



Seismic inversion of an Antarctic Sampling using python sbppy and a shallow high resolution seismic

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Abstract

We want to present a python library called sbppy which deals with sub-bottom profile data. In this work, we use it to invert an Antarctic sample acquired in Operantar 34 (AM10) and a High-resolution seismic survey acquired in Operantar 33. This contribution creates a synthetic trace to compare with the one obtained on Bransfield basin. The library sbppy may help users who need to use sub-bottom profile data in research and enable high-resolution shallow seismic data to the data science frameworks.

Introduction

This contribution wants to present a new python library called sbppy, which deals with sub-bottom profiling data also known as High-resolution Seismic. This Sub-bottom profiling data covers the upper part of the seafloor and is very common in Subsea Engineering, often used to determine the oil and gas pipeline routes. The High-resolution seismic can be seen as a single channel, and zero offset seismic since source and receiver are the same transducer. Its penetration capacity depends on the subsea material and the power of its source [1]. It reaches depths around 80 meters below the seafloor in muddy sediments with nowadays sensors [2]. The resolution depends on the velocity of the vehicle, which is acquiring the data (AUV or vessel) due to its ping rate. Also, the bandwidth used - it often operates with KHz frequency with sampling interval of a few microseconds of resulting in a large number of samples per trace, and a large number of traces pretty close to one another. These particularities bring a hard time to commercial softwares used to interpret and process conventional multichannel seismic.

To solve the issues regarding these particularities of this kind of data, a library – SBPPY was develop at LAGEMAR (Marine Geology Laboratory) of Universidade Federal Fluminense -. It opens High-Resolution seismic file and enables the users to access the desired fields in traces headers and binary headers. It is Object-oriented

and this way the access is simple and straight since each trace is a callable object. Using this library the user can write specific python routines using SBP data. It is possible to feed a neuronal network system wrote in Pythorch or Tensorflow directly, or plotting using libraries like Matplotlib[3] or even create probes with python-geoprobe [4] to use with Mayavi [5].

To exemplify the use of this library, we propose a preliminary inversion of a sediment core (AM10) acquired during Operantar 34 in Bransfield basin (figure 1), using a gravity-corer. The core was logged for Vp and density with a Geotek Multi-Sensor Core Logger on March 7 of 2018. With P-wave velocity and Density curves, we generated the Impedance and Reflectivity profile. After that a synthetic trace was created to compare with the high-resolution seismic trace #85037 from the SBP line P2-3Sisisters11.seg..

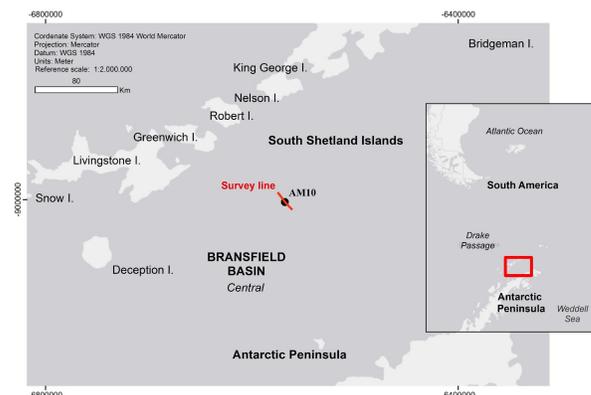


Figure 1 – Study Area in Bransfield Basin, with SBP line and AM10 sample.

Method

The seismic data was acquired during Operantar 33 on board of the Brazilian Navy Almirante Maximiano with a hull mount system Kongsberg SP120 at the Bransfield basin as shown in Figure 1. Figure 2 shows a zoom into the profile plotted using the sbppy and matplotlib libraries. This window is a matrix where the columns are traces from sbp file and lines are samples (sample interval is 48 microseconds).

