Structure and Tectonics of the Offshore Region Close to Kayak Island from Geophysical Information

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STRUCTURE AND TECTONICS OF THE OFFSHORE REGION CLOSE TO KAYAK ISLAND FROM GEOPHYSICAL INFORMATION

A Thesis

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by

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To my best teachers, my best friends, and the more precious gift that I have received from life: my parents Rosendo and Honoria, and my sister Ninfa America

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ABSTRACT

The principal goal of this research is to clarify the structure and tectonic setting of the Southern Alaska and, specifically, the offshore area close to Kayak Island.

Seismic reflection data collected in 1976 in the offshore region of Kayak Island in the Gulf of Alaska were reprocessed in order to improve the quality of the signal by applying seismic data processing techniques that were not available at the time in which the data were obtained. The processed data were then interpreted, focusing on identifying patterns that indicate the direction, as well as the intensity of deformation.

The deformation pattern observed in this research suggests that the major deformation of the region is located at the northwest side of Kayak Island.

INTRODUCTION

The role of the Yakutat micro plate in the interaction between the Pacific plate and the North American plate is not well established. In the Gulf of Alaska, the Pacific plate is obliquely subducting beneath the North American plate while the Yakutat micro plate appears to be simultaneously underthrusting and accreting to the North America plate (figure 1) (Bruhn et al., 2003). This complex tectonic setting has generated impressive geological structures like the Fairweather transform fault system and the major orogenic highland of the Saint Elias Mountains.

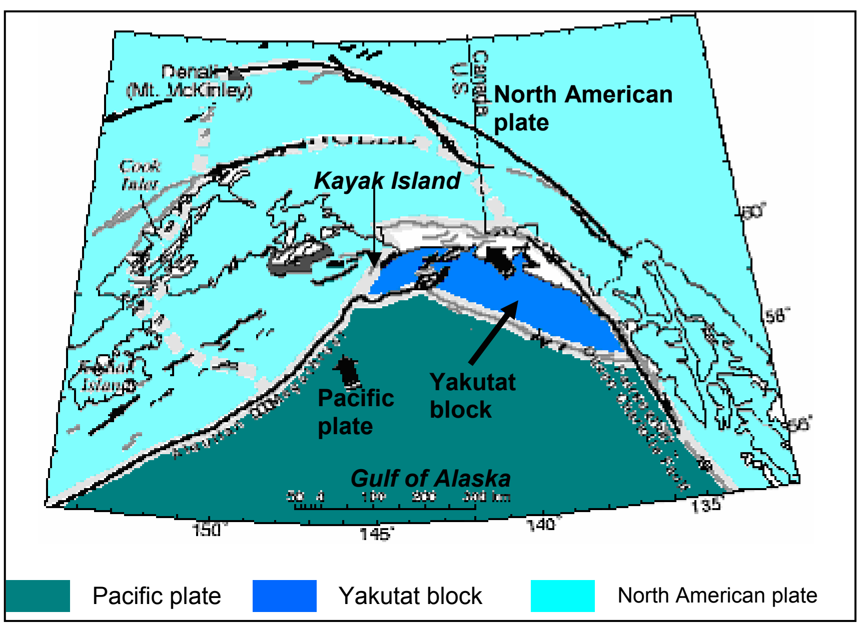


Figure 1: Map shown the Southern Alaska.

(Modified from http://www.scec.org/news/01news/es_abstracts/Haeussler_EarthScope.pdf)

In the last decades much research (e.g. Bruns and Schwab, 1982; Bruhn et al., 2003; Picornell et al., 2001; Fletcher and Freymueller, 1999; Zellers, 1995) has been done in order to understand the geological structure and the tectonic setting of the southern Alaska orogen. However, fundamental problems such as the way in which contraction and strike-slip deformation is partitioned, how the plate motion is accommodated, the way in which the Yakutat micro plate is being accreted, the location of deformation, and the micro plate boundaries are still without appropriate explanations (Fletcher and Freymueller, 1999;Brunh et al., 2004; Pavlis at al., 2004).

In the present research, existing seismic reflection data from the offshore region close to Kayak Island, located at 145°- 144°longitude and 59°- 60°latitude (figure 2.), were processed and interpreted using the programs ProMAX ™ and Kingdom Suite™ . The goal of this study is to identify the principal structures of the area, as well as the delineation of event sequences to clarify aspects related to the tectonic evolution of the Yakutat-Pacific-North America complex.

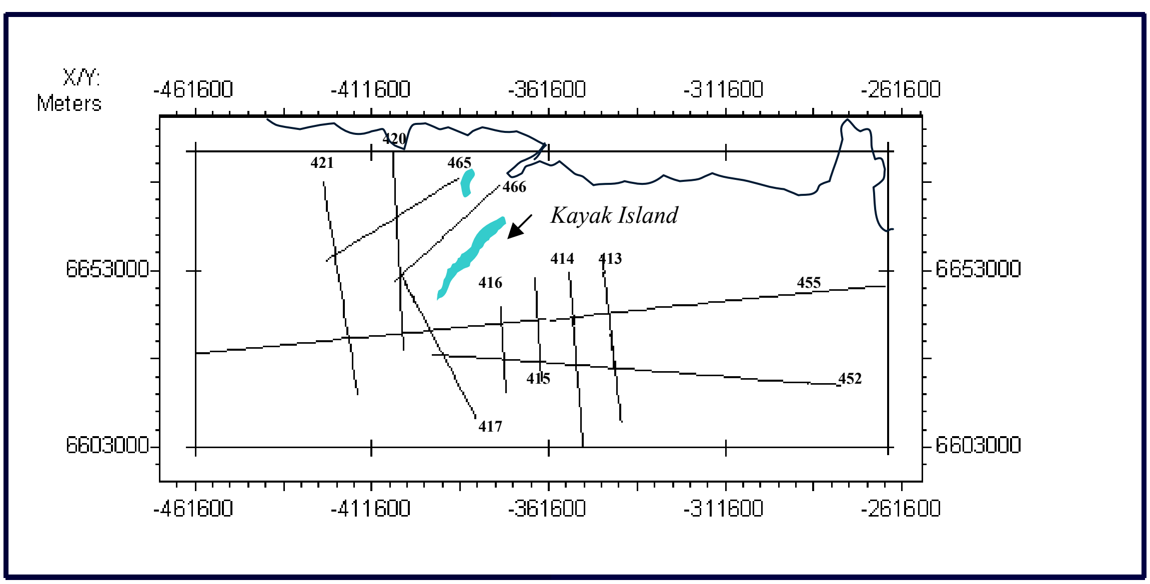


Figure 2: Map showing the research area.

In this report firstly a brief background related to the tectonic of southern Alaska is given. Following, the statement of this research is presented. Immediately after the seismic data processing sequence is described and afterward an interpretation of the seismic data is presented. Finally a discussion and summary of this research is done.

BACKGROUND

Southern Alaska Tectonic Setting and Principal Geological Features

The Southern Alaska tectonic system is characterized by oblique convergence between the Pacific and the North American plate (figure 1). The Pacific plate is moving northwestward relative to Alaska along the Queen Charlotte-Fairweather transform fault system and is converging with the North American plate in the eastern Aleutian trench and the Kayak Island-Pamplona zone (Bruhn et al., 2003, Pavlis et al., 2004). The Nuvel I model gives a velocity of the Pacific plate with respect to North America of ~51mm/yr near 142°W and 60mm/yr near 164°W (Bruhn et al., 2003).

Perhaps the most important feature of this region is the presence of a fragment of continental crust known as the Yakutat microplate, located between the Aleutian trench and the transform fault system (figure 1). The block is believed to have originated along the Kula-Farallon spreading center about 45 Ma and is the last of the allochthonous terranes that have been colliding and accreting to North America plate during the last 200 Ma (Bruns, 1983). The Yakutat block plays an important role in the dynamics of this area and may be responsible for the most prominent geological structures observed in the region (Pavlis et al., 2004). It is being driven obliquely underneath the North American continental crust but has a density similar to the overriding crust. As a result, great rates of uplift are observed in the Chugach as well as in

the St. Elias Mountains (Bruhn et al., 2003). Partitioning of collisional strain takes place due to the oblique motion of the Yakutat microplate, which adds complexity to the geological puzzle present in the region.

Summary of Previous Work and Ongoing Research

Saint Elias Mountains Orogen and Tectonic Project

In order to clarify the origin of St. Elias orogen in the Southern Alaska, two different models have been proposed: The collisional model (Plafker et al., 1994) and the transpressional model (Bruhn et al., 2004; Pavlis et al., 2004). The collisional model predicts that the St. Elias Mountains are the result of the collision between the Yakutat block and North American plate. According to this model, the Fairweather fault ends near Yakutat Bay, transferring slip into the thrust belt. In contrast, the transpressional model suggests the plate boundary between Yakutat and North America is a slip-partitioned, transpressional orogen in which the strike-slip component is accommodated on the Fairweather-Bagley transform fault system and the contractional component accommodated along active thrusts of the offshore fold and thrust belt. This model predicts that the Fairweather fault continues westward into the interior of the St. Elias Mountains (Pavlis et al., 2004).

In an effort to test those models, a project between the University of Utah and the University of New Orleans was proposed in 1998. One of the goals of this project was the analysis of seismic data from the region (Picornell, 2001; this paper). In particular, reflection data

from offshore have been used in order to describe the actively deforming fold and thrust belt in southern Alaska. Seismic data from the vicinity of Kayak Island (figure 2) are the topic of this paper.

A Study of the Pamplona Area

In 2001 Picornell presented a thesis entitled “Detachment folds in the Gulf of Alaska fold and thrust belt: New implication for the Tectonic framework of the Eastern Aleutian Arc.” The main goal of this research was to test the two principal models proposed to explain the kinematics of the Yakutat microplate by constructing a balanced cross section across the Gulf of Alaska. In order to do so, Picornell (2001) studied the area between Icy Bay and the Pamplona zone, trying to identify a region of contraction and to measure variations in the contraction. He based his study on seismic reflection data provided by the United States Geological Survey (USGS) and Western Geophysical, as well as well logs obtained from the Minerals Management Services and the State of Alaska. The principal conclusion of this research was that the Pamplona zone is not the location of the Yakutat block convergence and the Fairweather transform fault system is a secondary manifestation of the microplate interaction (Picornell, 2001).

Euler Poles Analysis

Pavlis et al. (2004) analyzed Euler poles for motion of the Yakutat microplate with respect to the North American and Pacific plates over the last 3 my. Based on the result of the Euler pole analysis, they reconstructed the Yakutat block motion. One of the conclusions of the reconstruction is that the NNW transport of the microplate into the NE subduction zone generates contraction of EW trending structures as the block constricts. This suggests that the

motion of the block was accommodated toward the Aleutian trench; however, it is not clear what structures accommodate the motion (Pavlis et al., 2004).

STATEMENT OF THE PRESENT RESEARCH

Where is the maximum motion of the Yakutat micro plate being absorbed? Picornell et al. (2001) suggest that the motion could be absorbed either on Kayak Island or in the offshore region around the Island (Picornell et al., 2001). The present research attempts to determine the role that the offshore region close to Kayak Island plays in the kinematics of southern Alaska.

If offshore Kayak Island is the locus of the Yakutat microplate convergence and the motion is accommodated in the area, the geological structure present in the region should show the effect of contraction by specific deformation patterns. Those patterns should be clearly identifiable in the seismic data.

Specific Objectives

1) To improve existent seismic data quality by applying an appropriate seismic data processing sequence.
2) To use a feedback processing-interpretation method to gain better management of the available seismic data close to Kayak Island.
3) To determine the geological significance of seismic information close to Kayak Island.

4) To determine the role that the offshore region close to Kayak Island plays in the kinematics of the Southern Alaska.

Methods and Procedures

Seismic Data Processing

Lines of seismic reflection data collected for the United States Geological Survey (USGS) in 1976 from the offshore region close to Kayak Island were re-processed using the software ProMAX™ software package from Landmark Graphics Corporation. The processing was performed following a sequence that includes editing of poor traces, definition of geometric parameters, muting, velocity analysis, deconvolution, normal move out, stacking, and migration.

Seismic Data Interpretation

Time migrated data were interpreted using the Kingdom suite™ software package. The interpretation includes: water bottom identification, identification of the principal horizons as well as unconformities, identification of folds and faults. Correlation of cross lines were performed and isochron for the whole set of lines are generated.

Processing and interpretation were performed following a feedback process. Figure 3 shows the way in which this process worked. Since the processing was done in ProMAX™ which works in a UNIX environment, and the interpretation was performed in the Kingdom suite which works in a DOS system environment, a conversion between the two systems had to be done whenever a set of data was moved from one to another package. SEGY files were

generated in order to transfer information between the two environments. The package WinSock 2.0™ was used to transfer the information.

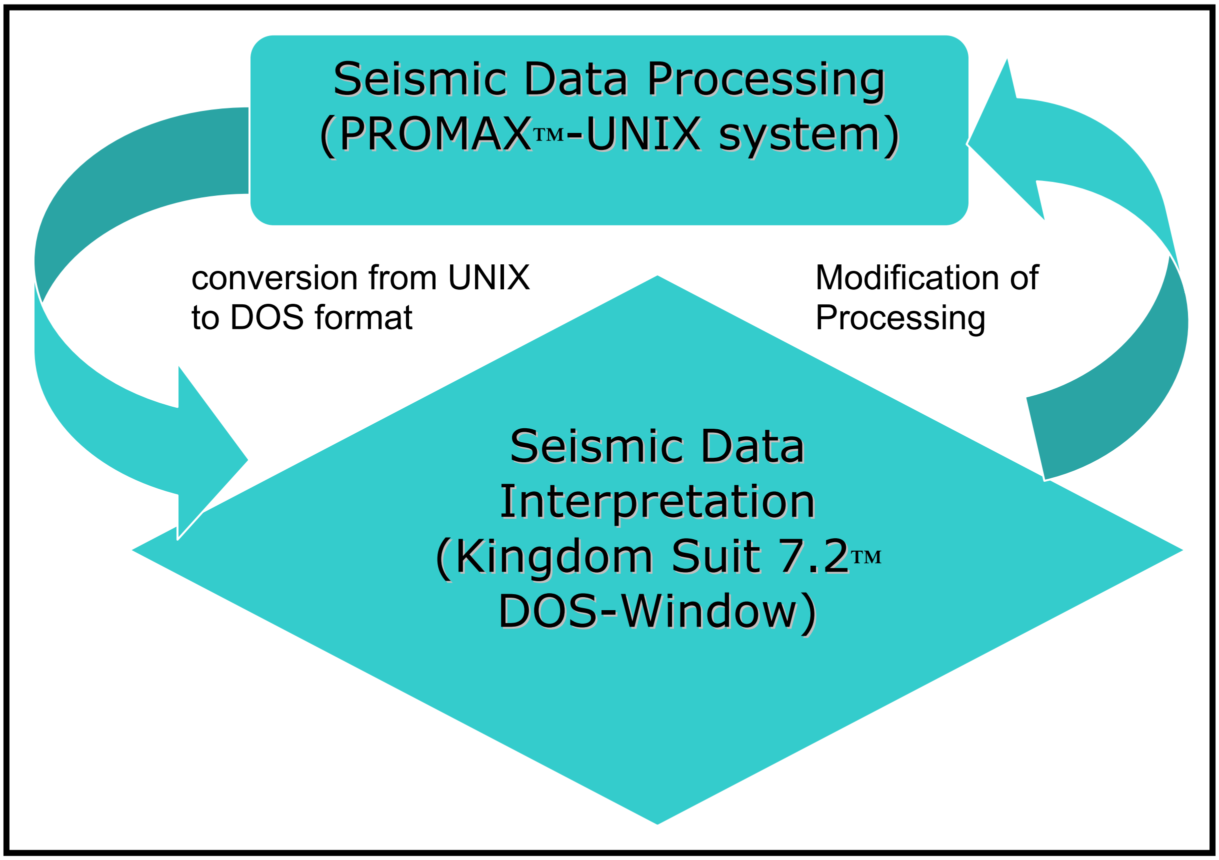


Figure 3: Flow of data processing and interpretation.

SEISMIC DATA PROCESSING DESCRIPTION AND RESULTS

The seismic data used in this research were processed originally by Bruns et. al (1982). The goal of the reprocessing described here was to increase the continuity of reflections, remove multiples and apply migration to the data using techniques that were not readily available in the early 1980's. The seismic datasets were input from either external files containing seismic data or from other ProMAX™ flow outputs, then processed and output as disk files and displays (figure 4).

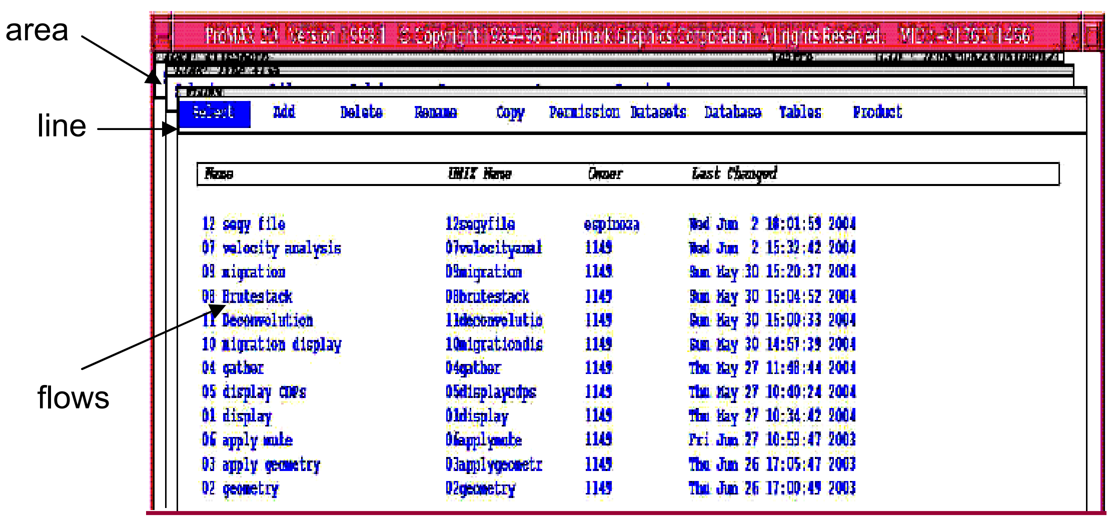


Figure 4: View of ProMAX™ environment.

Sequence of Processing Steps

The processing routine started with the display of the seismic data taken from digital tapes. The sequence included elimination of poor traces (editing), definition of geometric parameters, CDP sorting, muting, velocity analysis, prestack deconvolution, normal move out (NMO), automatic gain control, stacking, and time migration (figure 5).

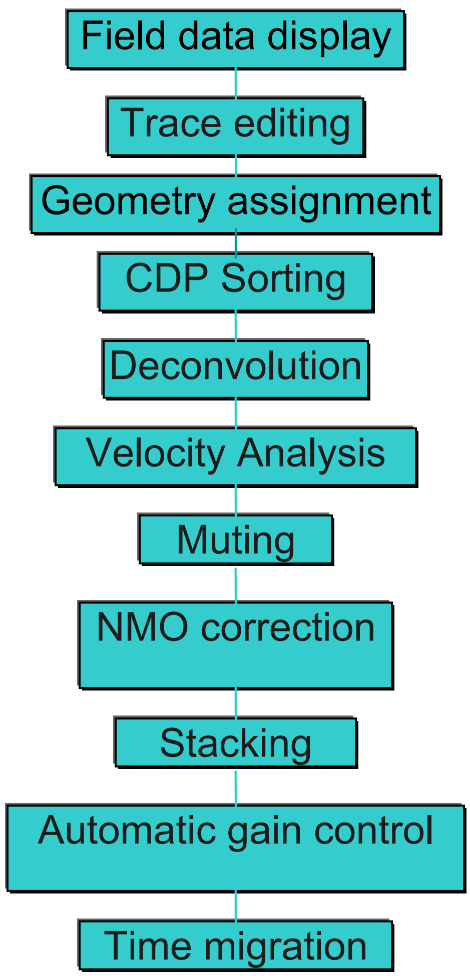


Figure 5: Seismic processing sequence followed in this research.

Description of Processing Steps

Field Files Display

Data were transferred from tapes in SEGY format into ProMAX ™ and displayed (figure 6). These displays were used to identify potential problems in the data and to asses the overall quality of the data prior to processing.

