Preliminary results

Melting - Half extension velocity 3mm/yr

Time [Ma]

Magmatic Crustal thickness

- MG Moho 35km
- MG Moho 40km
- WQ Moho 35km
- WQ Moho 40km
Rocks cool during extension

Muentener et al 2001
Magma-poor margins

Non-volcanic margins
Presenter’s notes: In the 1970’s and 80’s two very different models were put forward in an attempt to explain architecture and symmetry of conjugate margins and basins. However, it was soon clear that these models were oversimplifications of reality and that they could not explain the richness in extensional styles observed in Nature. Roger Buck took a very important step by describing and classifying extensional styles into narrow, wide and core-complex modes and showing that the transition of one to the other would occur with increasing lower crustal viscosity. (Notes by presenter continued on next slide)
By looking at the richness of extensional styles along the South American margin, we have come to the conclusion that there is a fourth extensional mode, the sequential faulting mode, which when combined with the previous modes can well explain the wide variety of margin architectures that we see. We have also found that the predominance of one or the other modes during extension is intimately related to the width and nature of the continent-ocean transition zone.
Modes of extension & oceanization

- Combination of 4 extensional modes can explain the wide variety of margins observed.

- The prevalence of any of these modes during extension also determines the style of oceanization (mantle exhumation vs abrupt transition to oceanic crust).

Buck, 1991

Sequential faulting mode

Ranero and Perez-Gussinye, 2010; Brune et al., 2014
3. Transition to oceanic spreading

- Very little magmatism.
- Slow extension (ultra-slow end-member)
- Cool Moho (~450-600°C) at the start of rifting (P-T-t data).
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Presenter’s notes: Finally we have been looking at (1) how the change in fault geometry from the little extended sectors, where faults are planar, to the more extended sectors where occurring faults appear listric—or detachment-like, (2) how is the related to the amount of differential thinning in the crust and (3) what are the implications of it for sedimentation, subsidence and heat-flow.
Effect of crustal thickness on margin width/symmetry

Strong mafic granulite

35 km crust - 5 km/Myr half ext

40 km crust - 5 km/Myr half ext
Effect of crustal thickness on margin width/symmetry

Case 2: Weak wet quartzite

Little subsidence for a long period in rift history, extremely wide margin

Same velocity = 5 mm/yr
Effect of crustal thickness on margin width/symmetry

Case 2: Weak wet quartzite

Very little subsidence for a long period in rift history, extremely wide margin

Wet quartzite
35 km

Wide margin ~ 300 km

Sequential faulting, @ 14 ma  distributed faulting ~ 150 km

break-up @ 28 ma

@ 24 ma
@ 8 ma

Distance [km]

Viscosity, 5 mm/yr, Wet quartz lower crust, 40 km crust, 48.98 ma

Wet quartzite
40 km

Wide margin ~ 580 km

Narrow margin

core complex
50 km
distributed faulting, 450 km
Sequential faulting, @ 41 ma

break-up @ 49 ma

@ 8 ma
@ 36 ma
@ 44 ma

Same velocity = 5 mm/yr
Modes of extension & oceanization

Sequential faulting mode

Core Complex Mode
- Lithosphere
- Asthenosphere
- Crust
- Mantle

Wide Rift Mode
- Lithosphere
- Asthenosphere
- Crust
- Mantle

Narrow Rift Mode
- Lithosphere
- Asthenosphere
- Crust
- Mantle

Cooling

Deep reservoirs of weak lower crust

Buck, 1991
Modes of extension & oceanization

**Type II**

- **Wide Symmetric**
- **Asymmetric**
- **Narrow Symmetric**

- Narrow lower crust

**Type I** (Huismans and Beaumont, 2011)

- Wide margin ~ 200 km
- Narrow margin

- Distributed faulting
- Sequential faulting
- Break-up @ 49 ma
- Break-up @ 28 ma
- Break-up @ 17 ma

- Serpentinised mantle
- Magmatic crust
Effect of crustal thickness on serpentinisation/melting. Strong mafic granulite

35 km crust, Maf gran, 23.01 ma

40 km crust, Maf gran, 19.1 ma

Accumulated serpentinisation, 23.01 ma

Accumulated serpentinisation, wet quartz, 19.1 ma

Area of melt production 23.01 ma

Area of melt production, 19.1 ma

Crust thickness 23.01 ma

Crust thickness 19.1 ma

Same velocity = 5 mm/yr
Effect of crustal thickness on serpentinisation/melting.

**Strong mafic granulite**

35 km crust, Maf gran, 23.01 ma

40 km crust, Maf gran, 19.1 ma

Narrow margin ~70 km

Wide margin ~200 km

Narrow margin ~60 km

**Same velocity = 5 mm/yr**
Presenter’s notes: Shown here is an example of the evolution of a rift with underplating from dikes. Top and bottom plots show degree of serpentinization and magmatic crustal thickness over time. The middle plot shows the formation of a dike at each time step (in pink color) and the resulting underplating and the thickness of the underplated melt over time (in green color). A remarkable result is that we can find very highly thinned and hyperextended margins which are not floored by serpentinite, but rather by melt. Work continues on implementing how the melt is distributed in space for the sill approximation.
West Iberia - Newfoundland margins
Brazil - African margins
Past and Current Research

Future Research

Continental margin formation and oceanization

1. Key controls on margin formation.

2. Interplay between deformation and sedimentation.

3. Margin formation, uplift, sediment transport and accumulation.
1. Key controls on margin formation.

Combined offshore/onshore experiments.
2. Interplay between continental margin deformation and sedimentation.
3. Interplay between margin formation, offshore uplift and consequences for sediment transport and accumulation.
Thank you!

Part 5 (additional slides)