Description of the Dataset "Geophysical Imaging of Deep EarthShape (GIDES): Seismic data of the Private Reserve Santa Gracia, Chile"

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Abstract

The dataset contains the seismic weight drop data acquired in Private Reserve Santa Gracia, Chile. The data acquisition was conducted as a part of the EarthShape project in the subproject of Geophysical Imaging of the Deep EarthShape (GIDES). The seismic line was setup to cut across an existing borehole location with core and geophysical logging data available (Krone et al., 2021; Weckmann et al., 2020). The data was acquired to image the deep weathering zone identified by the borehole data across the seismic profile. Included in the datasets are the raw data of the CUBE data logger, SEG-Y data of the recorded shots, and the shot and receiver geometry data.

Coordinates: 29.759060° S, 71.161130° W

Keywords: Geophysics, seismic, weight drop, weathering zone, critical zone, bedrock, Chile, granite, passive seismic, 3C sensor

1 Introduction

A vital aspect of comprehending the interplay between geological and biological processes lies in the imaging of the critical zone, located deep beneath the surface, where the transition from unaltered bedrock to fragmented regolith occurs. It had been hypothesized that the depth of such weathering zone is dependent on the climate condition of the area. A more humid climate with higher precipitation will result in a deeper weathering front. As a part of the EarthShape project (SPP-1803 'EarthShape: Earth Surface Shaping by Biota'), specifically the Geophysical Imaging of the Deep EarthShape (GIDES - Grant No. KR 2073/5-1), we aim to image the weathering zone using the geophysical approach. Using the seismic method, we can differentiate different weathered layers based on the seismic velocity while also providing a 2D subsurface image of the critical zone. We conducted a seismic weight drop experiment in the Private Reserve Santa Gracia, Chile, to observe the depth of the weathering zone in a semi-arid climate and compare the resulting model with existing borehole data (Krone et al., 2021; Weckmann et al., 2020). The acquired data can then be used for multiple seismic imaging techniques, including body wave tomography and multichannel analysis of surface waves.

2 Data acquisition

2.1 Experiment design

In January 2020, a seismic survey was conducted in the Private Reserve Santa Gracia, Chile, to investigate the deep weathering structure near the borehole location (Figure 1A). A 540 m-long seismic profile was created along a dirt road for this purpose. The elevation along the line ranged from 610 to 625 m (Figure 1B). The seismic acquisition parameters were specifically chosen to facilitate body wave tomography and surface wave analysis. To generate sufficient energy, seismic waves were produced using a 40 kg weight drop source. A total of 135 shot locations were positioned along the profile with 4 m spacing between each shot. The shots were recorded using a constant spread of 87 receivers, spaced 6 m apart along the entire line. An independent CUBE data logger was connected to each receiver point, and it was equipped with a three-component geophone featuring a response range of 4.5–150 Hz. The data from each geophone was saved in its respective CUBE. The source and receiver locations were projected onto a 500 m straight line using a method described by Zelt (1999), maintaining consistent source-receiver offsets. The maximum source-receiver offsets varied between 250 and 500 m.

