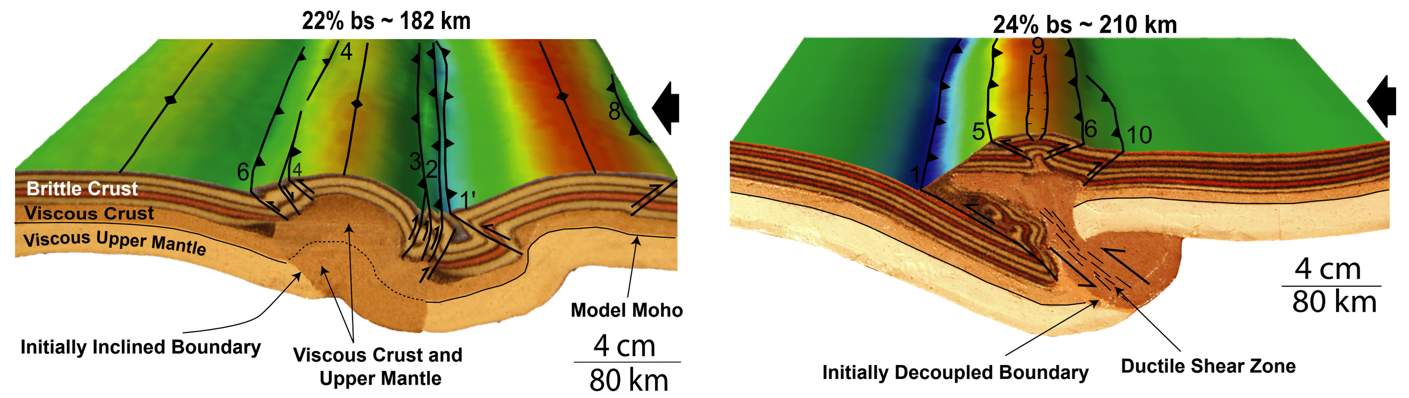


Willingshofer et al. (2013)

Luth et al. (2013)

EXPERIMENTS WITH A WEAK ZONE

Decoupling between the orogenic wedge and the foreland (B1, B2)

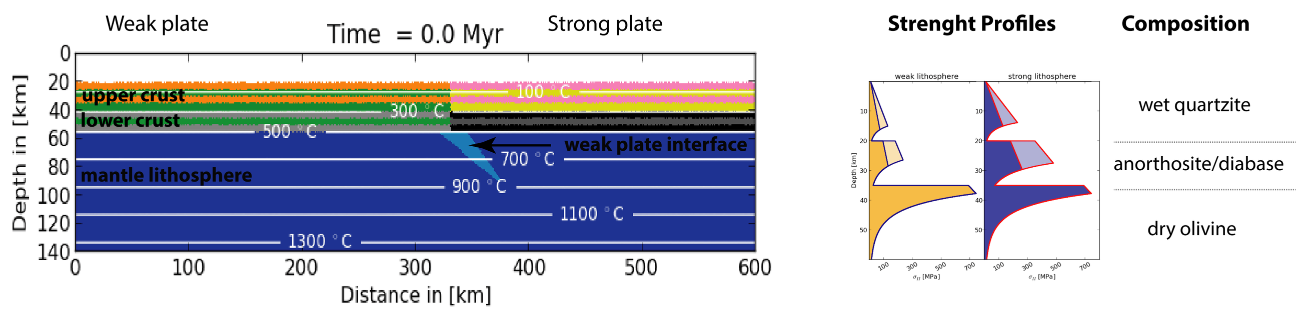


Willingshofer &Sokoutis (2009); Sokoutis & Willingshofer (2011)

