Seismic imaging of the overdeepened basin of Lienz (Austria) - Report

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Abstract
In 2016, the Leibniz Institute for Applied Geophysics (Hannover, Germany) carried out two seismic surveys in the Lienz basin. The measurements are part of a DFG-funded project, which investigates the benefit of the application of modern multi-component reflection seismics preparatory to scientific drilling, in particular to the ICDP-project DOVE (Drilling Overdeepened Alpine Valleys). Four P-wave seismic profiles, perpendicular to the valley axes, were recorded using vibroseismic technique to gain structure and facies information. In addition, two SH-wave reflection seismics, one 6-component profile, two small 3-D layouts for P-wave and S-waves, as well as one P-wave and SH-wave refraction seismic profiles were measured for primarily methodological studies. Data show a good quality and, in a first quality control, the bedrock as well as internal structures of the basin are imaged.

Coordinates: 46°49'N/12°49'E
Keywords: Seismic imaging, Multi-components

1. Introduction

Overdeepened valleys and basins are geological, environmental, and social relevant, since they form the major settlement areas in the Alps (Preusser et al., 2010). It is generally assumed that pressurized meltwater below glaciers excavated these valleys and basins. During the meltdown at the end of the glaciations, most valleys were refilled by glacial deposits or remain in form of lakes, e.g. Lake Constance. The term ‘overdeepened’ refers to their origin and the erosion below the fluvial base of the landscape.

The ICDP-project DOVE (‘Drilling Overdeepened Alpine Valleys’) intends to reveal the genesis and subsequent sedimentation and to correlate the glaciations across the alpine region (Anselmetti et al., 2016). A DFG-funded project intends to improve seismic imaging of overdeepened alpine valleys and basins with multicomponent techniques. Therefore, P-wave and S-wave reflection seismics are utilized to characterize the sediment succession of the valleys by means of structure, facies, and processing.

Beside the Tannwald basin in the alpine foreland, a second survey location is the inner alpine basin of Lienz, Austria. Here, three ice streams converged during the glaciations and continued as a single ice stream down the Drautal. We expect a valley fill about 500 m thickness, which can be assumed from gravitational investigation in the Lienz basin and a reflection seismic survey some 20 km further down in the Drautal. Aims of the survey are to image the geometry of the basin and to distinguish between different valley infill.

2. Data Acquisition

2.1 Experiment design and schedule

In August and September 2016, a LIAG field crew acquired 4 reflection seismic profiles in the Lienz Basin, Austria (Fig. 1, Table 1). The first field campaign was carried out between 15.08.-26.08.2016, the second between 12.-23.09.2016. Field crew members were Jan Bayerle (operator), Sven Wedig (driver), Erwin Wagner (technical support), Philipp Nagy (field crew), Dr. Hermann Buness (field crew and scientific support), Dr. Thomas Burschil (field crew and scientific support).

At the first campaign, mainly P-wave reflection seismics were carried out using LIAG’s vertical mini vibrator HVP-30 and up to 360 receivers connected to the Geometrics Geode recording system. Additional data cubes were used to fill gaps in the profile where cable lines could not be established, for several small 3-D spreads, and refraction surveying. Four 2-D profiles were

acquired with split-spread/roll-along technique. On LB-1P, DATA-CUBE3 recorder[1] registered a refraction seismic profile across the entire valley. Next to LB-4P, a 3-D survey was carried out with receivers on three additional inlines and sources on LB-4P and three crosslines.
At the second campaign, two SH-wave profiles were acquired, using LIAG's horizontal mini vibrator MHV4S and two LIAG's landstreamers, 120 m each. An extra refraction seismic SH-wave profile was registered on LB-1P. LB-1S was recorded in stages as single profiles. One multi-component profile LB-4M was acquired with 3-C receivers and horizontal source direction inline and x-line. Next to LB-4M, a 3-D survey was carried out using five receiver inlines and 3 x-lines.

