Brittle viscous coupling in extensional regime

an analogue modelling approach

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Mauduit and Brun, 2006 in prep.

NAC 8, 24 May 2006

Objectives:

assessing coupling between
Brittle and ductile strength

in extensional regimes

at basin scale,
crustal scale and
lithospheric scale

Is there any common rules?

Brittle strength

$$S_b = 2/3\ \rho\ g\ T_b$$

density

Thickness

Ductile strength

Coupling, Brittle strength and Ductile strength

$$S_d = \dot{\varepsilon}\ \mu\ /\ T_d$$

Strain rate

viscosity

Thickness

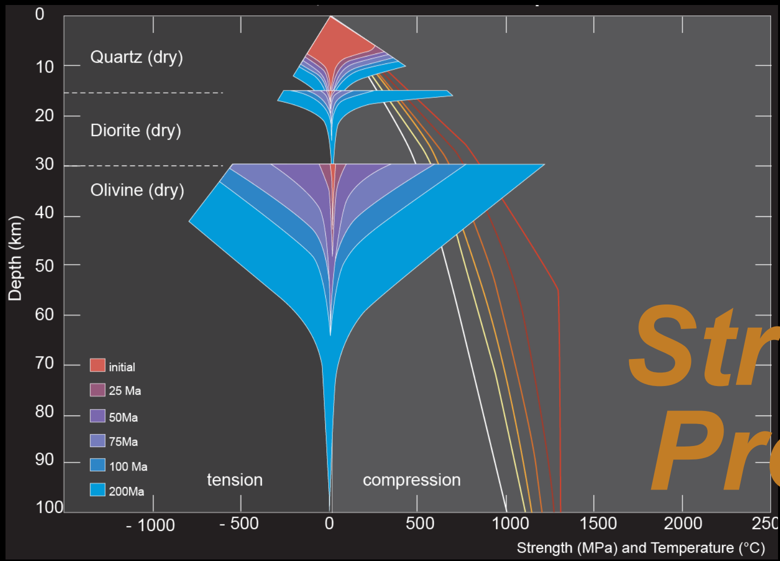
with Strain rate

$$\dot{\varepsilon} = A\ (\sigma_1 - \sigma_3)^n * e^{(-Q/R\ T)}$$

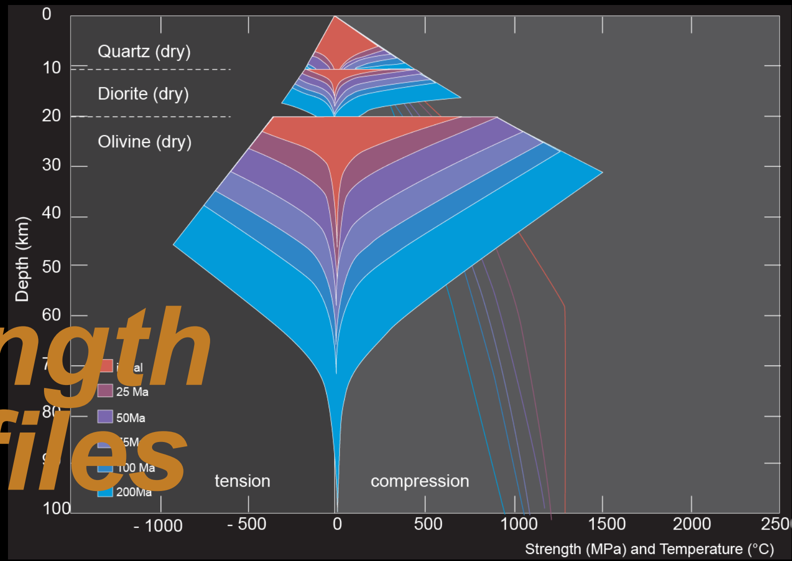
T° (K)

