Seismic pilot survey in the Mont Terri Underground Rock Laboratory (URL)
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1. Licence

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3. Data Description

This data publication contains a seismic survey which was acquired in the Mont Terri Underground Rock Laboratory (URL) in January 2019. The aim of the SI-A experiment (Seismic Imaging Ahead of and around underground infrastructure) is to provide a seismic characterization at the meso scale and to investigate the feasibility of tomographic and reflection imaging in argillaceous environments.

The survey covered the different facies types of Opalinus Clay: shaly facies, carbonate -rich sandy facies and sandy facies (Bossart et al. 2017). Three different seismic sources (impact, vibro, ELVIS) were used to acquire the seismic data. The impact and magnetostrictive vibro sources were particularly designed for seismic exploration in the underground (Giese et al. 2005, Richter et al. 2018). The ELVIS source was mainly designed for near-surface investigations on roads or in open terrain (Krawczyk et al. 2012). All data were recorded on 32 3-component geophones (GS-14-L3, 28 Hz) which were deployed in 2 m deep boreholes, fixed at the tip of rock anchors.

The data publication covers raw and preprocessed data stored in SEG-Y format.

4. File naming convention

The data is organized in several folders which are included in a compressed zip-file. The seismic data are divided by source type (impact, vibro, ELVIS) and each source type has an individual folder. The survey geometry is stored in the geometry folder. Table 1 contains an overview of the file inventory, and the contents of the individual folders is described in more detail in the following sections.

Table 1: Overview of the file inventory, including data format and a short description of the file content.

Directory	Files or subfolders	Format	Content
/geometry	impact_source_coordinates	txt	impact source point coordinates
	vibro_source_coordinates	txt	vibro source point coordinates
	elvis_source_coordinates	txt	ELVIS source point coordinates
	receiver_coordinates	txt	receiver point coordinates
/impact_data		sgy	3-C geophone data
/vibro_data	/vibro_P_data/	sgy	3-C geophone data, vibro source operated in P mode
	/vibro_S_data/	sgy	3-C geophone data, vibro source operated in P mode
/elvis_data	/elvis_P_30-160Hz/	sgy	3-C geophone data, ELVIS source operated in P mode, sweep frequencies are 30-160 Hz
	/elvis_P_30-360Hz/	sgy	3-C geophone data, ELVIS source operated in P mode, sweep frequencies are 30-360 Hz
	/elvis_SH_30-160Hz/	sgy	3-C geophone data, ELVIS source operated in SH mode, sweep frequencies are 30-160 Hz
	/elvis_SH_30-360Hz/	sgy	3-C geophone data, ELVIS source operated in SH mode, sweep frequencies are 30-360 Hz

4.1. Folder/geometry

The source and receiver coordinates are given as easting, northing and elevation above sea level using the local Swiss reference system CH1903+ (LV95, https://www.swisstopo.admin.ch/en/knowledge-facts/surveying-geodesy/reference-systems/switzerland.html).

All source coordinate files (impact_source_coordinates, vibro_source_coordinates, and elvis_source_coordinates) have the format listed in Table 2.

Table 2: Description of the source coordinate file format.

column	column header	units	description
1	ID	-	source number
2	east	m	easting (swiss coordinate system)
3	north	m	northing (swiss coordinate system)
4	elev	m	elevation above sea level
5-8	 ffid ffid_P / ffid_S P360 / P160 / SH160 / SH360	-	field Record Number of first sweep/hit at the source point impact data: ffid in col. 5 vibro data: ffid of P-source in col. 5; ffid of S-source in col. 6 ELVIS: ffid of P-source with sweep 30-360 Hz (P360) in col. 5; ffid of P-source with sweep 30-160 Hz (P160) in col. 6; ffid of SH-source with sweep 30-360 Hz (SH160) in col. 7; ffid of SH-source with sweep 30-360 Hz (SH360) in col. 8

