

BOTOSEIS: A NEW SEISMIC UNIX BASED INTERACTIVE PLATFORM FOR SEISMIC DATA PROCESSING

W. Lima, G. Garabito, I. G. Oliveira and J. C. R. Cruz

email: *german@ufpa.br*

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ABSTRACT

After eight years of the first distribution of the user's manual of the Seismic Unix (SU) package, it is yet a challenge to execute some seismic processing SU scripts, especially for inexperienced users. Up to now there are few friendly Graphical User Interfaces (GUI) for the SU package, namely Tksu, iSU and GêBR. In order to obtain a more robust and flexible way to work with the SU package, we present a new graphical user interface written in the Java programming language, which can be used under any operating system, the so-called BOTOSEIS. It is adequate to be used both as a production or as interactive development environment, by creating and managing projects, lines and flowcharts of seismic data processing. It is also possible to add SU based softwares, interactively, without knowledge about any programming language. The BOTOSEIS platform is structured by modules, which can be a single application or a combination of SU programs to produce a more complex result, e.g., iVIEW, iVELAN and iNIP-PICKING. The first is a GUI used for data visualization, the second is an important interactive tool for velocity analysis fitted for production environments, and the last is a software for data picking in the zero-offset seismic section that is fundamental for travelttime inversion methods.

INTRODUCTION

The Seismic Unix (SU) package was developed with the initial support of the Society of Exploration Geophysicists (SEG) and the Gas Research Institute (GRI). Nowadays it is supported by the Center for Wave Phenomena (CWP) of the Colorado School of Mines, United States of America (USA). It is a data processing environment for Unix-based systems, written mainly in C language, which extends the Unix operating systems for seismic processing production and research tasks, and it is completely free and open source (Cohen and Stockwell Jr., 2000). With SU package fundamental techniques of seismic data processing (e.g., spectral analysis, F-K filter, velocity analysis, NMO-DMO stack, deconvolution, migration and others) are applied by using command lines or script files. Due to this fact, students or professionals without experience in the use of commands and scripts have difficulties in using the SU package. Even so the SU software has been successfully used in the geophysical community, considering its important characteristics referring to facilities for seismic data processing without using any commercial package, which is a strong advantage for the academic institutions and researchers (Stockwell Jr., 1999).

In order to facilitate the access to the SU applications, the graphical interfaces Tksu, iSU and GêBR were developed by users of different institutions. The Tksu is developed in the Tcl/Tk language, it is a graphical environment to build interactively flowcharts for seismic processing. The iSU software has as main features the execution of a single process or a sequence of processes from a special dialog box. The GêBR software is developed by using GTKmm library at Campinas University (UNICAMP), Brazil. It is adequate to manage projects and seismic lines, and also to create, execute and manage flowcharts.

The SU package is not only the most famous geophysical free software, but it is also an excellent tool for new developments, students and researchers interested in seismic data processing. Therefore, to

facilitate the use of SU software it is necessary to have an efficient and robust graphical user interface.

To reach this goal, at Federal University of Para, Brazil, in recent years have been implemented projects to develop graphical user interfaces for SU software and some main processes of seismic data processing. As a result of this endeavor, we present the BOTOSEIS platform. It is a software written in the Java programming language with a graphical environment to create and manage projects, lines and processing flowcharts. The name BOTO refers to a legendary fish from the Amazon river frequently used as main character of local folk tales.

Besides the SU package, the BOTOSEIS platform includes three interactive modules (iVIEW, iVELAN and iNIP-PICKING) that are special tools based on SU applications. With iVIEW it is possible to obtain different visualization modes of multiple seismic sections, it has, also, dialog boxes for applying gains and for viewing headers of the seismic traces. The iVELAN is a GUI software based on SU applications for interactive velocity analysis in common-midpoint seismic domain, the so-called CMP method. The iNIP-PICKING is a software for semi-automatic amplitude picking of a selected point or of a target seismic horizon on a zero-offset (ZO) section, by using local properties of the interpreted reflector.

BOTOSEIS PLATFORM

Since 2003 years, researchers at Federal University of Pará, Brazil, have dedicated an important part of their time on the development of an interactive graphical interface, that is able to create and manage SU based processes, by resulting in the development of the BOTOSEIS platform. In order to make easier its application, the BOTOSEIS preserves some characteristics of well-known commercial seismic data processing packages. The BOTOSEIS user can create, manage and execute projects, lines and flowcharts from only one interactive environment. In the flowcharts the processes can be interactively inserted, moved or excluded.

