4D X-Ray CT data and surface view videos of analogue models exploring rift interaction in orthogonal and rotational extension (https://doi.org/10.5880/fidgeo.2020.031)

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1. Licence

2. Citation

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Zwaan, F., & Schreurs, G. (2020). Rift segment interaction in orthogonal and rotational extension experiments: Implications for the large-scale development of rift systems. Journal of Structural Geology, 104119. https://doi.org/10.1016/j.jsg.2020.104119

3. Table of contents

4. Data Description

This data set includes videos depicting the surface evolution of 29 analogue models on crustal extension, as well as 4D CT imagery (figures and videos) of two of these experiments. The experiments examined the influence of the method for driving extension (orthogonal or rotational) on the interaction between rift segments using a brittle-viscous set-up. All experiments were performed at the Tectonic Modelling Laboratory of the University of Bern (UB) using a rotational extension setting developed by Zwaan et al. (2020). Brittle and viscous layers are both 4 cm thick, extension velocities are 8 mm/h so that a model duration of 5 h yields a total extension of 40 mm (e = ca. 13%, given an initial model width of ca. 30 mm). Next to the mode of extension (orthogonal or rotational), we also test the effect of the degree of onderlap (angle ϕ, Table 1). Detailed descriptions of the experiments and monitoring techniques can be found in Zwaan & Schreurs (2020).

4.1. Monitoring of experiments

All experiments (Table 1) were monitored with top view photographs (SLR camera Nikon D-100 6.1 MPx). The photograph time steps are either 1 or 2 min. Two experiments (O9, and R15, see Table 1) were also successfully monitored with an X-Ray computed tomography technique using a 64 slice Siemens Somatom Definition AS X-ray CT-scanner (Zwaan et al., 2016) with time intervals of 30 min. CT-data was analysed with the software OsiriX (Pixmeo SARL).

***Table 1**: Overview of experiments: (!) part of top view time lapse missing, (CT) CT-scanned model, (x) failed CT-scan, * Transfer zone centre 5 cm to the left, ** Transfer zone centre 5 cm to the right, *** Thicker seed test*

O-series (orthogonal extension)			R-series (rotational extension)		
Experiment name in Zwaan & Schreurs (2020)	Lab code (UB)	Seed geometry (ϕ)	Experiment name in Zwaan & Schreurs (2020)	Lab code (UB)	Seed geometry (ϕ)
O1	EXP651	90˚	R1	EXP640	90˚
O2	EXP653	90˚	R2	EXP652	90˚
O3	EXP647	60˚	R3	EXP634	60˚
O4	EXP655	50˚	R4	EXP641	50˚
O5 (!)	EXP644	45˚	R5	EXP638	45˚
O6	EXP649	40˚	R6	EXP639	45˚
O7	EXP656	40˚	R7	EXP642	40˚
O8	EXP663	30˚	R8	EXP635	30˚
O9 (CT)	EXP659	30˚	R9	EXP664	30˚
O10	EXP645	30˚	R10 (CT) (x)	EXP662	30˚
O11	EXP650	20˚	R11*	EXP669	30˚
O12	EXP646	15˚	R12**	EXP671	30˚
			R13***	EXP672	30˚
			R14	EXP673	20˚
			R15 (CT)	EXP676	20˚
			R16	EXP648	20˚
			R17	EXP631	15˚

Table 2: Name convention of images and videos. See List of Files for the total overview of videos and images as well as the data publication folder structure.

Data type	Number	Name elements	Format
Surface videos*	29	ExperimentName_LabCode_top	.mov
3D external deformation images (CT)	2	ExperimentName_LabCode_3D_ext	.jpeg
3D interior deformation images (CT)	2	ExperimentName_LabCode_3D_int	.jpeg
3D external deformation videos (CT)	2	ExperimentName_LabCode_3D_CT	.mov

4.2. Data presentation

4.2.1. Surface view videos

The videos showing surface view evolution are produced by means of top view photographs taken at regular intervals of either 1 or 2 min (Fig. 1). We present 1.5 frame/second videos produced with 11 time steps taken at every 4 mm of extension (i.e. every 30 min). A stopwatch was used to check model timing on the top view images. Note that camera failure has caused the loss of part of the time lapse in experiment O5 (EXP644).