Strength Profiles in Nature

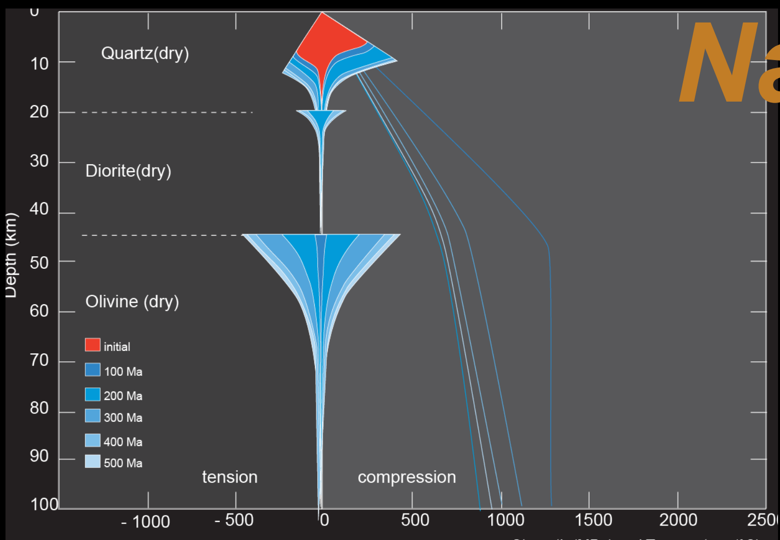
Normal lithosphere



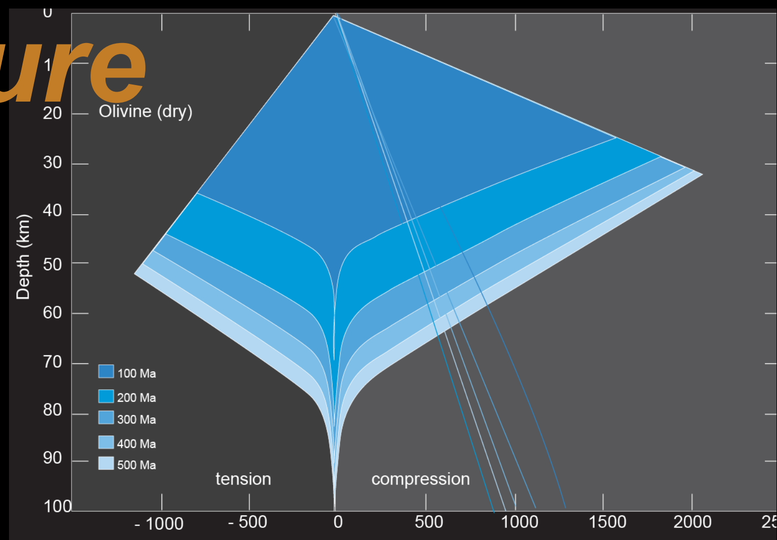
Extended lithosphere



Thickenned lithosphere



Oceanic lithosphere



Modified from Ziegler and Cloetingh, 2004

Strength Profiles in Analogue Modelling

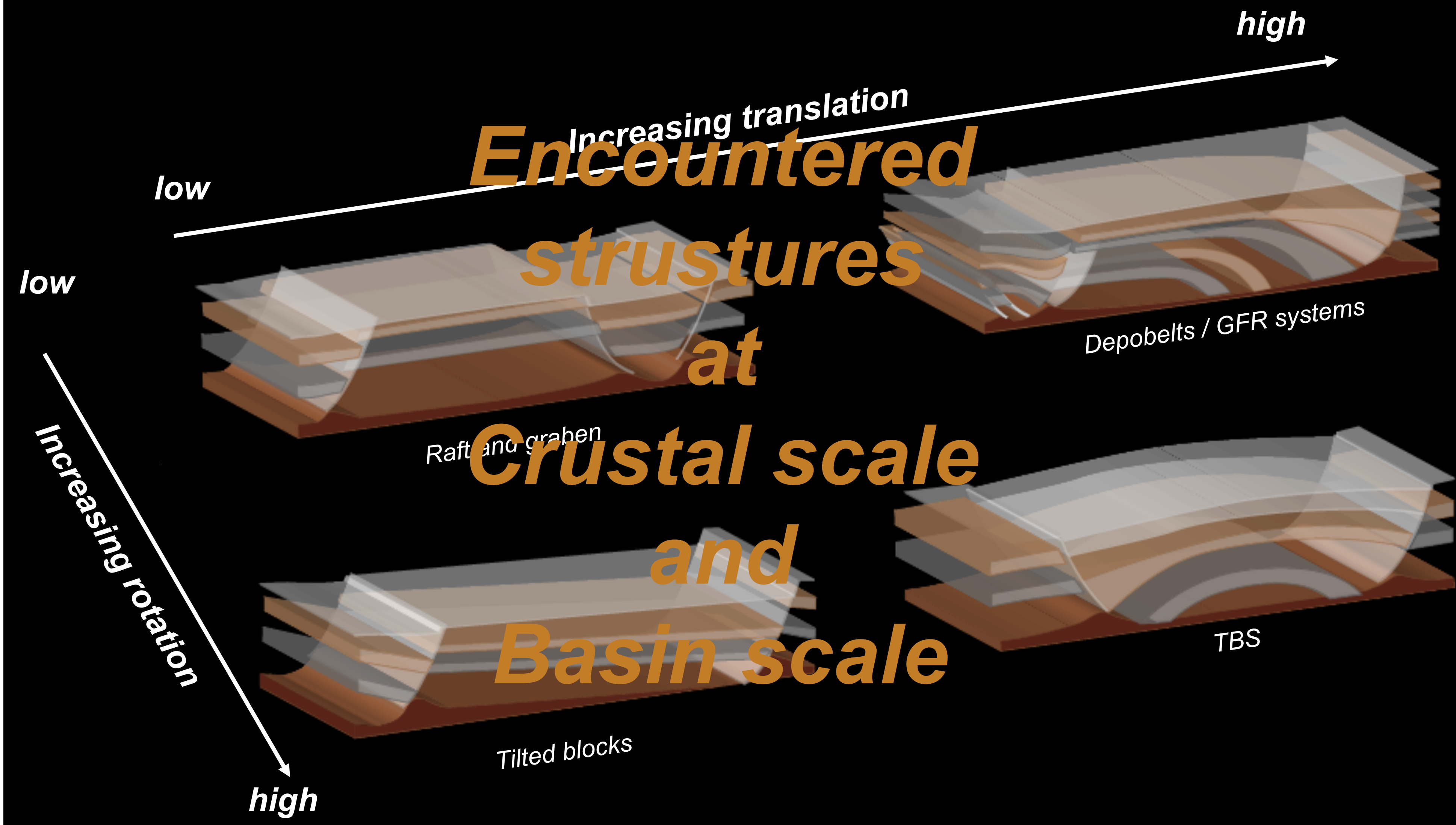
Young stable Lithosphere

Thickened Lithosphere

Old stable Lithosphere

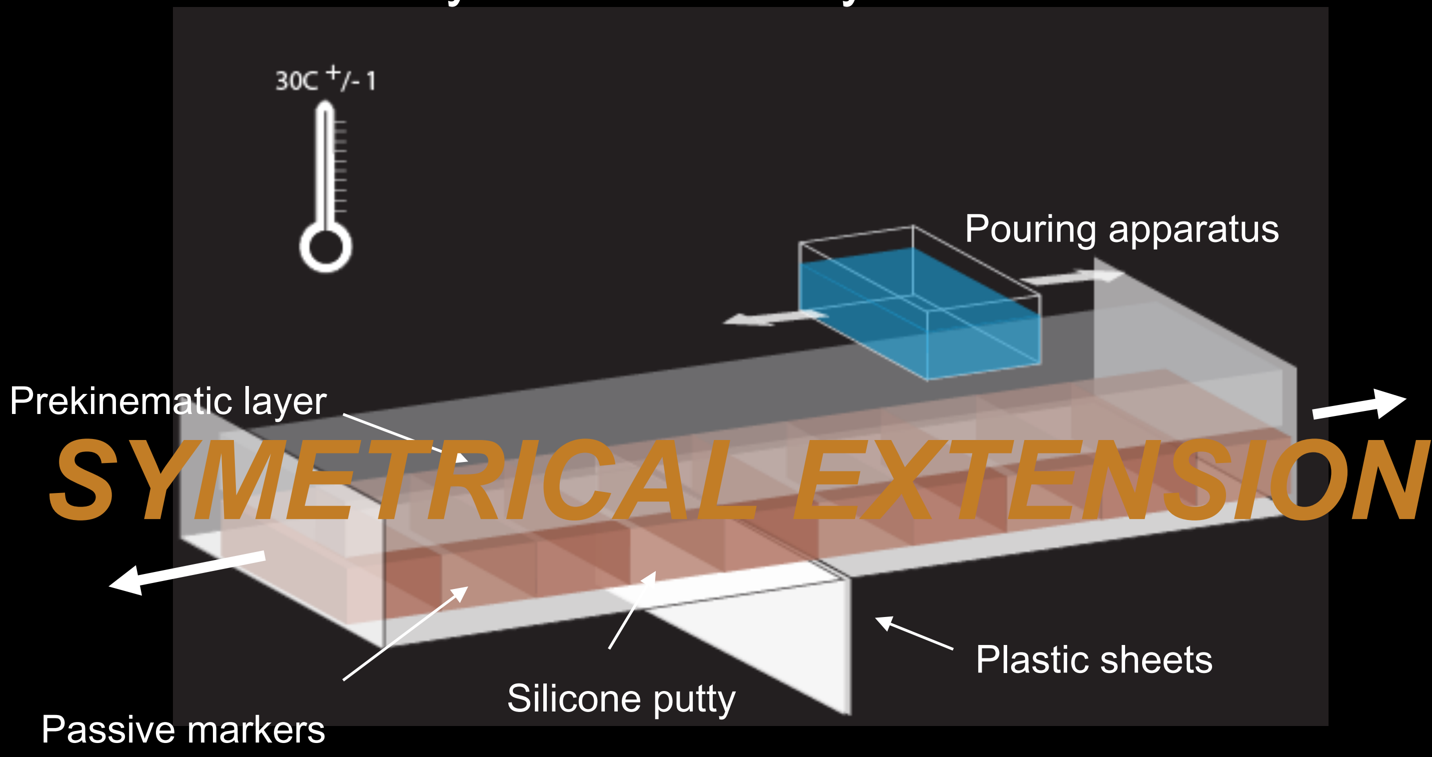