The BOTOSEIS platform offers the following possibilities: a) the main work environment is constituted by five areas, to be known: 1) *visualization of project, lines and flowcharts* 2) *visualization of programs grouped in categories*; 3) *visualization and interactive manipulation of processing flowcharts*; 4) *dialog window to insert parameters of the SU programs in a flowchart*; and 5) *visualization of errors and log files to verify the process*;

By means of the main interface the user creates and manages projects, lines and flowcharts. Also, it is possible to move, exclude, and add SU process in the flowchart, and to execute and stop a process. The BOTOSEIS allows the inclusion of SU modules or other Unix based packages in the interactive work environment.

In Figure 1 it is shown the main work environment of the BOTOSEIS platform. On the upper left we show the window for management of projects, lines and flowcharts and in the bottom the work place for selecting SU or others programs. In the central part there is a place to build flowcharts with options to run, pause, and kill a process, and also to obtain information of it. On the right we have the window to insert the parameters of the processes. In Figure 2 we have tool boxes to add interactively new programs in the BOTOSEIS platform, very important for customizing the BOTOSEIS environment.

INTERACTIVE MODULES

The philosophy behind BOTOSEIS development is to make possible the expandability and flexibility of the SU package in only one interactive environment, preserving the free software characteristics. It is structured by modules that can be a single program or a combination of SU based softwares, in order to produce a more complex result, e.g., the so-called iVIEW (Lima et al., 2006), iVELAN (Lima et al., 2007) and iNIP-PICKING (Oliveira, 2006) that are presented in this section.

iVIEW

The iVIEW is a tool for the visualization of seismic data with the functionalities of the three SU visualization programs (suximage, suxwigb and suxcontour) in only one graphical interface, written initially in the C++ programming language. Currently the iVIEW is being rewritten in the Java. This interface provides a more robust and flexible data visualization tool, by using the same advantages of the softwares ximage, xwigb, xcontour and others of the SU package.

The main features of iVIEW module are: a) The visualization modes: *image*, *wiggle*, *contour*, *image+wiggle* and *image+contour*; b) visualization of multiple sections; c) zoom tool; e) dialog boxes for header display and gain application.

We can see in Figure 3 the class diagram of the iVIEW, with the input and output data structure for various types of visualization of seismic data. In Figure 4 we show an example with the *image+wiggle* visualization mode using the iVIEW. It is important to point out that this result is fully based on the SU package. In Figure 5 we show the trace visualization in wiggle mode, with headers information displayed by a dialog window that is activated by a mouse click at the desired trace.

iVELAN

The iVELAN is an interactive software for velocity analysis using the common-midpoint technique, based on a combination of SU programs. Its first version was written in C++, but currently it is being rewritten in the Java language to guarantee better portability. The interactivity necessary to do the velocity analysis was reached by using a flexible graphical interface based on SU codes, that are organized in classes by means of a central work environment.

The main features of the iVELAN are: a) Selection and visualization of CMP sections into a given interval; b) image visualization of the coherence semblance panel; c) images of stacked traces from nearby CMP data sections by using constant velocities, the so-called constant velocity stack (CVS); d) visualization of the hyperbolic curve on the CMP section as the mouse pointer moves in the image of coherence (semblance) or CVS panel; e) the option to apply and remove normal moveout (NMO) correction.

An example of application of the iVELAN software is shown in Figure 6. On the left side we visualize the CMP data section, the red line is the NMO hyperbola to be fitted on the reflection data for optimal stacking velocity. On the upper left there are buttons to apply and to remove the NMO correction, and to advance for the next CMP section. The coherence semblance image in the central part of the figure is used to define interactively the best stack velocity at each ZO reflection traveltimes. On the right of the same figure we have the CVS panel that is built for various constant stack velocity values, and it can also be used to define the optimal velocity to apply the NMO correction. In Figure 7 on the left we can see the NMO corrected CMP data section.

iNIP-PICKING

The seismic velocity model is the most important information for performing pre-stack or post-stack depth migrations. To solve the velocity problem, (Billete and Lambaré, 1998) proposed a tomography method that depends only on zero-offset (ZO) traveltimes, and (Duvencek, 2004) presented a new tomography method that uses the ZO traveltimes and two parameters that are determined by the Common-Reflection-Surface (CRS) stack method (Garabito et al., 2001) and (Jäger et al., 2001), the radius of curvature of the normal incidence point (NIP) wave and the emergence angle of the reflection normal ray, the so-called NIP-CRS parameters. The amplitudes of the ZO traveltimes are extracted from ZO stacked section by picking the seismic events, and the associated CRS parameters pairs are automatically selected from CRS panels.