All seismic data were recorded with 32 3-component geophones (GS-14-L3, 28 Hz). The 3-C receivers (Fig. 1) were vertically spread over two levels in the underground lab, 2 m apart. The lower sensors were oriented horizontally (w/o inclination), while the upper sensors had an inclination of -40°. The individual components of the lower receivers were oriented vertically (#1), parallel (#2) and perpendicular (#3) to the tunnel wall. Their orientation is listed in file receiver_coordinates.txt. The azimuth defines the horizontal angle measured clockwise from north: north (0°), east (90°), south (180°), and west (270°). The inclination refers to the vertical angle measured from the horizontal (0°) upwards (positive) and downwards (negative). Nan values mean undefined angles, e.g. undefined azimuth for exactly vertically oriented components.

Table 3: Description of the receiver coordinate file format.

column	column header	units	description
1	ID	-	receiver number
2	east	m	easting (swiss coordinate system)
3	north	m	northing (swiss coordinate system)
4	elev	m	elevation above sea level
5	ch1	-	channel number of 1^{st} component (vertical)
6	ch2	-	channel number of 2^{nd} component (tunnel-parallel)
7	ch3	-	channel number of 3^{rd} component (tunnel-radial)
8	az1	°	azimuth of vertical component
9	in1	°	inclination of vertical component
10	az2	°	azimuth of tunnel-parallel component
11	in2	°	inclination of tunnel-parallel component
12	az3	°	azimuth of tunnel-radial component
13	in3	°	inclination of tunnel-radial component

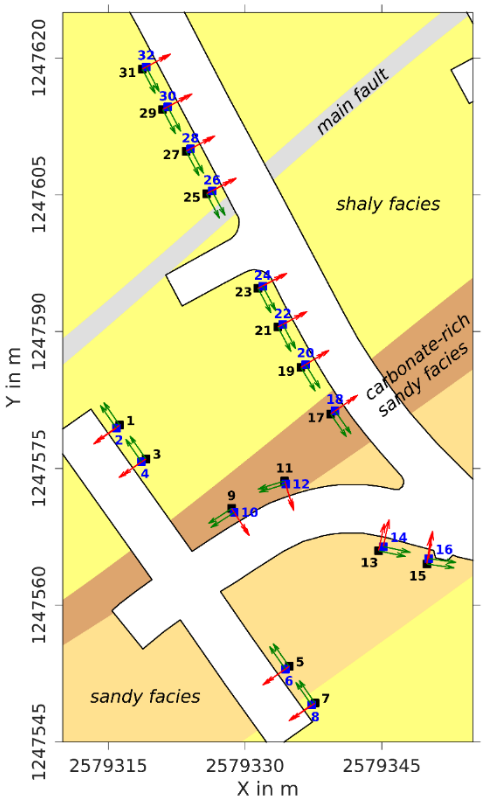

Figure 1: Overview map showing the receiver locations. The lower level sensors are shown as black squares and the upper level sensors are shown as blue squares. The arrows show the orientation of the tunnel-radial (red) and tunnel-parallel (green) component; the vertical component points upwards.

4.2. SEG-Y trace header

The survey geometry is inserted in the SEG-Y header. The position in the trace header is listed in Table 4.

Table 4: Description of the SEG-Y header.

Header	Byte	description
ffid	9-12	field record number
chan	13-16	channel number
sou_sloc	233-236	source number
sou_x	73-76	source X-coordinate
sou_y	77-80	source Y-coordinate
sou_elev	45-48	elevation of source
srf_sloc	237-240	receiver number
rec_x	81-84	receiver X-coordinate
rec_y	85-88	receiver Y-coordinate
rec_elev	41-44	elevation of receiver
	71-72	scalar to be applied to X- and Y-coordinates; negative scalar is used as divisor
	69-70	scalar to be applied to elevation; negative scalar is used as divisor