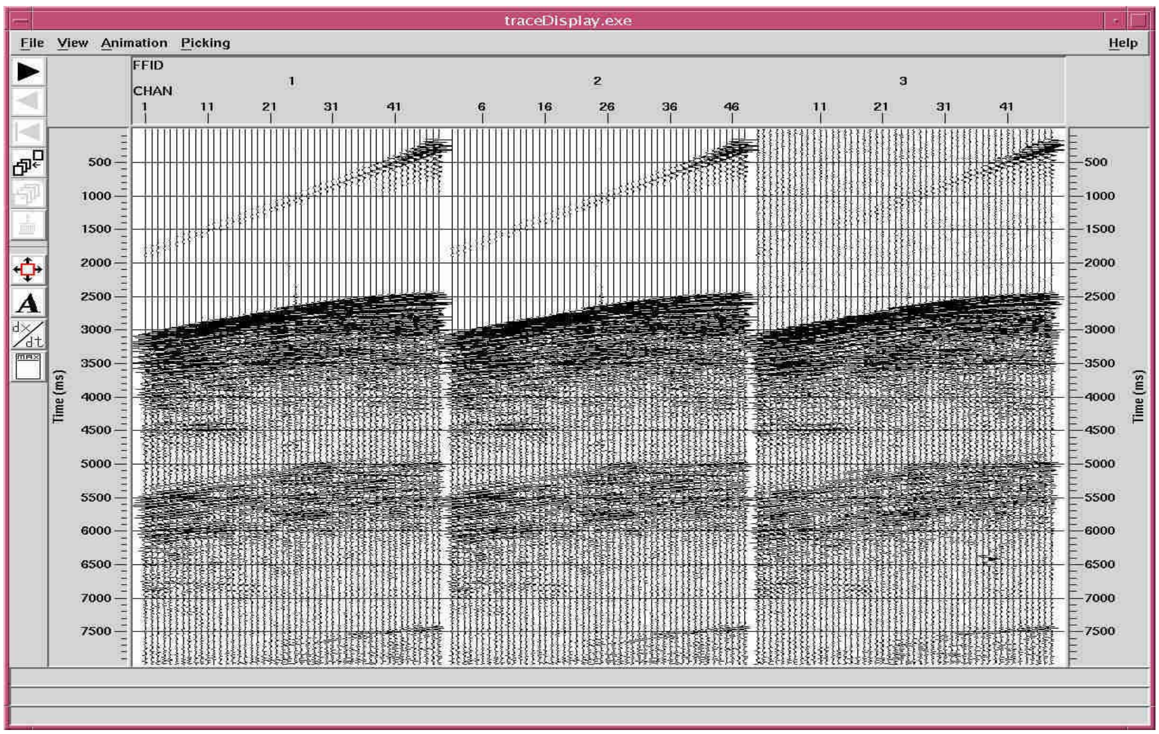
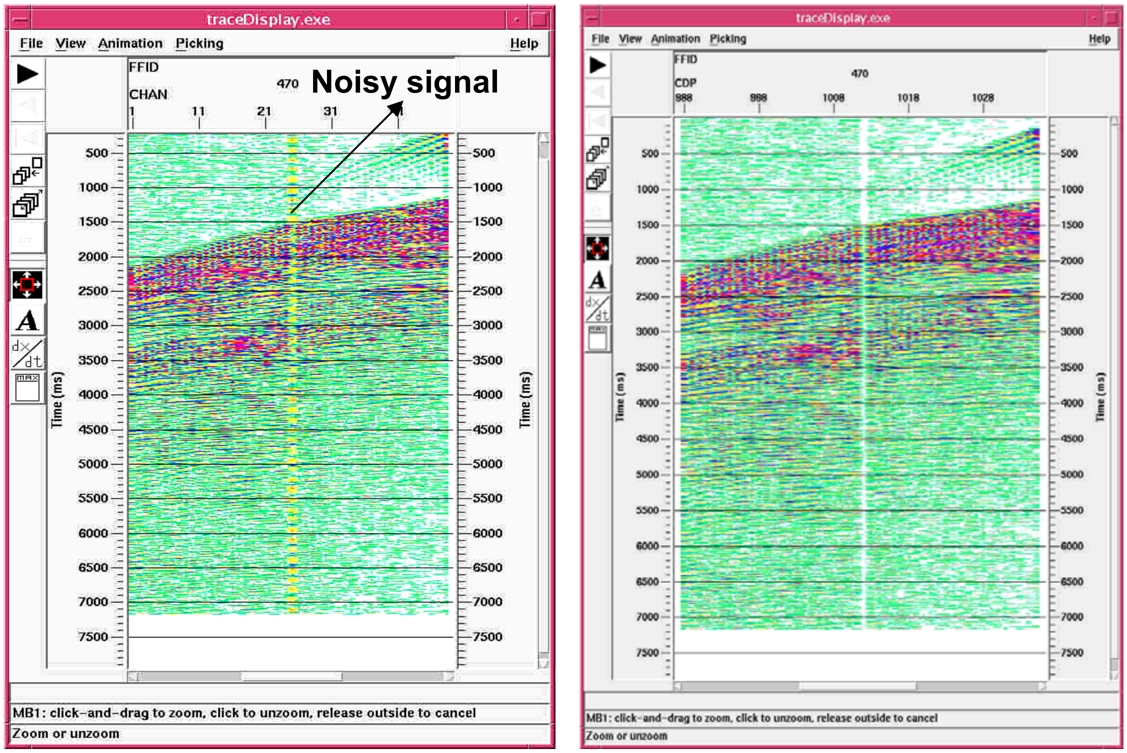


Figure 6: Field files display from line 414a.

Noisy traces (figure 7) were detected and eliminated from the field files.



a b

Figure 7: Record 470 of line 414a. a) before removal of noisy trace and b) after the noisy traces were removed.

In some cases, monofrequency signals or noisy traces were not evident (figure 8) until the stacking and migration processes were performed.

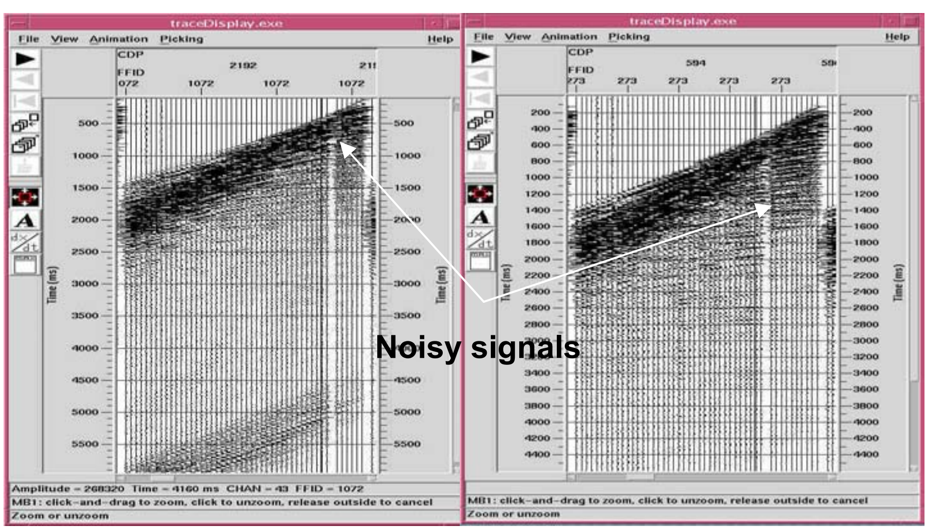


Figure 8: Two noisy signals detected in line 413.

When the data containing noisy traces are stacked, the problem becomes more evident (figure 9). A major problem occurs when the data are migrated (figure 10), because the noisy signal is amplified in the migration process, which results in a distortion in the seismic section that can lead to a misinterpretation. The problem is solved by elimination of the noisy trace before stacking (figure 11).

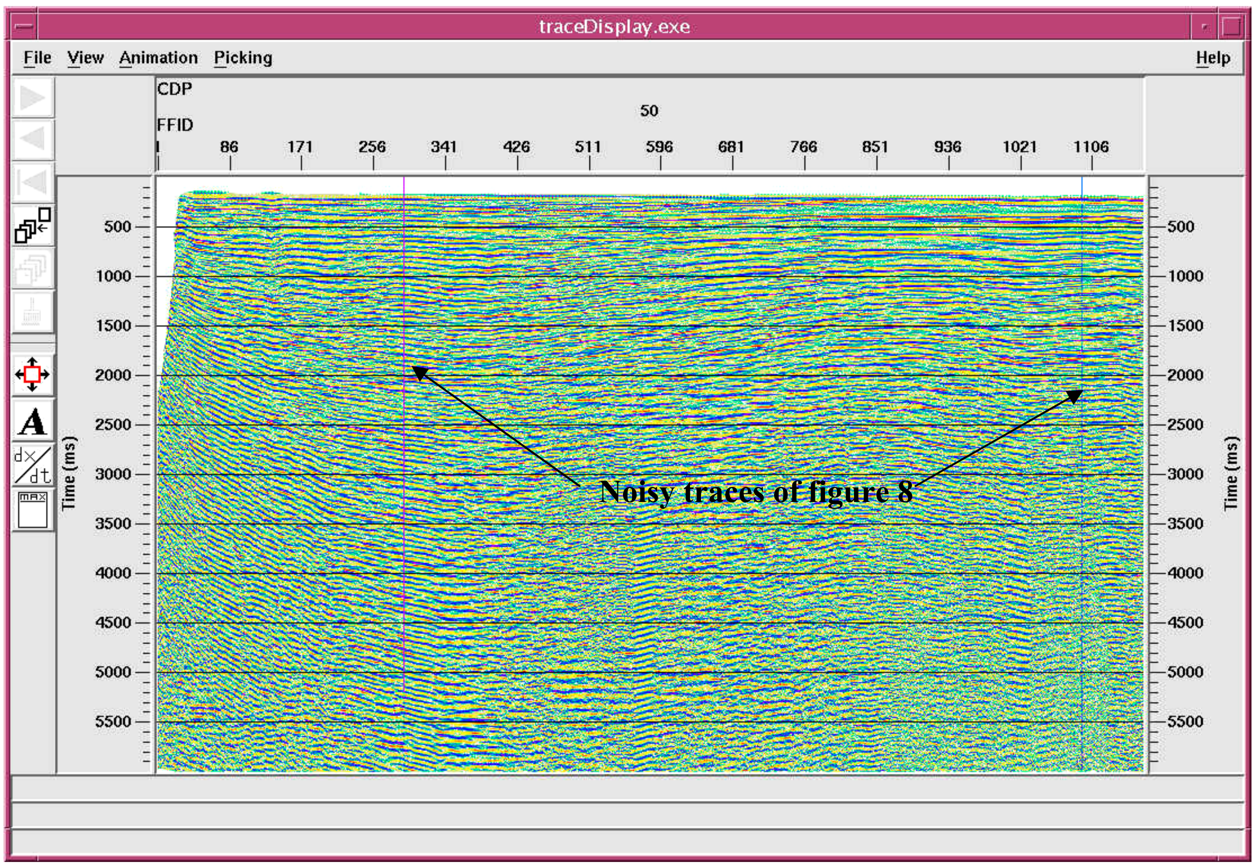


Figure 9: Line 413 after stacking. Noisy traces of figure 8 are indicated with arrows.

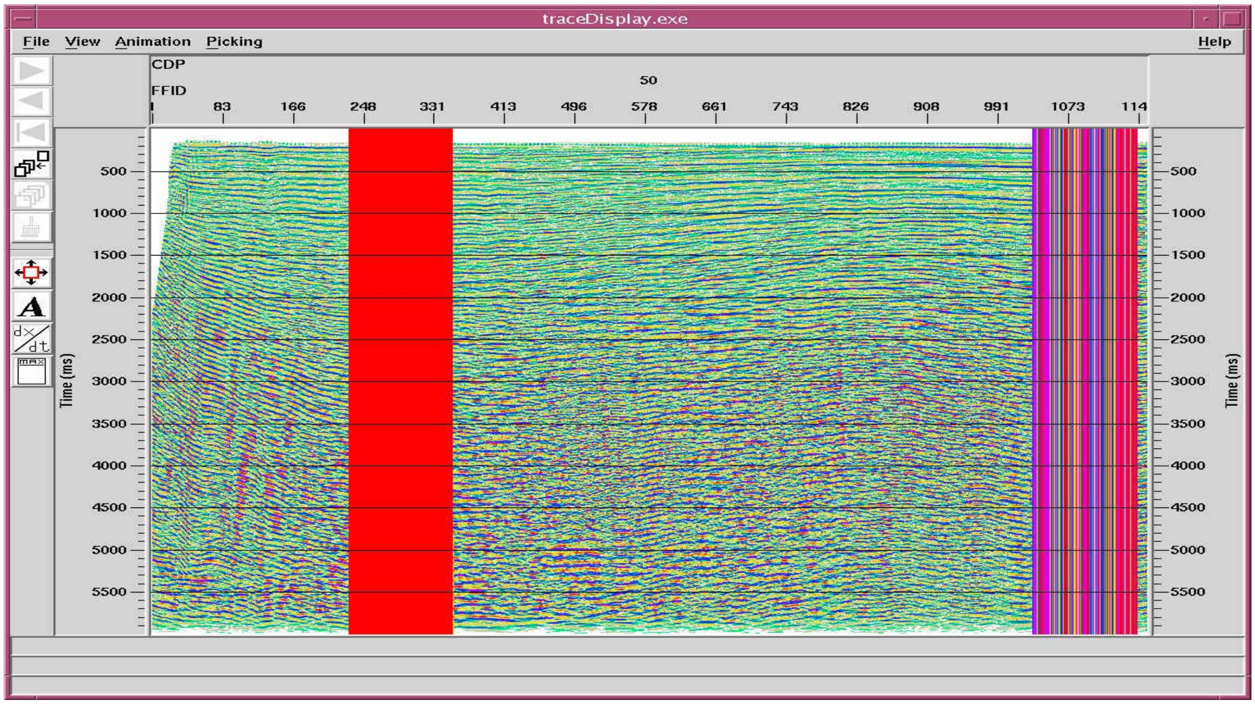


Figure 10: When the data of figure 8 are migrated the noisy trace is amplified, creating a big distortion.

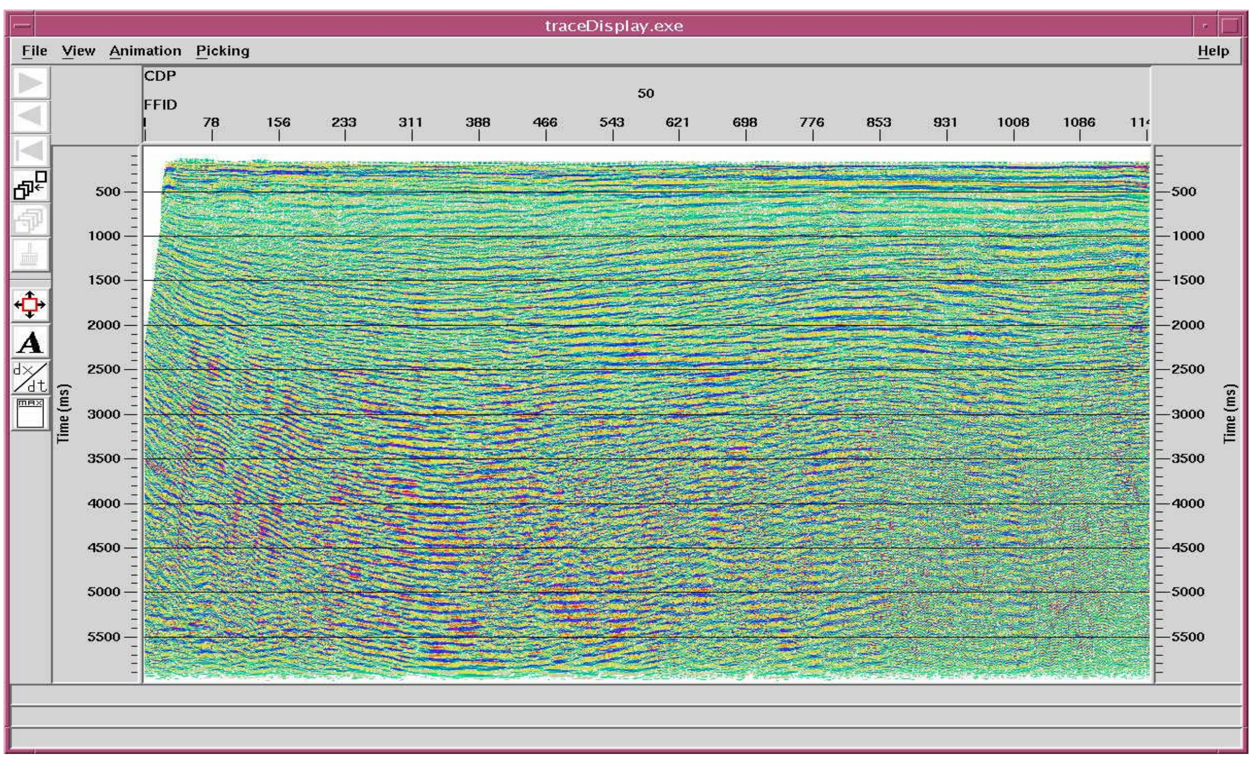


Figure 11: Line 413 when the source of distortion has been removed.

Another problem solved in the editing process is related to the occurrence of recognizable *end-of-file* marks for all of the files. The records appear in the display (figure 12) as a single file with 96 rather than 48 traces when the *end-of-file* mark is missing. The records have to be eliminated and replaced by two separate files or the subsequent processing will fail. Records with missing *end-of-file* marks were replaced with the closest adjacent normal records in the section in order to keep the number of records unaltered. Figure 12 shows a section of line 416 in which two records are displayed as an individual record (FFID 4) before line editing. Record 4 was replaced with copies of records 3 and 5.

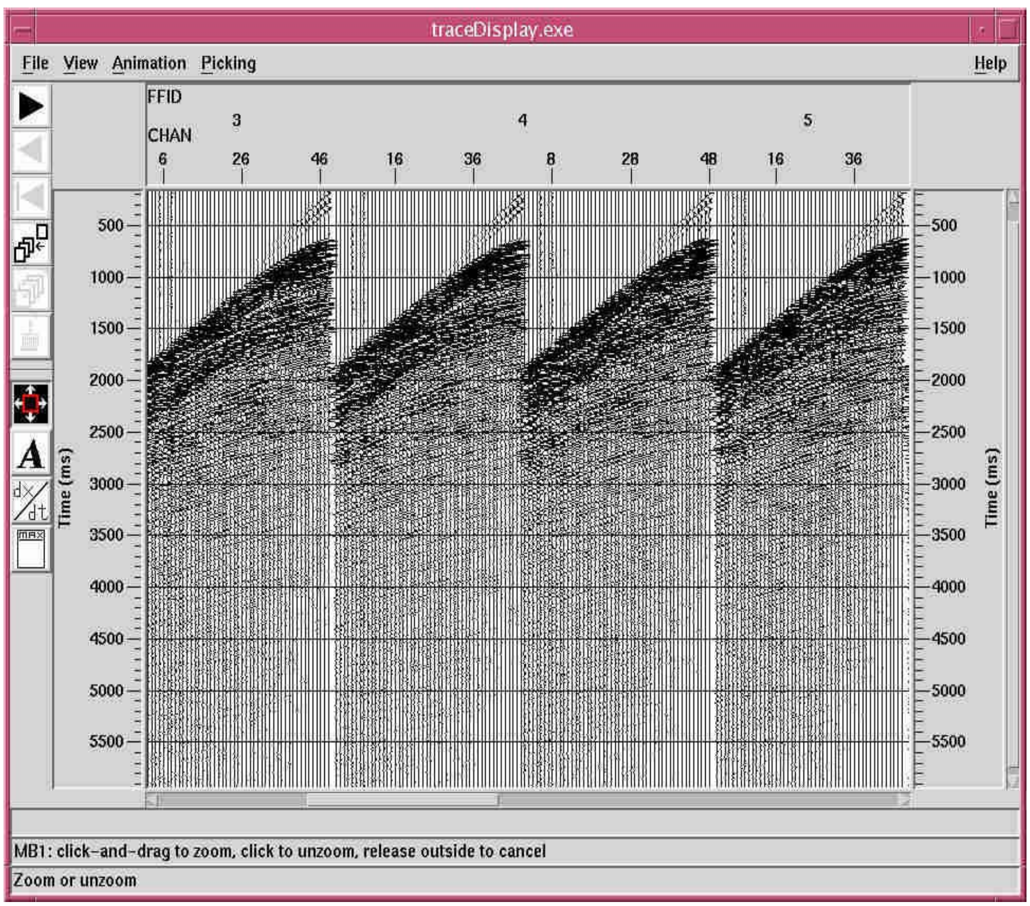


Figure 12: Two records of line 416 are displayed as a single record (FFID 4) before trace editing.

Geometry Assignment

To assign geometry parameters to the seismic data, the ProMAX™ 2D marine geometry spreadsheet function was used. An ordered parameter file (OPF) was created to store the geometry information for each seismic section (Figure 13). Once the OPF was generated, the geometry parameters were applied to the seismic section using the inline geometry header function. See Appendix A for a detailed description of the Geometry processing.

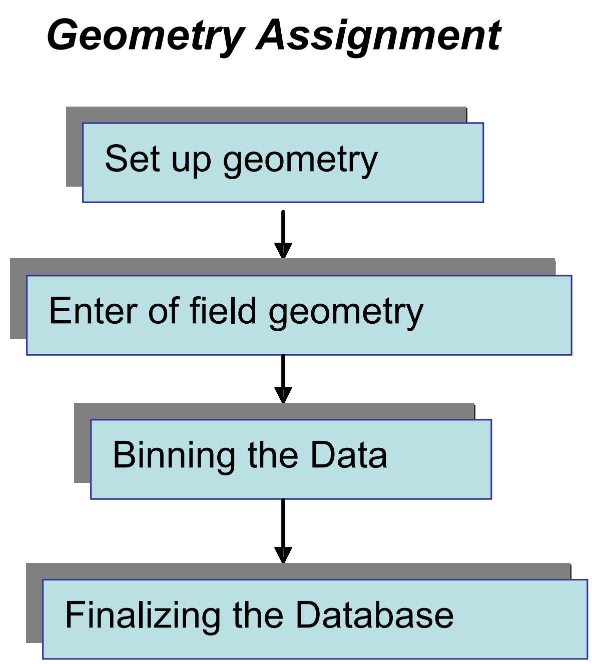


Figure 13: Sequence followed to assign geometry parameters to the seismic lines.

CDP Sorting

After the geometry was assigned to the field data, the data were transformed from FFID to common depth point (CDP) files (figure 14). All subsequent processing utilized the CDP files.