The iNIP-PICKING software is written in the Java language and it has two picking possibilities: point-to-point and horizon based picking. In the former case the user must choose point-to-point seismic events on the ZO stacked section, and in the last case some automatic criterion must be used to pick the ZO traveltimes from one selected point of a target seismic horizon.

As it was originally proposed by (Duvencek, 2004), in the point-to-point picking the amplitudes of the ZO traveltimes are extracted from a ZO stacked section, by using the iNIP-PICKING software, and the associated CRS parameters pairs are automatically selected from CRS panels.

In the other hand, for the horizon based picking, the iNIP-PICKING software follows the strategy: a) Based on the semblance panels of the CRS stack processing, it is selected reflection events of the ZO stacked section, so-called target seismic horizons; b) one point must be chosen of a target seismic horizon, the so-called reference point; c) At this selected point, the orientation of the target seismic horizon is determined by using the emergence angle of the CRS stack processing; d) it is calculated the mean amplitude of the predefined nearby points on the left and right positions of the reference point; e) the iNIP-PICKING

program uses the mean amplitude as criterion to searches for the best points on the left and right directions, only points of amplitude higher than the mean value is an acceptable event. In order to improve the picking result, in the final stage the user may edit the picked data to avoid undesirable events.

In Figure 8 we have an example of the target reflection event on the ZO section. The gray area indicates the target reflector marked with the yellow line. In the Figure 9 there is an example of a curved seismic horizon, where the red points on the event were picked by using the criterion above. In Figure 10 we look at 1076 picked points on the ZO-CRS stacked section of the Marmousi data.

CONCLUSIONS

In this paper we presented the first versions of the BOTOSEIS platform, and its interactive modules iVIEW, iVELAN and iNIP-PICKING. The BOTOSEIS is a platform for interactive applications of SU programs. The interactive modules are SU based tools for data visualization, velocity analysis and ZO data picking, respectively. These softwares can be considered important alternatives for using the facilities offered by the SU package for doing seismic data processing. These softwares are written in the Java programming language, in order to improve their portabilities and follow the free software philosophy like the SU package. They are adequate for students, researchers and other professional interested in seismic data processing developments.

In comparison with other softwares, like GêBr, the BOTOSEIS platform is more portable because it is based on Java language, and it is interactively module structured for preserving the main characteristics of commercial seismic processing package.

ACKNOWLEDGMENTS

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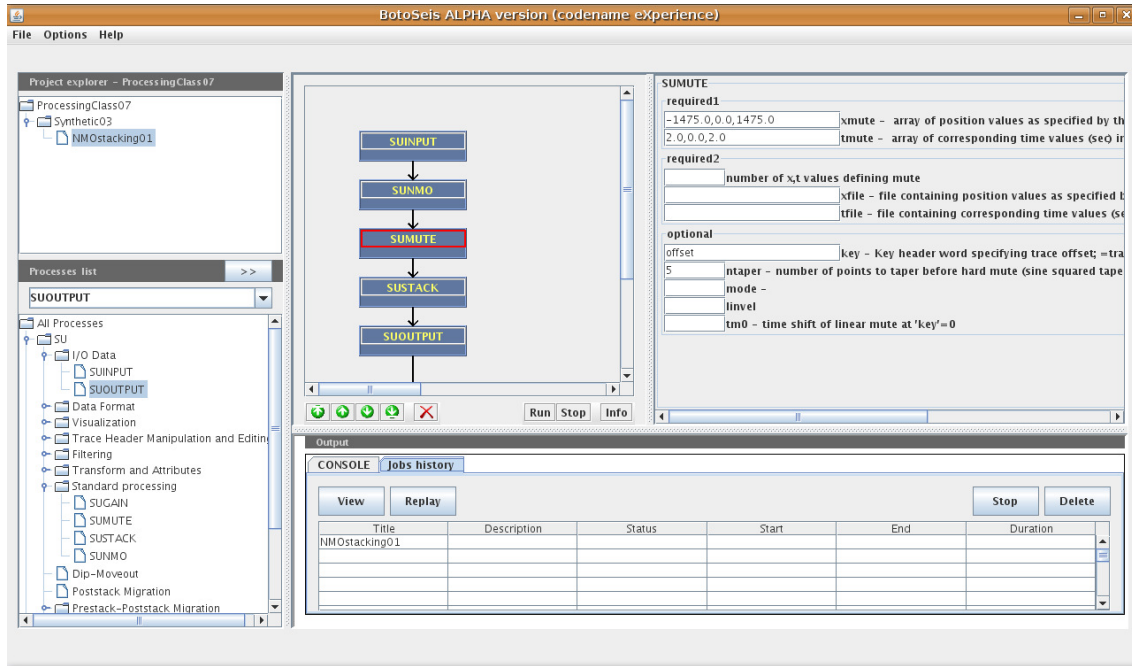


Figure 1: The main work environment of the BOTOSEIS platform with flowchart and dialog box for parameters edition.