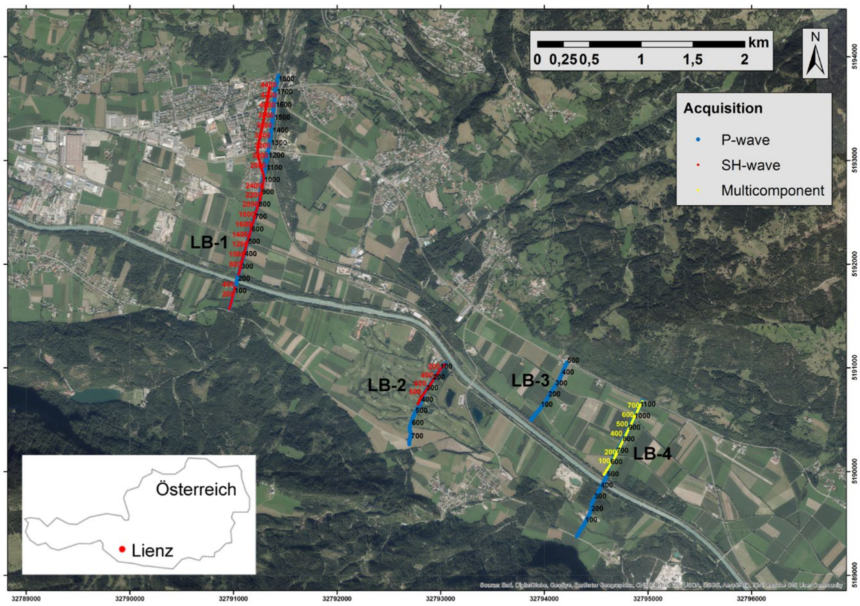

Figure 1: Location map of seismic profiles including CMP numbers.

2.2 Geometry/Location

Profile	Begin		End		# SP	# files
	UTM X (zone 32) UTM Y (zone 32)	Longitude (°E) Latitude (°N)	UTM X (zone 32) UTM Y (zone 32)	Longitude (°E) Latitude (°N)		
LB-1P	790957.92 5191568.69	12.81407131° 46.81406767	791434.91 5193818.99	12.82174357° 46.83406477	443	1304
LB-1S	790955.89 5191565.11	12.81404248° 46.81403641°	791350.12 5193718.20	12.82056997 46.83319686°	551	2204
LB-2P	793057.65 5191046.08	12.84119839 46.80845550°	792703.73 5190241.91	12.83605601 46.80139042°	185	370
LB-2S	793045.75 5191036.96	12.84103693 46.80837884°	792779.21 5190647.00	12.83730195 46.80499454°	121	274
LB-3P	793871.82 5190492.73	12.85149021 46.80312878°	794218.01 5191048.25	12.85637385 46.80796396°	132	264
LB-4P	794315.70 5189371.05	12.85657353 46.79286183°	794949.46 5190684.45	12.86570448 46.80437441°	271	1061
LB-4M	794575.73 5189967.81°	12.86035667° 46.79810516°	794949.88 5190684.59	12.86571007° 46.80437548°	243/ 243	2650

Table 1: Coordinates of start and end points of the profiles.

[1] https://www.gfz-potsdam.de/gipp → Instruments → Seismic Pool → Recorders → Recorder / DATA-CUBE3

2.3 Instrumentation

- 15 Geometrics Geodes, 24 channels each[2]
- Sensor SM6 (3-C geophones, 14 Hz, 3 spikes), Sensor SM6 (horizontal geophones, 14 Hz, mounted on LIAG Landstreamer), Sensor SM6 (vertical geophone, 20 Hz, 1 spike)
- 60 3-channel Omnirecs DATA-CUBE3
- Sensor PE-6/B (3-C geophones, 4.5 Hz)
- 1 Trigger cube
- Vertical minivibrator HVP-30, shear-wave minivibrator MVH4S

2.4 Acquisition parameters

Profiles were acquired in split-spread/roll-along technique or single layout. Cubes registered continuously and were correlated with a synthetic sweep signal afterwards. Therefore, a trigger cube registered the source trigger (signal 5 to 0, decreasing flank; 10-15 ms; from Pelton Sweep generator). See Table 2 for details.

	LB-1P	**LB-1S**	**LB-2P**	**LB-2S**	**LB-3P**	**LB-4P**	**LB-4M**
Profile	'Stadler'		'Golfplatz'		'Kapaun'	'Auernig'	
Length	2341 m	2225 m	886 m	480 m	655 m	1476 m	808 m
Layout	Split-spread/roll-along	Split-spread/roll-along		Split-spread/roll-along	Split-spread/roll-along		Split-spread/roll-along
Additional 3D	No	No	No	No	No	Yes	Yes
Receivers							
Spacing	2.5 m	1 m	2.5 m	1 m	2.5 m	2.5 m	2 m
Max #	360	240	360	240	264	360	80
Cubes	Yes	Yes	No	No	No	Yes	Yes
Sampling	1 ms	2 ms	1 ms	2 ms	1 ms	1 ms	2 ms
Listening time	2 s	3 s	2 s	3 s	2 s	2 s	3 s
Field correlation for Geode	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Source	HVP-30	MVH4S	HVP-30	MVH4S	HVP-30	HVP-30	MVH4S
Spacing	5 m	4 m	5 m	4 m	5 m	5 m	4 m
Sweep	Linear	Linear	Linear	Linear	Linear	Linear	Linear
Freq	20-200 Hz	10-100 Hz	20-200 Hz	10-100 Hz	20-200 Hz	20-200 Hz	10-100 Hz
Length	10 s	10 s	10 s	10 s	10 s	10 s	10 s
Taper type	Cosine	Cosine	Cosine	Cosine	Cosine	Cosine	Cosine
Taper length	200 ms	200 ms	200 ms	200 ms	200 ms	200 ms	200 ms

Table 2: Acquisition parameters

3. Data Processing

Cube data were extracted by GIPPtools cube2segy (Lendl, 2022) according to the trigger time. A python script converted the output file of the TRIGGER CUBE recorder into a geometry file for cube2segy.