4.3. Folder/impact data

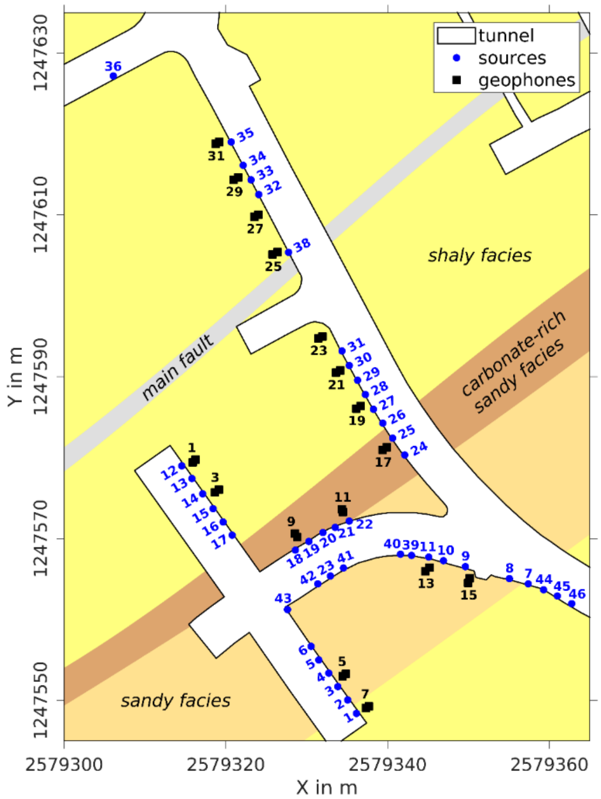

Figure 2: Overview map of the seismic impact survey showing source (blue dots) and receiver locations (black squares) with the corresponding source and receiver numbers.

We acquired 45 impact source points (Fig. 2) at the tunnel wall and at each source point 5 hits were carried out.

The file **impact_raw_data.sgy** comprises the raw data (individual hits at each source point) and the file the **impact_preproc_data.sgy** comprise the vertical stacked data. The header includes source point and receiver numbers as well as their corresponding coordinates.

4.4. Folder/vibro data

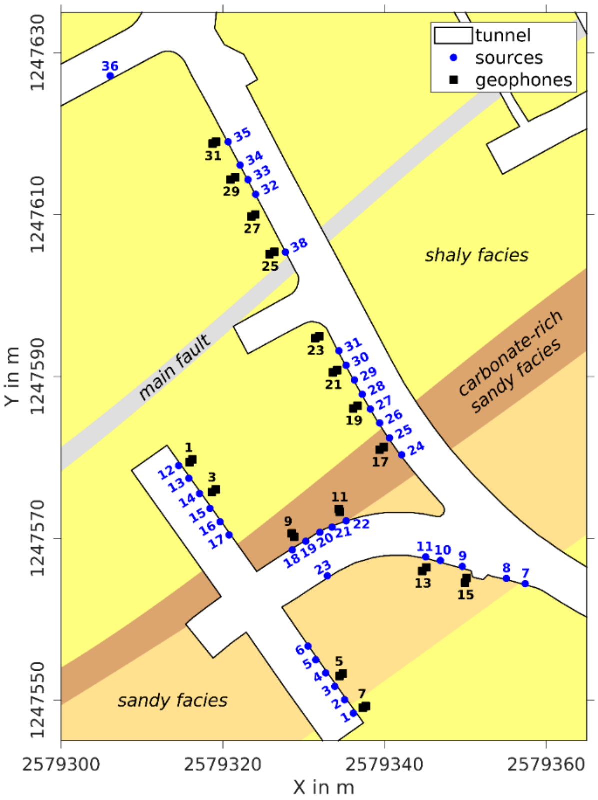

Figure 3: Overview map of the seismic vibrator survey showing source (blue dots) and receiver locations (black squares) with the corresponding source and receiver numbers.

We acquired 37 vibrator source points in P- and S-mode at the tunnel wall and at each source point 3 sweeps (100-1200 Hz, 18 s) were carried out.