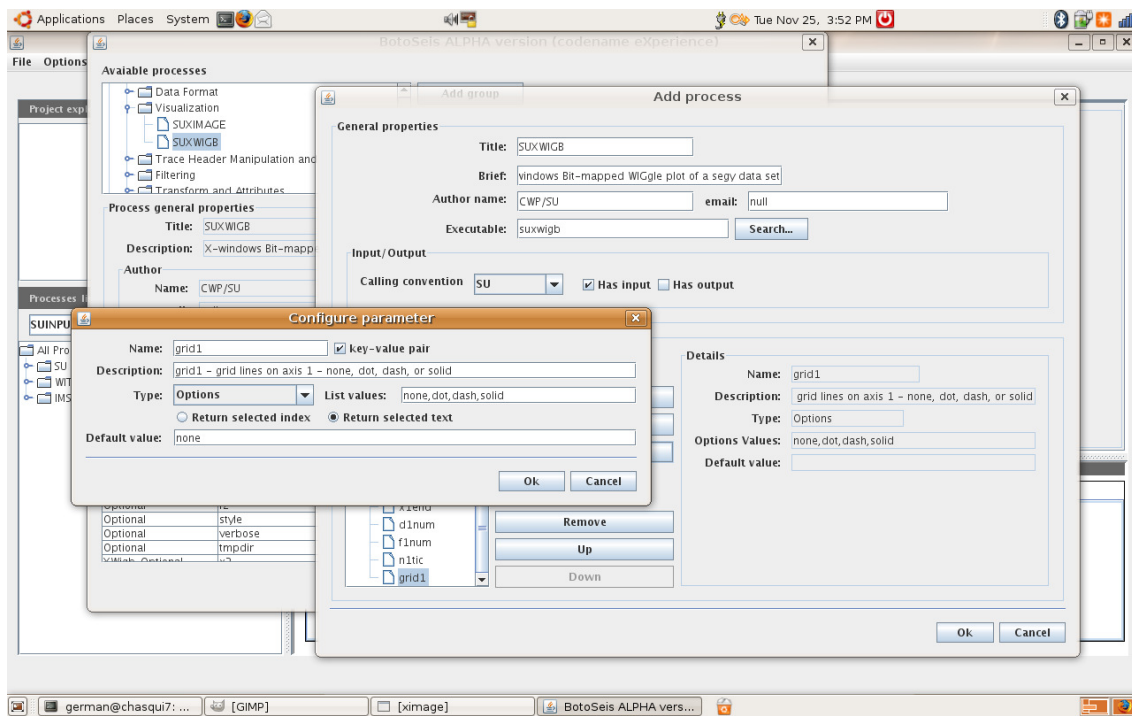


Figure 2: The tool boxes to add interactively new programs in the BOTOSEIS platform.

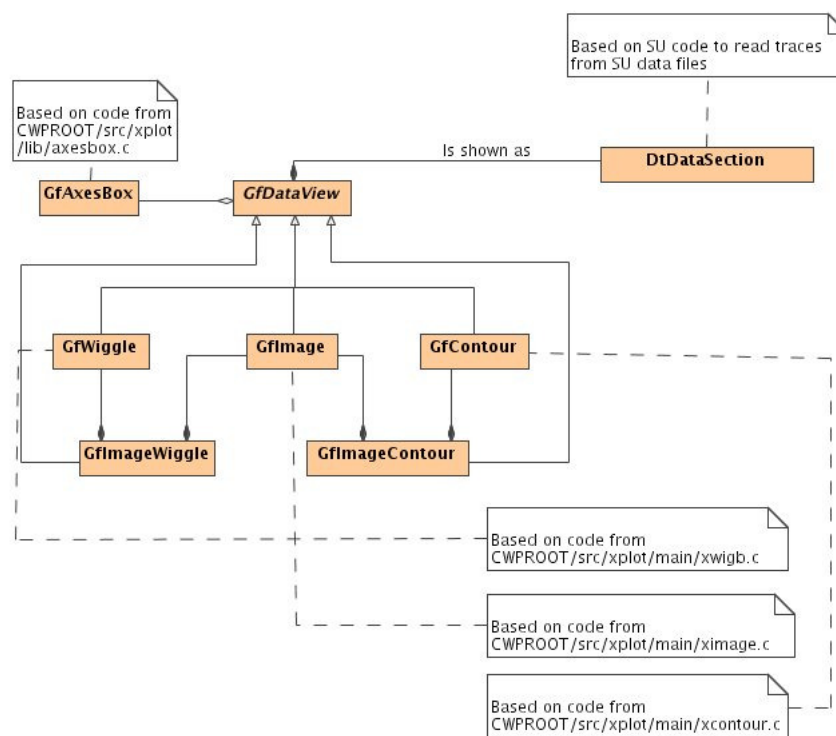


Figure 3: The class diagram of the iVIEW module, with the input and output data structure for various types of presentation of the seismic data.