Basin

Encountered strustures at Crustal scale and Basin scale

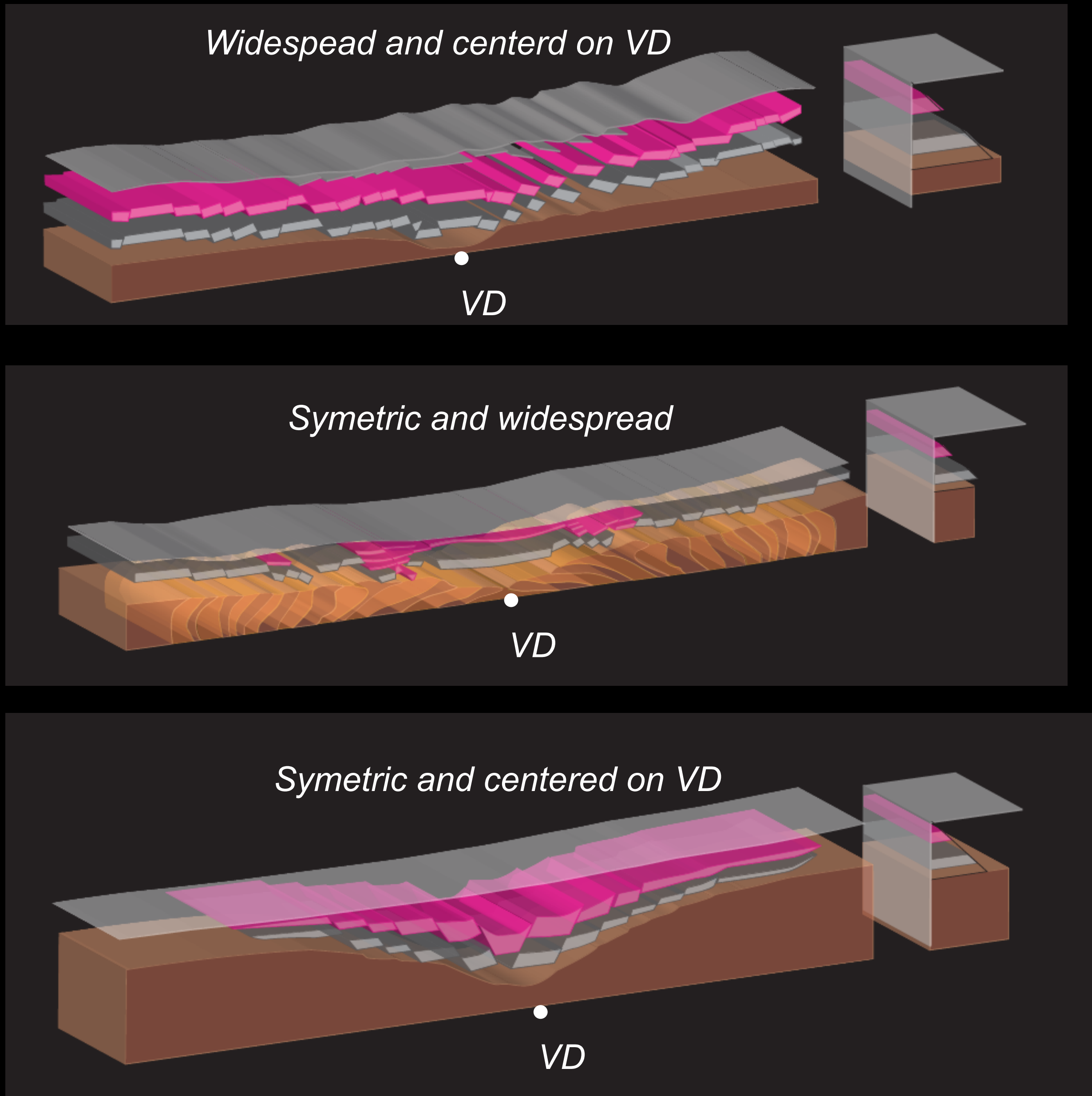


Experimental apparatus

Symetrical boundary conditions



Increase in brittle strength for a high coupling



High S_b

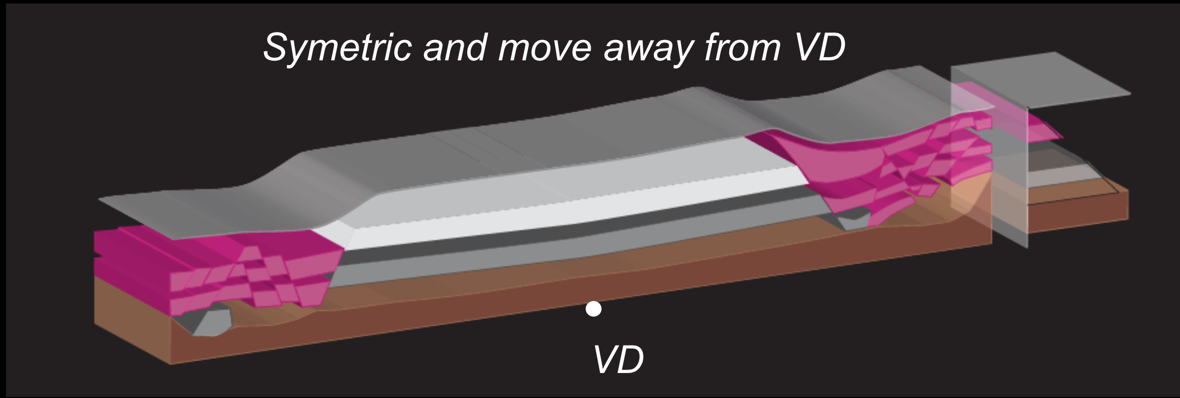
Interm S_b

Low S_b

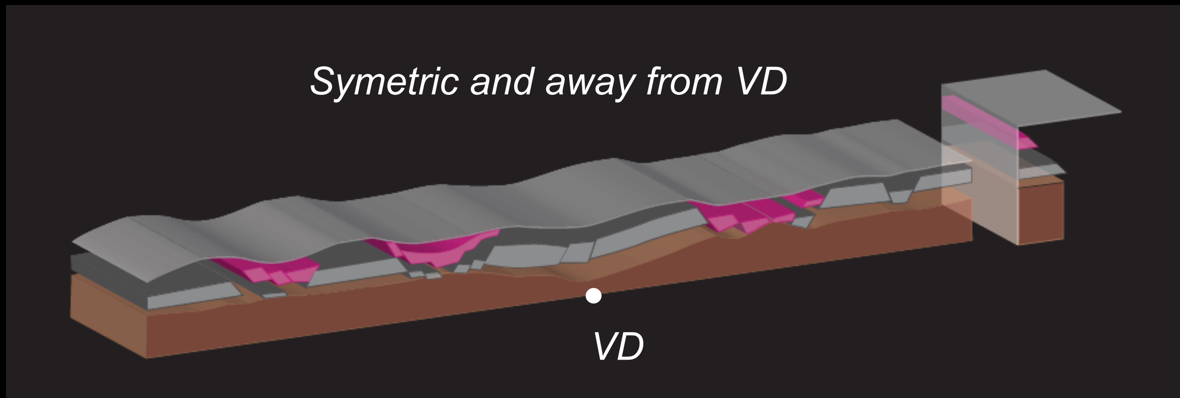
Modified from Allemand, 1990

Increase in brittle strentgh for a low coupling