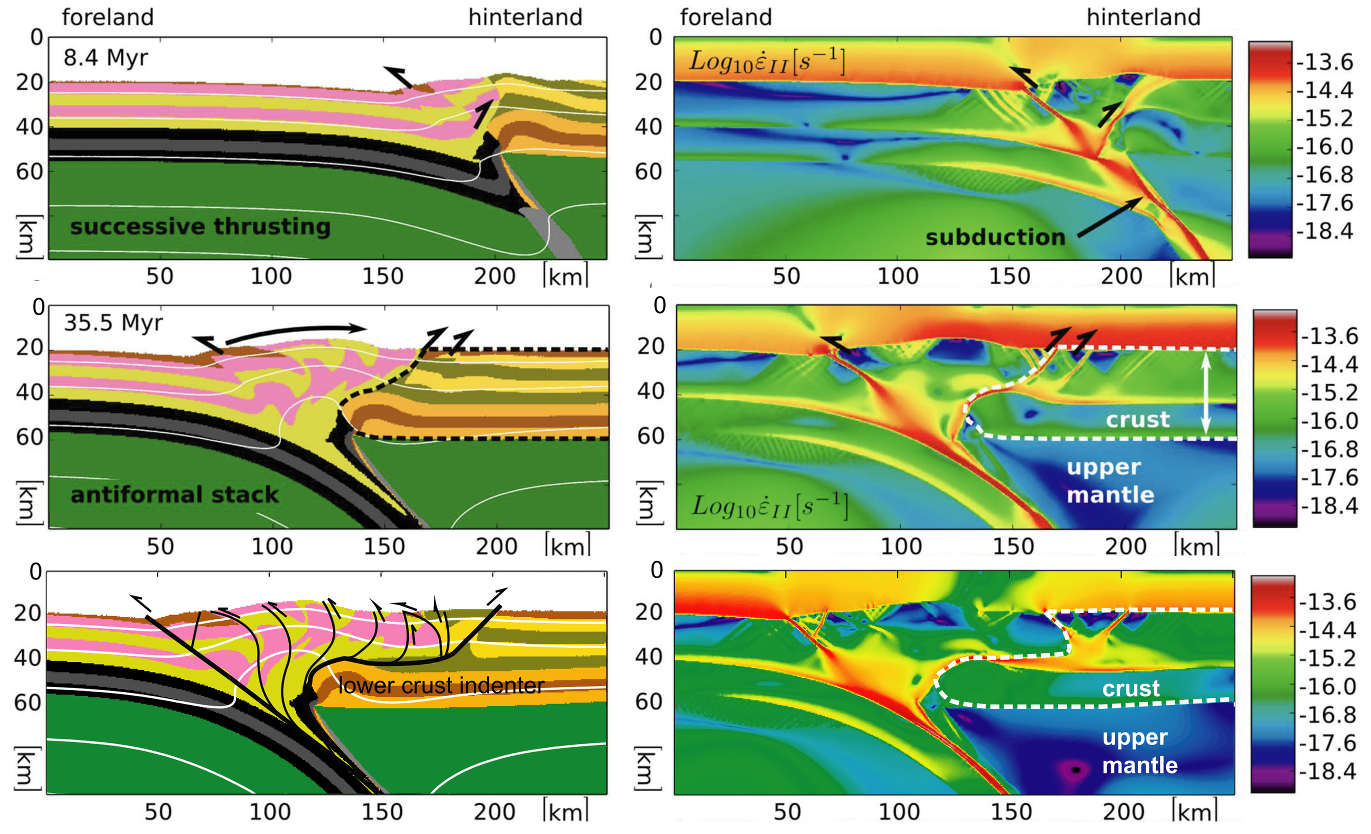
thrust fault — normal fault — antiform/synform — Reference level: Uplift, Subsidence