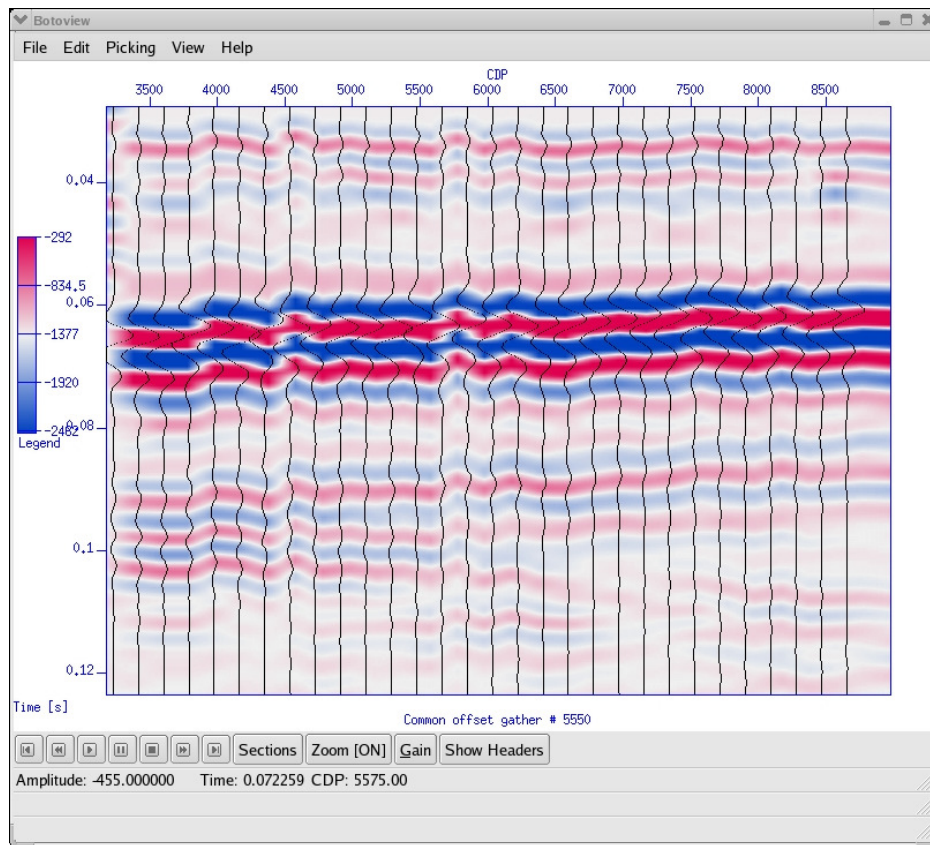


Figure 4: Visualization in image+wiggle mode by using the iVIEW software.

