4D X-Ray CT data and surface view videos of a systematic comparison of experimental set-ups for modelling extensional tectonics (http://doi.org/10.5880/fidgeo.2019.018)

1. Citation

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2. Data Description

This data set includes 40 videos (+ 1 image) depicting the surface evolution of 39 experiments on crustal extension, as well as 4D CT imagery (figures and videos) of 6 of these experiments. The experiments examined the influence of the method for driving extension (foam base, rubber base, plate base or conveyor base) for localization of deformation in overlying layers of brittle-only and brittle-viscous materials representing the earth's crust. All experiments were performed at the Tectonic Modelling Laboratory of the University of Bern (UB). Detailed descriptions of the experiments and monitoring techniques can be found in Zwaan et al. (2019).

2.1. 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 depend on the applied extension velocity, but are generally 1 or 2 min. Six experiments (Tables 2, 3) were also 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 varying time intervals (5-30 min, Tables 2-3). CT-data was analyzed with the software OsiriX (Pixmeo SARL).

Table 1: Overview of experiments.

	Experiment name in Zwaan et al. (2019)	Lab code (UB)	Layering	Seed	Extension					Remarks
					Type	Velocity	Duration	Total		
Foam base (F series)	F1	EXP668	Brittle- only	No seed	Symmetric	8 mm h^{-1}	5:00 h	4 cm		
	F2	EXP665		Seed		8 mm h^{-1}				
	F3	EXP667				8 mm h^{-1}				
	F4 (CT)	EXP670				8 mm h^{-1}				
	F5	EXP678	Brittle-viscous	No seed		8 mm h^{-1}				
	F6	EXP657		Seed		8 mm h^{-1}				
	F7 (CT)	EXP661				8 mm h^{-1}				
Rubber base (R series)	R1	EXP674	Brittle- only	No seed	Symmetric	1st phase: 8 mm h^{-1} 2nd phase: 40 mm h^{-1}	5:00 h 0:30 h	4 cm 2 cm	6 cm	V1 V2
	R2	EXP629		Seed		20 mm h^{-1}	2:00 h	4 cm		
	R3	EXP630				10 mm h^{-1}	3:30 h	3.5 cm		
	R4 (CT) (25)	EXP534				20 mm h^{-1}	2:40 h	5.6 cm		
	R5 (CT)	EXP632				10 mm h^{-1}	4:00 h	4 cm		
	R6 (CT)	EXP633				20 mm h^{-1}	3:00 h	6 cm		
	R7	EXP698	Brittle-viscous	No seed		1st phase: 8 mm h^{-1} 2nd phase 40 mm h^{-1}	5:00 h 0:30 h	4 cm 2 cm	6 cm	V1 V2
	R8	EXP699		Seed		8 mm h^{-1}	5:00 h	4 cm		
	R9	EXP700		No seed		80 mm h^{-1}	0:30 h			
	R10	EXP701				480 mm h^{-1}	0:05 h			
Plate base (P series)	P1	EXP686	Brittle-only	No seed	Symmetric	8 mm h^{-1}	5:00 h	4 cm		
	P2	EXP687			Asymmetric	8 mm h^{-1}				
	P3	EXP680	Brittle-viscous		Symmetric	8 mm h^{-1}				
	P4	EXP691				2 mm h^{-1}	20:00 h			PA
	P5	EXP692				40 mm h^{-1}	1:00 h			
	P6	EXP688			Asymmetric	8 mm h^{-1}	5:00 h			N/A
	P7	EXP689				8 mm h^{-1}	5:00 h			
	P8 (40)	EXP694			Symmetric	2 mm h^{-1}	5:00 h	2 cm		PA
	P9 (40)	EXP695				80 mm h^{-1}	0:15 h	2 cm		
	P10	EXP693		Seed		8 mm h^{-1}	5:00 h	4 cm		
Conveyor base (C series)	C1	EXP725	Brittle-only	No seed	Symmetric	40 mm h^{-1}	1:00 h	4 cm		
	C2	EXP726			Asymmetric	40 mm h^{-1}				
	C3	EXP737				40 mm h^{-1}				
	C4	EXP727	Brittle-viscous		Symmetric	8 mm h^{-1}	5:00 h			
	C5 (BE)	EXP728				8 mm h^{-1}	5:00 h			
	C6 (BE)	EXP729				8 mm h^{-1}	2:00 h	2 cm		
	C7 (20)	EXP730				8 mm h^{-1}	5:00 h	4 cm		
	C8 (10)	EXP731				8 mm h^{-1}	5:00 h			
	C9 (10)	EXP738				80 mm h^{-1}	0:30 h			
	C10 (10)	EXP739				40 mm h^{-1}	1:00 h			
	C11 (CT) (10)	EXP741				40 mm h^{-1}	1:00 h			
	C12 (40)	EXP740				80 mm h^{-1}	0:30 h	2 cm		