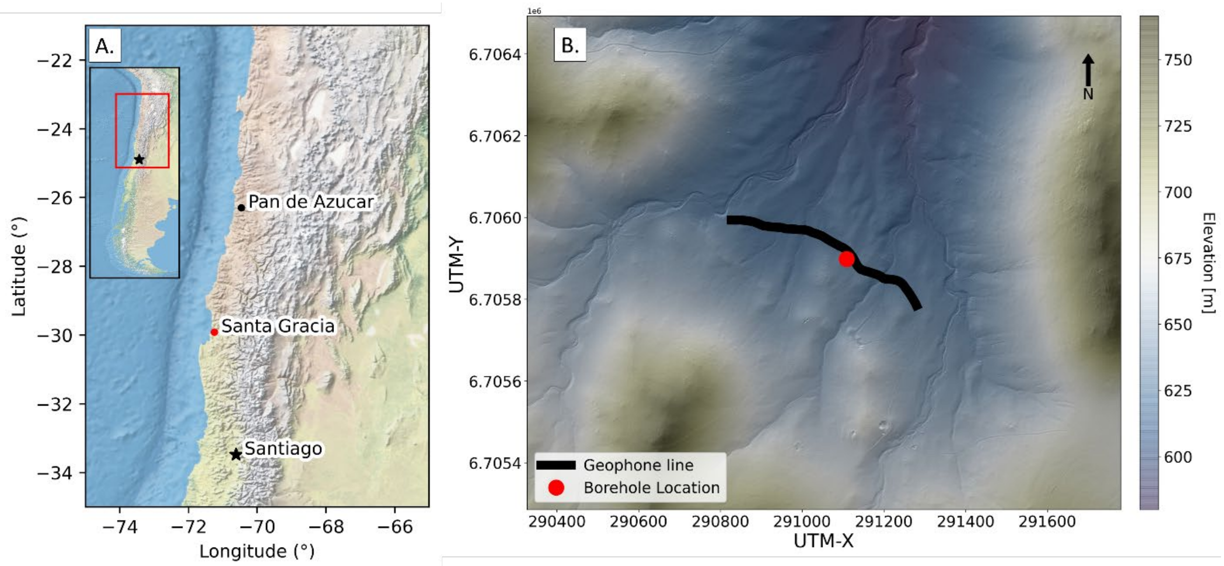

Figure 1 Overview map of the data acquisition. (A) Location map of the Santa Gracia National Park, and (B) seismic line over topography map of the study site.

2.2 Instruments

We used 87 CUBE3 seismic data loggers (more information at GIPP website – www.gfz-potsdam.de/gipp), each of which was connected to 3 components geophone with 4.5 Hz eigenfrequency. The CUBE3 data logger continuously recorded the seismic vibrations detected by the geophones while also syncing GPS time and location data. For the seismic source, we used a 40 kg accelerated seismic weight drop (PEG-40 by Geomatrix) which was connected to a trigger CUBE which recorded the GPS time of each shot conducted. A summary of the data acquisition parameters can be found in Table 1.

2.3 Acquisition parameters

Table 1 Acquisition parameters of the seismic experiment

Parameter	***Value***
Profile length	512 m
Geophone type	4.5Hz Geophone 3-C by Sensor Netherland/India, 4.5 Hz Eigenfrequency
Geophone spacing	6 m, 87 Geophones
Datalogger	DATA-CUBE3 by DiGOS
Source	Seismic Accelerated Weight Drop PEG-40 by Geomatrix
Shot spacing	4 m, 135 shots
Shot stacking	1 - 4
Sampling rate	400 Hz
Recording length	Continuous
Line orientation	SEE – NWW, geophones pointing inline to NWW.

2.4 Geometry

For the geometry, we provide 2 data information: the shot location and receiver location. Receiver location was obtained by processing the CUBE data logger GPS data which were averaged over time. A complete table of the receiver points can be found under ./info/rp.dat. An example of the first 10 data lines and a description of the table is given as follows in Table 2.

Table 2 Example of the first 10 lines of the receiver location data

Receiver-idx	*CUBE*	*longitude*	*latitude*	*elevation(m)*
1	961	-71.158656	-29.760642	623.88
7	473	-71.158686	-29.760596	623.68
13	464	-71.158716	-29.760549	623.44
19	963	-71.158746	-29.760502	623.10
25	954	-71.158776	-29.760456	622.84
31	466	-71.158806	-29.760409	622.35
37	958	-71.158835	-29.760362	621.79
43	960	-71.158872	-29.760317	621.27
49	477	-71.158909	-29.760272	620.73
55	463	-71.158943	-29.760228	620.58

[1] Receiver idx: Nominal inline receiver location
[2] CUBE: CUBE number
[3] longitude: Receiver longitude
[4] latitude: Receiver latitude
[5] elevation: Receiver elevation

As for the shot location, we extracted the coordinates recorded by the trigger cube connected to the weight drop source. A complete set of the source point can be found under ./info/sp.dat with examples of the first 10 lines of the data given in the following Table 3.