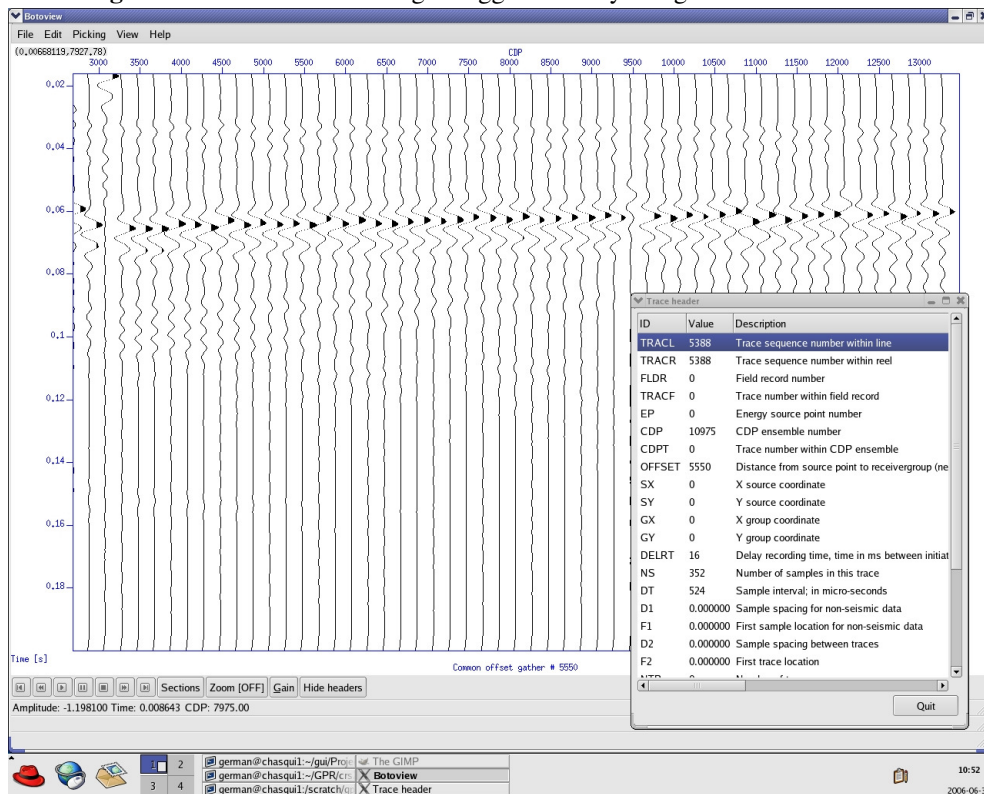


Figure 5: Visualization in wiggle mode. The trace headers information are displayed in an appropriate window.

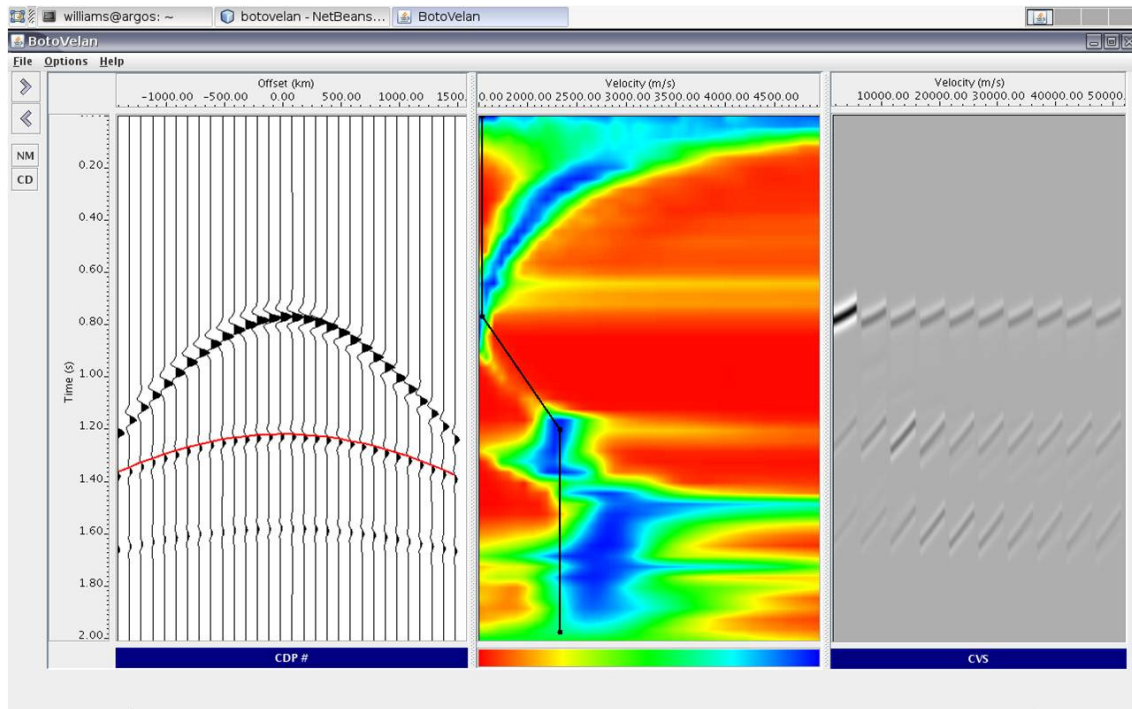


Figure 6: Example of application of the iVELAN software for velocity analysis.