NUMERICAL MODELLING

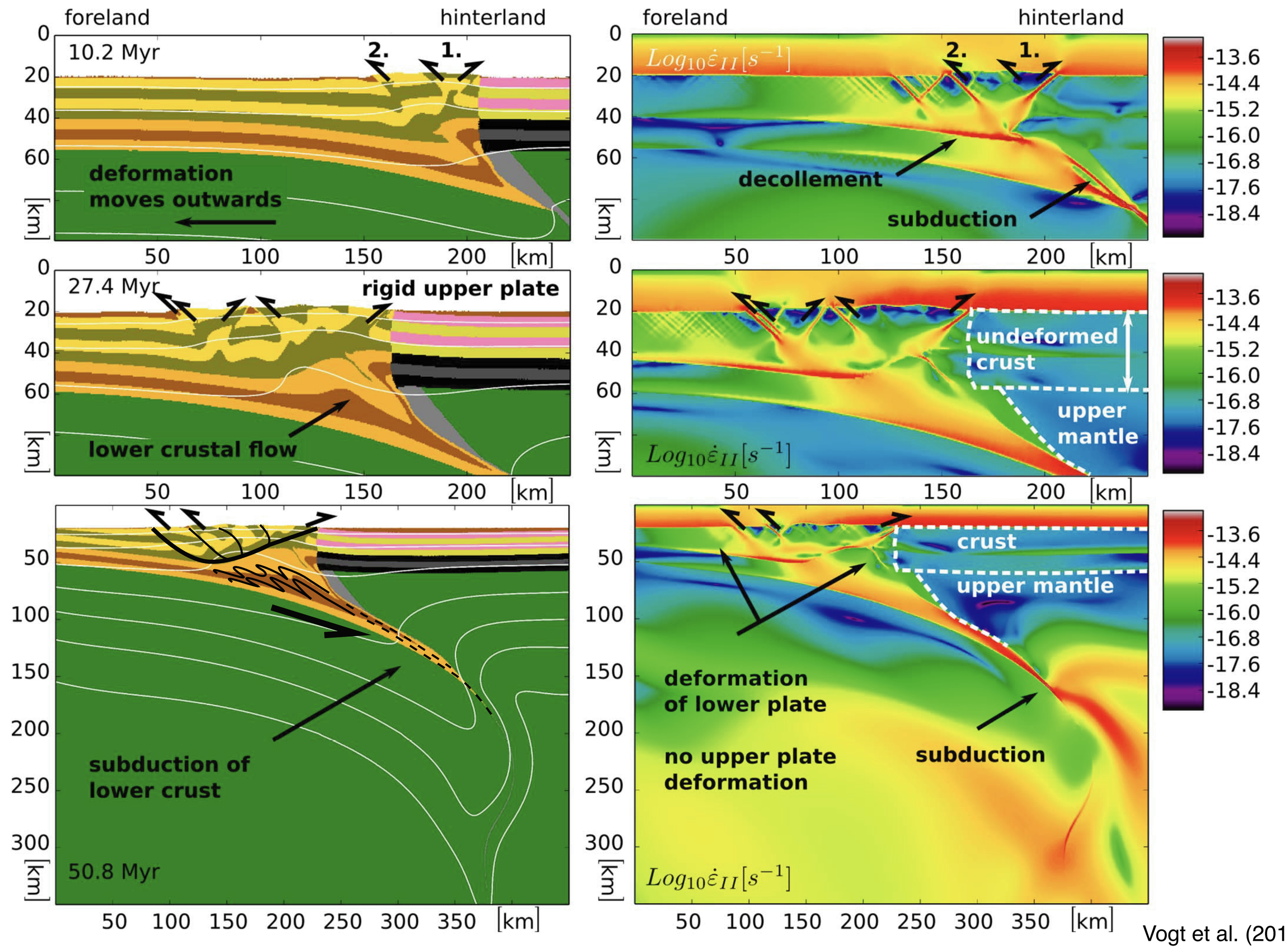
MODELLING SETUP



Strong Lower Plate - Weak Upper Plate (C1)