Table 3 Example of the first 10 lines of the shot location data

WD-idx	FFID	longitude	latitude	elevation(m)	shottime	WD-repeat
1	1001	-71.158656	-29.760642	623.79	2020-01-17T16:49:19.1214236	1
1	1001	-71.158656	-29.760642	623.79	2020-01-17T16:52:40.7510764	2
1	1001	-71.158656	-29.760642	623.79	2020-01-17T16:52:55.7242361	3
5	1005	-71.158676	-29.760611	623.69	2020-01-17T16:55:36.6722222	1
5	1005	-71.158676	-29.760611	623.69	2020-01-17T16:55:53.2953125	2
5	1005	-71.158676	-29.760611	623.69	2020-01-17T16:56:05.9091320	3
9	1009	-71.158696	-29.760580	623.56	2020-01-17T16:59:39.5801389	1
9	1009	-71.158696	-29.760580	623.56	2020-01-17T16:59:46.2313194	2
9	1009	-71.158696	-29.760580	623.56	2020-01-17T16:59:51.1435763	3
13	1013	-71.158716	-29.760549	623.36	2020-01-17T17:01:16.9747917	1

[1] WD-idx: Nominal inline receiver location
[2] FFID: Shot number
[3] longitude: Receiver longitude
[4] latitude: Receiver latitude
[5] elevation: Receiver elevation
[6] shottime: Shot-trigger date
[7] WD-repeat: Number of shots per location

3 Data pre-processing

The vertical component of the recorded data for each CUBE3 data logger was pre-processed at the Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences (GFZ). The raw data are provided under the folder ./raw/ which contains the data for each CUBE and the date of the data acquisition. These RAW data, including two horizontal components, were then converted to a miniseed format for further processing. The miniSEED data can be found under ./mseed/. Based on the shot time recorded, we then produced time series (1 second before the shot and 3 second after the shot) of the vertical components of all 135 shots from each continuous record. To increase the signal-to-noise ratio, we also performed vertical stacking of the gather with the same shot location and convert them to a commonly used SEG-Y format for further data processing. The pre-processed data can be found under ./segy/.

4 Data description

We provided data from different stage of the data pre-processing, including the raw data from the CUBE data logger, miniSEED data converted from the CUBE data, and the final SEGY data used for the processing. An overview of the folder structure is presented in Table 4.

Table 4 Directory structure of the given data

Directory	***Content of directory***	***Sub-directory***	***Content of sub-directory***
./raw	Raw data extracted from the cube.	./cube-XXX/YYMMDD/	Cube data divided into different cube number (XXX) and the starting date of the recording (YYMMDD).
./mseed	miniSEED data converted from the raw data in ./raw.		
./segy	SEGY data of the vertically stacked receiver gather.		
./info	Shot and receiver location data		

4.1 Raw data

The raw data extracted from the CUBE data logger are stored under ./raw folder. The files are named according to the CUBE number and the date of recording. For example, 01170000.974 will refer to the recording from CUBE number 974 that was operating on the 17th of January. The raw data contains all 3 components of the recording and the data can be extracted using the GIPP Tools (Lendl, 2021).

4.2 miniSEED

The miniSEED data are stored under ./mseed/ and contain all the miniSEED data of the 87 geophones with all 3 components. The miniSEED data was named according to the CUBE number and the starting date of the recording. For example, c0463191124000000.pri0 will refer to the recording of the vertical component (pri0) from CUBE number 463 (c0463) starting on 2019-11-24 (191124) at 00h:00m:00s (000000). These miniSEED files contain continuous recording and can be used for ambient noise data processing.