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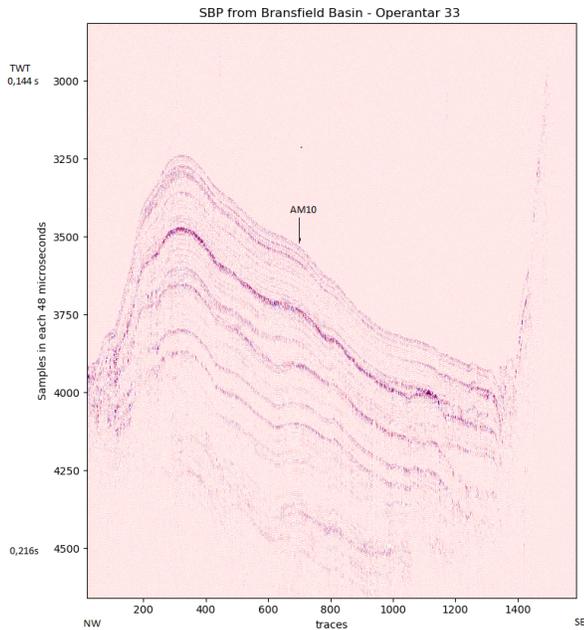


Figure 2 – Sub-bottom Profile plotted using sbppy and matplotlib, number of samples in vertical axis and traces on horizontal axis.

One year later in Operantar 34, we acquire a geological core (AM10) with a gravity corer. Figure 1 shows the coordinates of this geological sampling.

The core was logged using the Multi-Sensor Core Logger (MSCL), produced by Geotek Ltd. The MSCL makes high quality measures with high resolution (1 cm) along the core. For this work, we only used the data of Compressional Wave Velocity and Gamma Density..

The MSCL measures density through the interaction of gamma rays with the sediment. The sensor consists of a ten milli-Curie 137 Cesium capsule with collimators of 2.5 to 5mm in diameter and a scintillation detector. During the measurement, it emits, disperse and transmit photons through the sediments. It determines the density of the material by counting not attenuated photons. Thus, the gamma detection system only counts the photons that have maintained the same primary source energy [6].

Two diametrically opposed ultrasound transducers measures the P-wave velocity at the frequency of 250 kHz positioned perpendicular to the axis of the core. It measures the elapsed time between the transmission and detection of a sound wave after being attenuated. It calculates the velocity by dividing the tube diameter by the signal's transit time [6].

Due to logistic issues, the core was split into five subsections each one with 1 m long. This operation uses a plastic cap to seal the core, which leads to wrong measures at the top and base of each section. Figure 3 shows the VP, density and Core Length profiles after the deletion process.

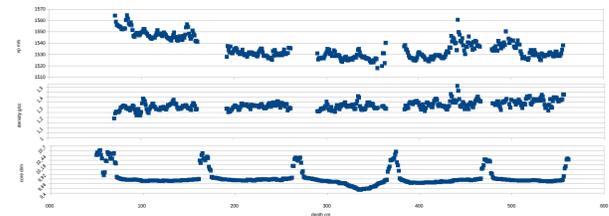


Figure 3 – P-wave velocity profile, density profile and core length profile.

The product of these two profiles (VP and density) generates an impedance measure, which we use to create a reflectivity function. This function models the elastic Impulse response expect from Earth. Since we are trying to use it with Sub-bottom profile data it is good to put them both in the same time domain. At this point it is essential to notice that the SBP has a higher sample interval (four times) than the reflectivity interval which is critical to avoid artifacts or have some alias effect. Figure 4 shows the resultant reflectivity and the reflectivity resampled to the sample interval of the SBP data (48 microseconds).

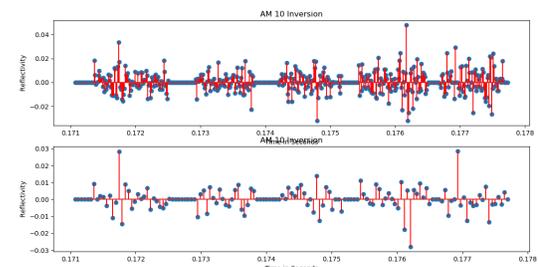


Figure 4 – Reflectivity and Reflectivity resampled. It is possible to note the gap between data due to corers' edges.