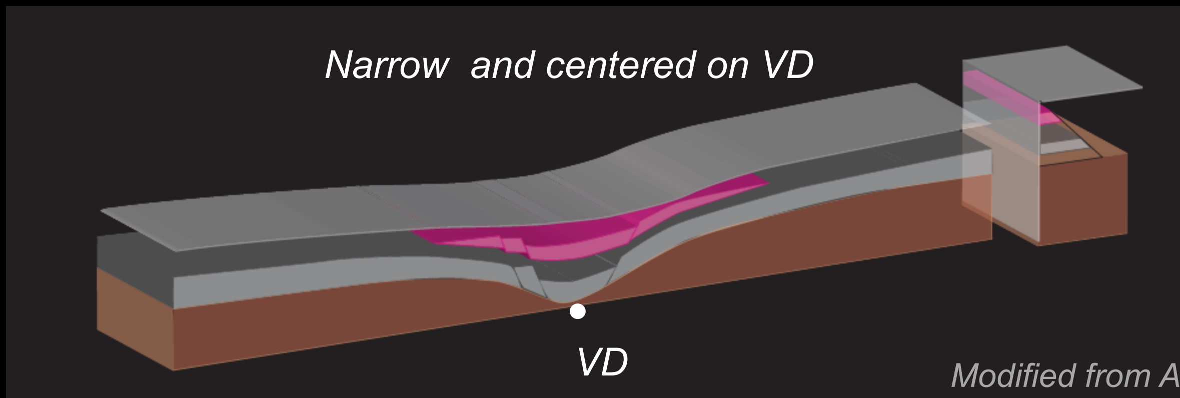
High S_b



Interm S_b



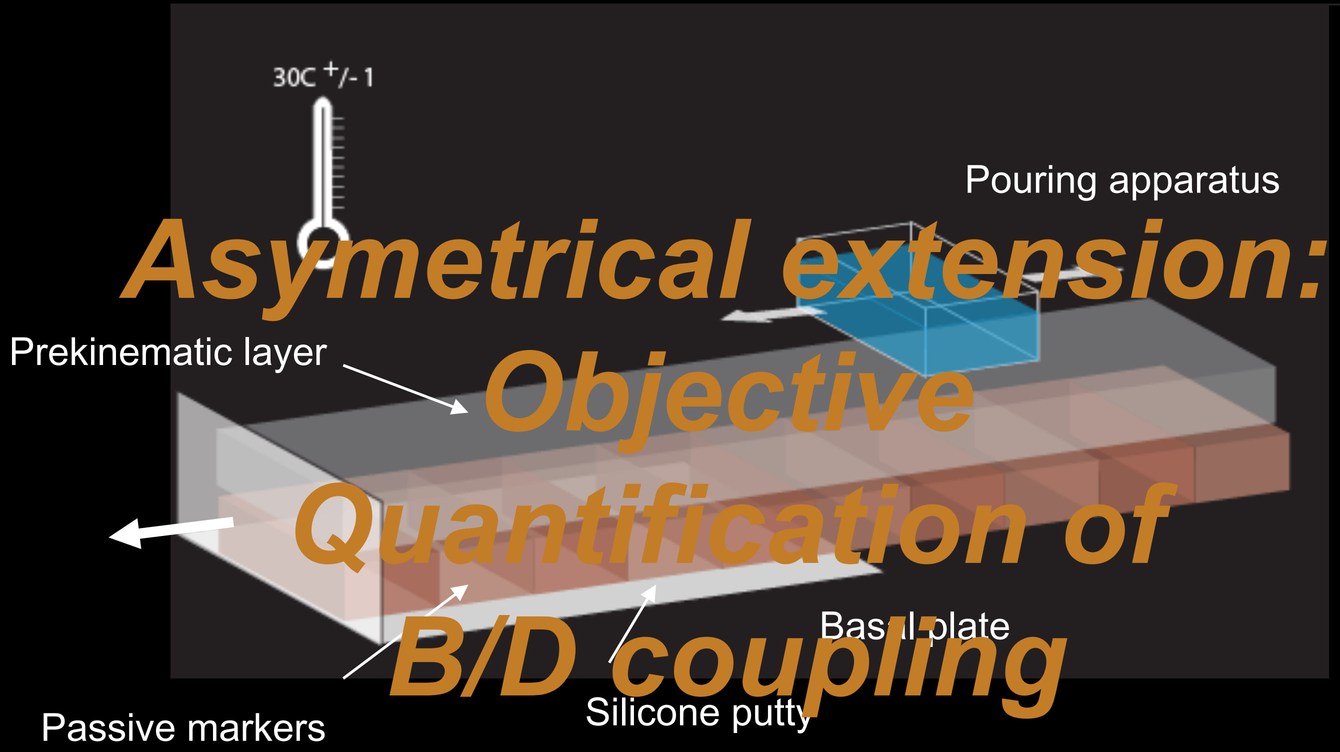
Low S_b



Modified from Allemand, 1990

Experimental apparatus

Asymetrical boundary conditions



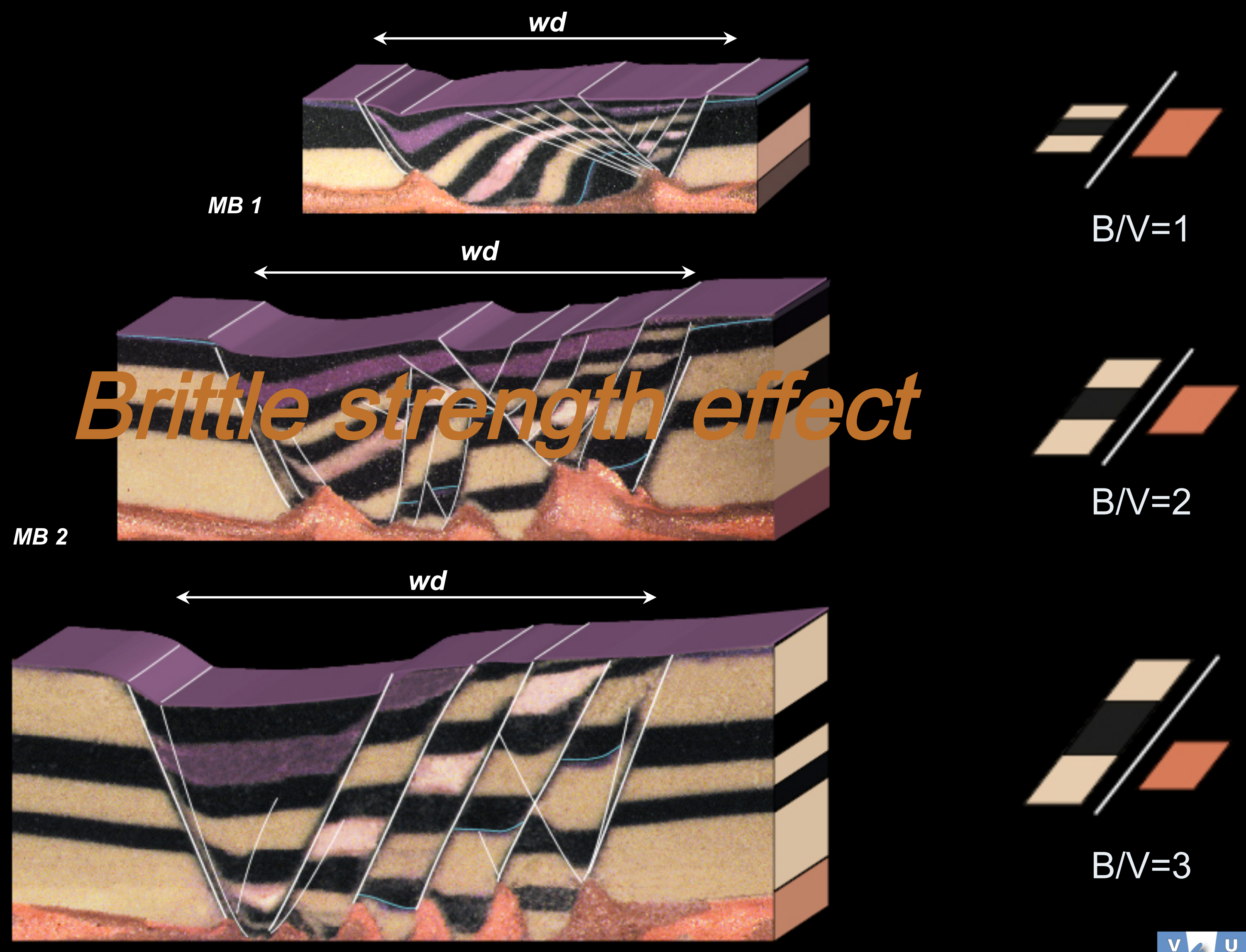
Asymetrical extension: Objective Quantification of B/D coupling

Boundary conditions

Sb / Sd	Low 		 High
High	*MB 7*	*MB 8*	*MB 9*
	MB 4	*MB 5*	*MB 6*
Low	*MB 1*	*MB 2*	*MB 3*

