The early evolution of the Romanche Fracture Zone

Insights from analogue modelling experiments

UNIVERSITÄT BERN

Laura Sergi, Guido Schreurs

Institute of Geological Sciences, University of Bern, Baltzerstrasse 1+3, 3012 Bern, Switzerland

Introduction

The Romanche Fracture Zone is an active transform boundary that offsets the Atlantic mid ocean ridge by 880km. It originally developed during the Aptian transtensional rift phase as part of the Atlantic opening. The rifting produced E-W trending strike-slip movement, as well as NE-ENE trending transtensional faults along the Romanche Fracture Zone. Near the late Albian a change in plate-movement vectors must have occurred, indicated by the matching pair of zones of transpressional fold belts at the South Amercian and African continental margins observable today. The belts show structures such as large fold, thrust and positive flower structures. The transpression occurred in a WNW direction.

Objectives

- Analogue modelling of the plate movements in two stages:
  - Transtension (red arrows in figure below)
  - Transpression (blue arrows in figure below)
- Varying placement and angle of pre-existing weak zones (seeds) in order to generate the structures observed today in the transpressional fold belts

Material Properties

Granular materials	Quartz sand
Grain size range	60–250 µm
Density (sieved)	1560 kg/m^3
Angle of internal peak friction	36.1°
Angle of dynamic-stable friction	31.4°
Cohesion	9 ± 98 Pa

Viscous material	PDMS/corundum sand mixture
Weight ratio PDMS : corundum sand	0.965 : 1.00 kg
Mixture density	ca. 1600 kg/m^3
Viscosity[a]	ca. 1.5×10^5 Pa · s
Type	Near-Newtonian ($n = 1.05$)[b]

[a]The viscosity value holds for model strain rates $<10^{-4}$ s^{-1}.
[b]Stress exponent n (dimensionless) represents sensitivity to strain rate.

Figure 3: Material properties of the model layers

F. Zwaan & G. Schreurs (2017)

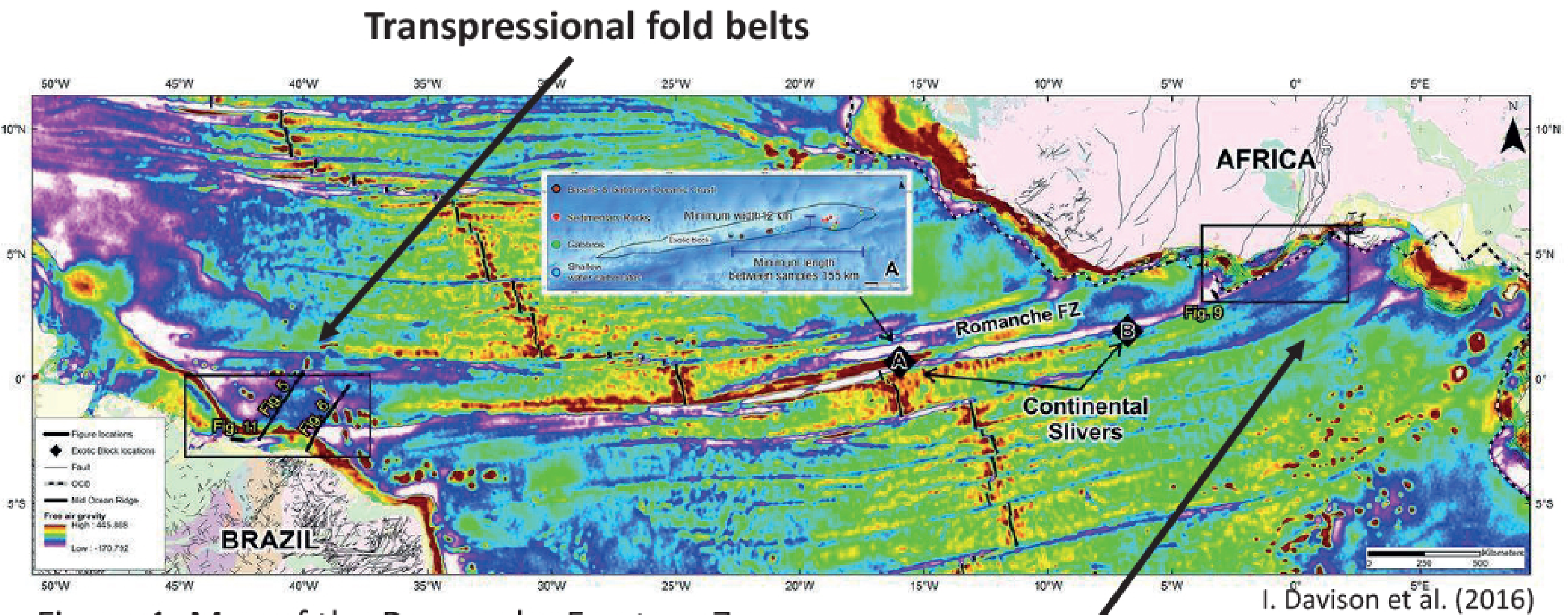

Figure 1: Map of the Romanche Fracture Zone

I. Davison et al. (2016)

Methods

- Analogue modelling in shear box
- 2D quantitative surface analysis
- 3D stereoscopic Digital Image Correlation (DIC)
- X-Ray CT-analysis of one model (EXP 1120)