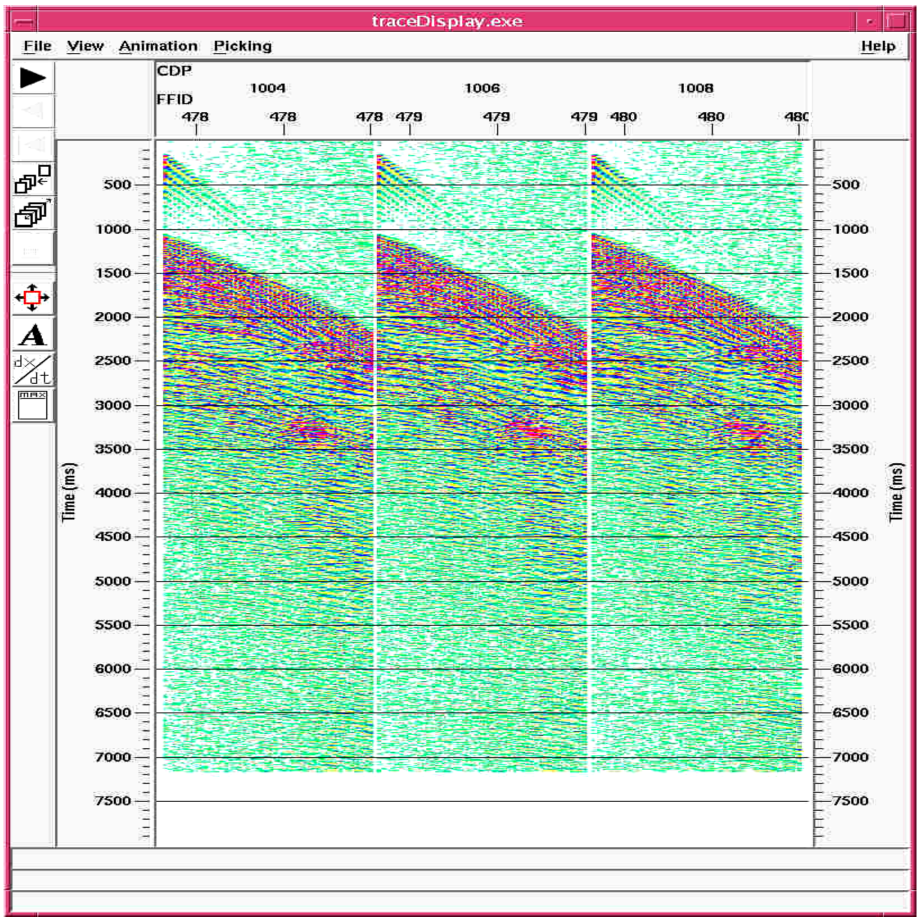
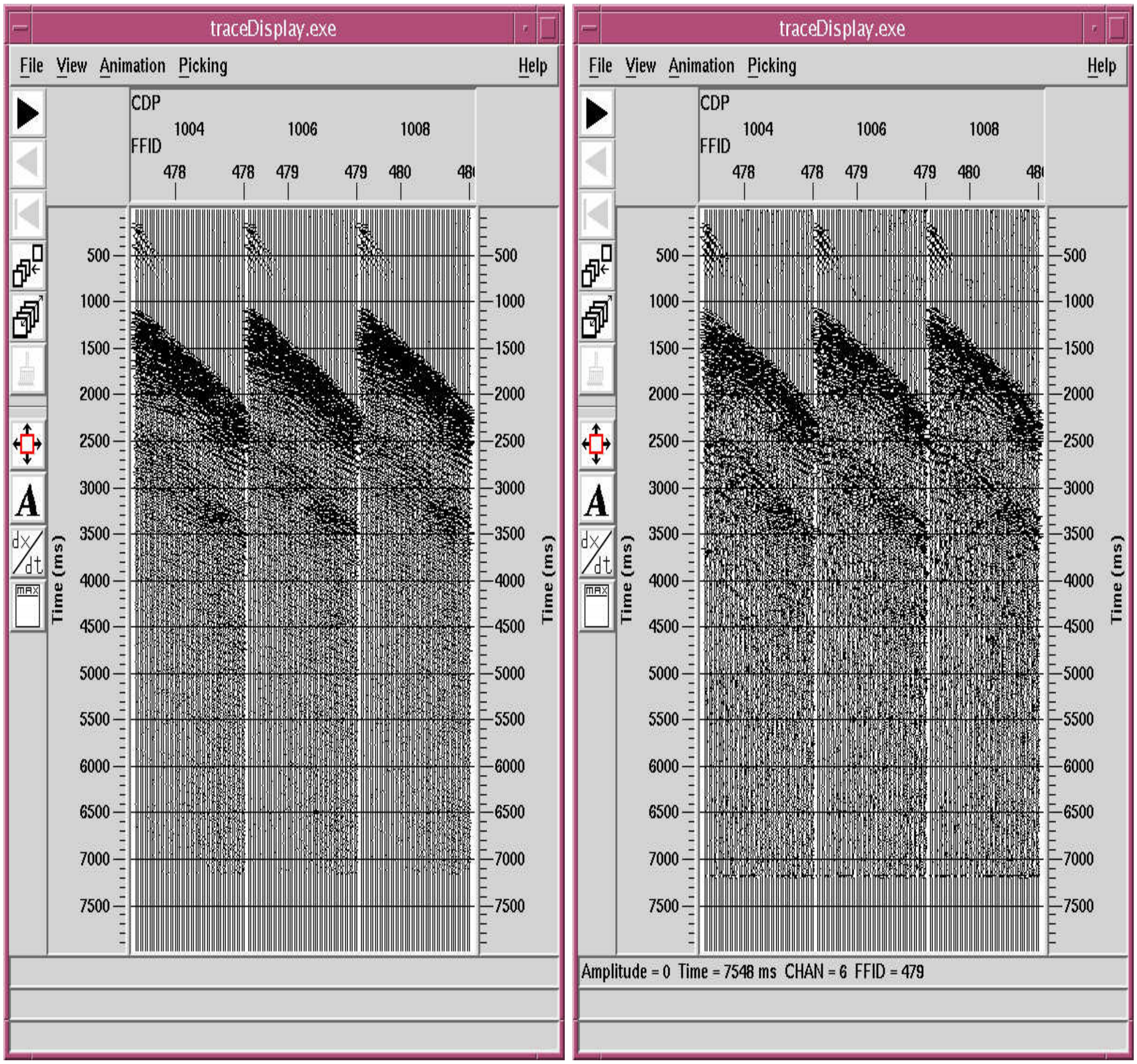


Figure 14: Section of CDP gathers line 414a.

Deconvolution

Spiking /Predictive Deconvolution was applied to each CDP in order to reduce reverberation and multiple effects. Minimum phase spiking which applies a Wiener-Levinson

spiking deconvolution was performed. Figure 15 shows a section of line 414a before and after deconvolution. The attenuation of unwanted signals is evident after applying deconvolution.

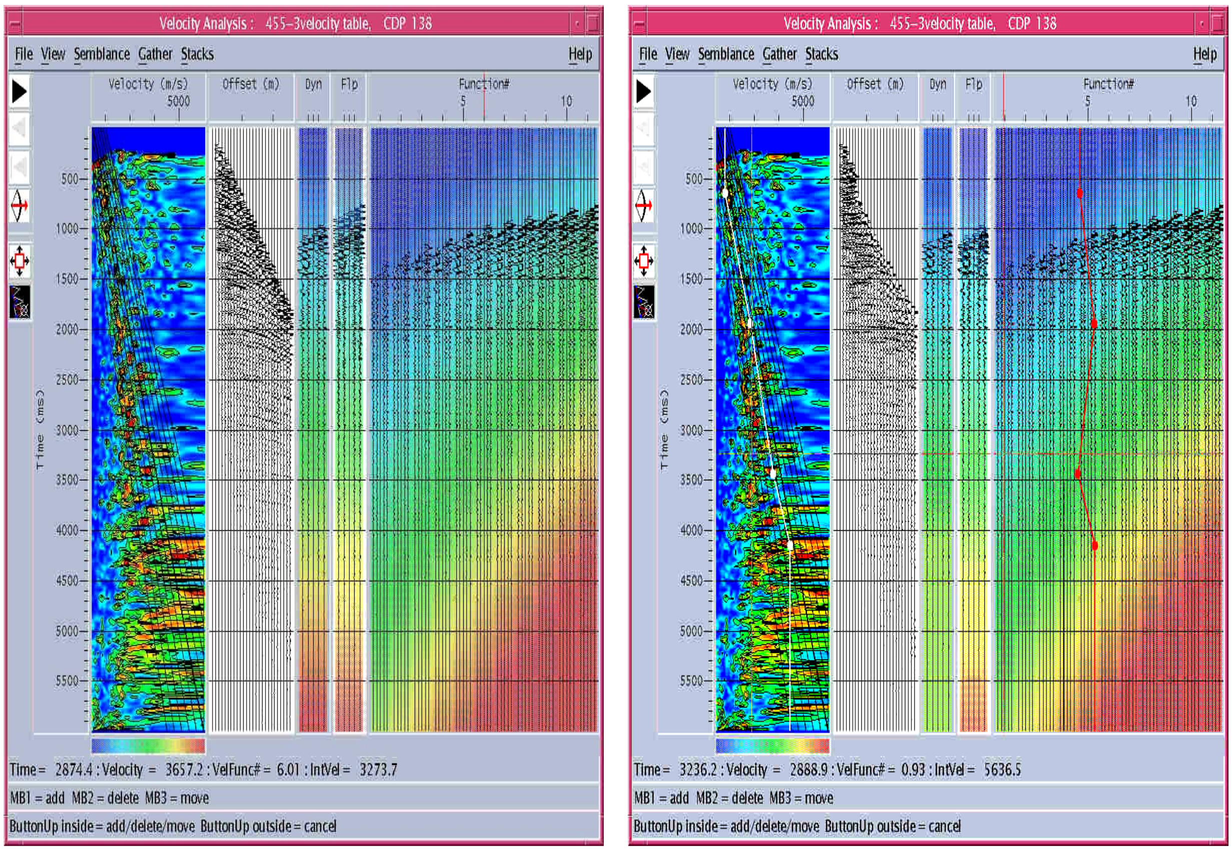


a **b**

Figure 15: CDP 1004 to 1008 from line 414a, before (a) and after (b) deconvolution.

Velocity Analysis

ProMAX™ has an impressive interactive velocity analysis program which allows picking or selecting time velocity values while simultaneously viewing the effect of the NMO on the traces (figure 16).



a **b**

Figure 16: a: Velocity analysis panel before picking velocities and b. velocity analysis panel after picking velocities. The interactive panel allows the processor to see the effects of applying the picked velocities when NMO is performed.

Muting

A top mute was applied to all of the CDP’s to remove refracted energy and shallow noise. A zone was defined where the seismic amplitudes were set to zero. Strong noise signal were also observed in some specific areas other than at the top. In these cases at surgical mute was used to remove the noisy signals. Figure 17 shows a section of line 414b in which local noise is observed. Figure 18 is the stacked section corresponding to this line before the noise was removed. The surgical mute is applied in the specific zones in which the strong noise is observed (figure 19), and this improves the stacked section as seen in figure 20.

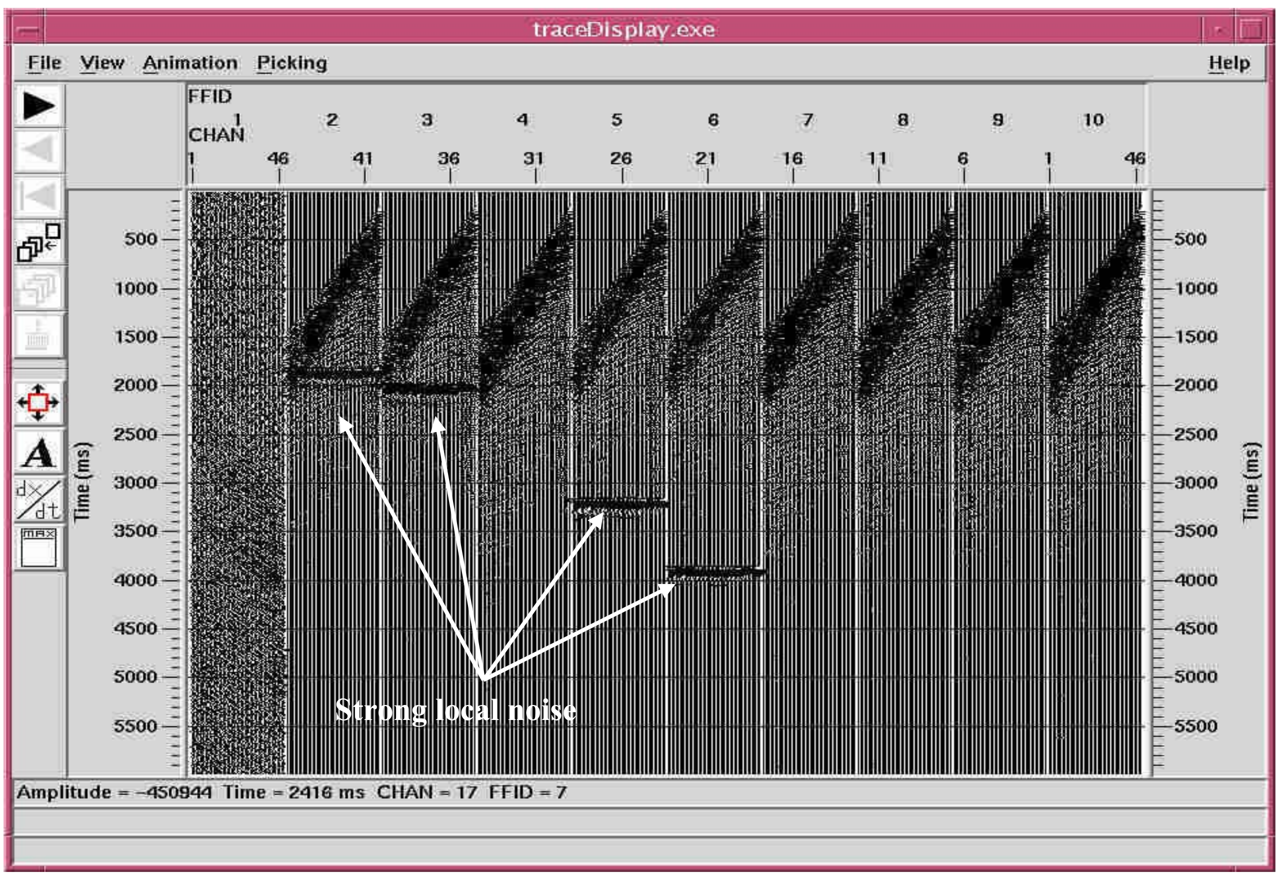


Figure 17: A section of line 414b where strong local noise is observed.

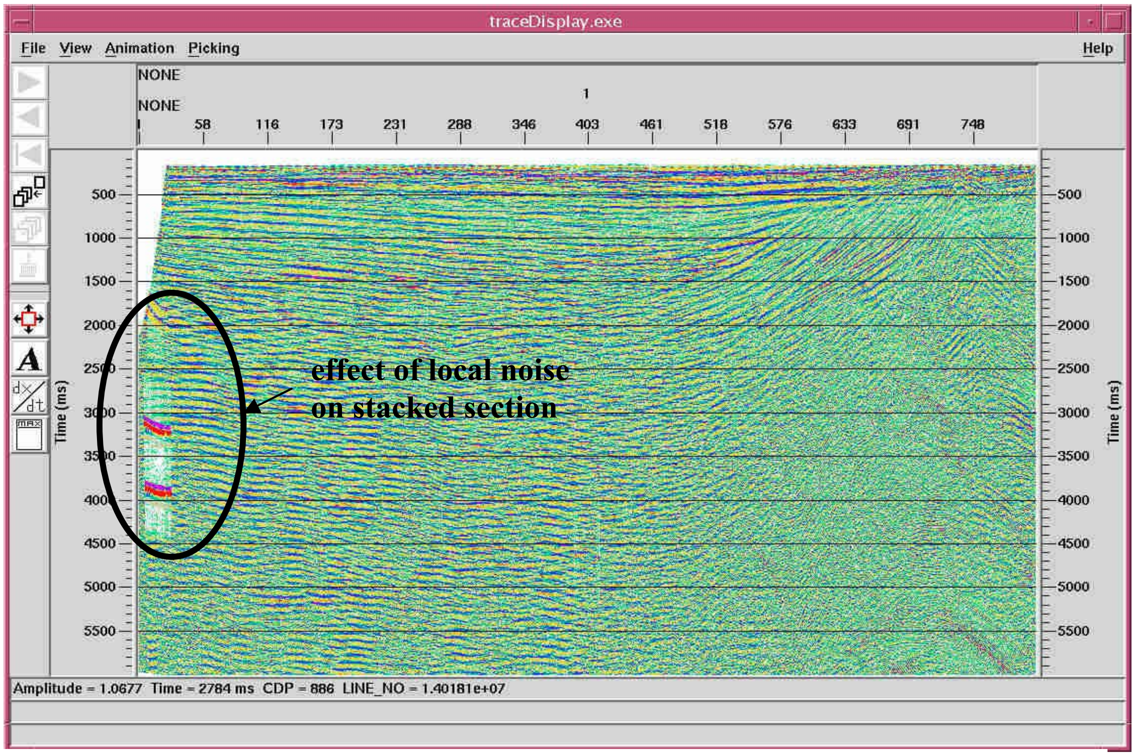


Figure 18: Line 414b after stacking without correction of local noise.

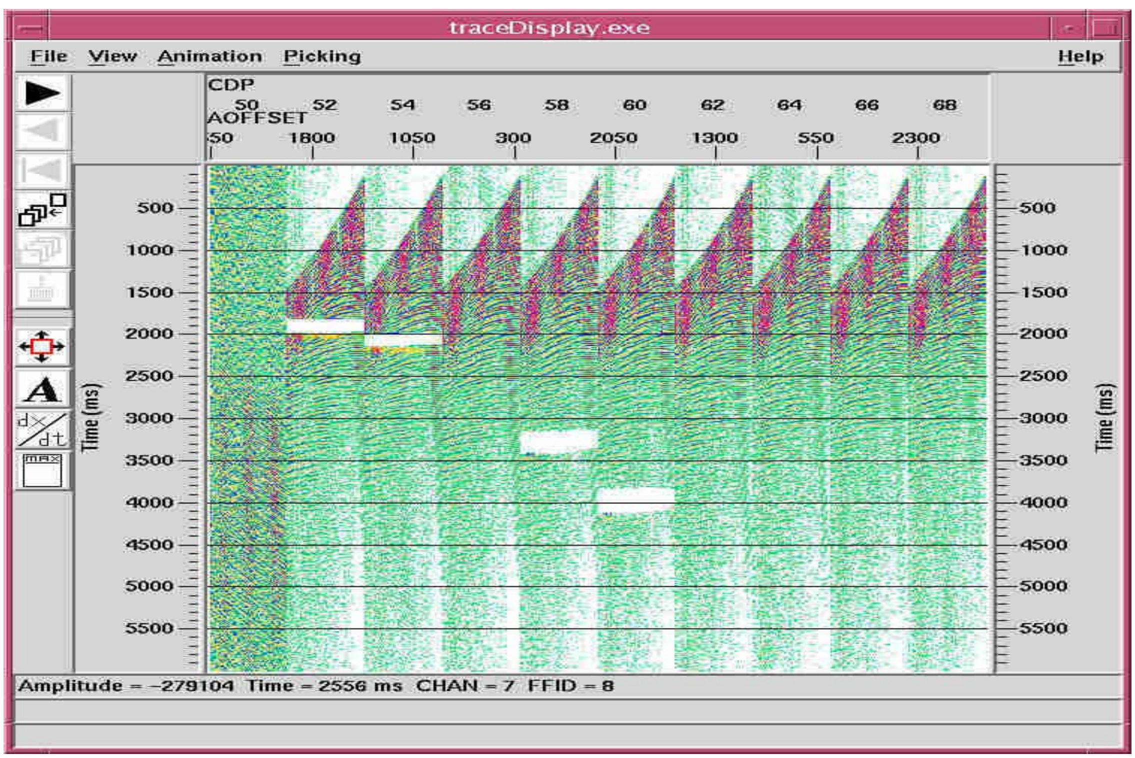


Figure 19: Result of surgical mute performed over line 414b.