(CT) CT-scanned experiments
N/A Time-lapse not available due to camera problems
PA Time-lapse only partially available due to camera problem
(BE) Attempt to reduce boundary effects (see text and Fig. C2 in Appendix C in Zwaan et al. 2019 for details)
V1 Video 1 (first phase)
V2 Video 2 (second phase)
(25) Initial width: 25 cm instead of 30 cm
(40) Experiments with a total 40 mm thickness (20 mm brittle, 20 mm viscous) and 20 mm total extension
(50) Experiments with a total 50 mm thickness (40 mm brittle, 10 mm viscous)
(60) Experiments with a total 60 mm thickness (40 mm brittle, 20 mm viscous)

Table 2: General details of CT-scanned experiments.

Experiment name in Zwaan et al. (2019)	Lab code (UB)	Extension velocity	CT scanning time steps	CT scanning displacement per time step	Model Duration	Total displacement	Total no. of scans
F4	EXP670	8 mm h^{-1}	30 min	4 mm	5:00 h	4 cm	11
F7	EXP661	8 mm h^{-1}	30 min	4 mm	5:00 h	4 cm	11
R4	EXP534	20 mm h^{-1}	20 min	6.7 mm	2:40 h	5.6 cm	9
R5	EXP632	10 mm h^{-1}	15 min	2.5 mm	4:00 h	4 cm	17
R6	EXP633	20 mm h^{-1}	15 min	5 mm	3:00 h	6 cm	13
C11	EXP741	40 mm h^{-1}	5 min	3.3 mm	1:00 h	4 cm	13

Table 3: Selected time steps of CT-scanned experiments shown in images and videos. *Shown as (time/displacement), the grey slots indicate the reference extension (4 cm). Note that these 5 steps do not cover all CT intervals (Table 2).*

Experiment name in Zwaan et al. (2019)	Lab code (UB)	Step 1	Step 2	Step 3	Step 4	Step 5
F4	EXP670	30 min/4 mm	60 min/8 mm	120 min/16 mm	180 min/24 mm	300 min/40 mm
F7	EXP661	30 min/4 mm	60 min/8 mm	120 min/16 mm	180 min/24 mm	300 min/40 mm
R4	EXP534	20 min/6.7 mm	40 min/13.3 mm	80 min/26.7 mm	120 min/40 mm	160 min/56 mm
R5	EXP632	30 min/5 mm	60 min/10 mm	90 min/15 mm	150 min/25 mm	240 min/40 mm
R6	EXP633	30 min/10 mm	45 min/15 mm	75 min/25 mm	120 min/40 mm	180 min/60 mm
C11	EXP741	10 min/3.3 mm	20 min/6.7 mm	30 min/10 mm	45 min/13.3 mm	60 min/40 mm

Table 4: 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	Number	Name elements	Format
Surface videos*	40 + 1*	ExperimentName_LabCode_top	.mov*
3D external deformation images (CT)	6	ExperimentName_LabCode_3D_ext	.jpeg
3D interior deformation images (CT)	6	ExperimentName_LabCode_3D_int	.jpeg
3D external deformation videos (CT)	6	ExperimentName_LabCode_3D_CT	.mov

** Due to a camera error, no time lapse for P6 (EXP688) is available, only a final surface image (jpeg file)*

2.2. Data presentation

2.2.1. Surface view videos

The videos showing surface view evolution are produced by means of top view photographs taken at regular intervals (Fig. 1). These intervals may differ from experiment to experiment due to, for instance, different extension velocities. Therefore we present standardized 1.5 frame/second videos produced with 11 time steps taken at every 4 mm of extension (i.e. 30 min for reference experiments). Some exceptions are due to different total amounts of extension in certain experiments (Table 1). Also, camera failure (indicated as PA or N/A in Table 1) has caused the loss of the latter part of the time lapse of some experiments, although we always ensure that an image of the final result is included. For two-phase experiments, two videos are available (one of the first phase and one covering both phases). In most cases, a stopwatch was used to check model timing.

Figure 1: Example of experiment surface view time step (EXP699 at end of experiment). *The 4 x 4 cm square surface grid provides scale and the stopwatch provides the timing of every surface view.*

2.2.2. 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). CT scans were made at different intervals that differ from experiment to experiment due to varying extension velocities (Tables 2, 3). 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 6 time steps, including the initial and final state of the experiment, as well as the time step representing 4 cm extension (i.e. the reference total extension in Zwaan et al. 2019, which is in most cases the final stage as well, Table 3).