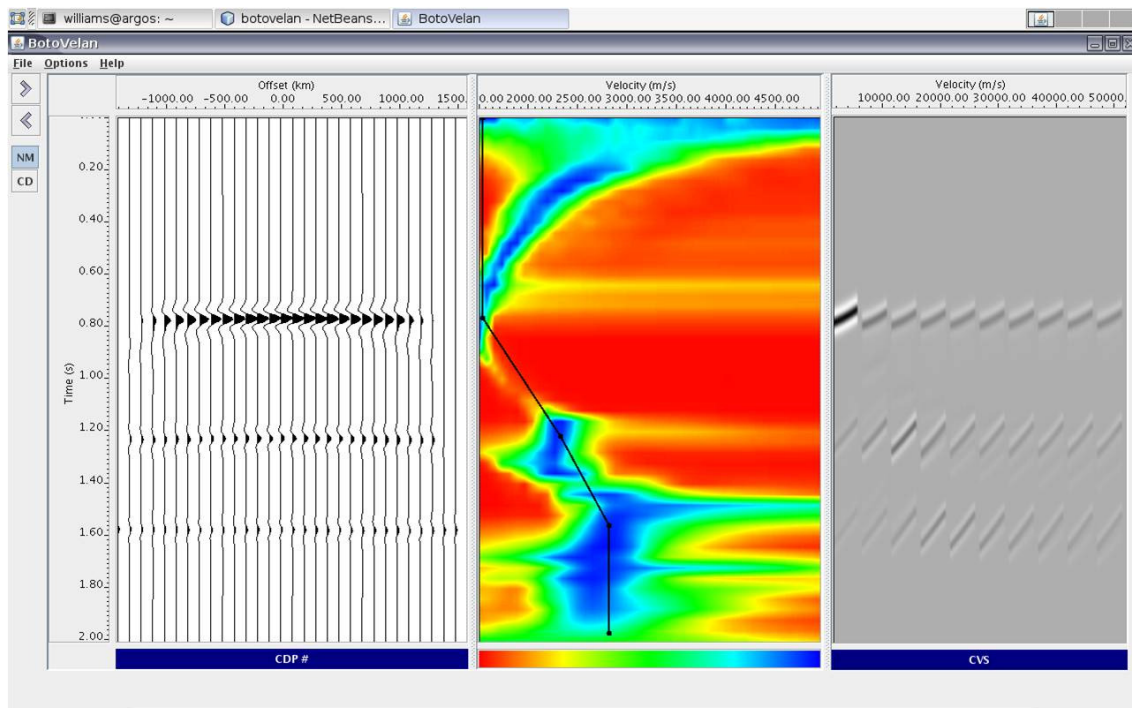


Figure 7: The NMO corrected CMP section applied using the picked velocities displayed in red line.

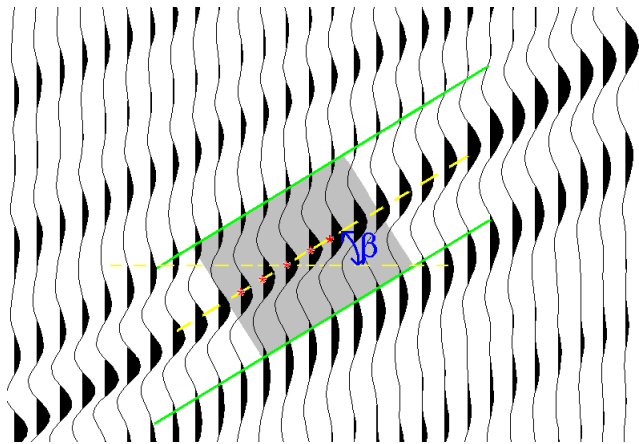


Figure 8: Example of the target reflector on the ZO section, with the reference point and the assigned angle to start the iNIP-PICKING software.