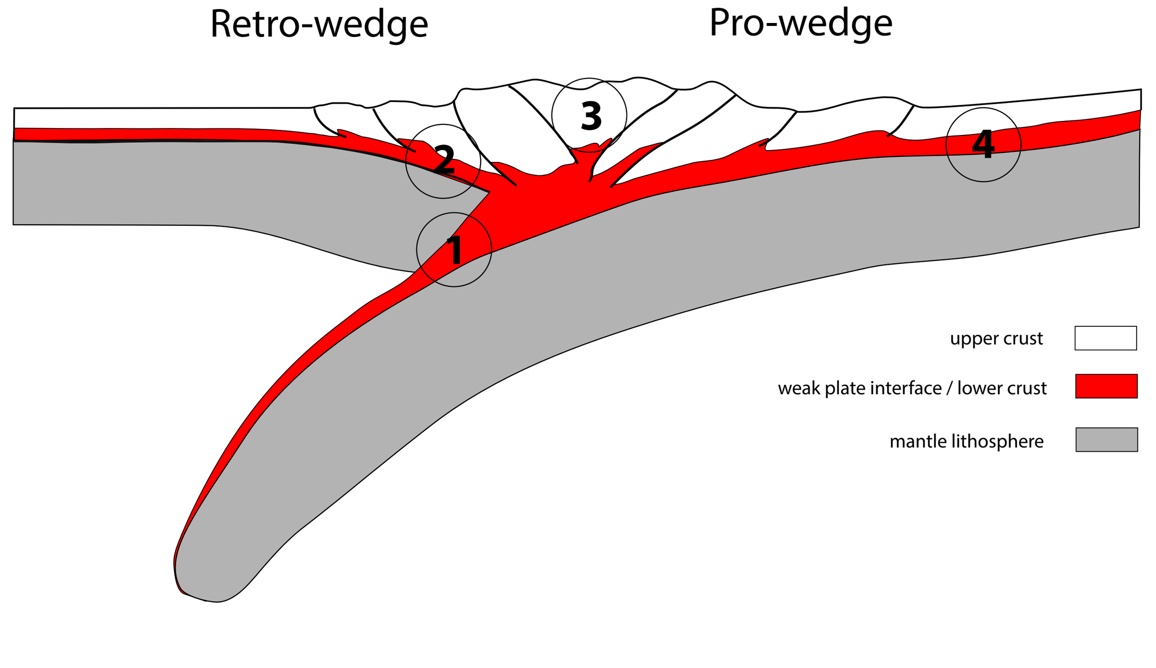


Weak Lower Plate - Strong Upper Plate (C2)



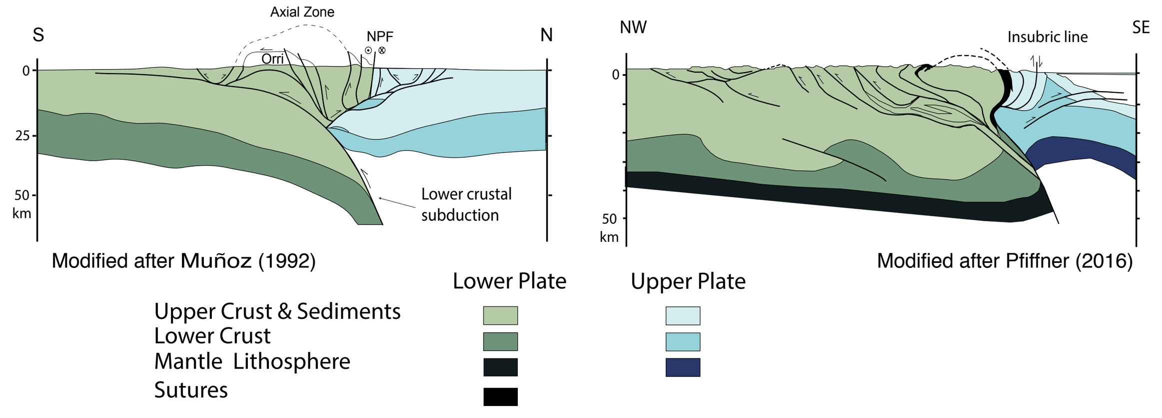
Vogt et al. (2018)

SUMMARY OF MODELLING RESULTS



1. strong decoupling at the plate interface favours continental subduction and dominant pro-wedge deformation *(A1, B1, C2)*
2. weak layers within the crust of the upper plate facilitate upper plate deformation *(A4, C1)*
3. a strong subducting plate produces antiformal stacks and material transfer onto the upper plate is through a retro-shear zone/fault *(B2)*
4. lateral variations in plate rheology can lead to back-stepping instead of foreland-propagation of deformation *(A2)*

NATURAL EXAMPLES



CONCLUSIONS

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