Formation of retro-wedges during collision: insights from analogue and numerical modeling

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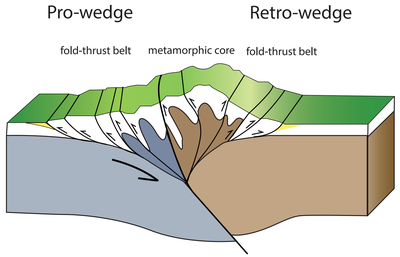
INTRODUCTION

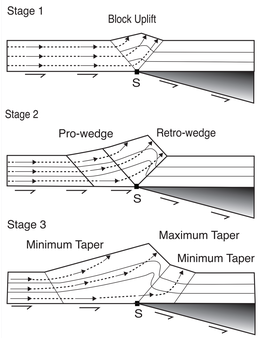
We challenge the generally accepted view that continent-continent collision results in doubly vergent orogenic wedges with well-developed retro-wedges on the overriding plate. In fact we argue that retro-wedge formation is restricted to specific rheological conditions within the lower and upper plates as well as the plate contact; thus being the exception rather than the rule during collision.

We use a combination of physical analogue and numerical experiments to infer favourable rheological conditions for the development of retro-wedges. In both analogue and numerical experiments the contact between the colliding and neutrally buoyant continents is weak and represents the inheritance of a former subduction boundary. The degree of plate coupling however is not constant and is together with the rheological structures of the lower and upper plates, in particular the presence of decoupling horizons, key variable in this study.

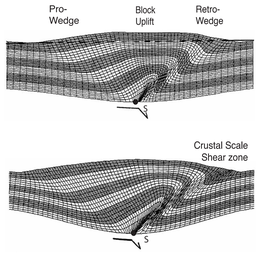
Conceptual Model of Collision Zones



Numerical Model of Collision Zones



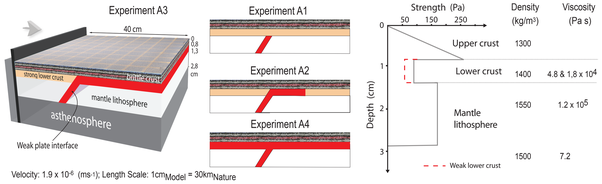
Stages of basic model development. From Willett et al. (1994).



Deformation after 40 (upper figure) and 100km (lower figure) of shortening. From Beaumont & Quinlan (1994).

ANALOGUE MODELING

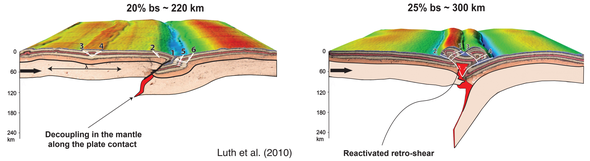
EXPERIMENTS WITH DECOUPLING ZONES



	Density (kg/m³)	Viscosity (Pa s)
Upper crust	1300	
Lower crust	1400	4.8 & 1.8 x 10^4
Mantle lithosphere	1550	1.2 x 10^5
Weak lower crust	1500	7.2

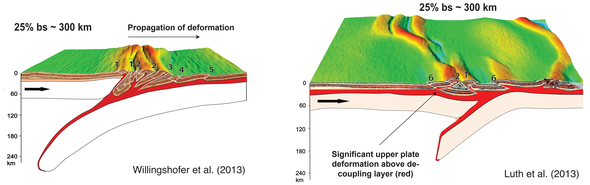
Velocity: 1.9 x 10^{-6} (ms^{-1}); Length Scale: 1cm$_{Model}$ = 30km$_{Nature}$

Decoupling at the plate interface (A1, A2)



Luth et al. (2010)

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

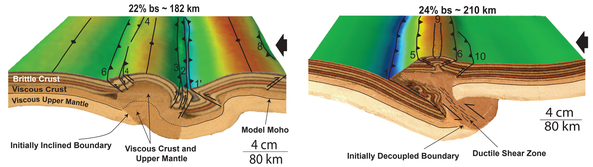


Willingshofer et al. (2013)

Luth et al. (2013)

EXPERIMENTS WITH A WEAK ZONE

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



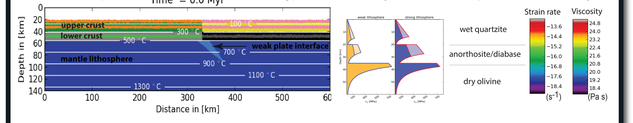
Willingshofer &Sokoutis (2009); Sokoutis & Willingshofer (2011)

thrust fault | normal fault | antiform/synform

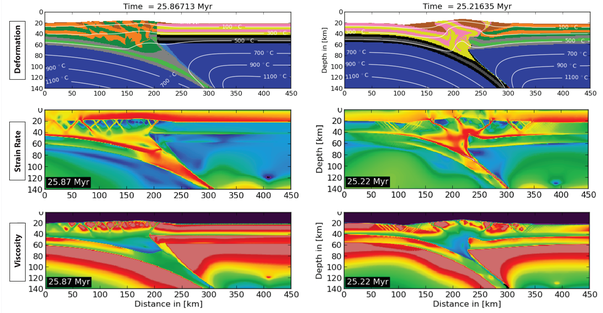
Reference level
Uplift | Subsidence

NUMERICAL MODELING

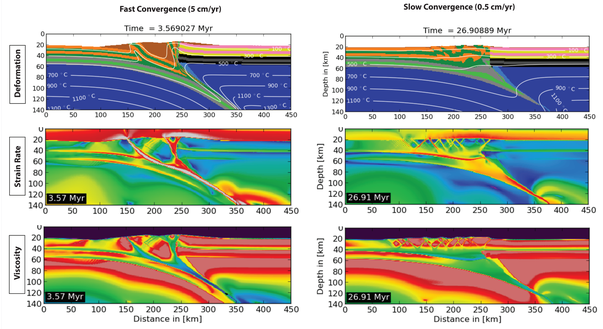
MODELING SETUP



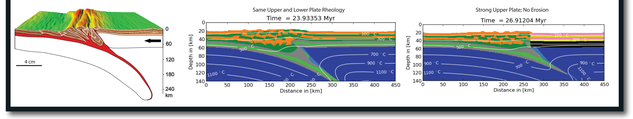
INFLUENCE OF PLATE RHEOLOGY (C1, C2)



INTERPLAY CONVERGENCE VELOCITY - PLATE COUPLING (C3, C4)

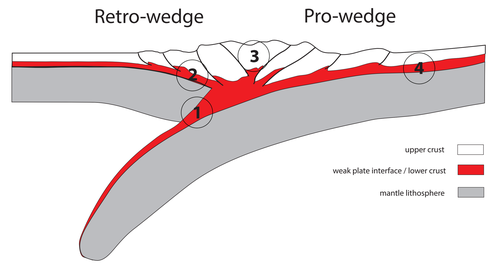


COMPATIBILITY ANALOGUE - NUMERICAL MODELING



CONCLUSIONS

FAVOURABLE CONDITIONS FOR THE FORMATION OF RETRO-WEDGES



1. **strong coupling at the plate interface** *(experiments A1, B1)*
2. **weak layers within the crust of the upper plate** *(experiment A4, C2)*
3. **weak orogenic wedge** *(experiments B1, B2)*
4. **lateral increase of lower crust rheology** *(experiment A2)*

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