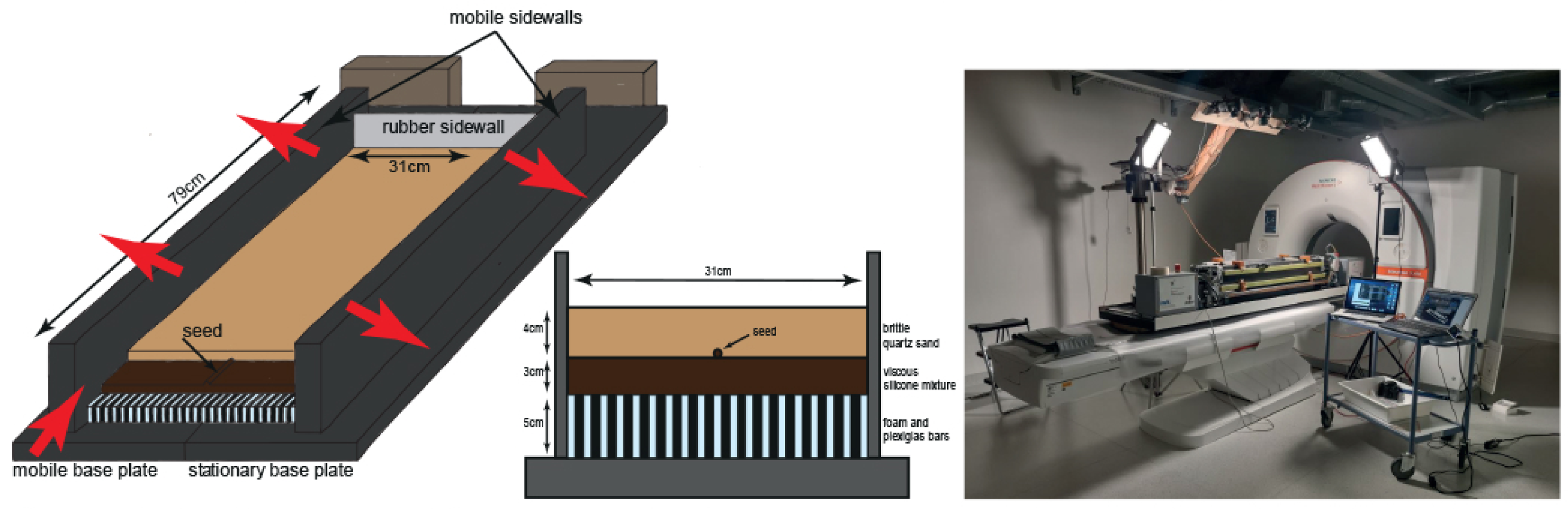

Figure 2: Analogue modelling set up. On the left a top view picture of the shear box with two orthogonally moveable side walls. The base plate is split in two, the right part is stationary and the left is able to move to create strike-slip movements. Red arrows indicate the movement capabilities. The centre image shows the layering of the model, a base of plexiglas and foam bar, a viscous silicone layer representing the lower crust, with seeds (thickness of ~0.8cm) that represent pre existing weak zones in the rock. The top layer is brittle quartz sand that represents the upper crust. The left image shows the CT-scanner at the institute for forensic medicine.