To generate a synthetic trace to compare with the one from the SBP data, we convolve the reflectivity function calculated from MSCL profiles with the wavelet generated by convolution between the chirp-signal with itself [7]. The Chirp Signal has a 10 ms pulse length and a linear form starting at frequency 2500 Hz and end frequency of 6500 Hz. Figure 5 shows the chirp signal in time, and its Wavelet generated.

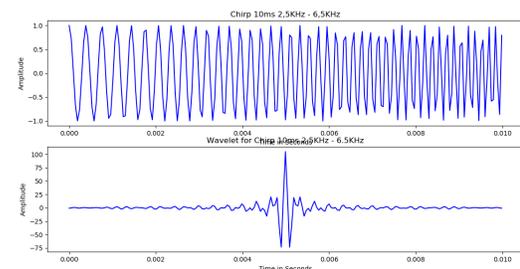


Figure 5 – Chirp in time and its wavelet.

To compare the two traces we used sbppy to load the traces from survey seg file to a sbppy data structure. The method readtraces returns a numpy matrix where it is possible to access the data traces from sbp file. Once this

data is in a numpy array, the user can print using any plotter library like matplotlib for example. Using the sbppy library, we plotted the Figure 2.

It is easy to get useful information from the sbp file like the minimum and maximum coordinates using the methods getMinMaxCoords(). We used methods to read the trace header to check which trace is the closest one to core AM10. We choose the trace #85037 to compare with the synthetic trace.

Results

After retrieving the trace #85037 information using sbppy, it is ready to compare with the synthetic trace generated. No USBL system was used to control the exact position of the corer device at the seafloor; Thus, the coordinate used is referenced to the ship's GPS system. Due to lack of data at the top and bottom of each sub-section the synthetic trace was not a perfect match. We have a lot of expected attenuation, which we want to measure in future works to know if it is possible to have an indication of the sediments type. In fact, the lack of data make an impact in continuity of the trace, some Gibbs effects caused by it.

Figure 6 shows them both the synthetic and the original field trace. Figure 7 is a zoom in. Figure 8 is a cross-correlation between the two signals where it is possible to confirm a misfit.

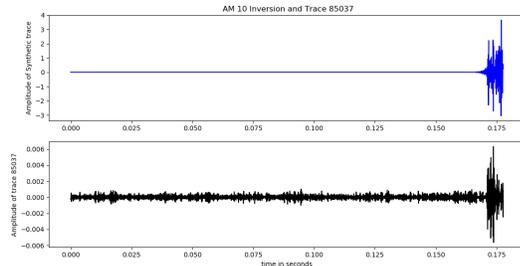


Figure 6 – The Synthetic trace on top and Acquired on Bottom.

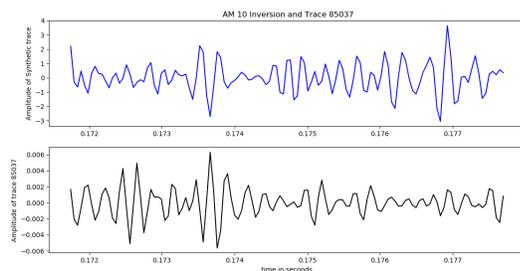


Figure 7 – A zoom in the begging of both traces to compare phase and amplitudes.

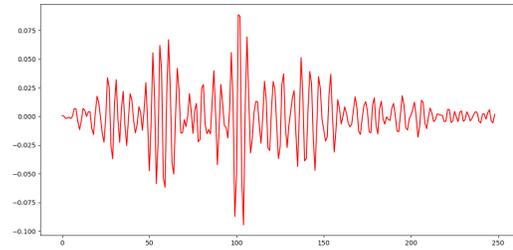


Figure 8 – A cross-correlation between the synthetic trace, and the original trace, the misplacing is shown.

Conclusions

We conclude that sbppy library enables users to access the information in sbp files and to afford it in a structured way. It will help in future studies regarding spreading punctual information like geotechnical sampling or geological sampling into SBP files which has 2D behavior or even 3D. The library will help to push high-resolution seismic to data science frameworks. The quality of a synthetic trace depends on the continuity of the profile, and perhaps with more extended profiles, we may reach better results.

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