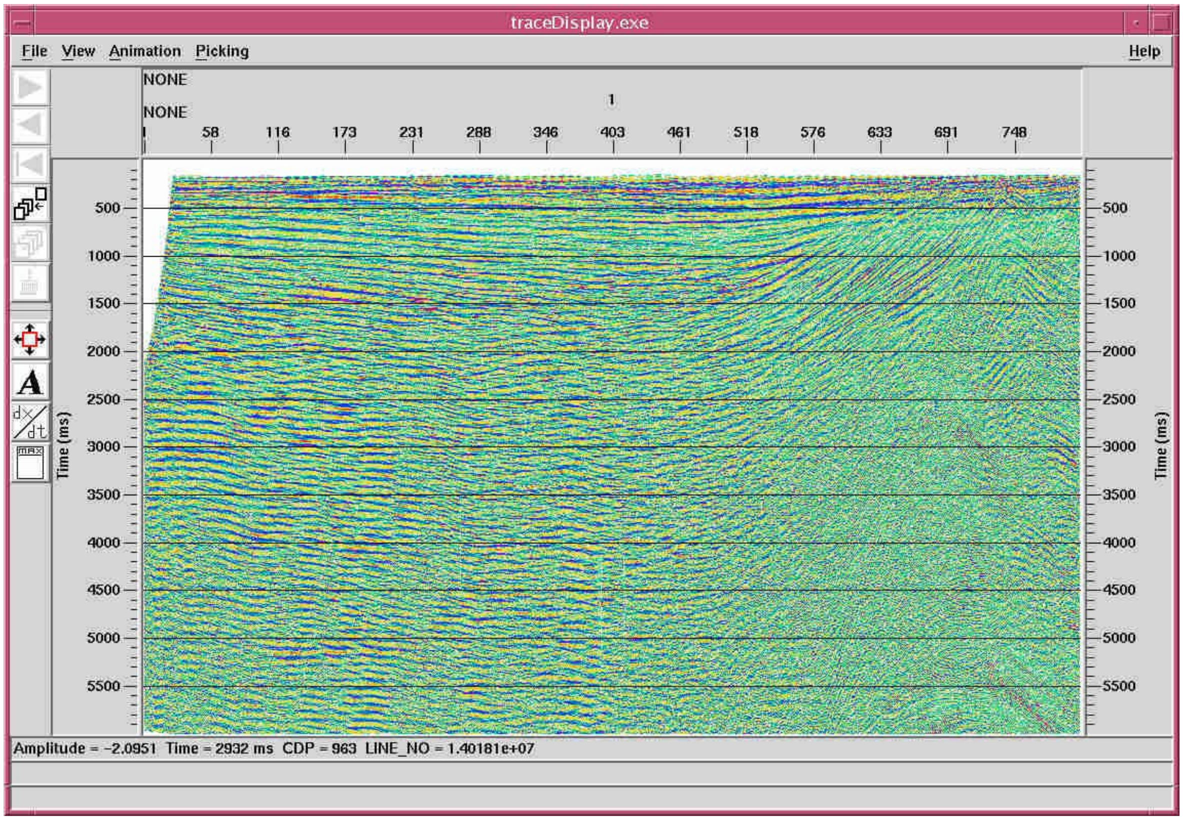


Figure 20: Line 414b after stacking and surgical mute performance.

Stacking

After correction, the data were stacked (figure 21) using the median stack method. As can be seen in figure 21, the amplitudes of the seismic waves are strongest in the shallow area, and become too weak to distinguish deeper in the data. In order to enhance the weak signals, automatic gain control was applied to the stacked section (figure 22).

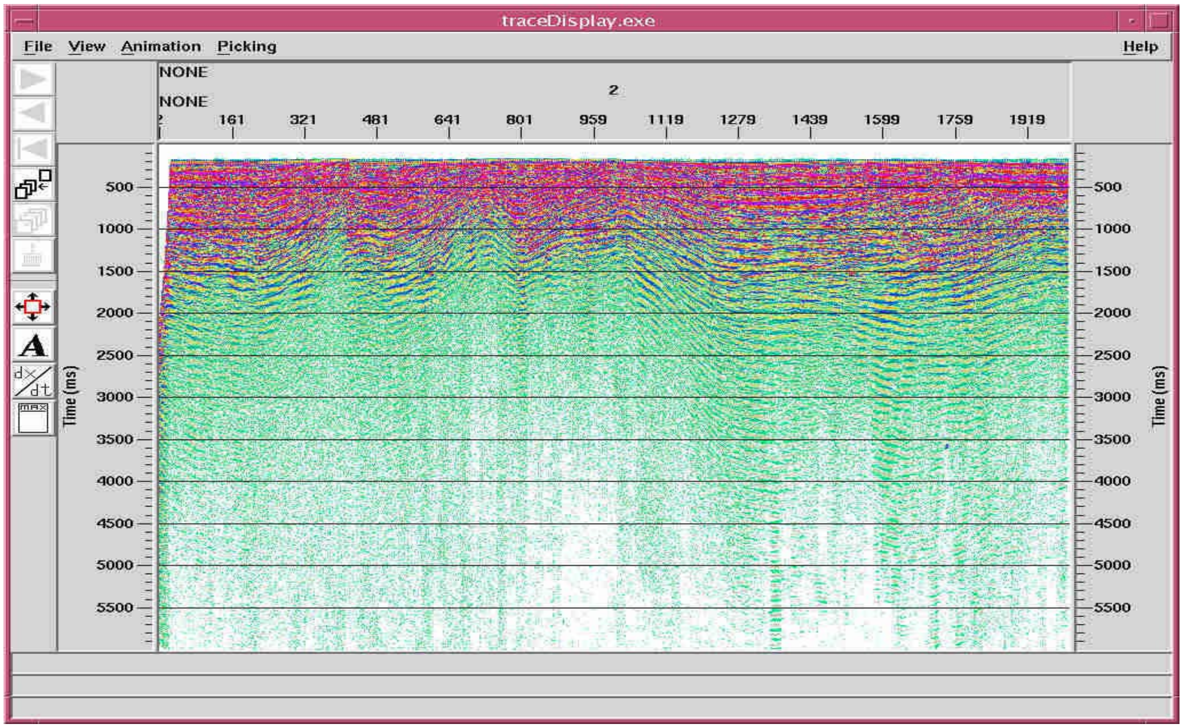


Figure 21: Line 421a after stacking

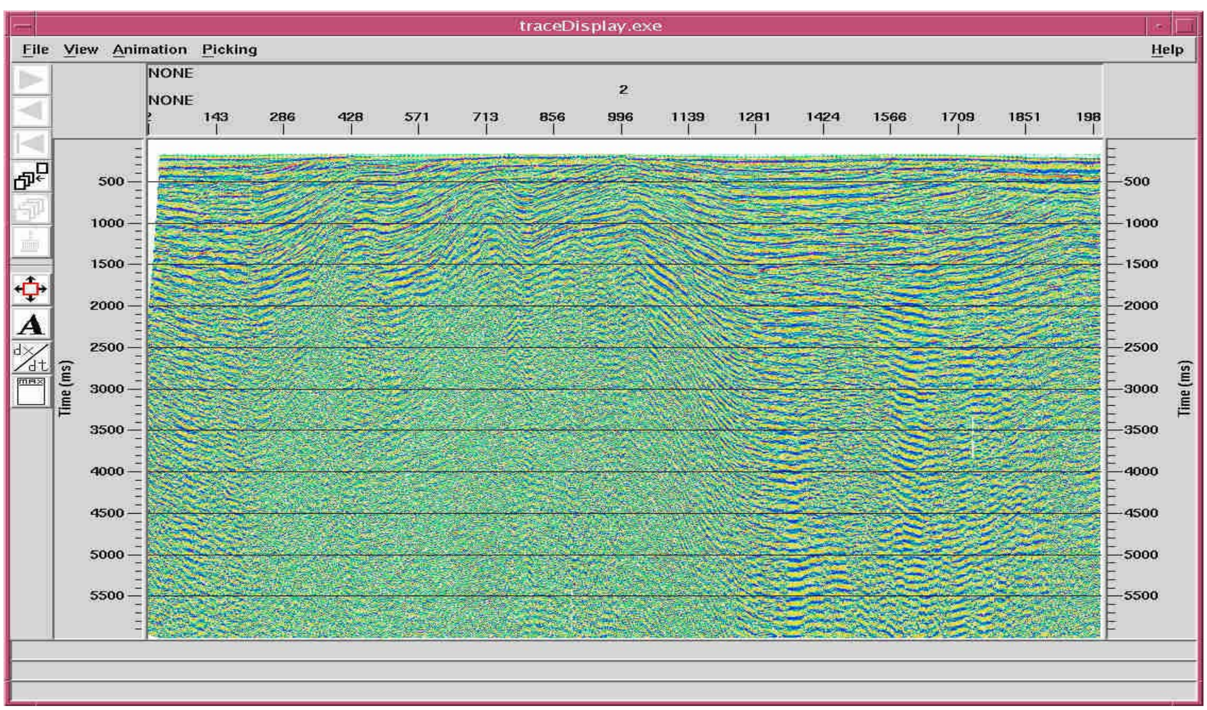


Figure 22: Line 421 a after applying automatic gain control (AGC).

Time Migration

In order to remove diffractions and move reflection events to their correct spatial location, post stack Kirchhoff time migration was applied to the data. A trial and error method was used to define the migration aperture. Figures 23-26 show a section of line 414 migrated using differently migration apertures. The 3000m and 6000m apertures gave the best migrated image and, thus, two different migrated lines were used for comparison during the interpretation process. The final time migrated seismic sections are shown in Appendix B. Once the data were processed, the migrated section was stored in a SEGY file and transferred from the UNIX system to the DOS system to be interpreted in the DOS environment using Kingdom™ software.

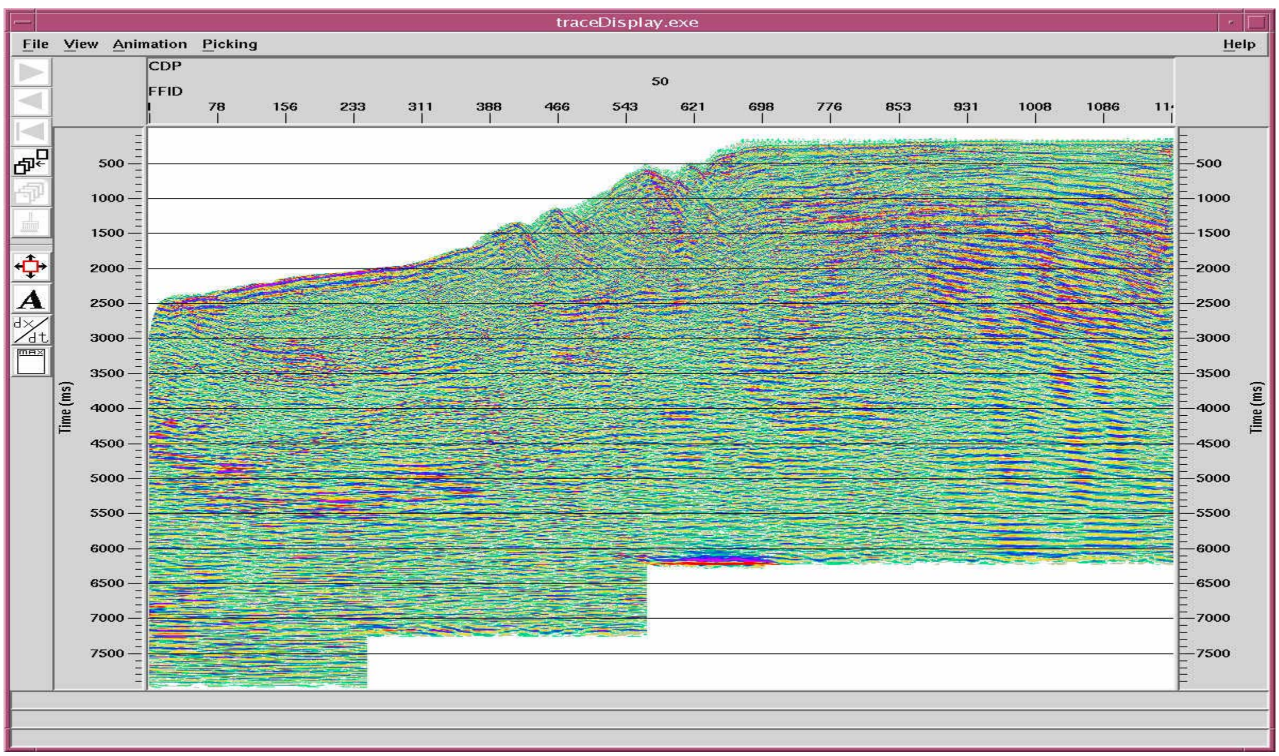


Figure 23: Line 414a after Kirchhoff time migration with an aperture of 1000m

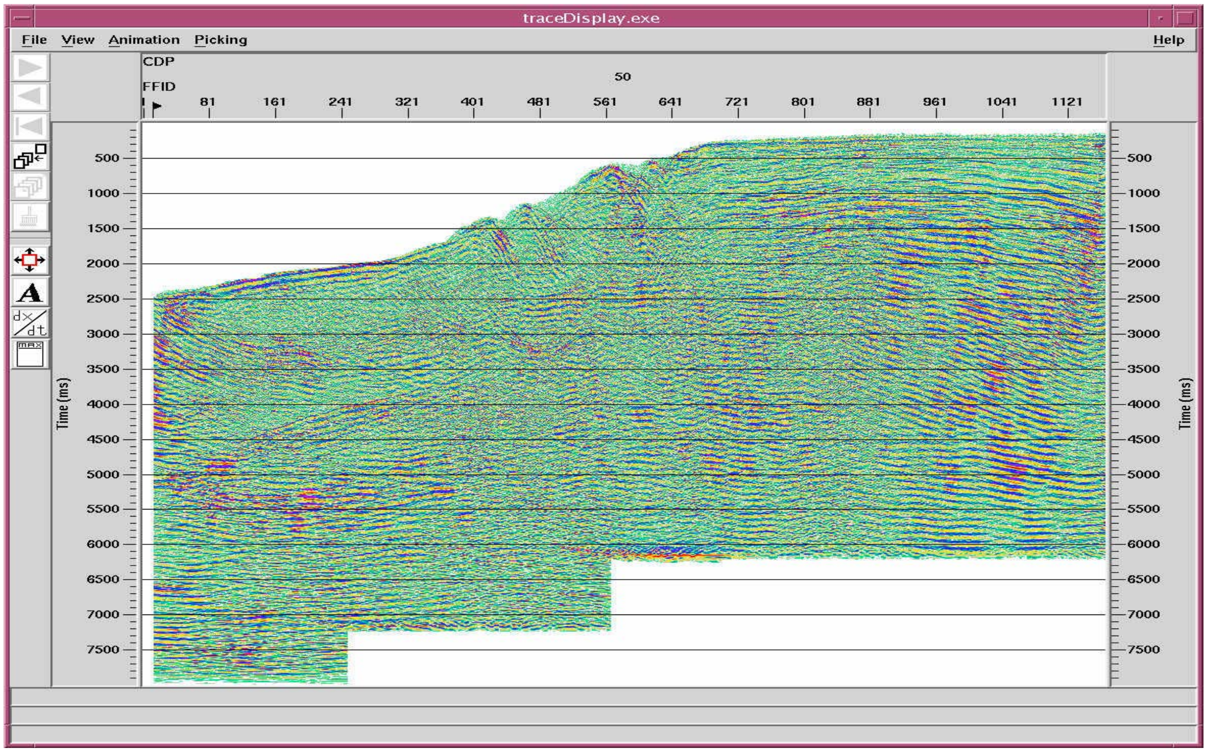


Figure 24: Line 414a after Kirchhoff time migration with an aperture of 3000m.

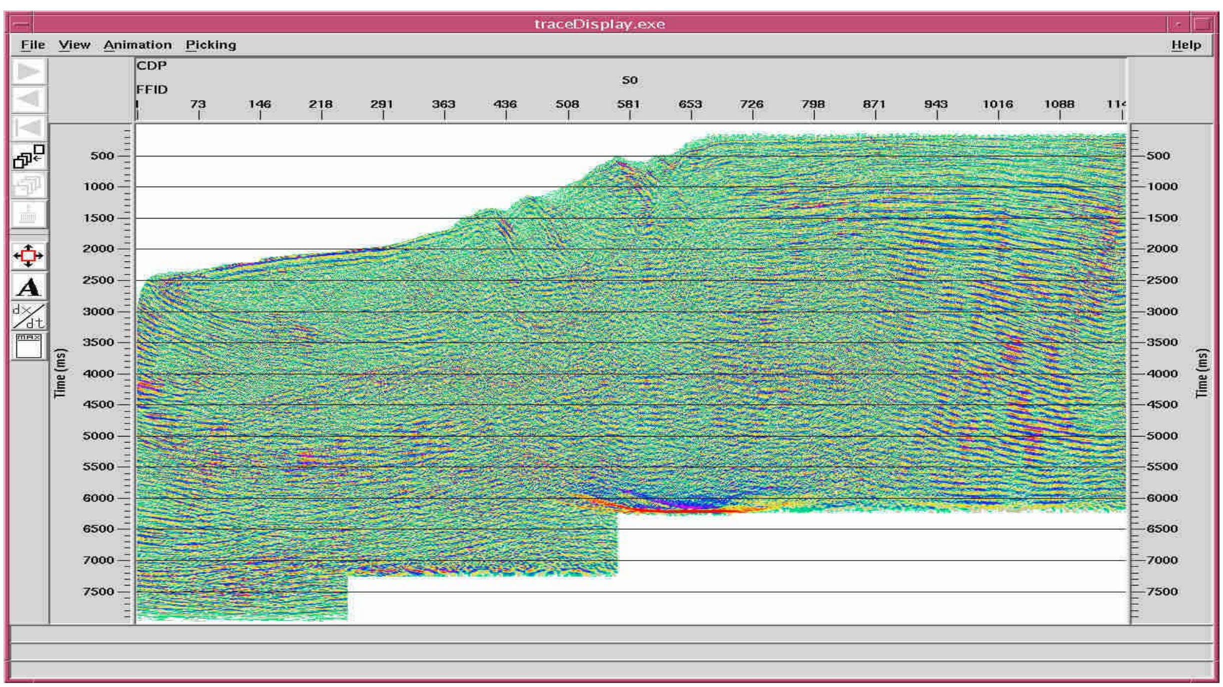


Figure 25: Line 414a after Kirchhoff time migration with an aperture of 6000m.

Comparison Between Different Processed Results

When the data were processed the first time (Bruns et al., 1982), one of the problems detected was the discontinuity of reflectors, which made the correlation of reflectors across the whole seismic section difficult. Other problems were the presence of strong multiples associated with the water bottom, as well as the degradation of the acoustic signal. These problems were inherent to the nature of the area and circumstances in which the data were collected. Certainly multiples associated with the water bottom are a major problem in marine data, which are now addressed during data collection. However, applying newer techniques available in the present, such as migration and deconvolution, can improve the quality of the final section in older data. Figure 26 shows a section of line 414a which was processed previously following a sequence that did not include migration (Bruns et al, 1982).

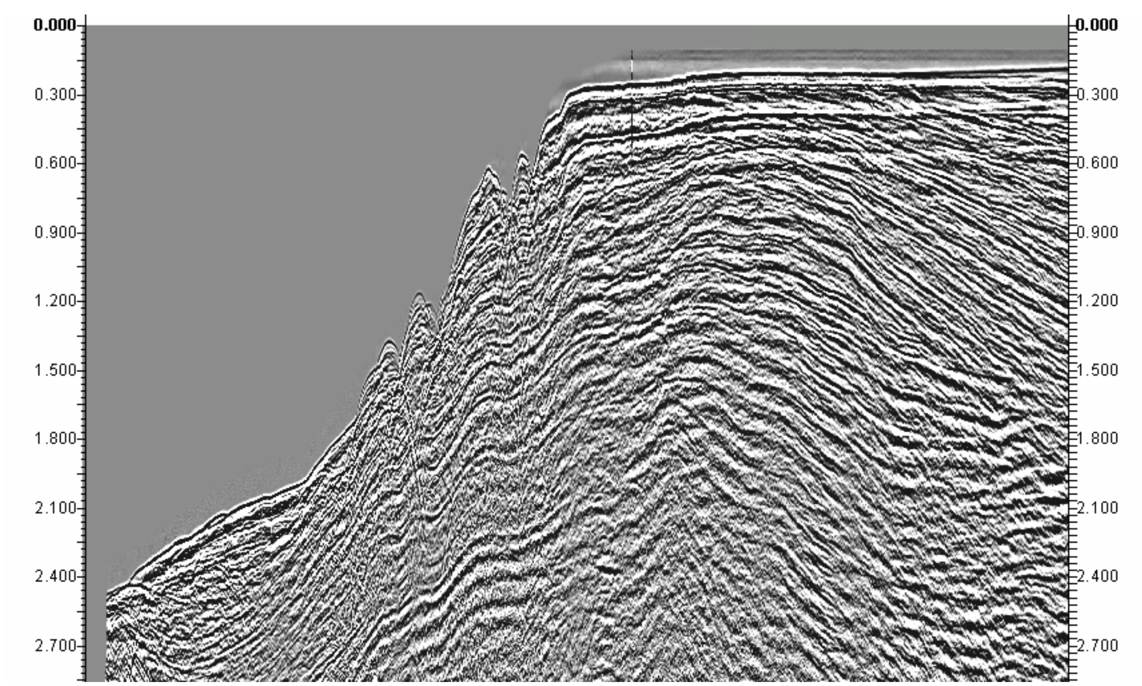


Figure 26: Section of line 414a from previous processing.

As can be seen in figure 26, the shallow area has a problem with signal quality which makes it difficult to identify some of the reflectors because the area covered by strong multiples. Figure 27 shows the same section of line 414a after the processing sequence performed in the present research. Improvement is observed in the shallow area where the reflectors are well defined, and multiples have been attenuated. In general an enhancement of signal quality is observed.