Results

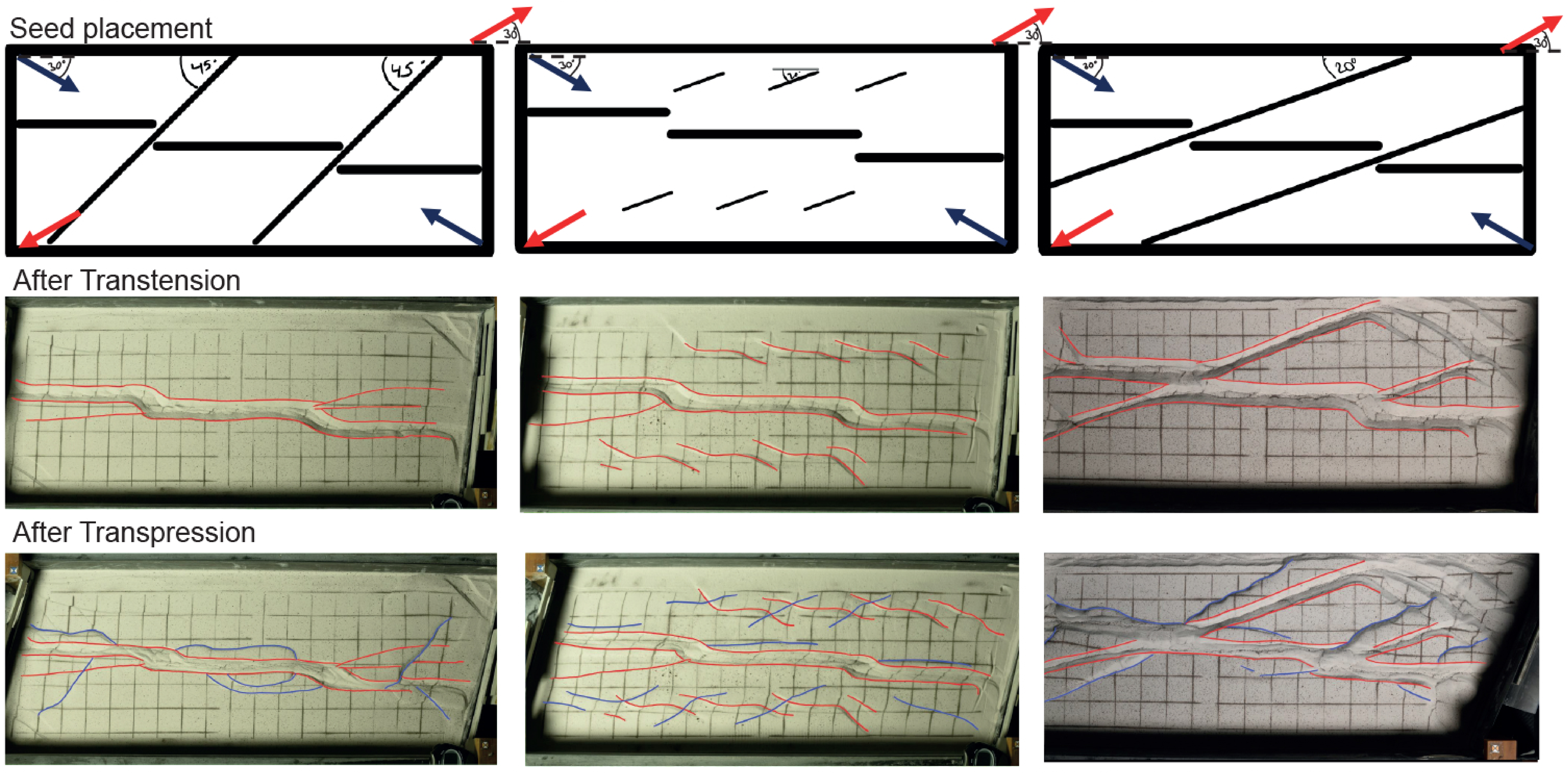

Figure 4: 2D Image results after transtension and transpression each at an angle of 30°. The horizonal seeds have the same placement in all of the models. The oblique seeds were placed in varying angles and lengths to determine when transpressional structures occur. In experiments 1039 and 1047 the amount of strike-slip displacement is 69mm at a speed of 34.6mm/h, the amount of extension and compression is 10mm at a speed of 10mm/h. For experiment 1120 the amount of displacement for the strike-slip movement is 138mm at a speed of 34.6mm/h and for the extension and compression it is 20mm at 10mm/h.

The red marks show the extent of the strain after transtension, and the blues marks after the transpression. The initial rifting along the middle seeds is similar in all the experiments. The differences in strain appear due to the placement of the oblique seeds. At a higher angle in EXP 1039 the seeds are not activated during transtenison and there are no boundary effects. However the seeds are not active during transpression either and folding only occurs along the now closing rift. At a smaller angle in EXP 1047 and 1120 the oblique seeds are already active during the first phase, showing some strike-slip movement in EXP 1047 and even rifting in EXP 1120. However during the second phase the oblique seeds are activated and show transpressional folding along both the oblique seeds and closing rift.

Preliminary conclusions

- The angle in which the oblique seeds are placed, as well as the direction of the divergence and convergence, determine if any transpressional structures occur after the transpressional phase

Future Work

- Complete 3D surface analysis
- Analysis of X-Ray CT data for insights on the internal deformation of the model

References

- Davison, I., Faull, T., Greenhalgh, J., O Beirne, E., & Steel, I. (2016). Transpressional structures and hydrocarbon potential along the Romanche Fracture Zone: a review. Geological Society, London, Special Publications, 431(1), 235-248.
- Zwaan, F., & Schreurs, G. (2017). How oblique extension and structural inheritance influence rift segment interaction: Insights from 4D analog models. Interpretation, 5(1), SD119-SD138.