Seismic profiles recorded with Geometrics Geode device are not processed yet. A first quality control was carried out so far and shows good data quality. Reflection seismic processing will follow.

4. Data Description

Raw cube data as well as data after vibro-seismic correlation are subject of this dataset/report and are available at the "GIPP Experiment and Data Archive". Data registered by Geometrics Geode

[2] Not part of this dataset

(not from GIPP) will be available at FIS-Geophysik at LIAG.

4.1 File format (s)

- SEG2 files for data registered by Geometrics Geode.
- SEGY files for cube data before and after vibroseismic correlation (e.g., Barry et al., 1975).
- Raw continuous DATA CUBE3 data.
- Txt file of trigger cube.

4.2 Data content and structure:

Directory ***raw*** contains subdirectories for both field campaign with folders for each DATA CUBE3 (data files) and the TRIGGER CUBE (txt file). Directory ***segy*** divides in subdirectories for each profile. Folder *BEFORE_CORRELATION* contains SEGY files of the vertical geophone component for P-wave profiles, all components for S-wave profiles, for each DATA CUBE3 before vibroseis correlation. Trace length is 13500 ms with 500 ms advance. Folder *AFTER_CORRELATION* contains one SEGY file for all cubes, sorted by CUBE number. Details can be found in Table 3. Geometry is loaded to SEGY headers (see e.g. Table 4). Profile LB-1S is split in 5 parts, numbered from South (1) to North (5). Directory ***info*** contains locations for the CUBE positions during the 3-D layout.

Directory	*Sub-directories*	*Sub-sub-directories*	*Content*
info/			Cube positions: GEOM_M4.xlsx & GEOM_P4.xlsx
raw/	/Cubes_1	Cube-??? [cube-S/N]	Cube raw data; all cube data of first field campaign plus geometry files, (python) scripts, trigger lists etc.
	/Cubes_2	Cube-??? [cube-S/N]	Cube raw data; all cube data of first field campaign plus geometry files, (python) scripts, trigger lists etc.
segy/	LB-1P	AFTER_CORRELATION/	LB-1P-cubes-corr.segy
		BEFORE_CORRELATION/	LB-1P-cube???-raw.segy [cube S/N]
	LB-1S	BEFORE_CORRELATION/	LB-1S-?-cube???-?-raw.segy [parts 1-5, cube S/N and component 0, 1 or 2][3]
	LB-4M3D	AFTER_CORRELATION/	LB-4M3D-cubes-corr.segy
		BEFORE_CORRELATION/	LB-4M3D-cube6???-?-raw.segy [cube S/N and component 0, 1 or 2]
	LB-4P	AFTER_CORRELATION/	LB-4P-cubes-corr.segy
		BEFORE_CORRELATION/	LB-4P-cube???-raw.segy [cube S/N]
	LB-4P3D	AFTER_CORRELATION/	LB-4P3D-cubes-corr.segy
		BEFORE_CORRELATION/	LB-4P3D-cube???-raw.segy [cube S/N]

Table 3: Data/-directory structure

Byte-#	*SEG-Y description*	*SU header word[4]*	*Comment*
1-4	Trace sequence number within line	tracl	
5-8	Trace sequence number within reel	tracr	
9-12	Original field record number	fldr	
13-16	Trace sequence number within original field record	tracf	

[3] Channel 0: Z; channel 1: profile direction; channel 2: direction perpendicular to profile

[4] Seismic Unix; Cohen &6 Stockwell (2010)

17-20	Energy source point number	ep	
21-24	CDP ensemble number	cdp	
25-28	trace number within the ensemble	cdpt	
29-30	Trace identification code	trid	
37-40	Distance from source point to receiver group	offset	
41-44	Receiver group elevation	gelev	
45-48	Surface elevation at source	selev	
69-70	Scalar for elevations and depths	scalel	
71-72	Scalar for coordinates	scalco	
73-76	X/Y source and receiver coordinates	sx	Coordinates is UTM32; leading “32” is omitted at x-coordinates
77-80		sy	
81-84		gx	
85-88		gy	
89-90	Coordinate units	counit	
115-116	Number of samples in this trace	ns	
117-118	Sample interval of this trace in microseconds	dt	
157-158	Year data recorded	year	

Table 4: SEGY-header settings (from example LB-1P-cubes-corr.segy)

5. Data Quality/Accuracy

Cube data contain a DC-signal, which can easily be removed.

6. Data Availability/Access

Data is archived at the *GIPP Experiment and Data Archive* where it will be freely available for further use under a “Creative Commons Attribution 4.0 International License” (CC BY 4.0).

When using the data, please make proper citation (see below) and acknowledge the use of GIPP instruments.

Recommended citation:

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