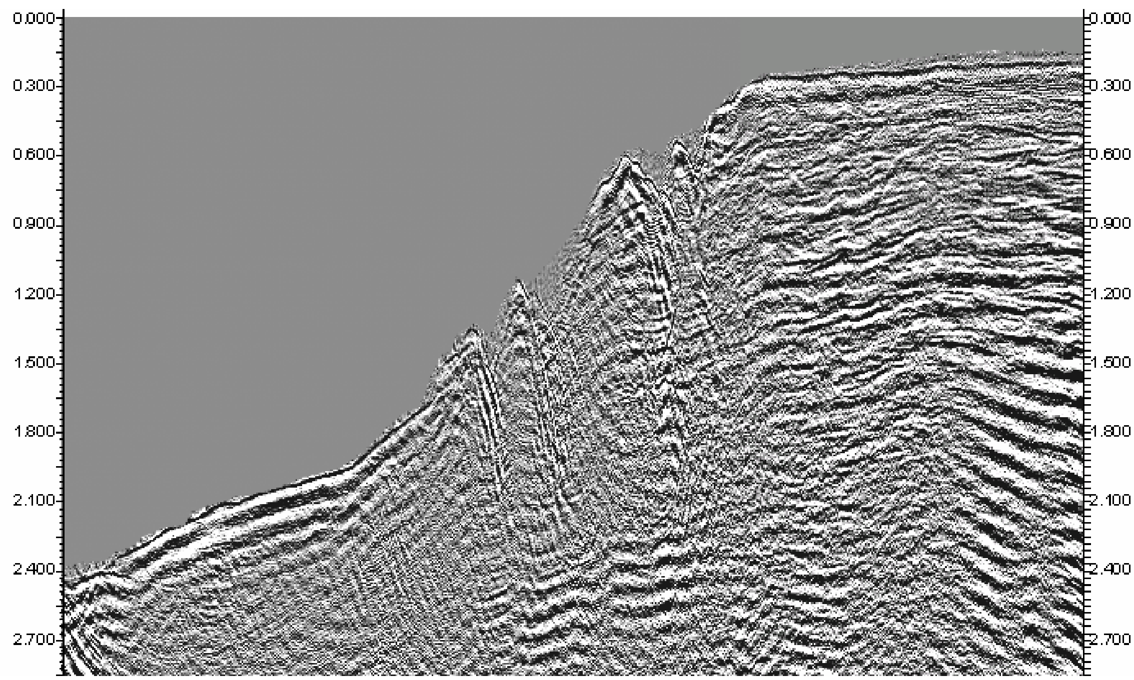


Figure 27: Section of line 414a from present processing.

Figures 28 shows a section of line 420 from previous processing and figure 29 presents the same section from present processing. The effects of migration result in a clear location of reflectors.

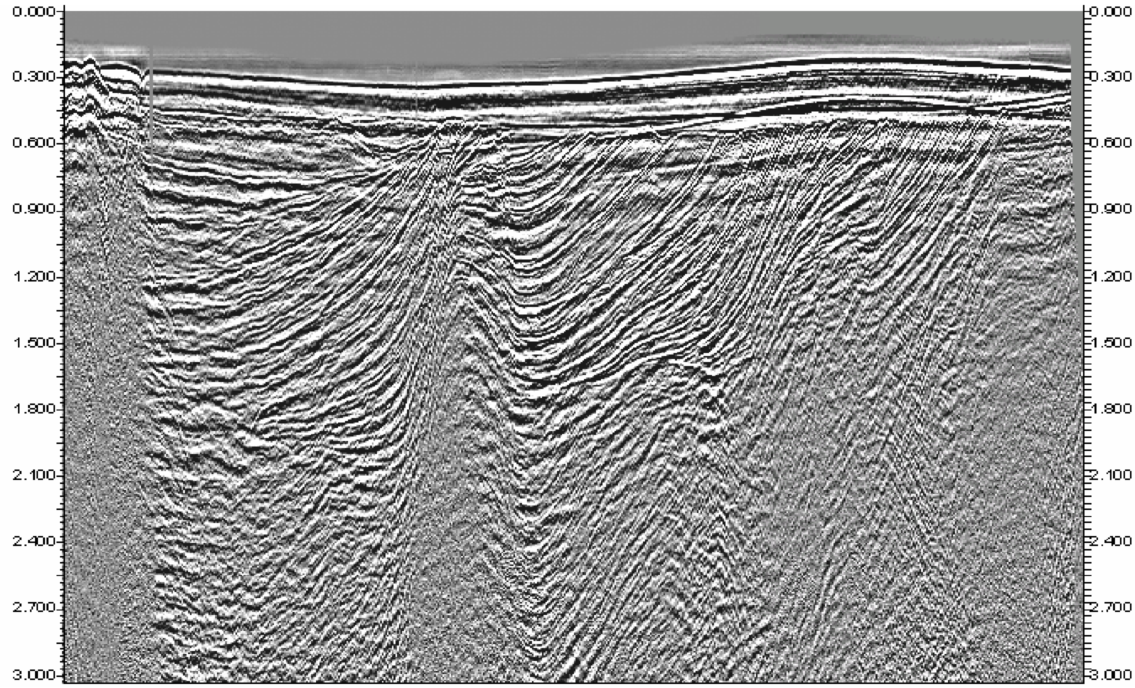


Figure 28: Section of line 420 from previous processing.

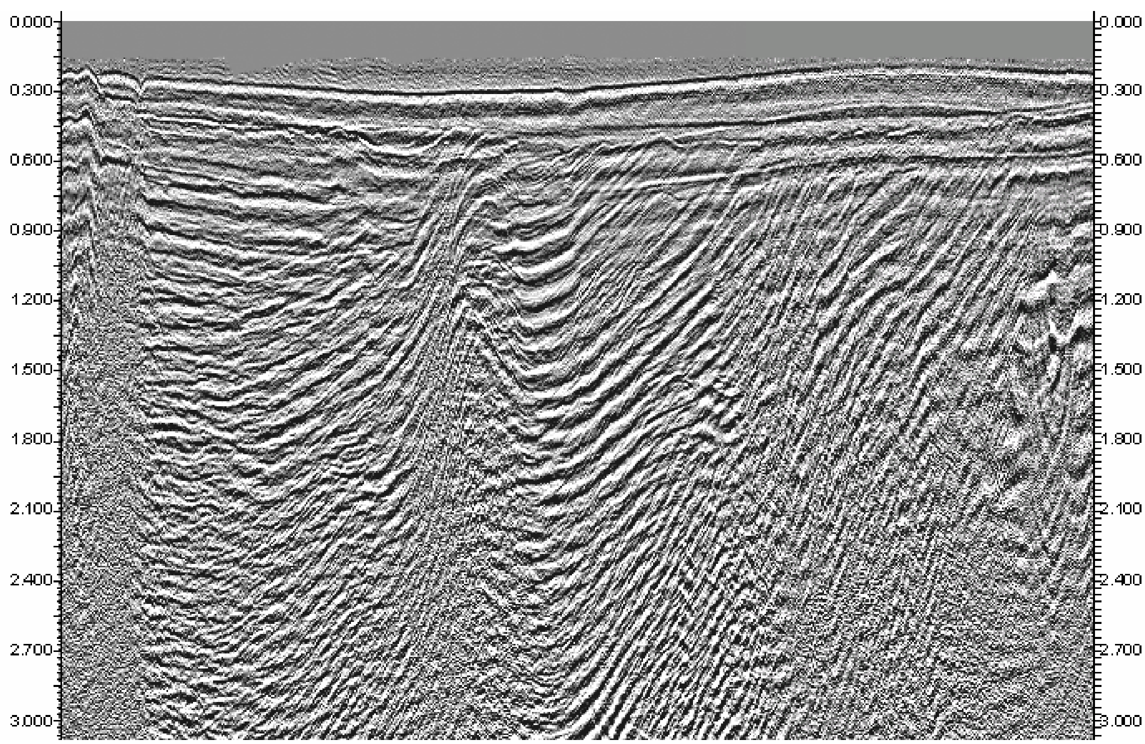


Figure 29: Section of line 420 from present processing.

SEISMIC DATA INTERPRETATION

The goal of the interpretation in this research was to clarify the structure close to Kayak Island and to determine whether or not it is the western boundary of the Yakutat microplate. Therefore, the interpretation was focused on identifying patterns that indicate the direction as well as the intensity of deformation. Six reflectors were mapped though the region to provided a measure of how the structure has evolved over time. Bruns and Schwab (1982) published structure maps and seismic stratigraphy of the Yakataga segment of the continental margin. Their research includes the southeastern side of the present study area; specifically, they present a description and seismic interpretation of lines 414 and 417. However, not much emphasis was placed on the northwestern area of Kayak Island, which is part of the present research. Lines 414 and 455, presented here, were also interpreted by Zellers (1995) who used well data to infer the age of a series of unconformities and applied seismic stratigraphy to interpret depositional packages in the data. She used the data without the revised processing and migration so there are some minor differences between her interpretation and that presented here. In particular, reflecting events that appeared most continuous throughout the area of Kayak Island were chosen for this interpretation, rather than using exactly the same ones that Zellers (1995) had identified. This was particularly important because most of the data presented here were located west of where she worked. Some of the interpreted events in this research coincide closely with hers. In general, in this research more horizons in the shallow part of the data, which was greatly

enhanced by the reprocessing, were selected and fewer horizons were used in the deeper part of the data where the uncertainties in interpretation were greatest.

Horizons A and B (figures 30-46) are located above the shallow unconformity that corresponds to a glacial maximum, 250,000 (Zellers, 1995) to 10,000 (Sheaf et al., 2002) years ago, and C-F correspond to reflectors within the Yakataga formation (Zellers, 1995). Event F corresponds closely to the deepest event, the base of the brown layer, interpreted by Zeller (1995) to be an approximately 4.2 Ma. unconformity. Similarly, horizon E in the interpretation presented here corresponds roughly with the base of the green layer in Zellers' interpretation as a 0.6 Ma unconformity. Horizon A is the water bottom and is easily traced throughout the data.

All of the faults identified here were very high angle. For that reason, we were not able to infer what the stress regime was from the faults. Even with careful reprocessing, the fault interpretation was not well constrained by the data, and hence only very obvious faults are included in the interpretation. After the faults and horizons were interpreted on the individual lines (Figures 30 - 46), contour maps were prepared for the individual horizons, and isochron maps (Figures 47 - 61) were used to show how the structural patterns changed over time.

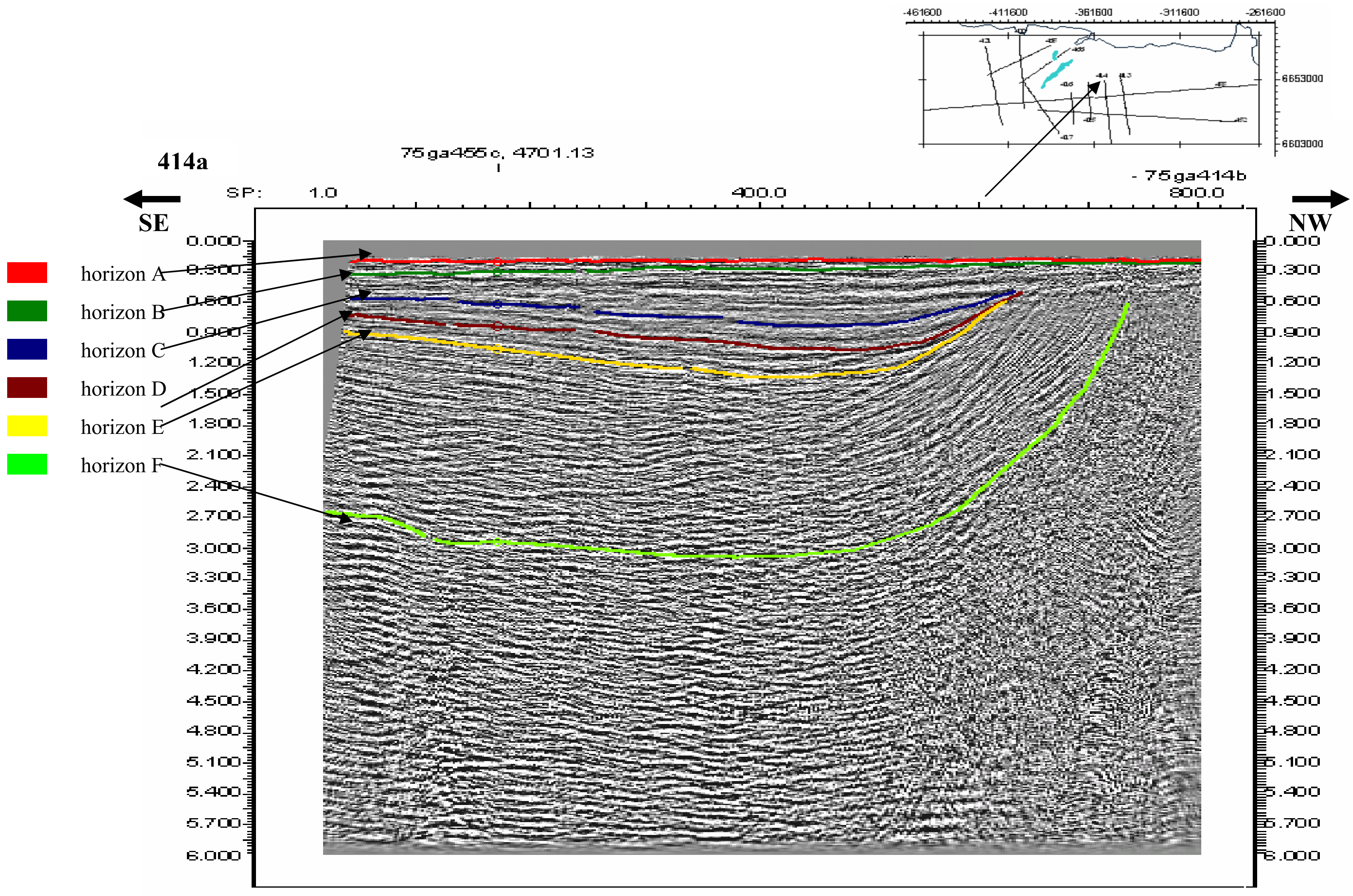


Figure 30: Interpretation of seismic section 414b.

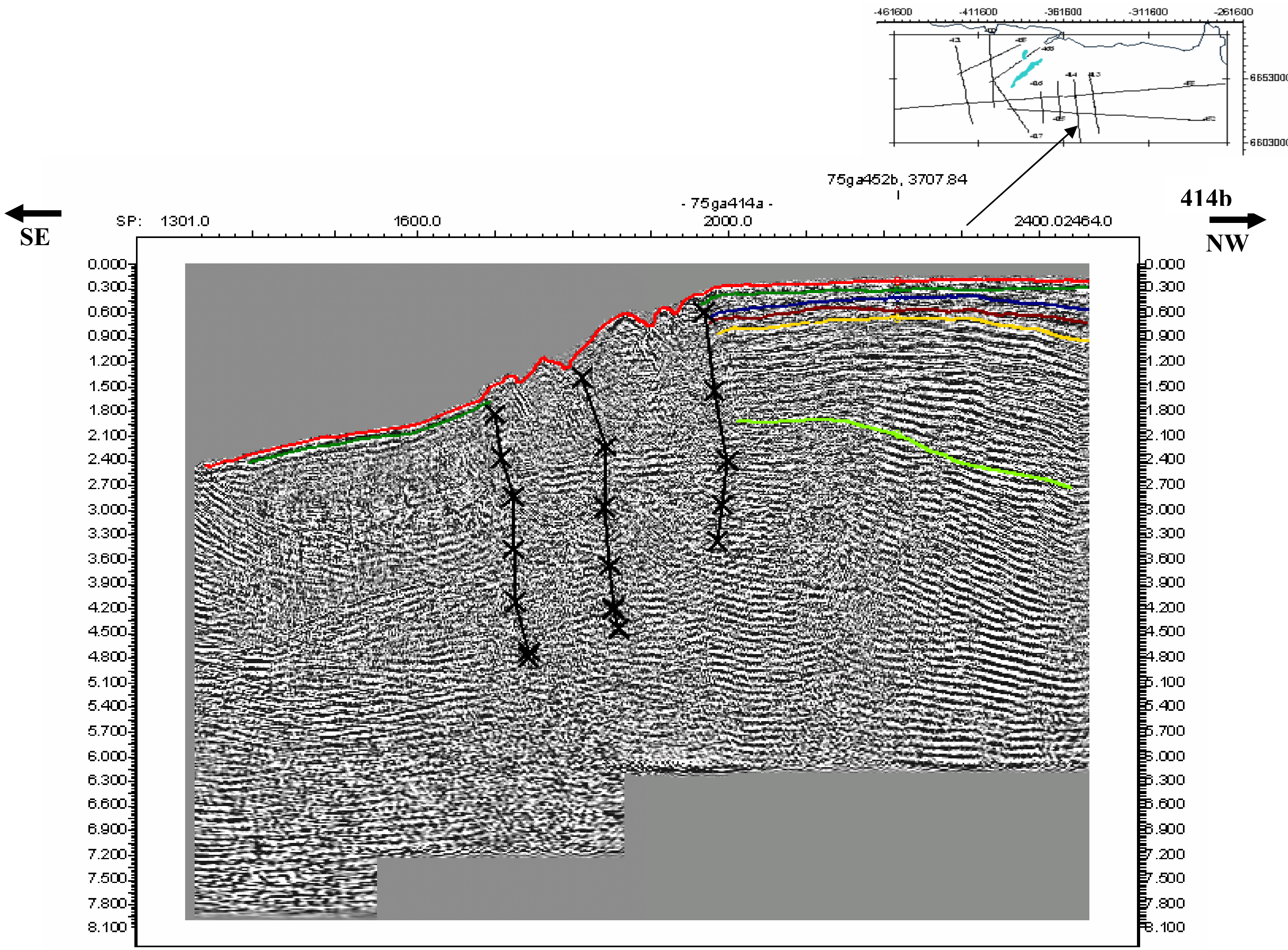


Figure 31: Interpretation of seismic section 414a.

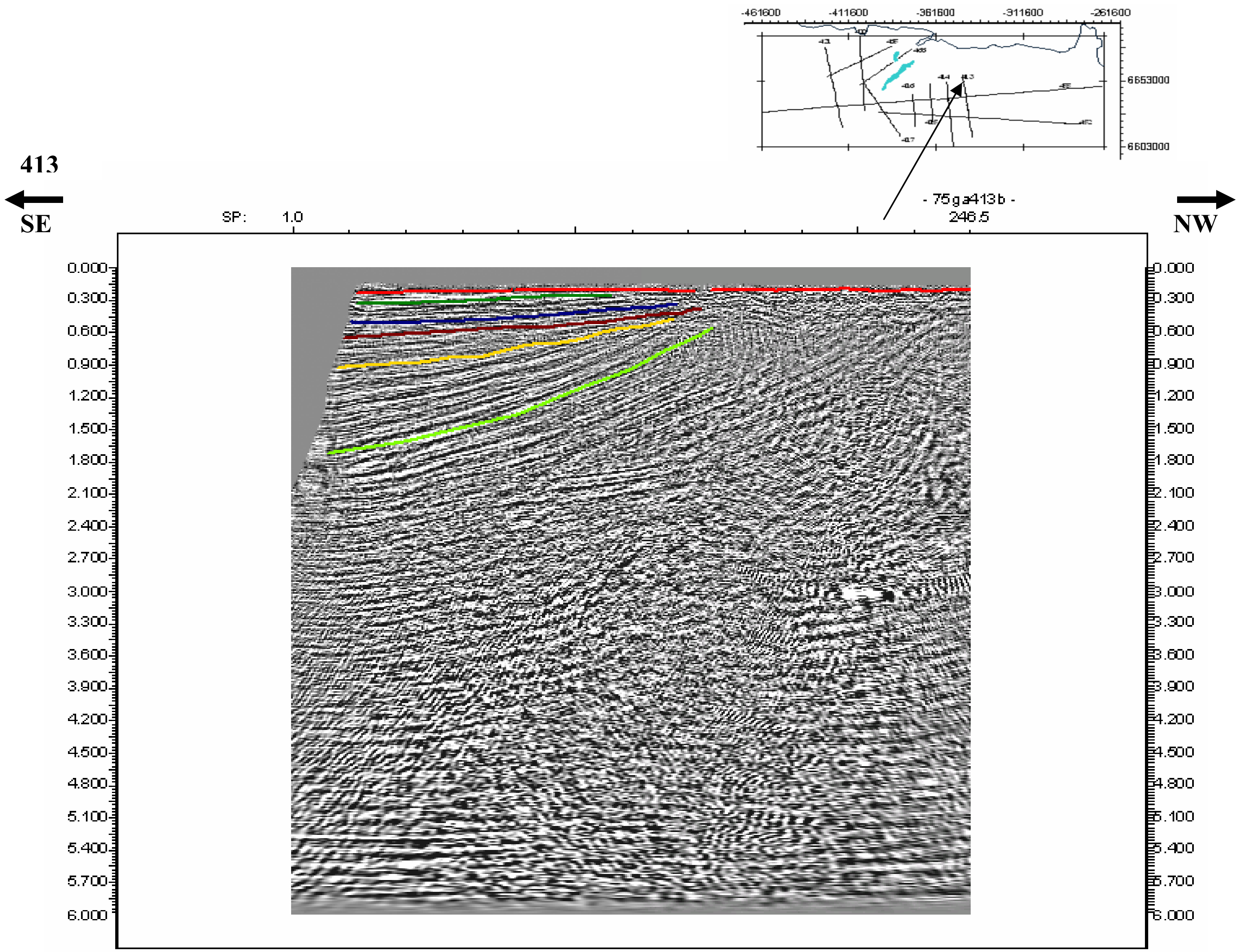


Figure 32: Interpretation of seismic section 413b.