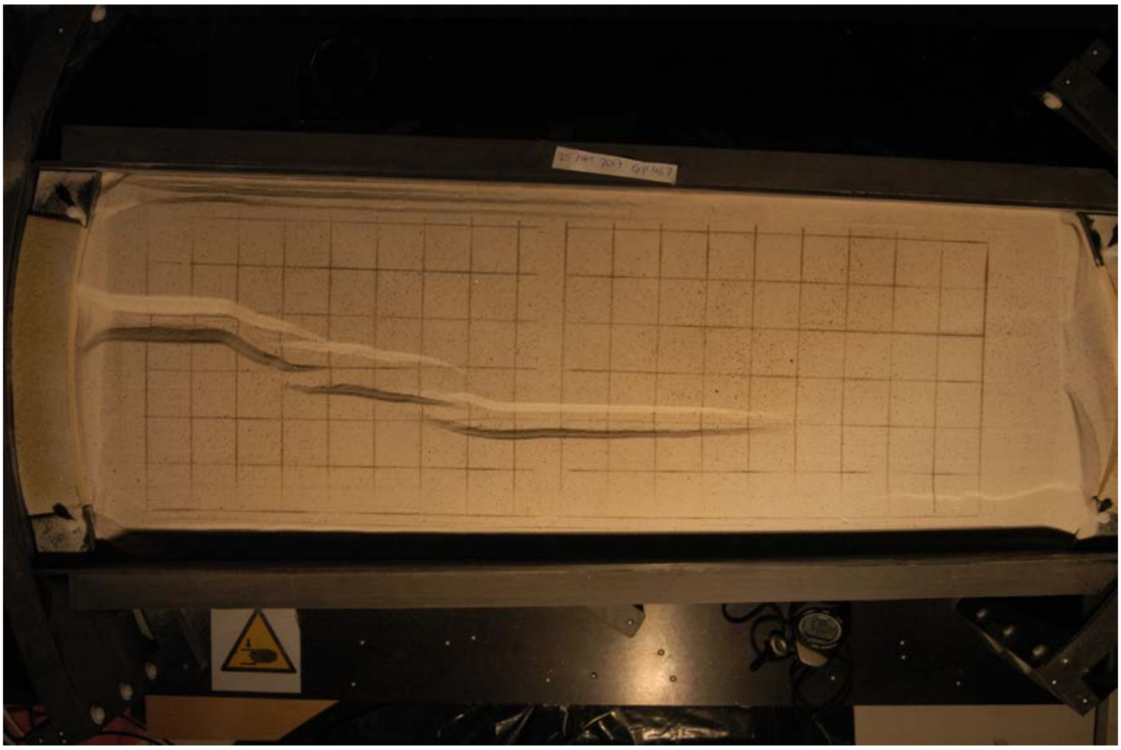

Figure 1: *Example of experiment surface view time step (experiment R16 / EXP648 at end of experiment). The 4 x 4 cm square surface grid provides scale and the stopwatch provides the timing of every surface view.*

4.2.2. Depiction of 3D external deformation (CT-derived images)

The CT datasets allow the creation of 3D images depicting the external evolution of the respective experiments (Fig. 2). Note that due to technical considerations, only the central part of the experiment was scanned and the actual model domain is longer. For every experiment, we present six time-steps, including the initial and final state of the experiment.