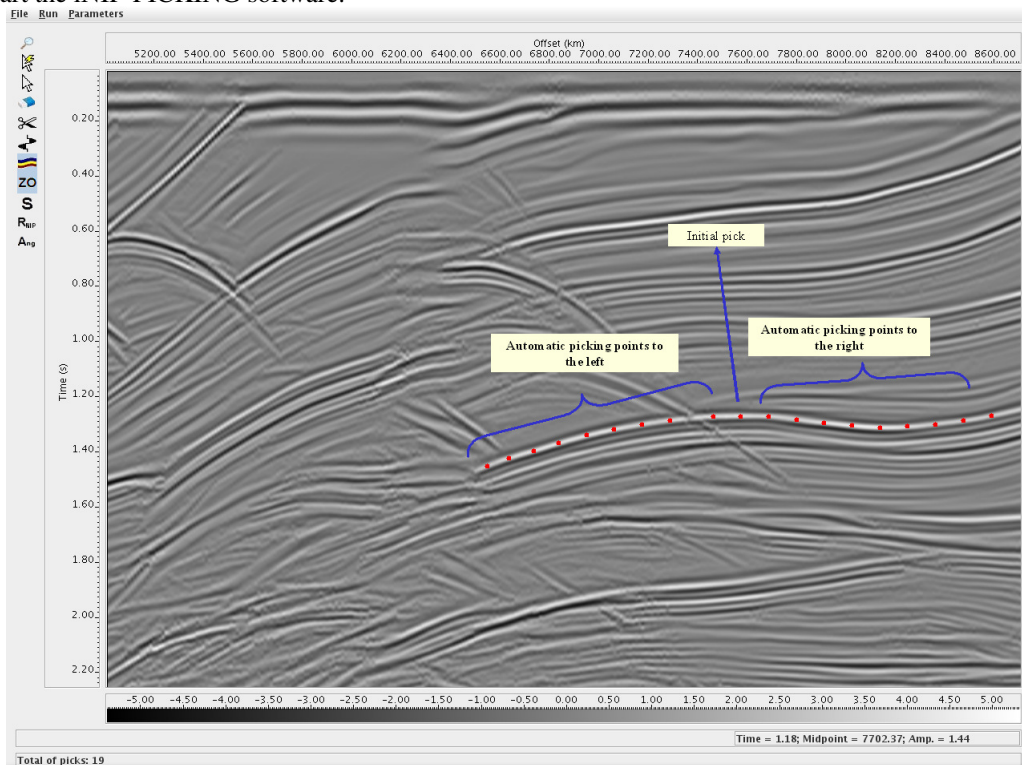


Figure 9: Example of picked points on a curved seismic horizon, by using the iNIP-PICKING software.

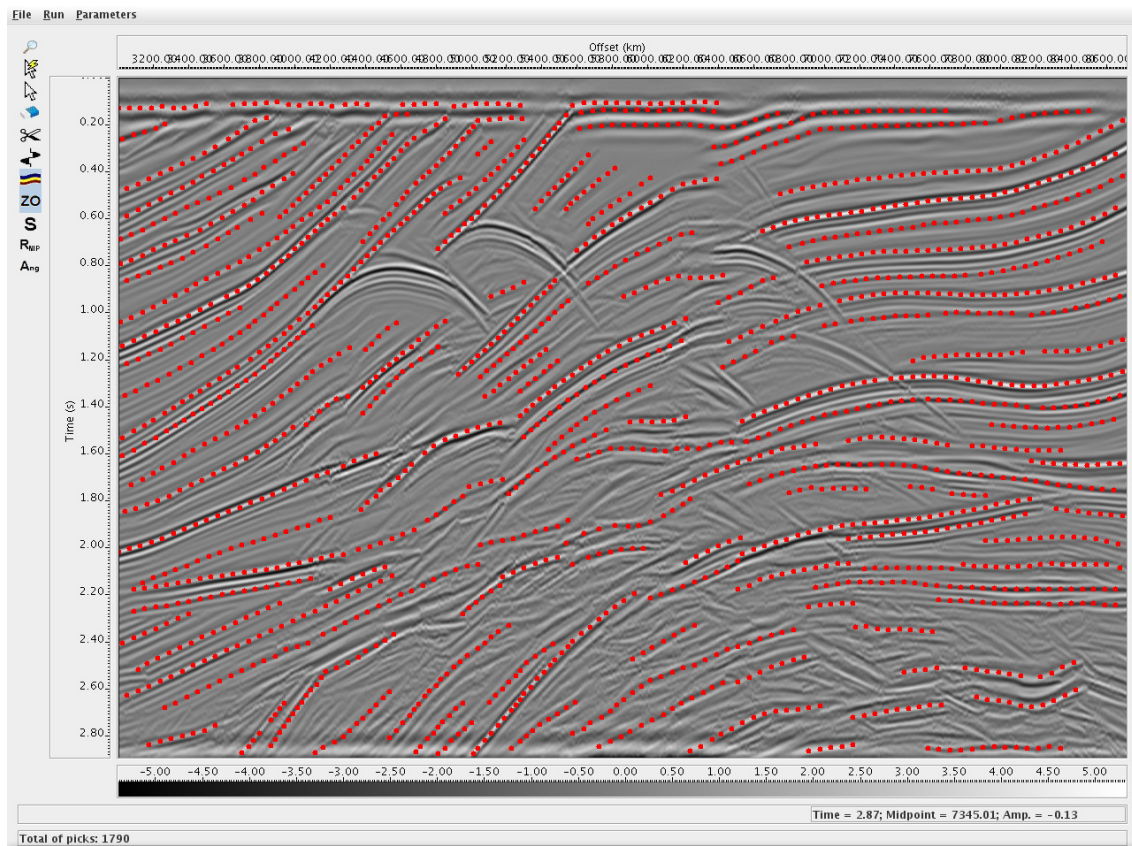


Figure 10: Points on the ZO-CRS stacked section of the Marmousi data, as result of applying the iNIP-PICKING software.