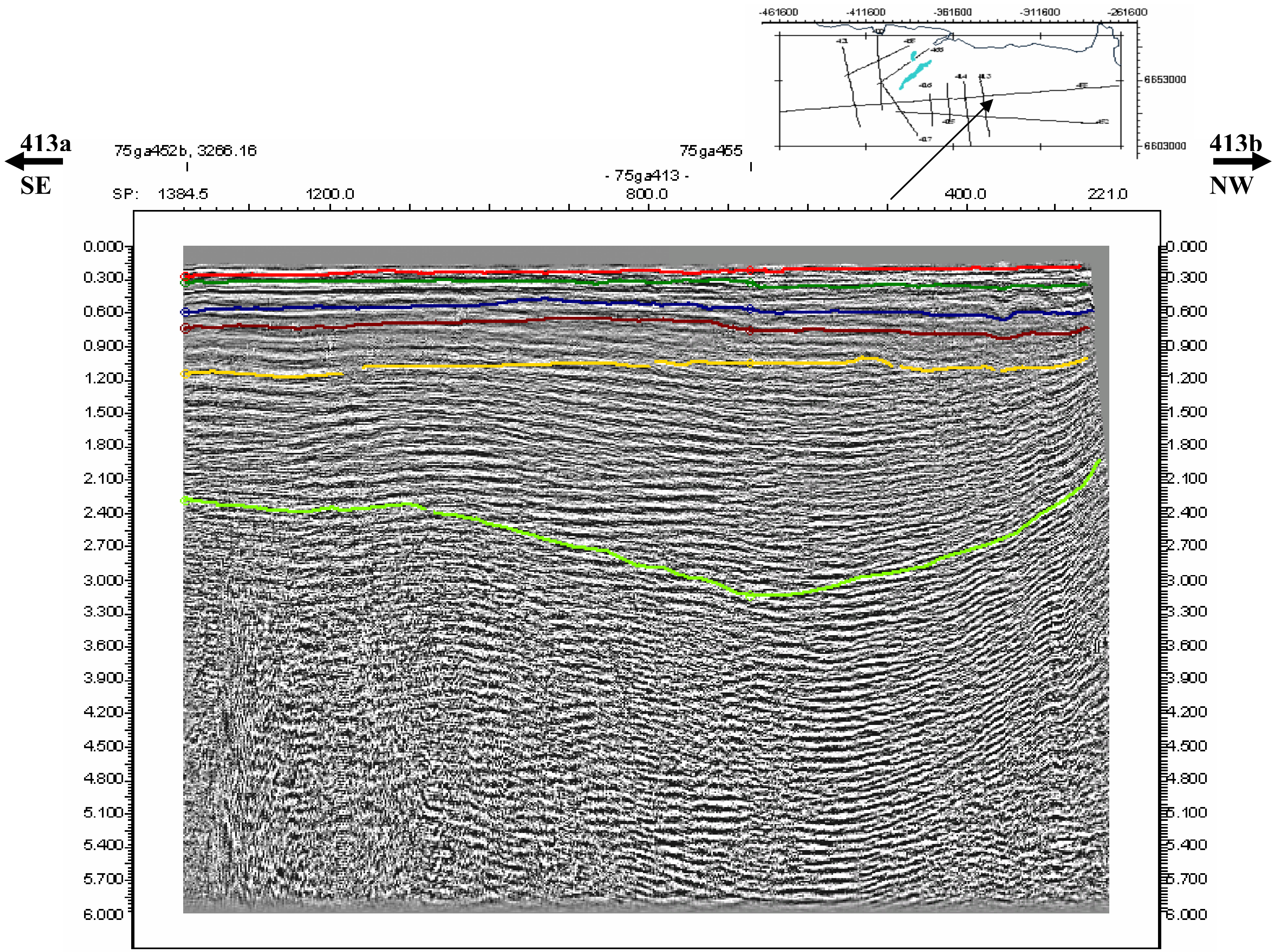


Figure 33: Interpretation of seismic section 413.

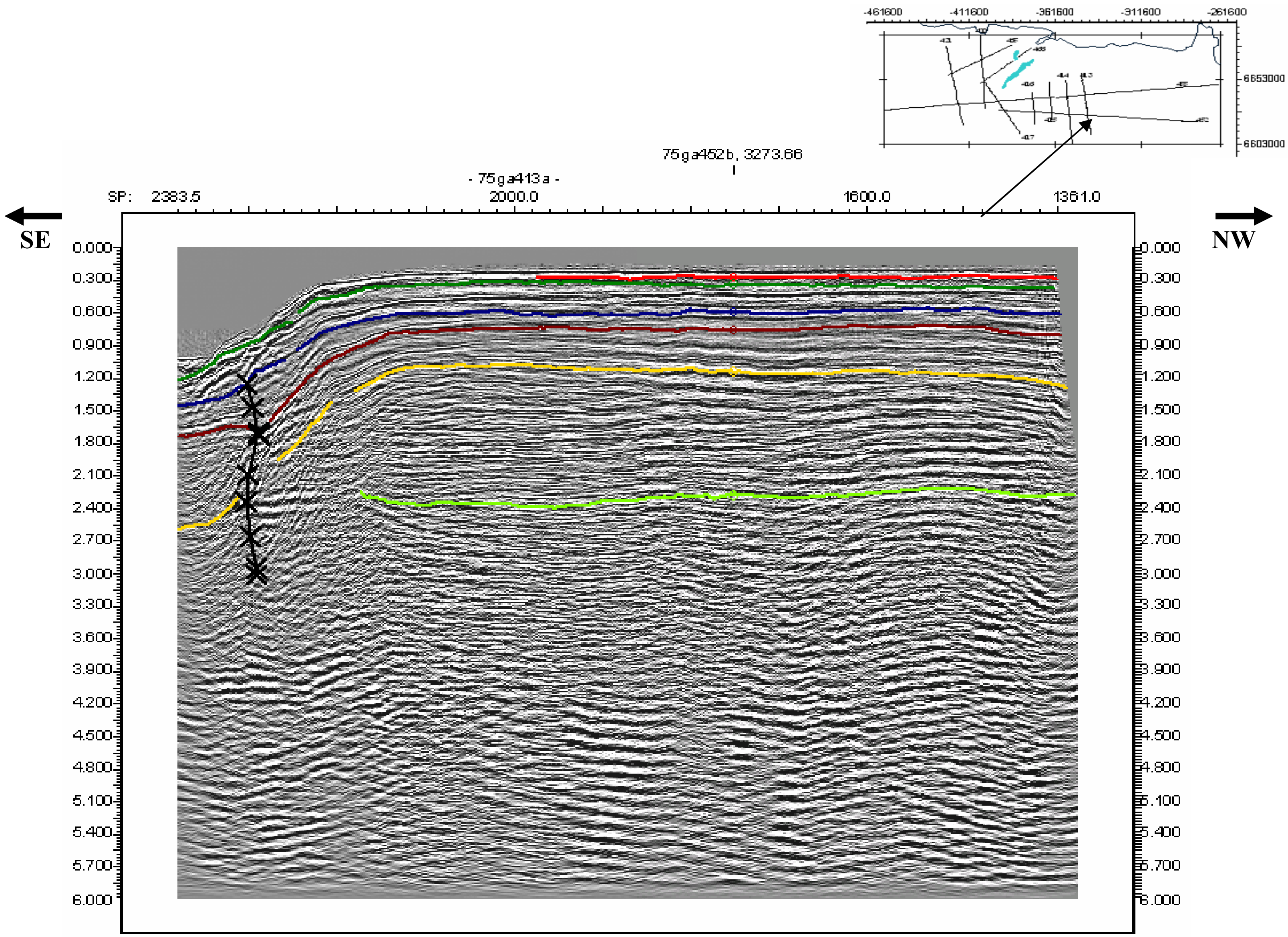


Figure 34: Interpretation of seismic section 413a.

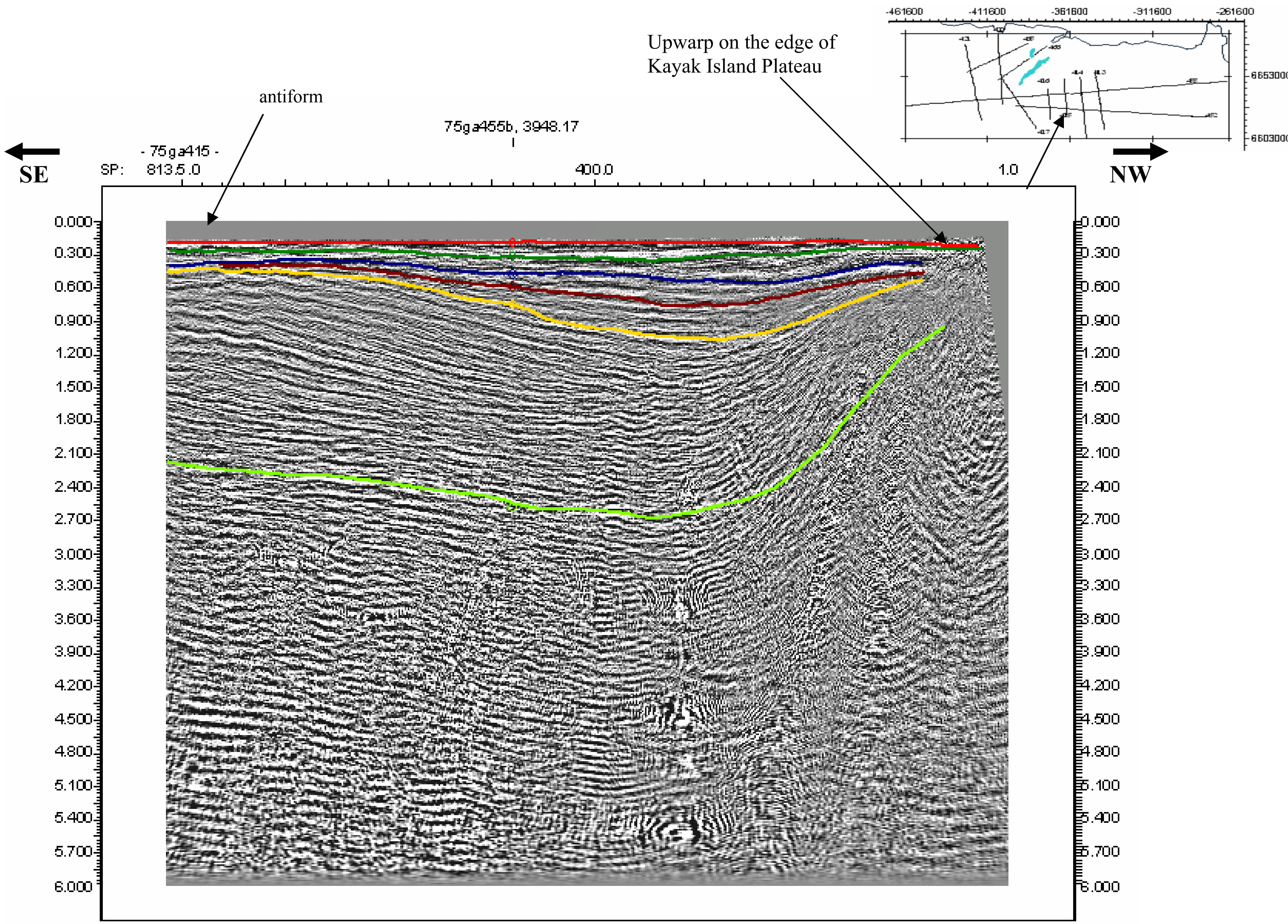


Figure 35: Interpretation of seismic section 415.

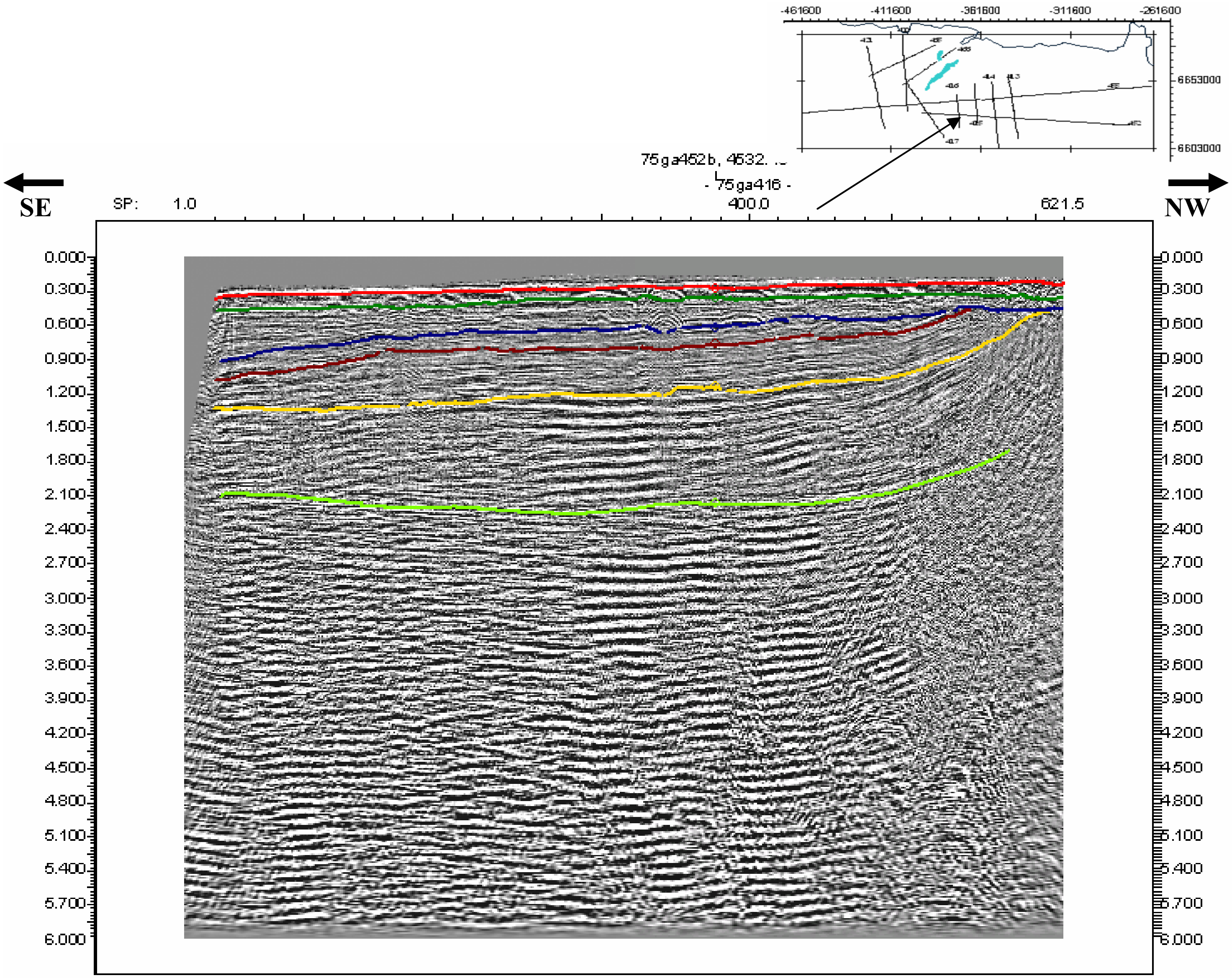


Figure 36: Interpretation of seismic section 416.

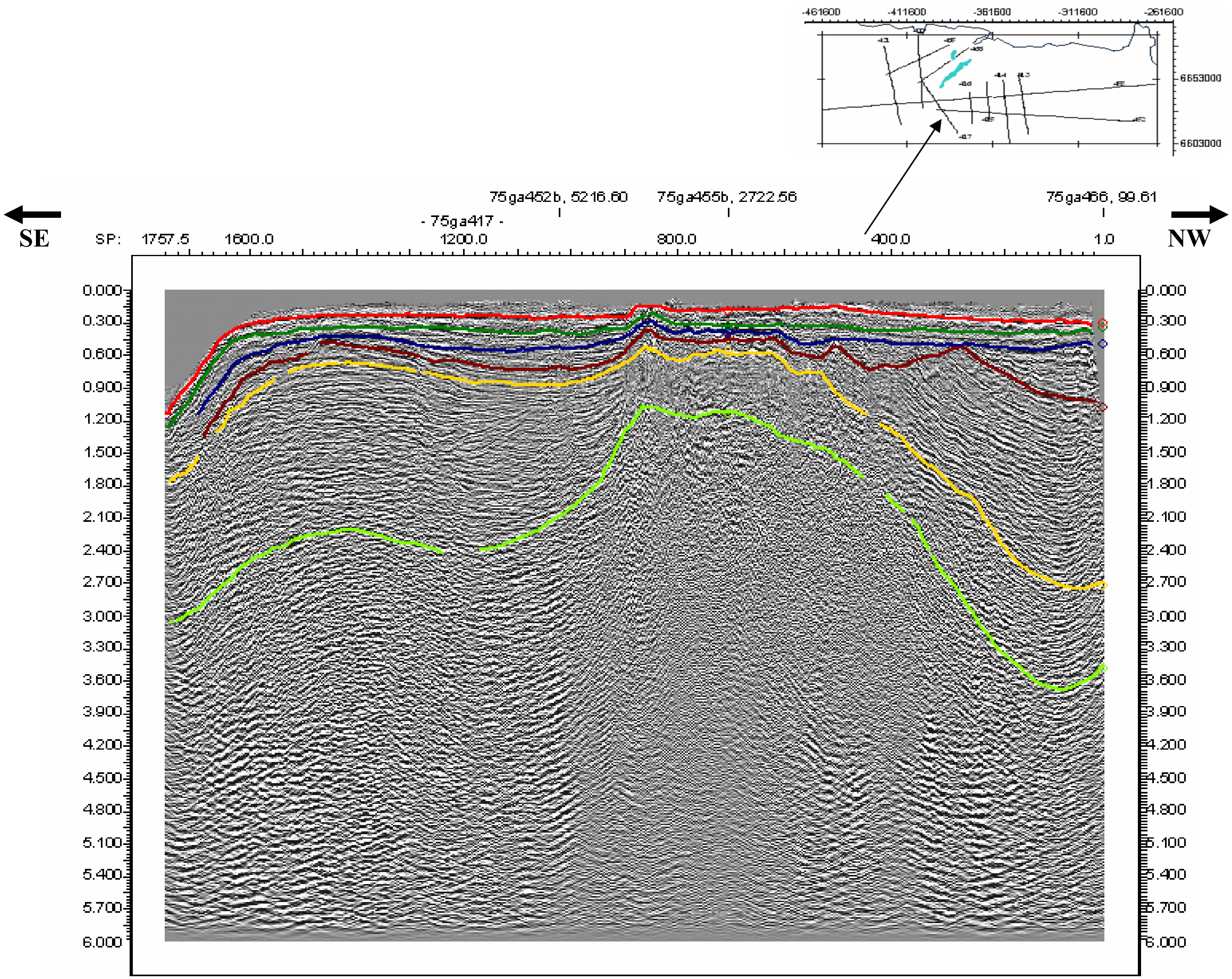


Figure 37: Interpretation of seismic section 417.

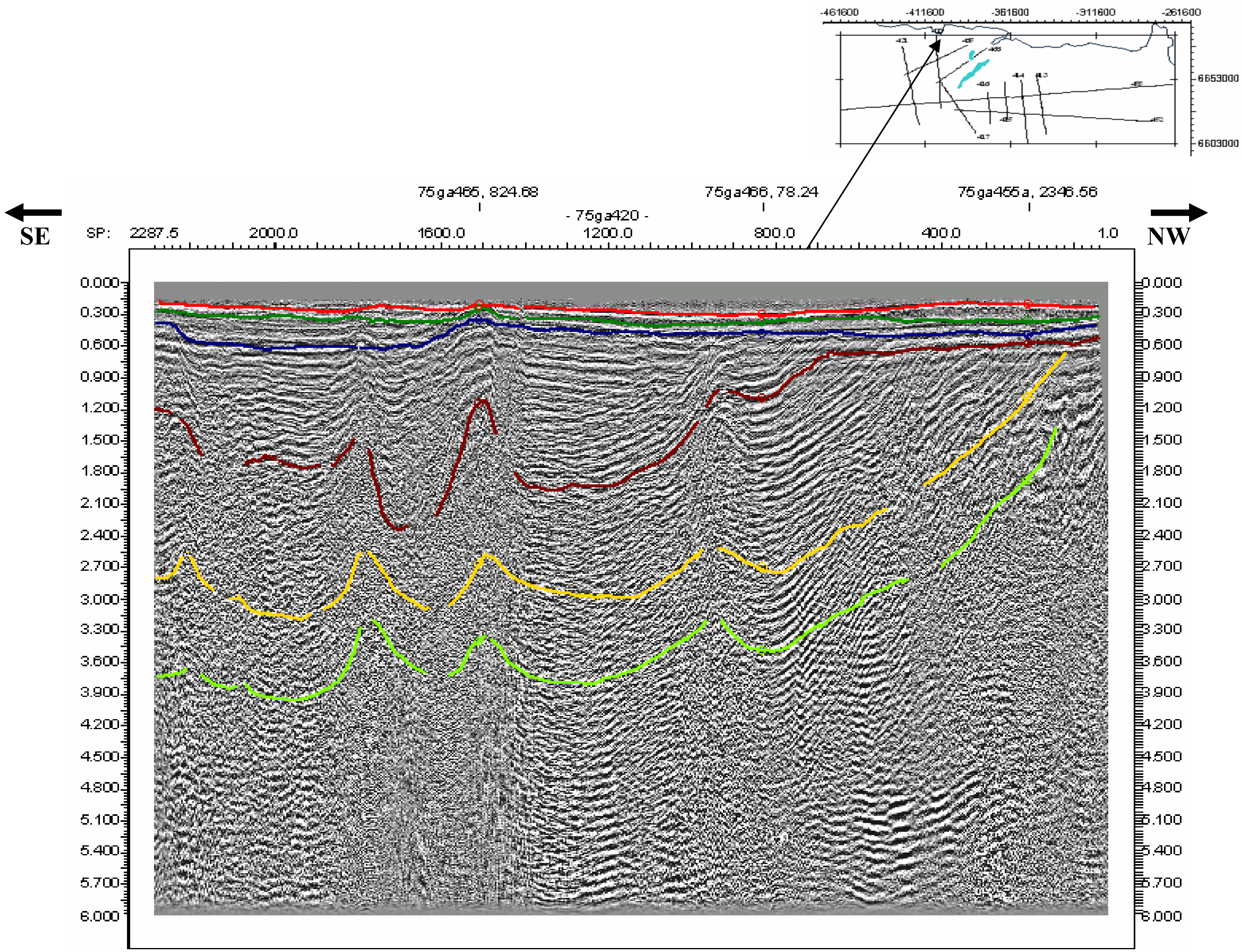


Figure 38: Interpretation of seismic section 420.