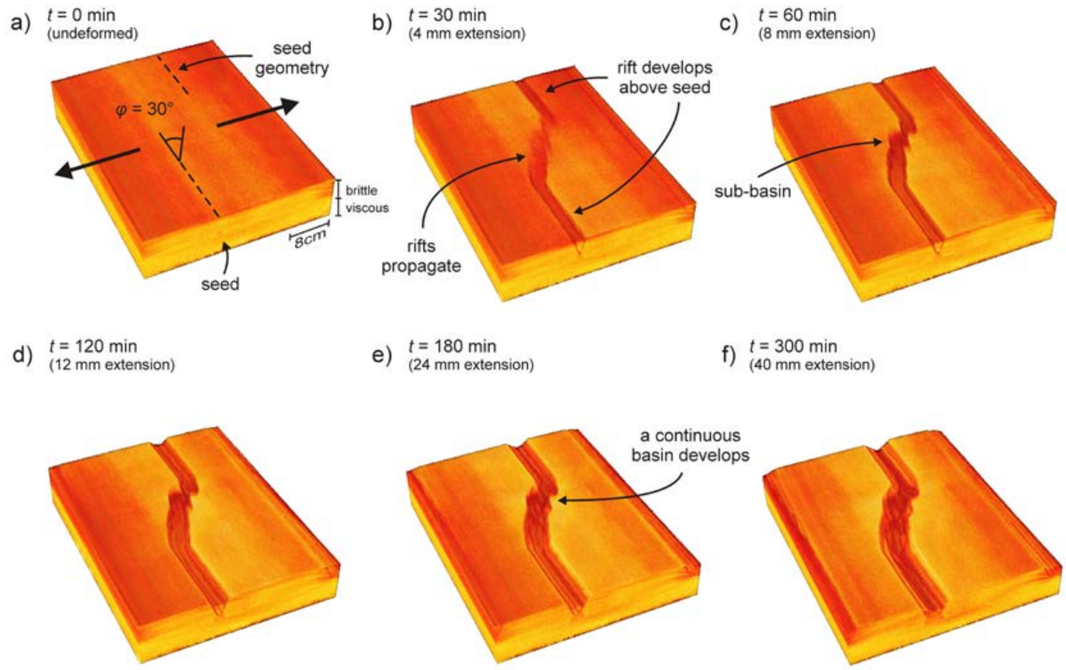

Figure 2: *Example of a 3D CT-derived surface evolution image (experiment O9 / EXP659). The image shows six time-steps including the initial undeformed model and the final stage of deformation after 40 mm of extension. Note that the sides of the images also provide a section view. Colour variations are based on CT-scanning values and do not represent topography.*

4.2.3. Depiction of 3D interior deformation (CT-derived)

The CT datasets allow the creation of horizontal and vertical sections through the model interior during evolution of the experiment (Fig. 3). Similar to the 3D external CT images presented in Section 4.2.2, we provide six time-steps of every experiment including the initial and final state of the experiment.

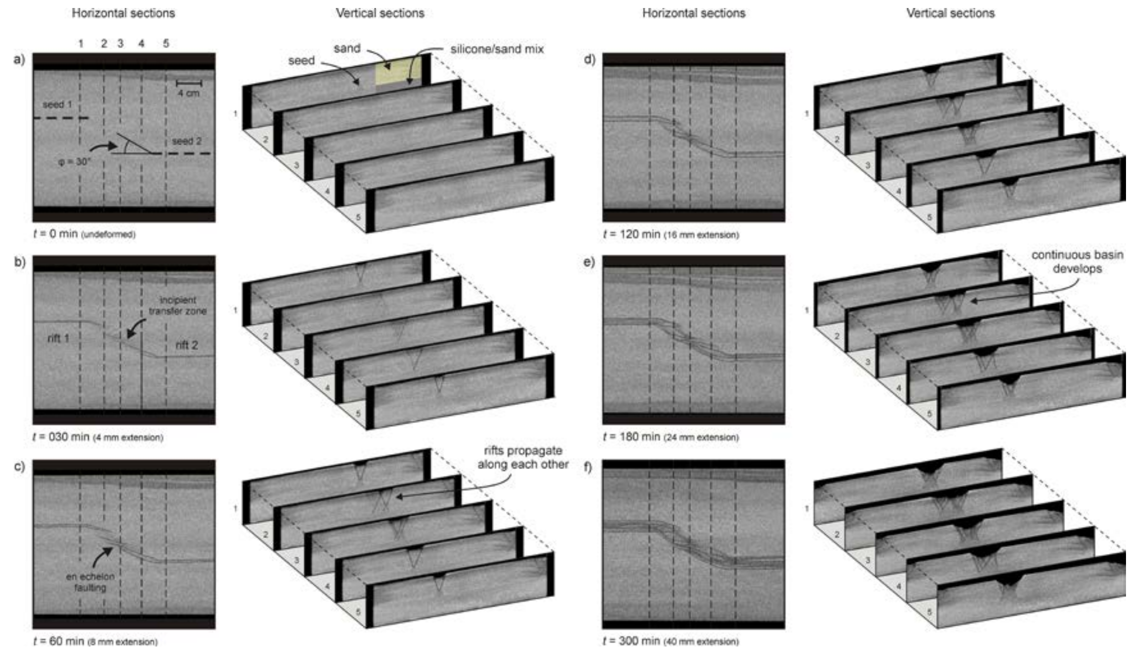

Figure 3: *Example of a 3D CT-derived interior evolution plot for (experiment R15 / EXP676). The figure shows six time-steps including the initial undeformed model and the final stage of deformation with 40 mm extension. The time steps are presented in pairs with to the left a horizontal CT section through the middle of the sand layer depicting the internal structures in map view, and to the right serial cross-sections of five vertical CT sections showing structural variation with depth.*

4.2.4. Videos of 3D external deformation (CT-derived)

The two videos showing the 3D external surface view evolution are produced by means of the 3D external CT-derived images described in Section 4.2.2. (Fig. 2 and Fig. 4) and show six time-steps (1.5 frame/second) including the initial undeformed model and final stage (40 mm extension). Annotation is provided within the videos themselves as well.