Brittle strength effect

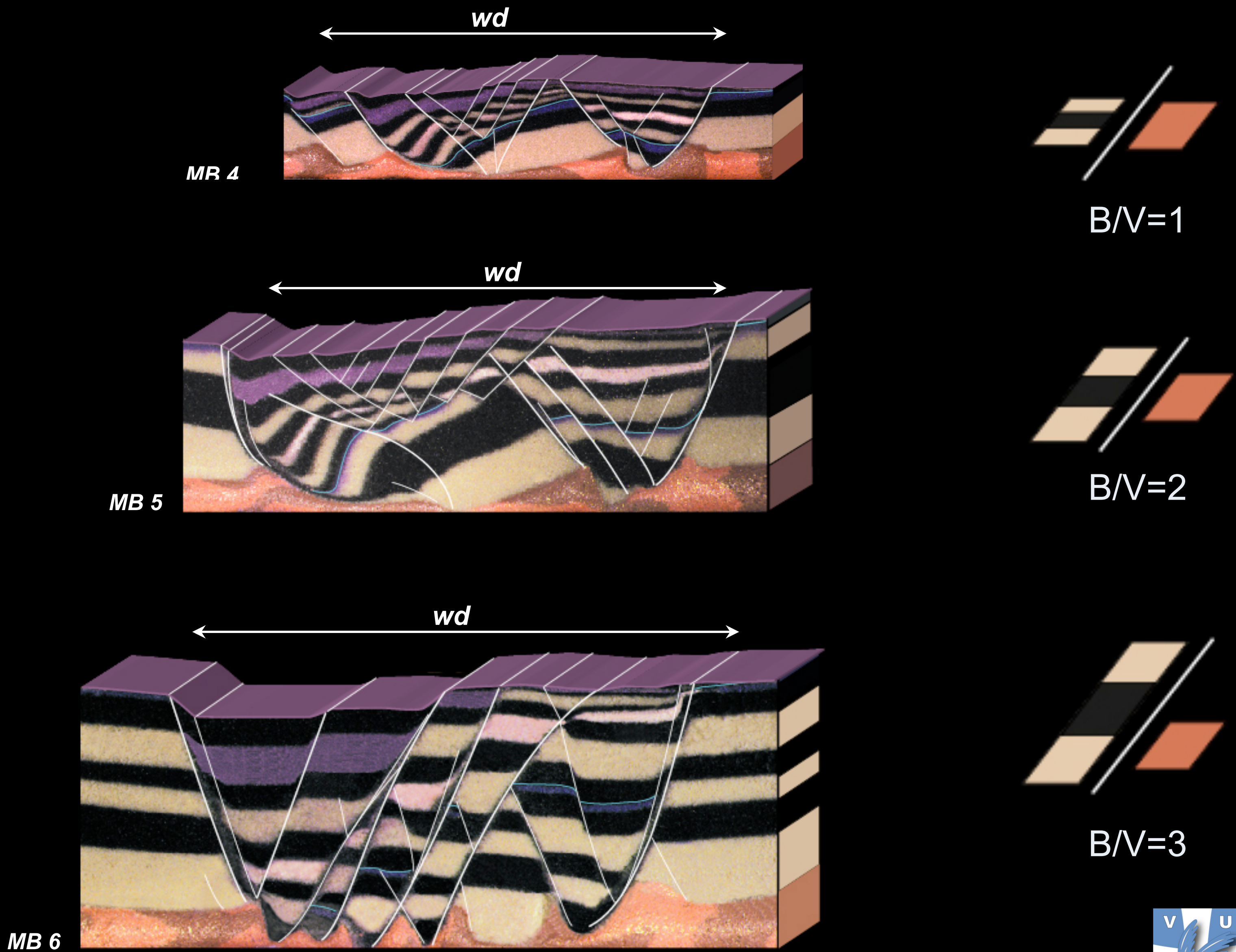
Low Velocity



Brittle strength effect

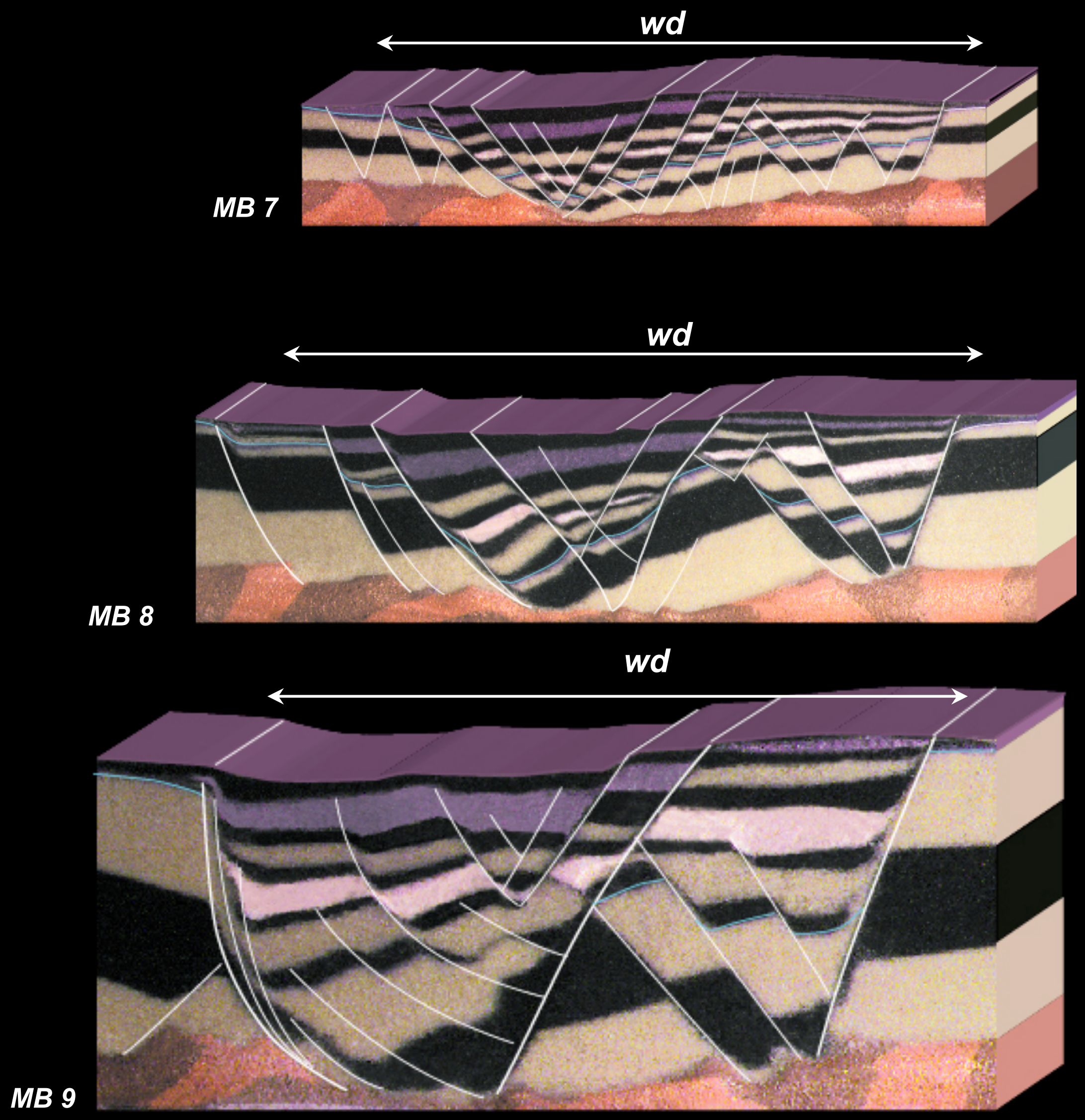
Brittle strength effect

Medium Velocity

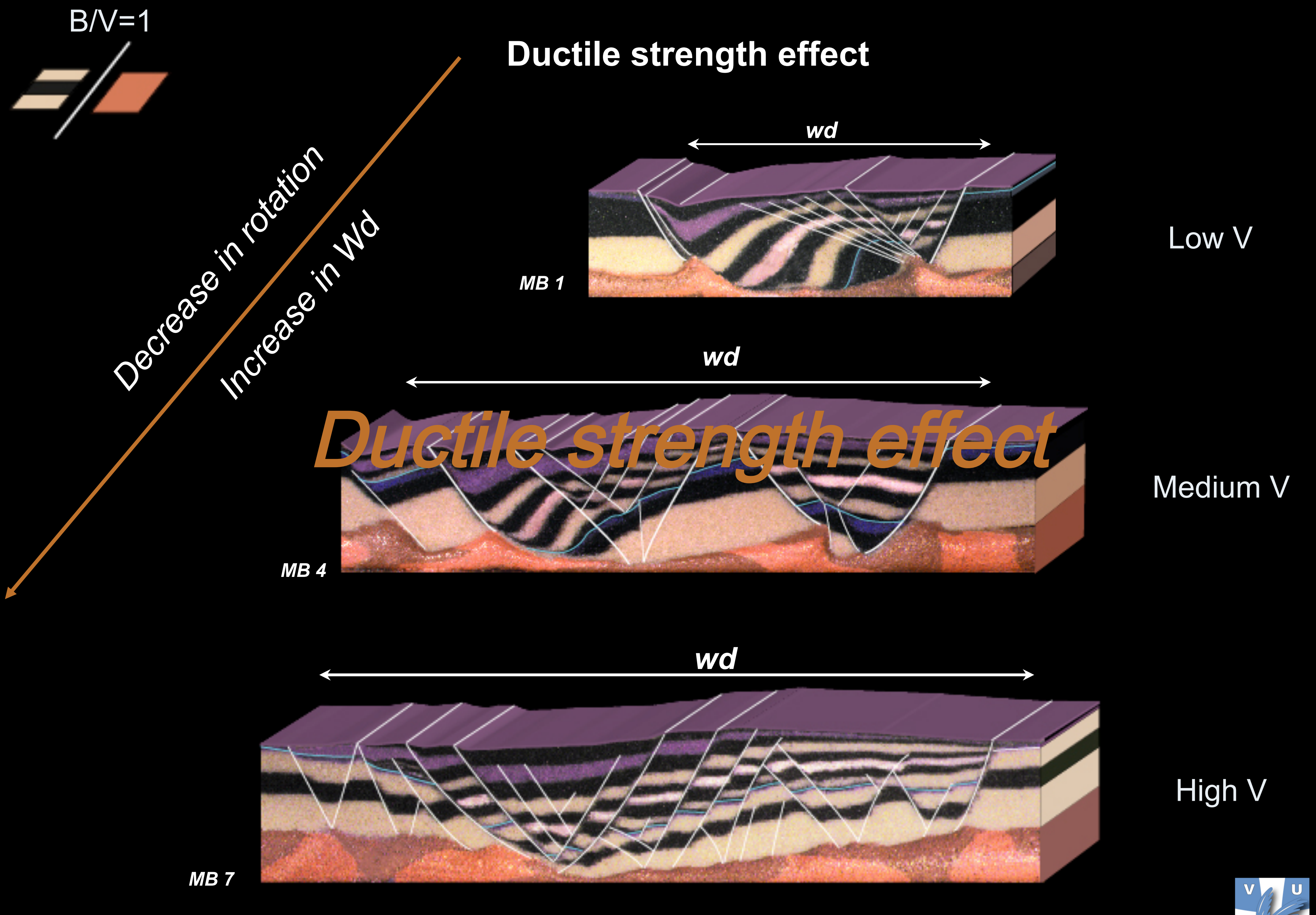