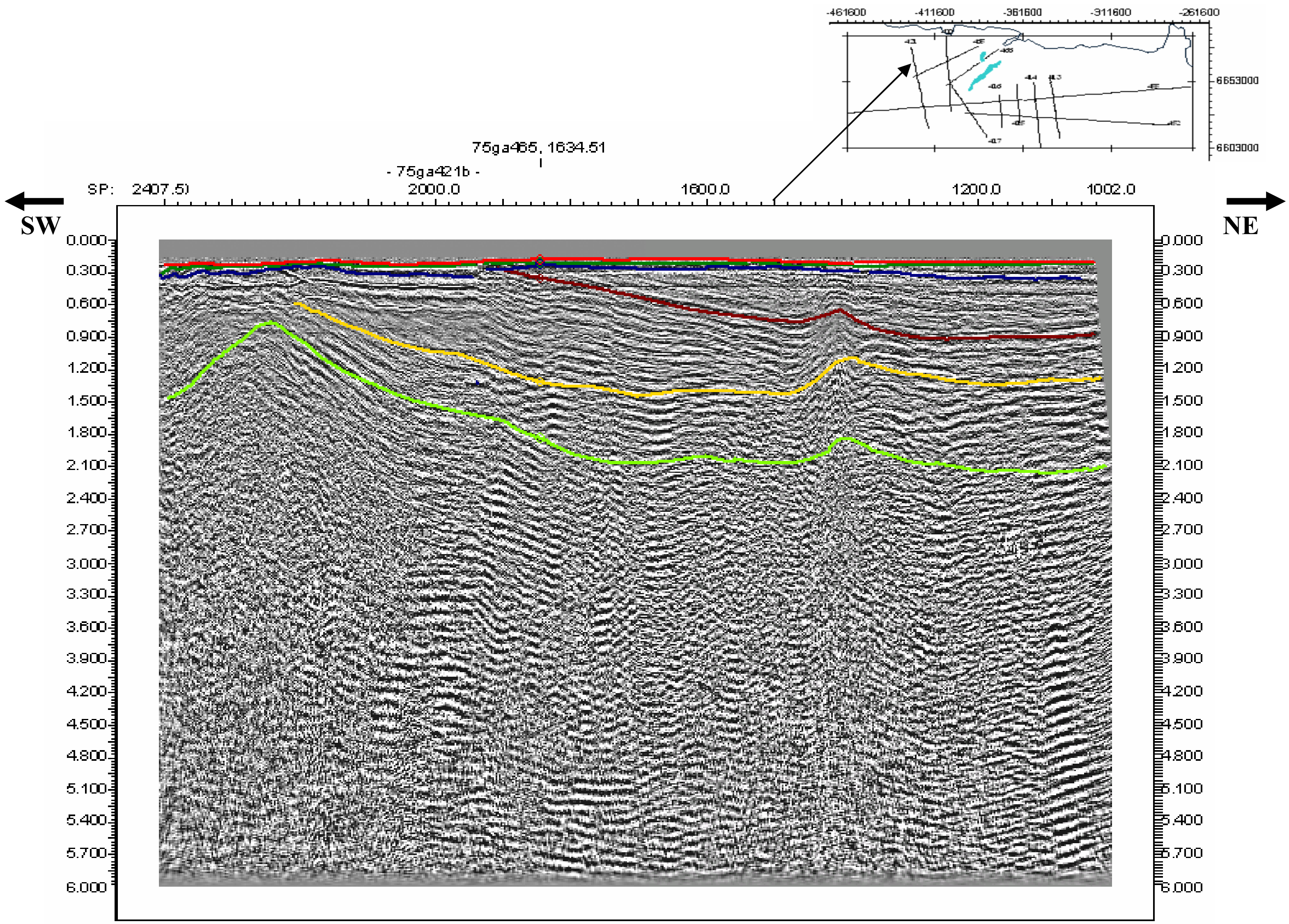


Figure 39: Interpretation of seismic section 421.

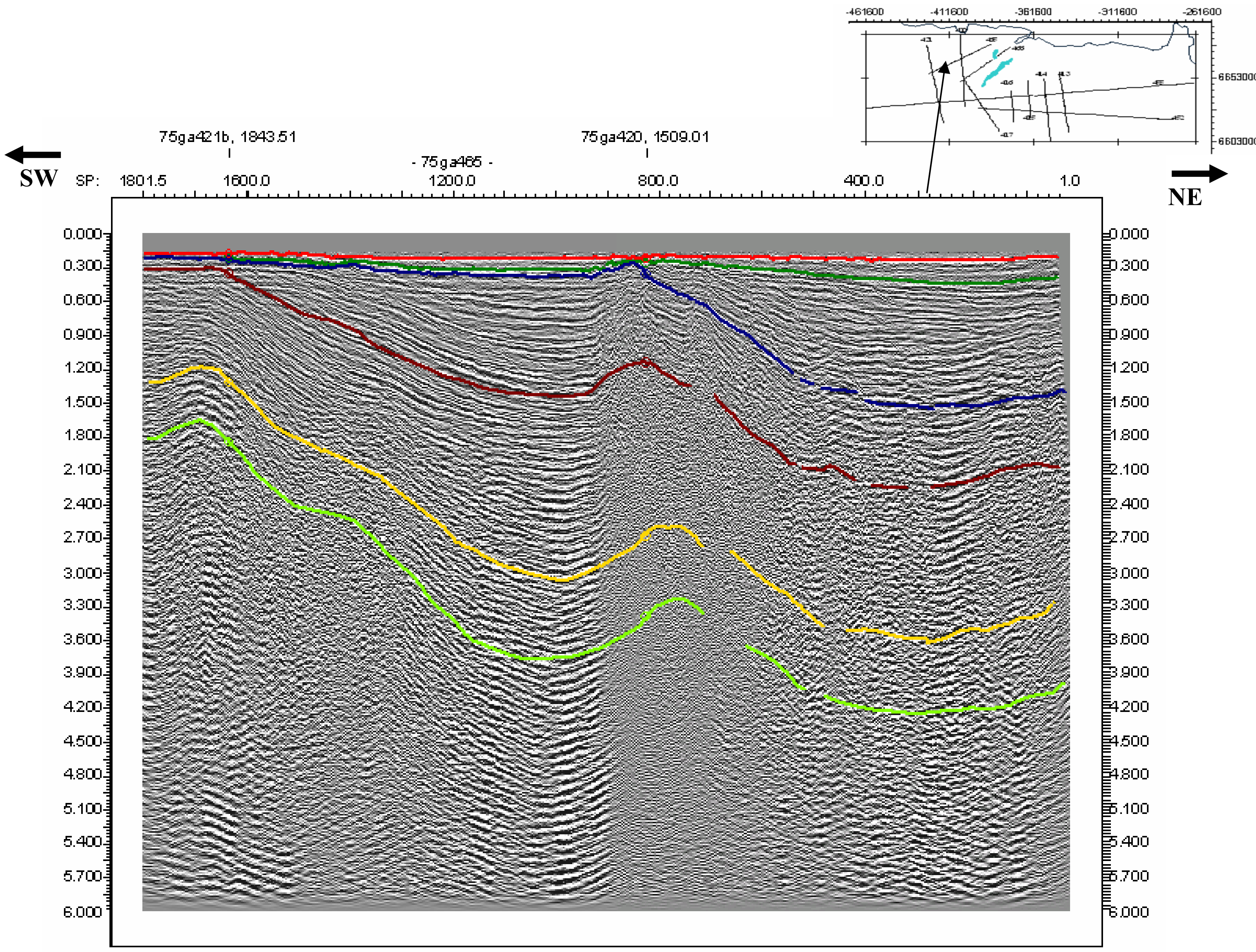


Figure 40: Interpretation of seismic section 465.

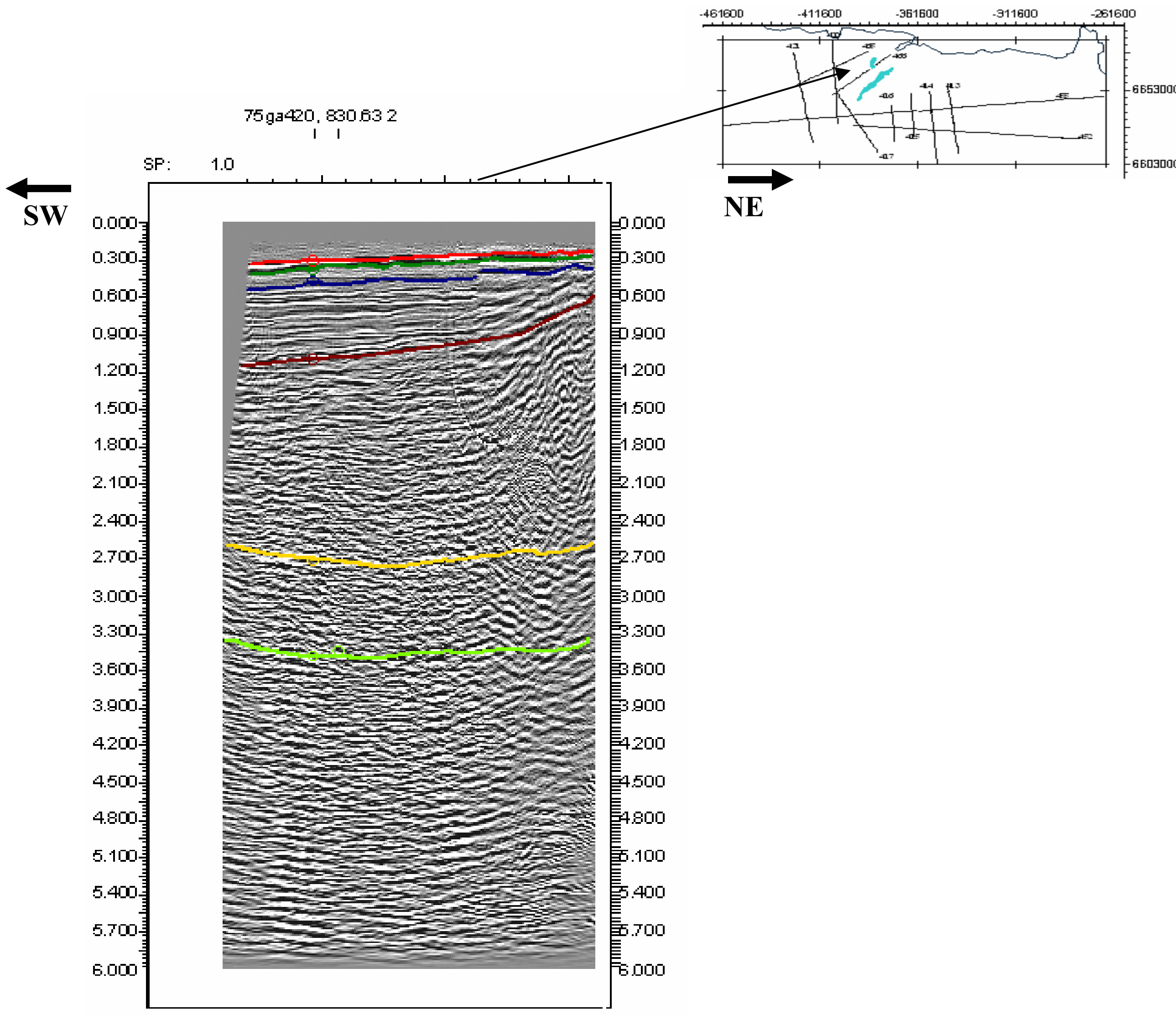


Figure 41: Interpretation of seismic section 466.

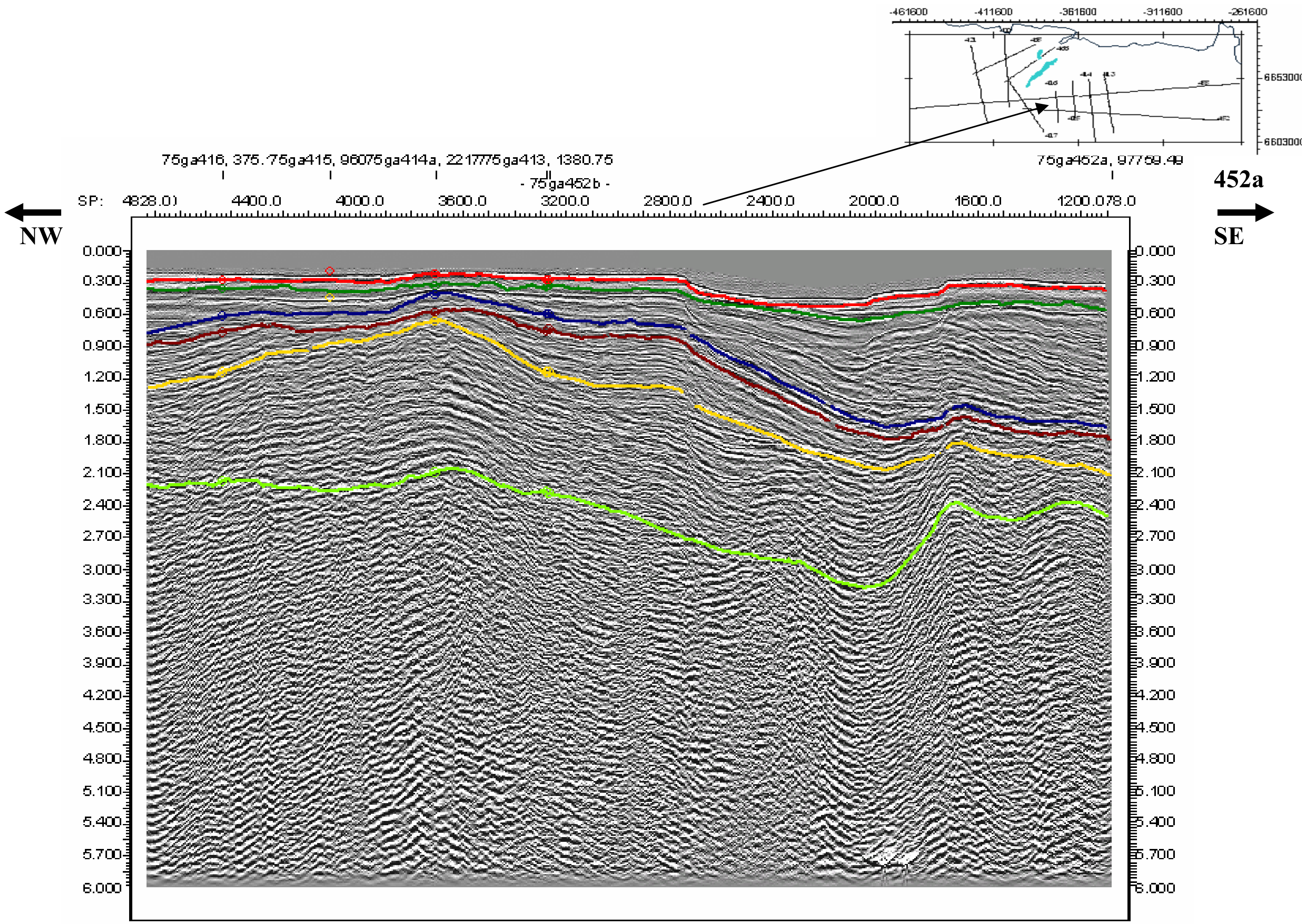


Figure 42: Interpretation of seismic section 452b.

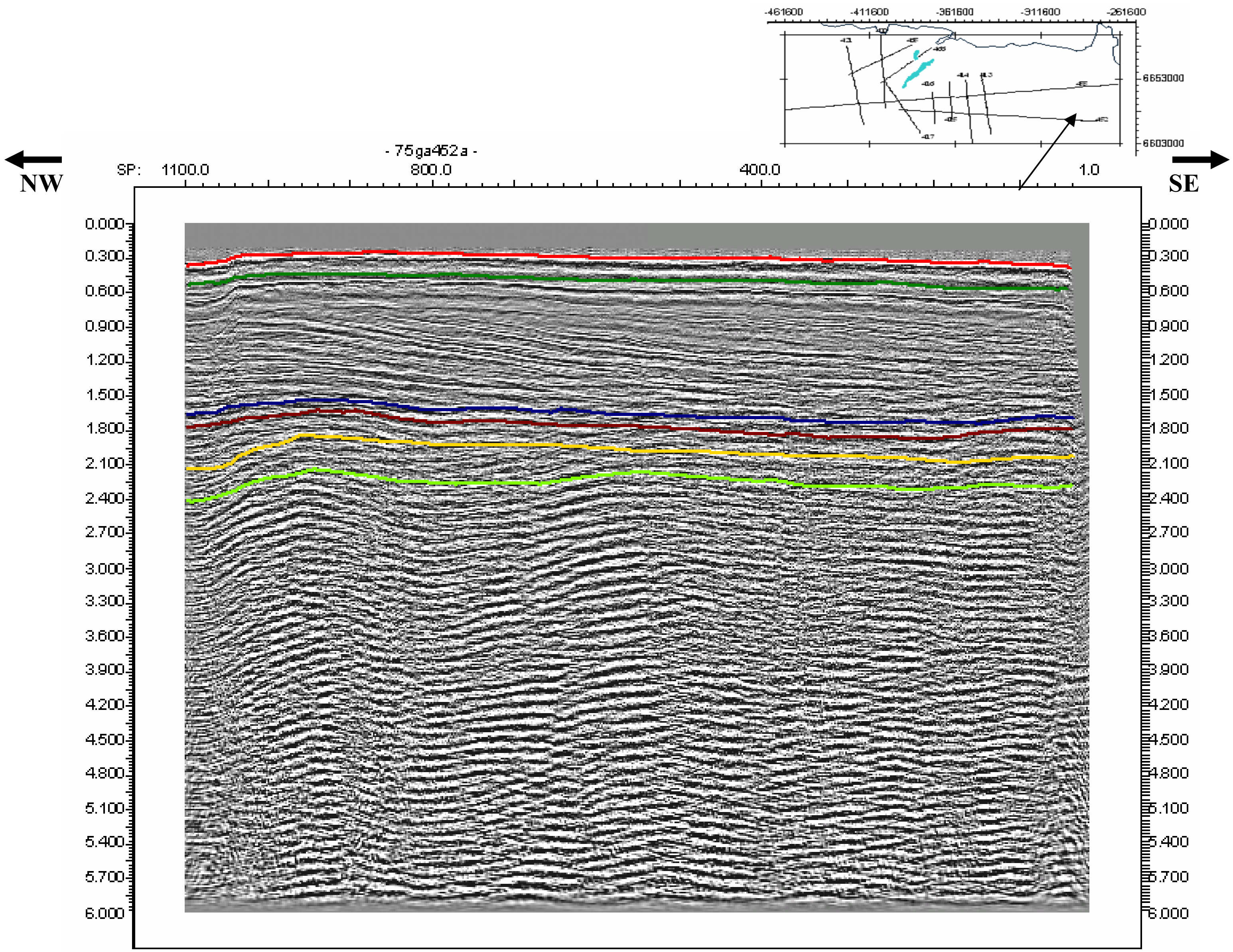


Figure 43: Interpretation of seismic section 452a.

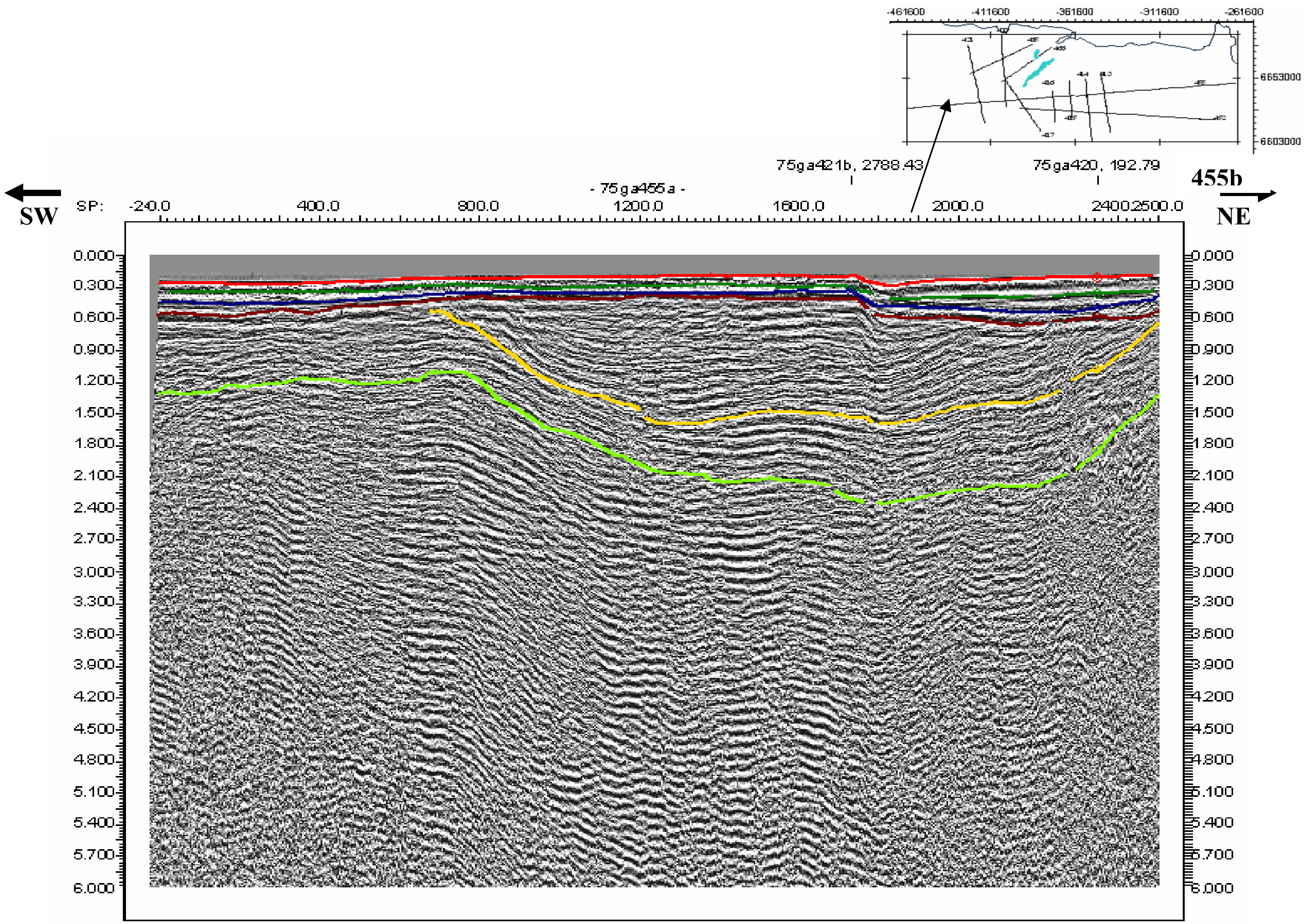


Figure 44: Interpretation of seismic section 455a.