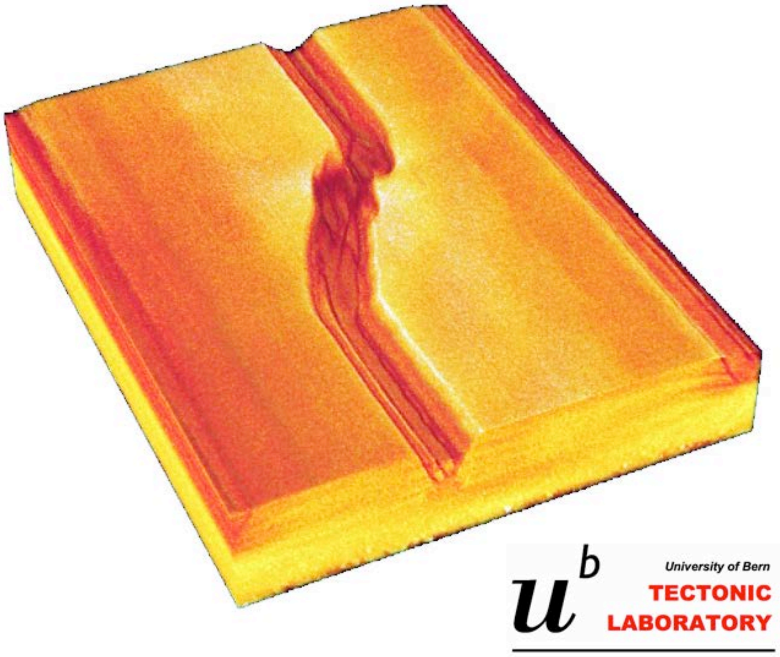

Figure 4: *Still from a 3D CT-derived external evolution video (experiment O9 / EXP659). Compare each of these videos with the corresponding 3D CT-derived external evolution for context (example in Section 2.2.2).*

5. File description

For each of the 29 experiments the following data are provided:

(i) Surface view videos of the experiments (mov format)

For the two successful CT-scanned experiments the following files exist:

(i) 3D CT-derived images depicting the external evolution of the experiments (jpeg format)
(ii) Images with horizontal and serial vertical CT sections showing the 3D internal evolution of the experiments (jpeg format)
(iii) Time lapse videos of 3D CT-derived images depicting the external evolution of the experiments (mov format)

An overview of all files of the data set is given in the **List of Files.**

4. Acknowledgements and funding

We would like to thank Nicole Schwendener for helping us with the CT-scanning, the University of Bern (via Marco Herwegh) for funding both the upgrading of the orthogonal extension apparatus and the development of the new rotational extension machine. We also acknowledge the engineers from IPEK Rapperswil (Theodor Wüst, Reto Gwerder, Rudolf Kamber, Michael Ziltener, Christoph Zolliker and Claude Grau), who realized the improvements to the existing orthogonal extension machine and subsequently designed and constructed the new rotational extension machine. Moreover, we are grateful to the Berne University Science Foundation, which provided generous financial support for the new rotational extension machine, as well and the Swiss National Science Foundation, the principal funder of this project (grant no. 200021_147046, http://p3.snf.ch/project-147046). We thank Kirsten Elger for helping us to create this data publication.

5. References

Zwaan, F., & Schreurs, G. (2020). Rift segment interaction in orthogonal and rotational extension experiments: Implications for the large-scale development of rift systems. Journal of Structural Geology, 104119. https://doi.org/10.1016/j.jsg.2020.104119

Zwaan, F., Schreurs, G. & Rosenau, M. (2020). Rift propagation in rotational versus orthogonal extension: Insights from 4D analogue models. Journal of Structural Geology 135, 103946. https://doi.org/10.1016/j.jsg.2019.103946

Zwaan, F., Schreurs, G., Naliboff, J. & Buiter, S. J. H. (2016). Insights into the effects of oblique extension on continental rift interaction from 3D analogue and numerical models. *Tectonophysics*, 693, 239-260, https://doi.org/10.1016/j.tecto.2016.02.036