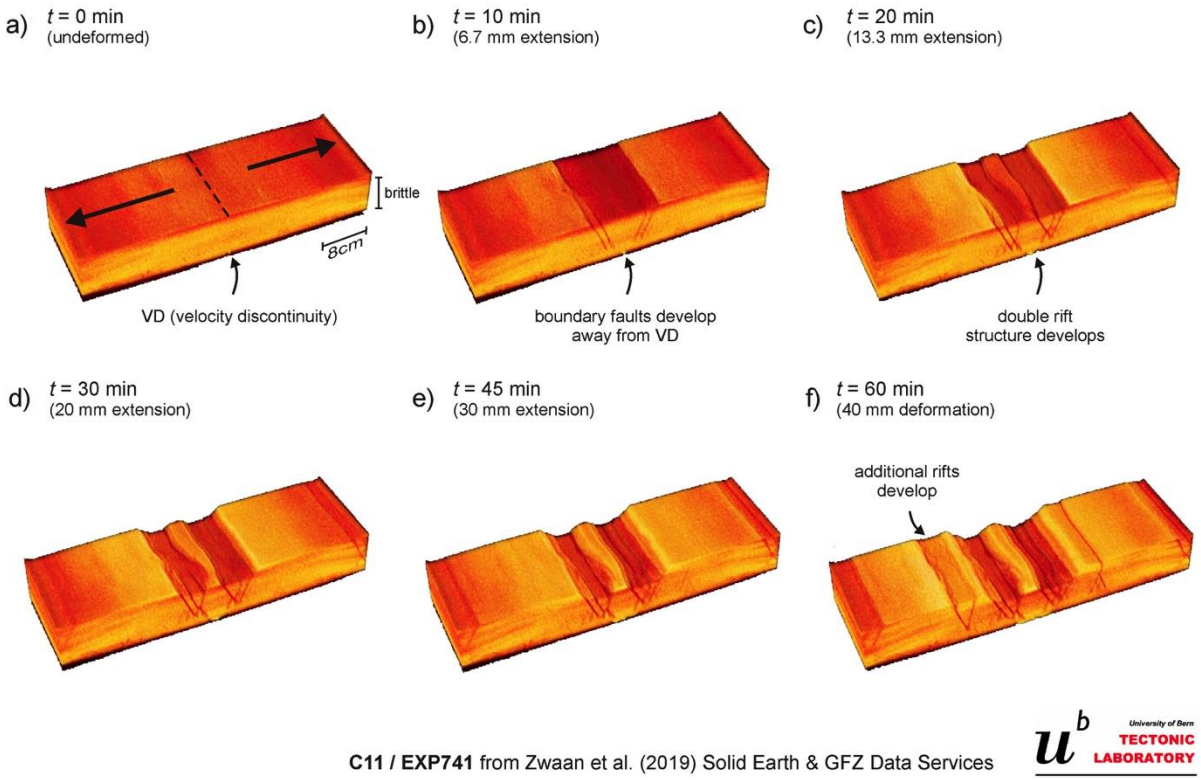

Figure 2: Example of a 3D CT-derived surface evolution image (experiment C11/EXP741). *The image shows 6 time-steps including the initial undeformed model, the final stage and the reference 40 mm extension stage (see Table 3). Note that the sides of the images also provide a section view. Colour variations are based on CT-scanning values and should not be taken do not represent topography.*

2.2.3. 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). CT scans were made at different intervals that differ from experiment to experiment (Tables 2, 3). Similar to the 3D external CT images presented in Section 2.2.2., we provide 6 time-steps of every experiment including the initial and final state of the experiment, as well as the time-step representing 4 cm extension (i.e. the reference total extension in Zwaan et al. 2019, which is in most cases the final stage as well, Table 3).