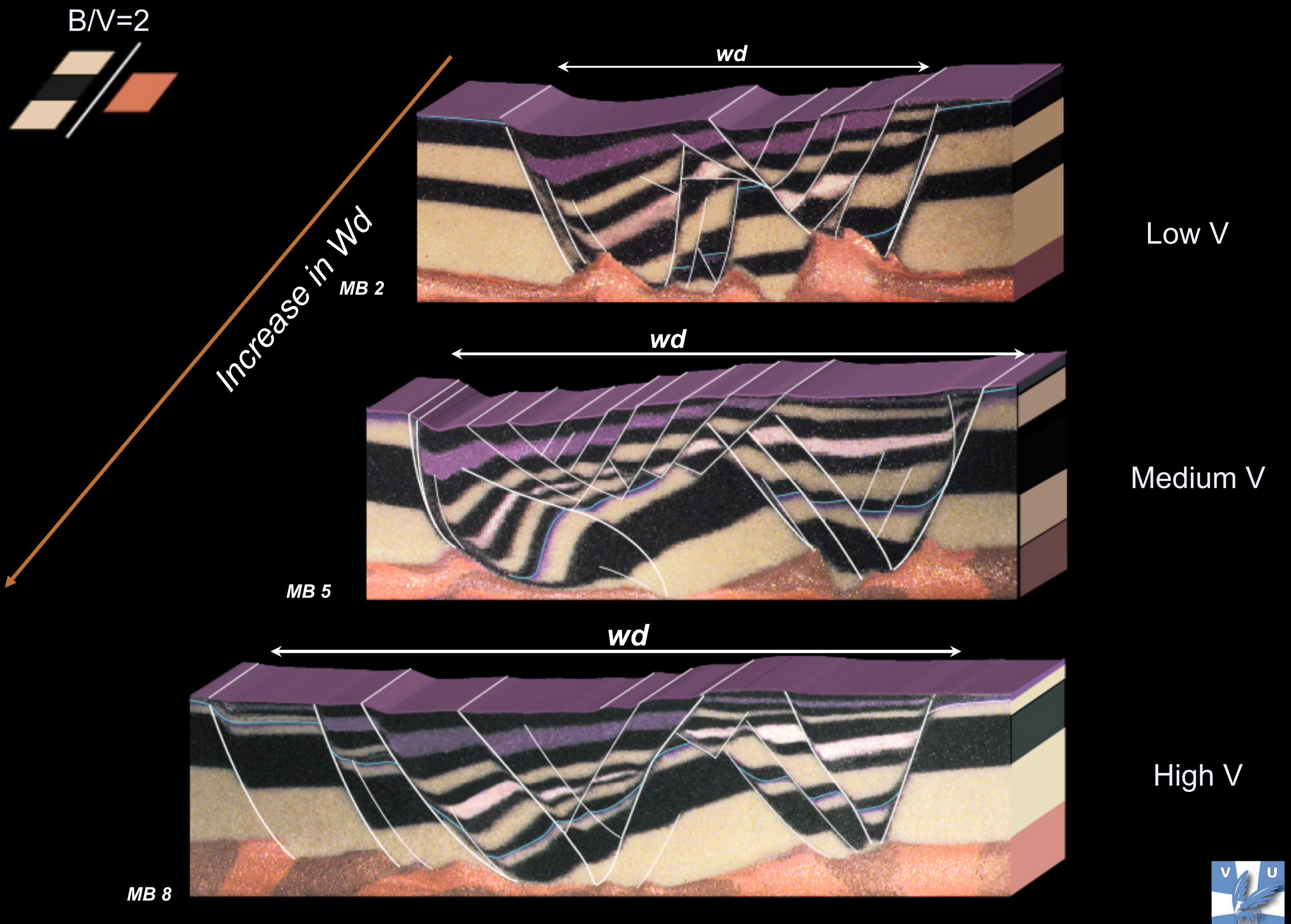
Brittle strength effect

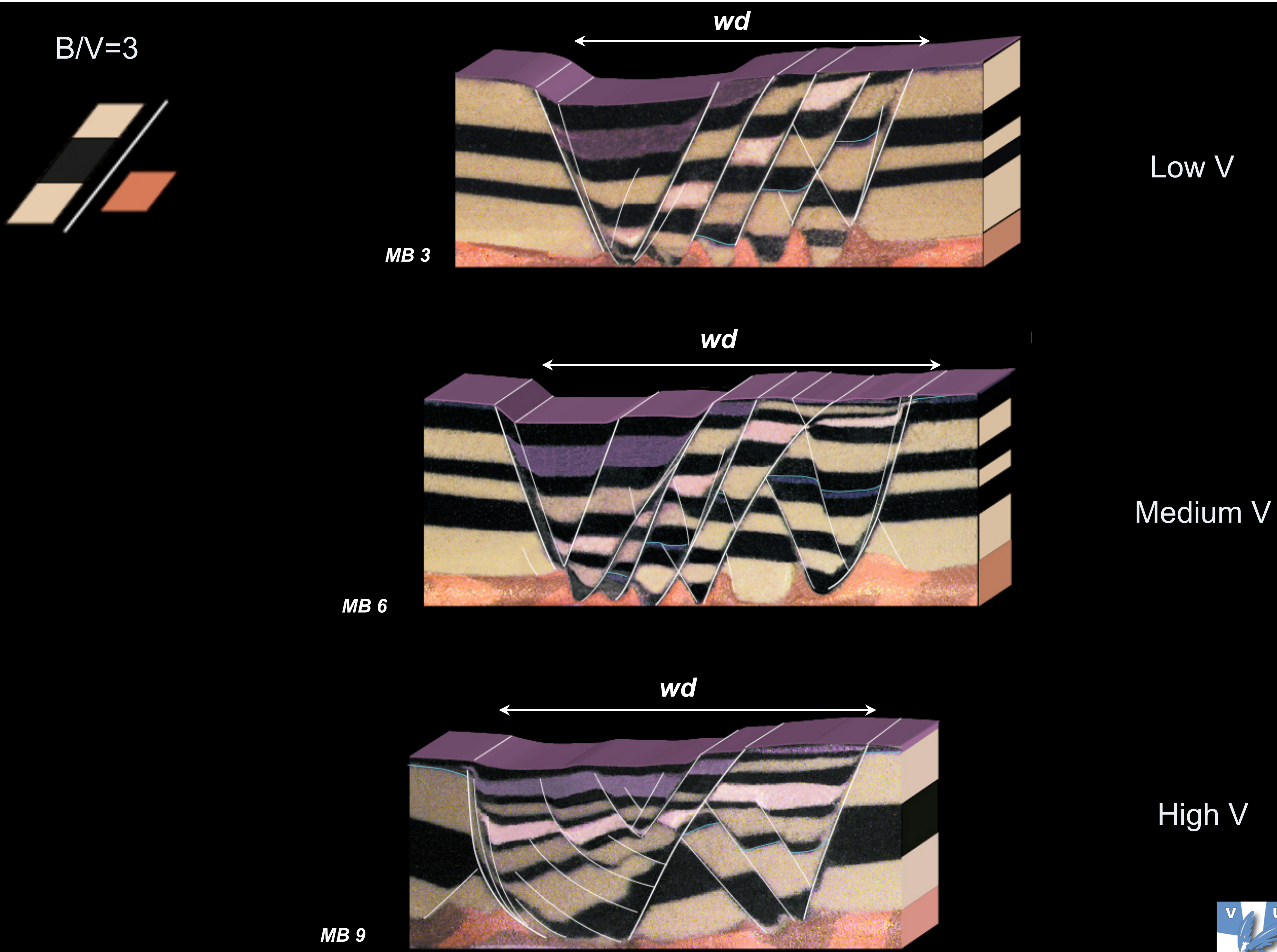
High Velocity



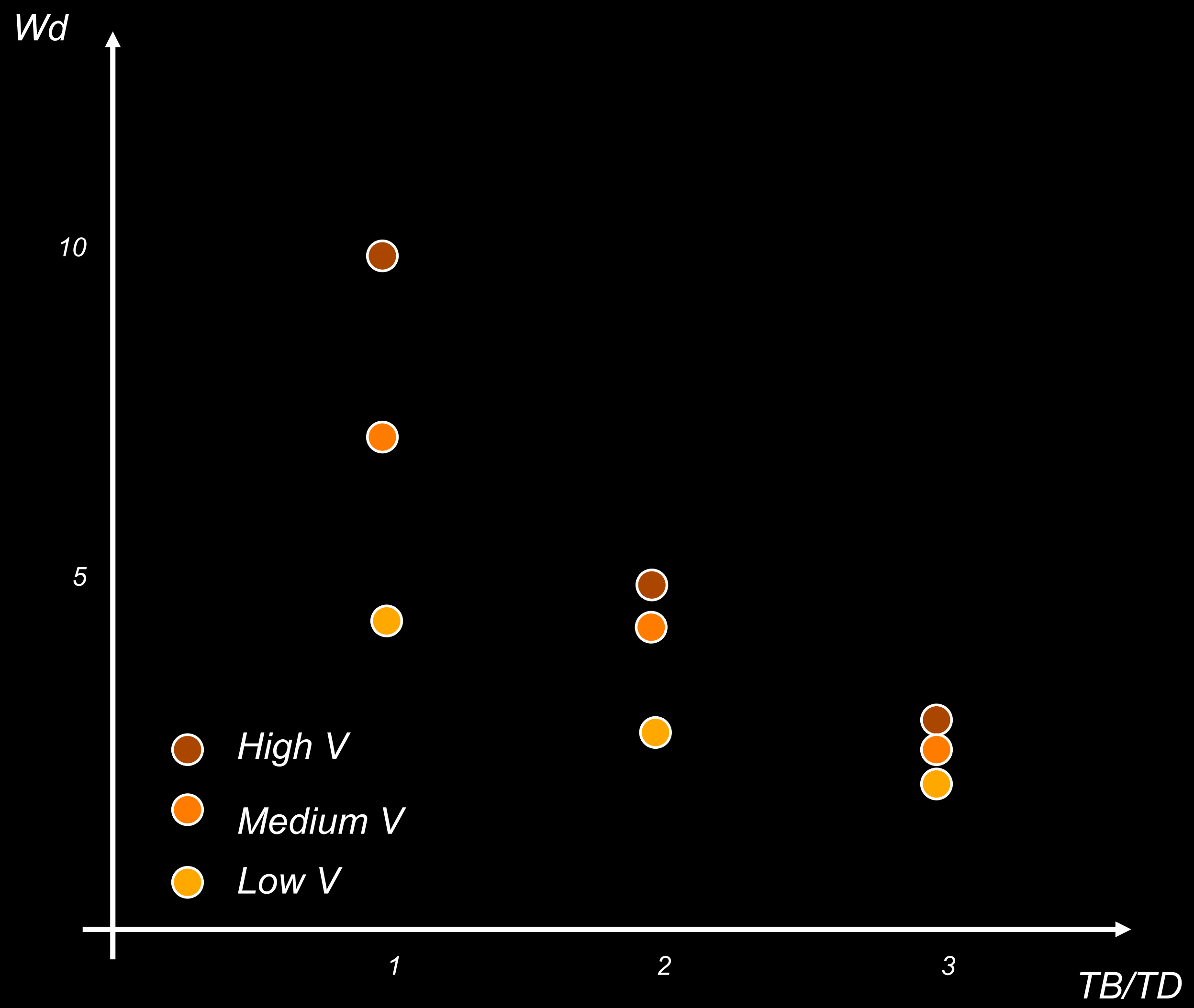
Ductile strength effect



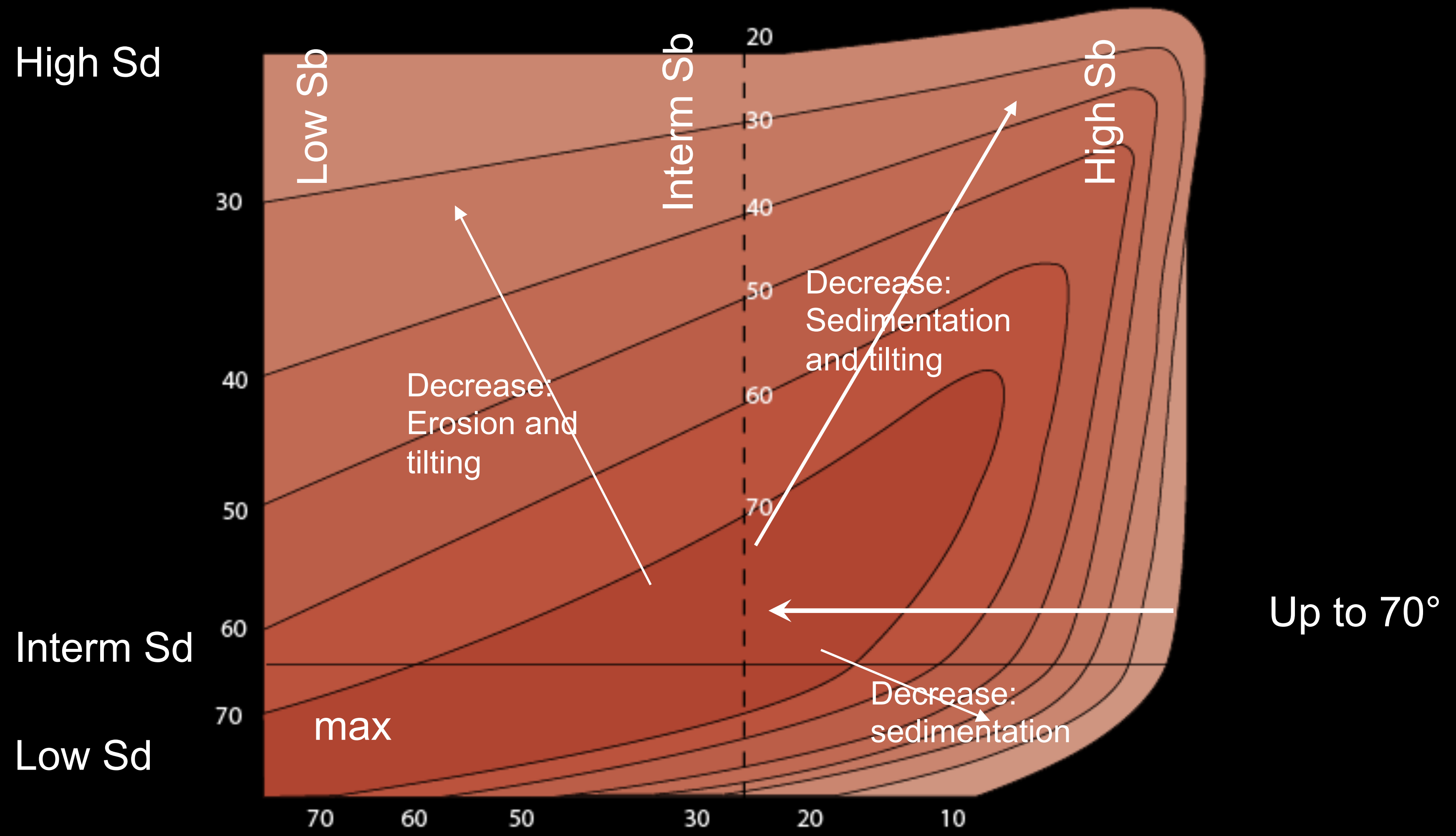