4.3 SEG-Y

The pre-processed data stored under ./segy/ contains vertically stacked time series data of all the shots and receivers. In total, the data has 87 x 135 traces of vertical component seismic recording. The file includes basic header information such as the signed offset, receiver index, and weight drop index. For further processing of the geometry, please use the receiver and weight drop index contained in the trace header of the SEGY file with the shot and receiver location data provided under ./info/. Some useful information that can be found in the trace header is shown in Table 5.

Table 5 SEG-Y data description

Byte-#	***SEG-Y description***	***Min val***	***Max val***	***Comment***
1-4	Trace sequence number within original field record	1	11745	
9-12	Receiver ID	1	535	Refer to ./info/rp.dat
13-16	Shot ID	1001	1537	Refer to ./info/sp.dat
37-40	Signed offset	-499	501	Source – receiver offset

Please note that the SEGY file was compiled as a receiver gather so that we have more trace density per shot. For the shots and receivers coordinates, please use the Receiver and Shot ID following the described shot and receiver information provided under ./info/.

5 Data quality/accuracy

The general quality of the data is good as the study area is located in a remote area with a minimum source of noise. Any remaining noise was also suppressed by the vertical stacking. However, we encountered equipment problems due to the extreme heat and could not maintain a consistent shot stacking for each shot point by the end of the profile, resulting in a diminishing signal-to-noise ratio at the far offset. Nevertheless, we managed to stack at least 2 shots for each shot point.

6 Data availability

The data is stored and archived at the GIPP Experiment and Data Archive. The data is openly accessible for additional purposes under a CC-BY 4.0 license following an embargo that will be lifted after July 1st, 2024. When utilizing the data, kindly acknowledge this data publication by providing a proper reference. The suggested citation is as follows:

Trichandi, R.; Bauer, K.; Ryberg, T.; Scherler, D.; Bataille, K.; Krawczyk, C. M. (2024): Geophysical Imaging of Deep EarthShape (GIDES): Seismic data of the Private Reserve Santa Gracia, Chile. GFZ Data Services. https://doi.org/10.5880/GFZ.201924.1

7 Acknowledgement

We express our gratitude for the support received from the German Science Foundation (DFG) priority research program SPP-1803 'EarthShape: Earth Surface Shaping by Biota' (Grant No. KR 2073/5-1 awarded to Charlotte M. Krawczyk). We would like to extend our appreciation to CONAF and the Park Rangers for granting us the opportunity to work in the national parks and for facilitating access to the research site. Special thanks go to M. Krüger, N.E. Hernandez Soto, and N. Carreño for their valuable assistance during the seismic data acquisition in Santa Gracia, Chile. Finally, we would like to acknowledge the Geophysical Instrument Pool Potsdam – GIPP (Grant number GIPP-201924) for providing us with all the necessary equipment for the seismic campaign.

8 References

Krone, L. V, Hampl, F. J., Schwerdhelm, C., Bryce, C., Ganzert, L., Kitte, A., Übernickel, K., Dielforder, A., Aldaz, S., Oses-Pedraza, R., Perez, J. P. H., Sanchez-Alfaro, P., Wagner, D., Weckmann, U., & von Blanckenburg, F. (2021). Deep weathering in the semi-arid Coastal Cordillera, Chile. *Scientific Reports*, *11*(1), 1–15. https://doi.org/10.1038/s41598-021-90267-7

Lendl, C. (2021). GIPPTools (2021.168). *Zenodo*. https://doi.org/10.5281/zenodo.4972595

Weckmann, U., Bauer, K., Krawczyk, C., Kück, J., Übernickel, K., & von Blanckenburg, F. (2020). Geophysical borehole logging data from Santa Gracia, Chile. *GFZ Data Services*. https://doi.org/10.5880/GFZ.2.7.2020.001

Zelt, C. A. (1999). Modelling strategies and model assessment for wide-angle seismic traveltime data. *Geophysical Journal International*, *139*(1), 183–204. https://doi.org/10.1046/j.1365-246X.1999.00934.x