The files **vibroP_raw_data.sgy** and **vibroS_raw_data.sgy** comprise the raw data (uncorrelated, individual sweeps at each source point) and the files the **vibroP_preproc_data.sgy** and **vibroS_preproc_data.sgy** comprise the pilot-sweep correlated and vertical stacked data. The header includes source point and receiver numbers as well as their corresponding coordinates.

Table 5: Description of the channel configuration of the vibro data.

channel	description
1 - 96	32 3-C receivers
97	signal of head #1
98	signal of head #2
99	sweep signal

4.5. Folder/elvis_data

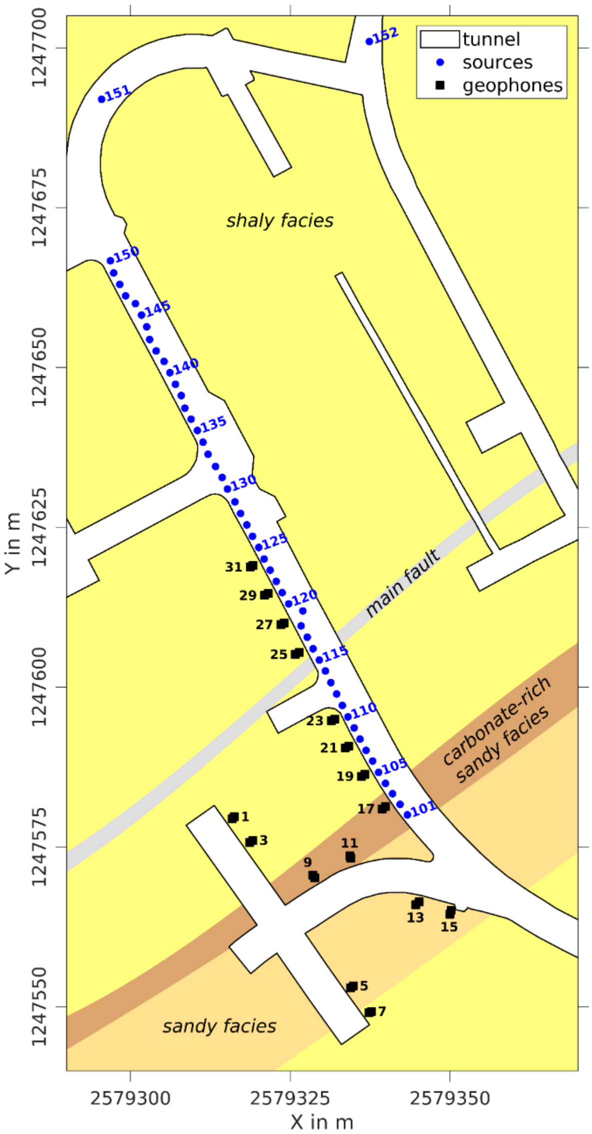

Figure 4: Overview map of the seismic ELVIS vibrator survey showing source (blue dots) and receiver locations (black squares) with the corresponding source and receiver numbers.

We acquired 52 ELVIS source points in P- and SH-mode. In contrast to the impact and vibro acquisition, the ELVIS source is operated on the floor. At each source point 5 sweeps were carried out (5x P, 5x SH+, 5x SH-). The pilot sweeps are required for vibroseis correlation. We used two different sweeps: (a) 30-160 Hz, 10 s and (b) 30-360 Hz, 10 s.

The files **elvis_P*_raw_data.sgy** and **elvis_S*_raw_data.sgy** comprise the raw data (uncorrelated, individual sweeps at each source point) and the files **elvis_P*_preproc_data.sgy** and **elvis_S*_preproc_data.sgy** comprise the correlated and vertical stacked data. The header includes source point and receiver numbers as well as their corresponding coordinates. The files **elvis_P*_sweep.sgy** and **elvis_SH*_sweep.sgy** comprise the synthetic sweep signal.

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