B/V=2
wd
Increase in Wd
MB 2
Low V
wd
MB 5
Medium V
wd
MB 8
High V


B/V=3
wd
Low V
MB 3
wd
Medium V
MB 6
wd
High V
MB 9

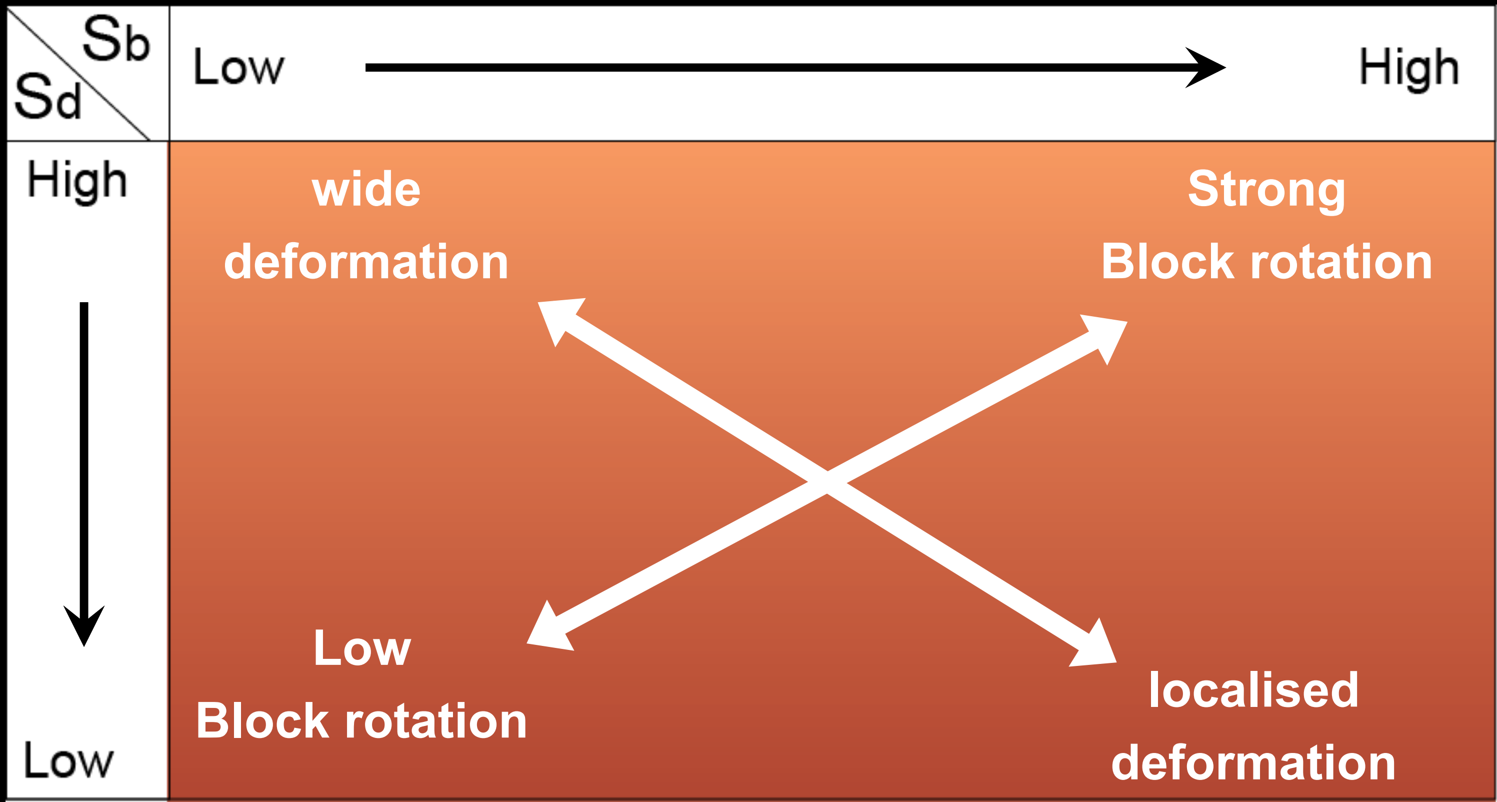
Width of the deformed zone as a function of TB/Td