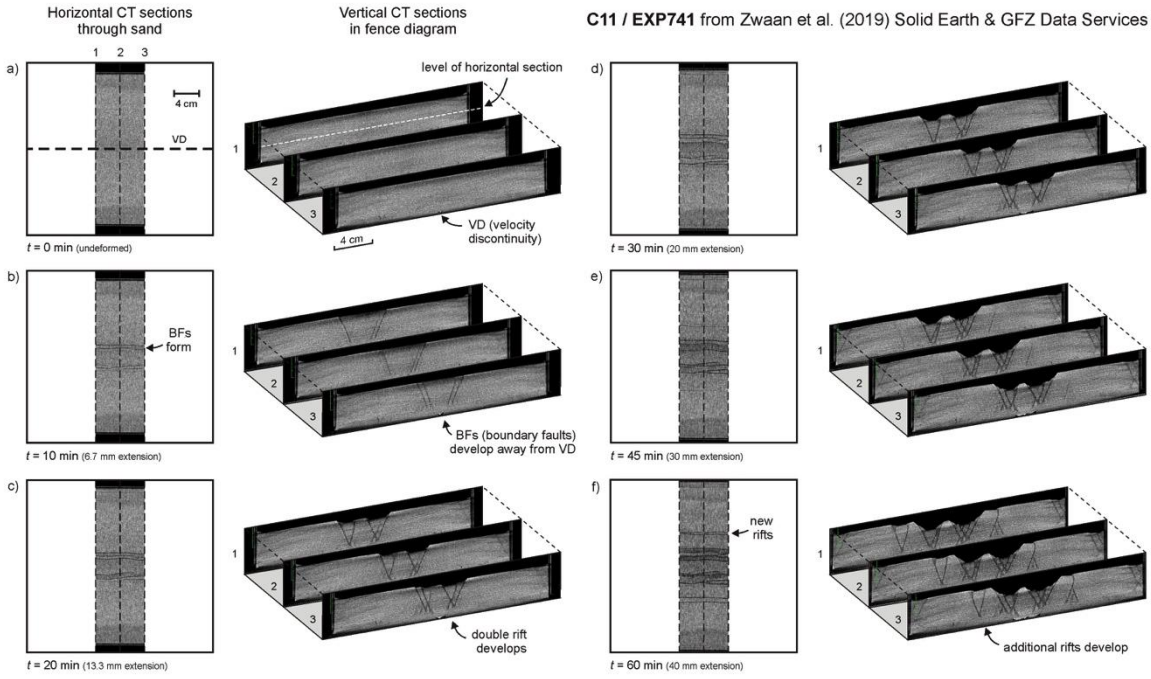

Figure 3: Example of a 3D CT-derived interior evolution plot for (experiment C11/EXP741). *The figure shows 6 time-steps including the initial undeformed model, the final stage and the reference 40 mm extension stage (see Table 3). The time steps are presented in pairs with to the left a horizontal CT section trough the middle of the sand layer depicting the internal structures in map view, and to the right a fence diagram of three vertical CT sections showing structural variation with depth.*

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

The 6 videos showing the 3D external surface view evolution are produced by means of the 3D external CT-derived images described in Section 2.2.2. (Fig. 2) and show 6 time-steps including the initial undeformed model, the final stage and the reference 40 mm extension stage (see Table 3). Annotation is provided within the videos themselves as well.

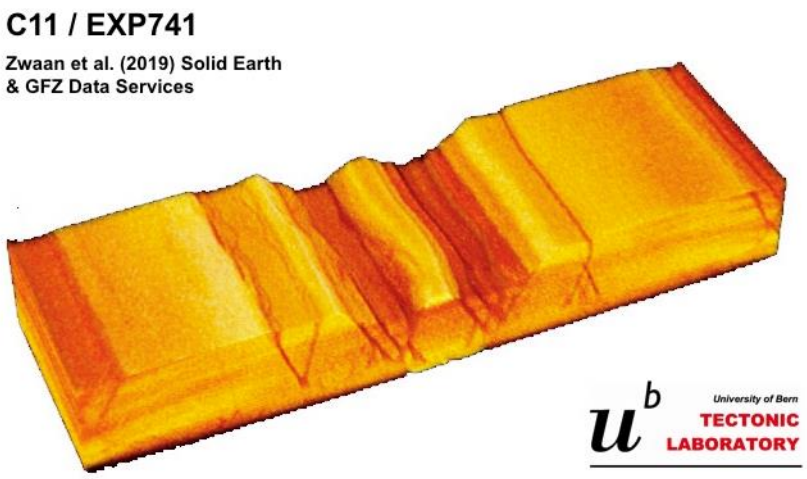

Figure 3: Still from a 3D CT-derived external evolution (experiment C11 / EXP741). *Compare each of these videos with the corresponding 3D CT-derived external evolution for context (example in Section 2.2.2)*

3. File description

For each of the 39 experiments the following exists (see also Table 4):

(i) 40 Surface view videos of the experiments (mov format) + 1 final surface view image of experiment P6 (jpeg format)

For the 6 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 vertical CT sections (fence diagrams) showing the 3D internal evolution (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. References

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

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