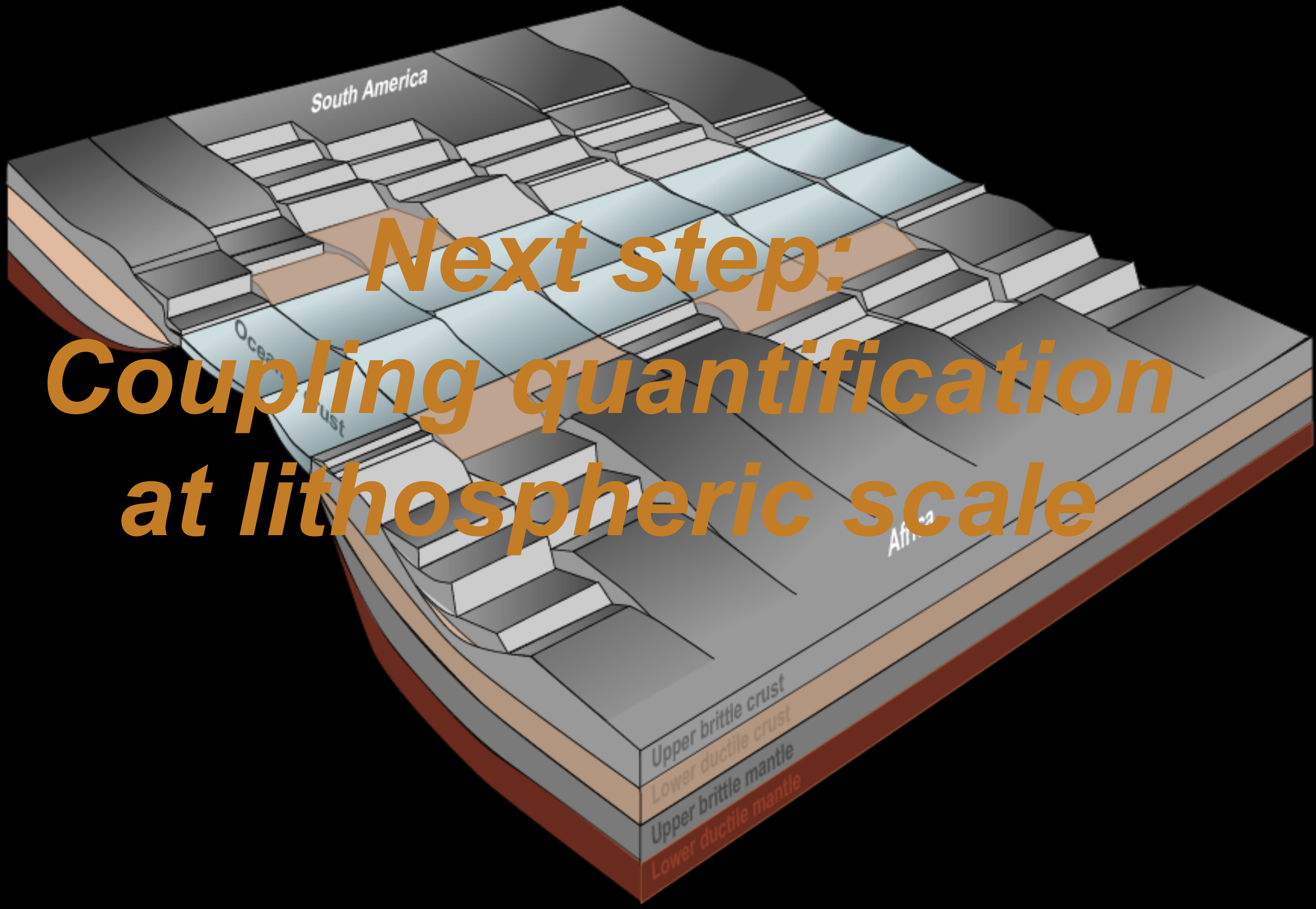
Rotation in Sb/Sd space



Brittle /ductile strength

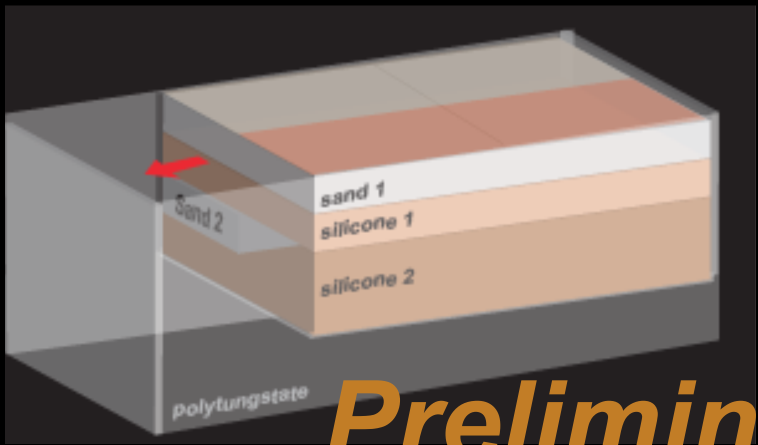


Explaining conjugate passive margins



Next step:
Coupling quantification at lithospheric scale

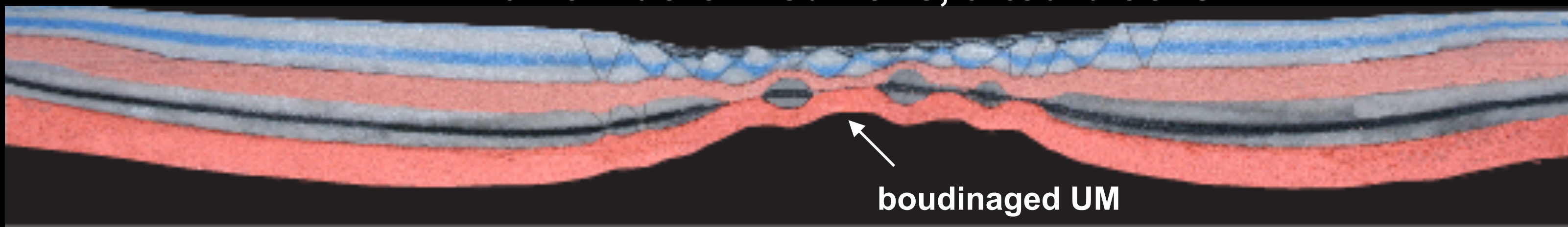
Preliminary results



3 and 4 layers model

top view

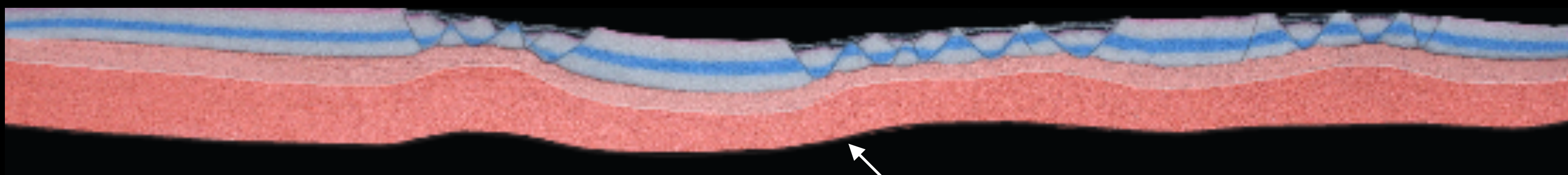
narrow deformed zone, tilted blocks



BC
DC
BM
DM

boudinaged UM

wide deformed zone, horsts and grabens



BC
DC
DM

homogeneous thinning

Conclusions

Variations in coupling between brittle and ductile layers can explain the whole range of extensional structures

Localised extension results from low brittle ductile coupling

ie   strong brittle strength   and/or   low ductile strength

Transitions from horst and graben to tilted blocks result from an increase in ductile strength

Strong block rotations indicates strong ductile strength

ie   High viscosity   and/or   High strain rate