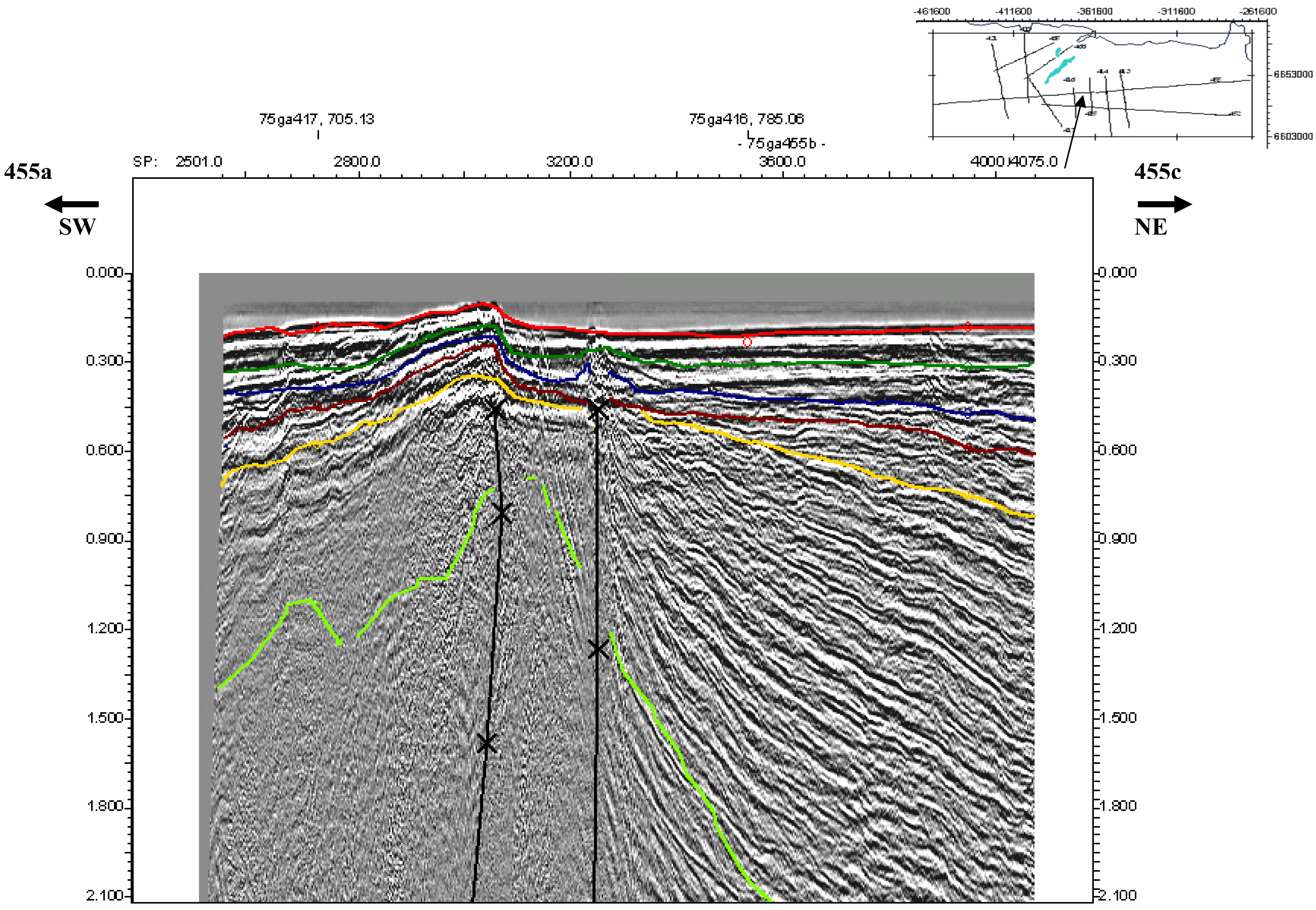


Figure 45: Interpretation of seismic section 455b (unmigrated). Modified from Bruns et al., 1982

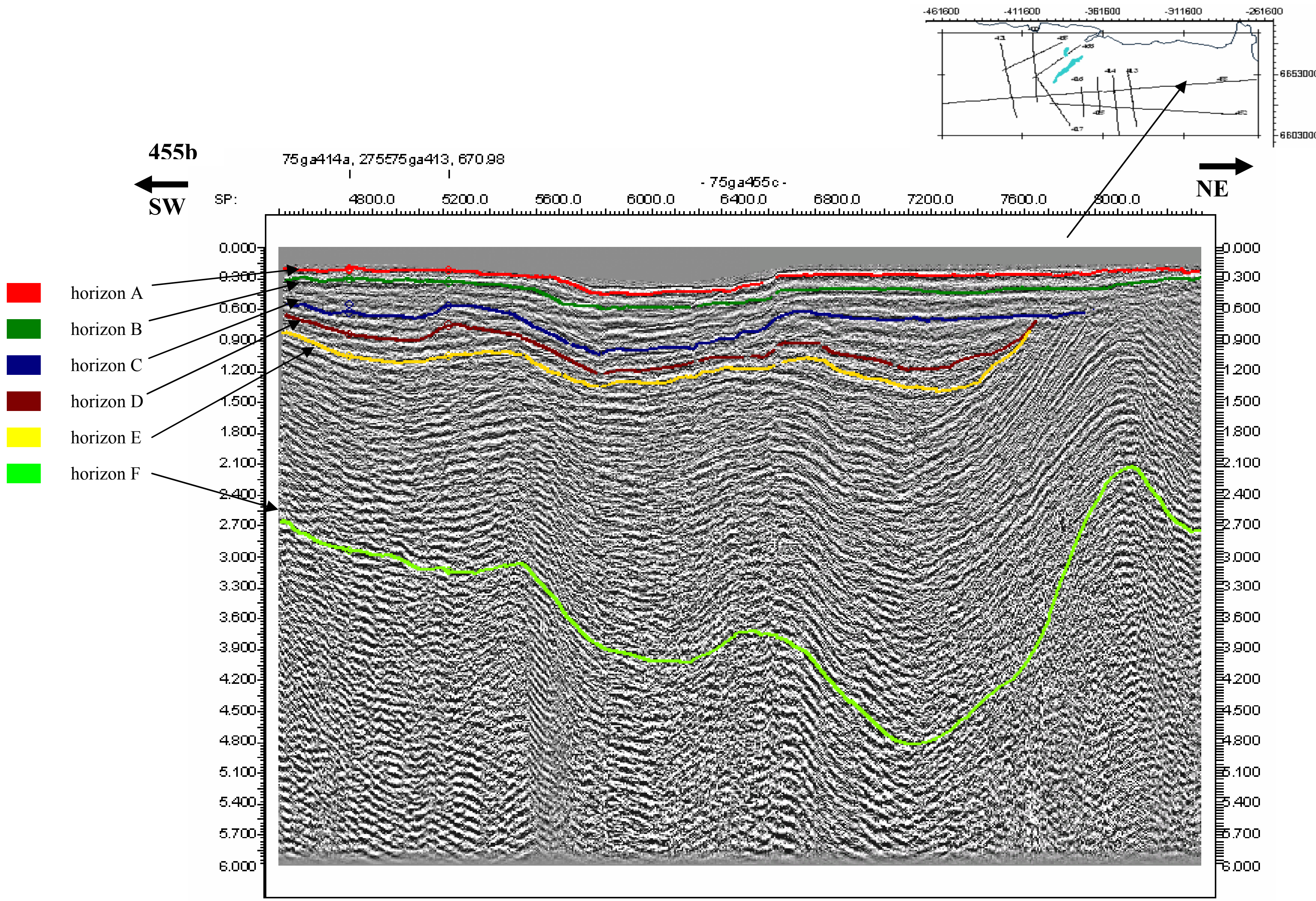


Figure 46: Interpretation of seismic section 455c.

Description of Seismic Sections

Seismic Section 414

Seismic section 414 (figures 30 and 31) trends northwest (figure 2). It was divided into two lines, 414a and 414b from south to north, respectively. The most significant features on this line are, from south to north, the continental shelf, a gentle antiform-synform pair, and a sharp upwarp along the margin of the Kayak plateau. Three high-angle faults are mapped on the continental slope, and only horizon A can be traced with confidence south of those faults.

Seismic Section 413

Seismic section 413 is divided into three segments (figures 32, 33, and 34). Line 413b is close to the onshore area, line 413 is located in the middle of lines 413a and 413b, and line 413b is the most southeastern line. The whole section covers a length of 43km and it is parallel to line 414. Many of the features of line 413 are similar to those observed in line 414. For instance, the antiform is present in line 413, almost parallel to the position observed in line 414; however in line 413 it is less pronounced. Horizons A to F are also defined in line 413; horizons A and B are conformable and flat. An unconformity is present between horizon B and C. Horizons C-F appear relatively conformable, and those horizons fold following the same antiformal structure observed in line 414. In the most southern side (figure 34), a high angle fault is observed. This fault may be related to the same fault system observed in line 414 and reported by Bruns (1982).

Seismic Section 415

Seismic section 415 (figure 35) is 25 km long and parallel to lines 414 and 413. It is is very similar those lines, with an antiform in the northwestern and an unconformity between horizon B and C. This result suggests that the upwarp is asymmetric, changing the axis southwest ward from line 413 to line 415.

Seismic Section 416

Seismic section 416 (figure 36) covers around 23 km and is parallel to lines 413, 414 and 415. This line crosses lines 455 and 452 and is close to the south end of Kayak Island. The 6 horizons identified in the previous lines are observed also in this section. Moreover, the principal features, such as the upwarp and the unconformities are similar to those observed in the other lines.

Seismic Section 417

Seismic section 417 (figure 37) covers around 42 km and is located in the southwestern area of Kayak Island, trending northwest. This section is very important because it crosses lines 455, 452, 466 and 465 and covers a region on the opposite side (NW versus SE) of Kayak Island. The strategic location of the line allows comparison of structures on the NW and SE sides of the Island. In this section the most relevant feature is the strong shallow deformation; faults and folds are observed even in shallow horizons A and B. Comparing the NW area to the SE area indicates strong and diverse deformation is present in the NW area while the SE area is more passive. Horizons A, B, C and D are well defined on section 417 but horizons E and F are discontinuous and, thus, were inferred from the surrounding reflectors.

Seismic Section 420

Seismic section 420 (figure 38) covers part of the northwest side of Kayak Island, crossing section 417 and section 455. This line shows strongly deformed portions, high angle faults that offset shallow reflectors, and unconformities. By comparing this section and the section located on the southeastern side of Kayak Island, it is evident that the northwest side of Kayak Island is much more deformed than the southeastern side. An important observation here is that the shallowest sediments seem to be subject to deformation. In fact, areas between horizon A and B, which appear flat in the southeastern section, are strongly deformed in some regions of this seismic section.

Seismic Section 421

Seismic section 421 (figure 39) is almost parallel to line 420 on the northwest side of Kayak Island. This section crosses line 455 and line 465. Similar features to those observed in section 420 are present in this section. The section is characterized by strong deformation. One of the principal problem for the interpretation of this seismic section is the presence of strong multiples in the shallow area which could not be reduced even with the detailed processing sequence described previously.

Seismic Section 465

Seismic section 465 (figure 40) runs parallel to Kayak Island on the northwest side. The line intercepts lines 420 and 421.The principal feature is the presence of an anticline and the unconformities located in shallow regions.

Seismic Section 466

Seismic line 466 (figure 41) is the closest section to Kayak Island on the northwest side. This line is almost parallel to line 465 and Kayak Island as well. The line does not cover a very extensive region. For this reason the major features of the area are not well defined; however, there is an indication of an anticline and unconformities. Moreover, when this line is compared with line 465, which is parallel to it, the general pattern is similar.

Seismic Section 452

Seismic section 452 (figures 42 and 43) runs from northwest to southeast and crosses lines 413, 414, 415, 416 and 417. This line is very important because it allows correlation of the data to give a clear 3D idea of the geological structure imaged in the 2D data. The southeast side the seismic section shows some unconformities but no significant faults and folds are observed (figure 43). On the other hand the northwestern most portion of the line (figure 42) shows significant deformation. Some of this deformation may be attributed to surface processes rather than tectonic processes. For instance, the dip observed around SP 2800 (figure 42) could be caused by glacial scouring and not tectonic interactions.

Seismic Section 455

Seismic section 455 (figures 44, 45, and 46) is the largest section in the study area and runs from southwest to northeast crossing lines 421, 420, 417, 416, 415, 414 and 413.This line is the most strategic line because it crosses the major lines and goes across the entire region. The line is divided in three section, 455a, 455b and 455c. The seismic data of section 455b was not available for processing in this research; however, due to the relevance of this section to the

interpretation, a previously processed section (Bruns et al., 1982) was used (figure 45). The behavior of this line is very similar to line 452. Shallow features such as channels which may be related to glacial processes rather than tectonic processes are present. High angle faults as well as fold and unconformities are shown. Finally, the general pattern of major deformation into the northwestern side is shown in this line.

Horizons and Isochrones Maps

To determine the pattern of evolution of deposition in the study area, contour maps of each defined horizon and contour maps of the isochron between the horizons were plotted (figures 47-57).

Horizon A (red)

Horizon A is the shallowest reflector in the data set (figures 30-46). It corresponds to the water bottom and is well defined throughout the area. Figure 47 shows the time contour map corresponding to this horizon. This horizon is subhorizontal with a slight southern dip toward the continental shelf.

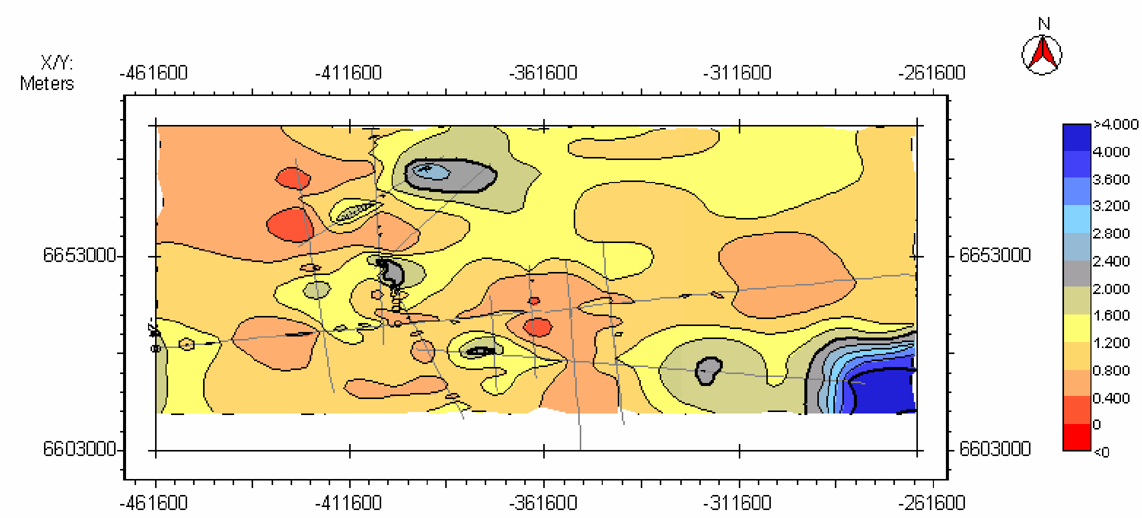


Figure 47: Contour map of horizon A.

Horizon B (olive)

Horizon B (figure 48) lies directly below and usually within 0.1 sec of horizon A. However, the contour maps of these horizons are slightly different because horizon B is more flat

than horizon A. This may be related to the fact that horizon A is the near horizon to the surface and surface processes may be more evident in this horizon.

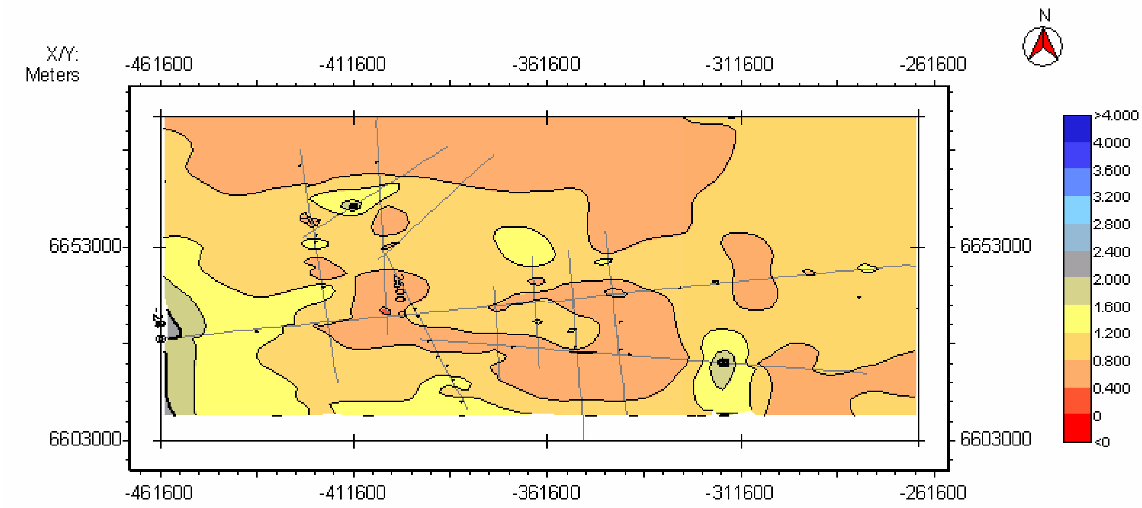


Figure 48: Contour map of horizon B.

The isochron shown in figure 49 further indicates a pattern of thinning sediments between A and B along two approximately north trending-regions. Parallel areas of sediment thickening are also observed to suggest there has been some differential movement between the times of deposition of the two horizons.

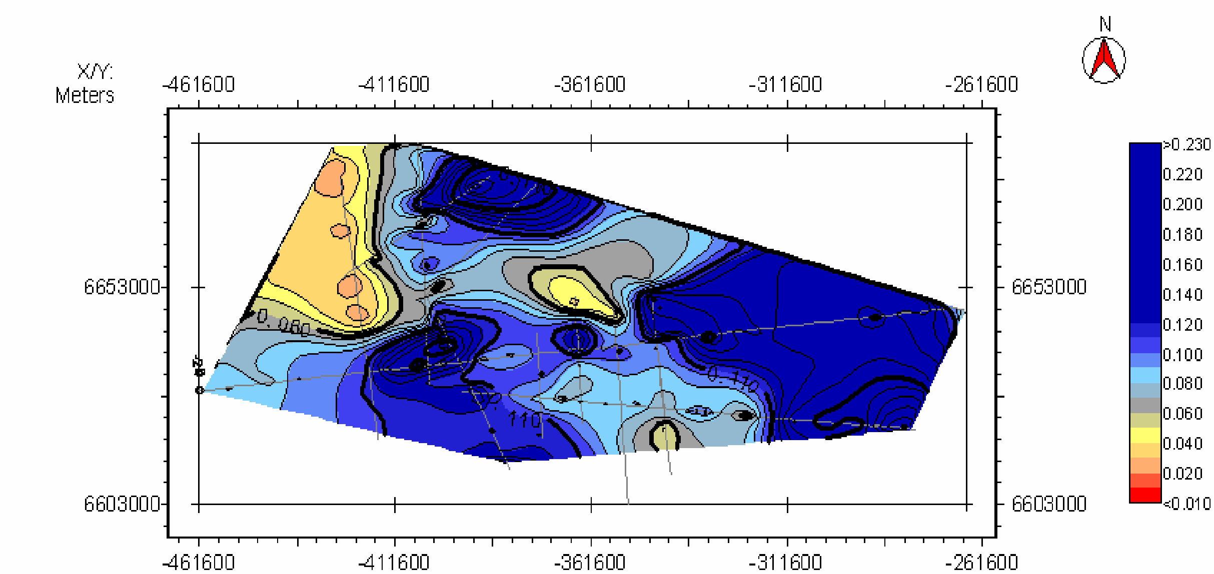
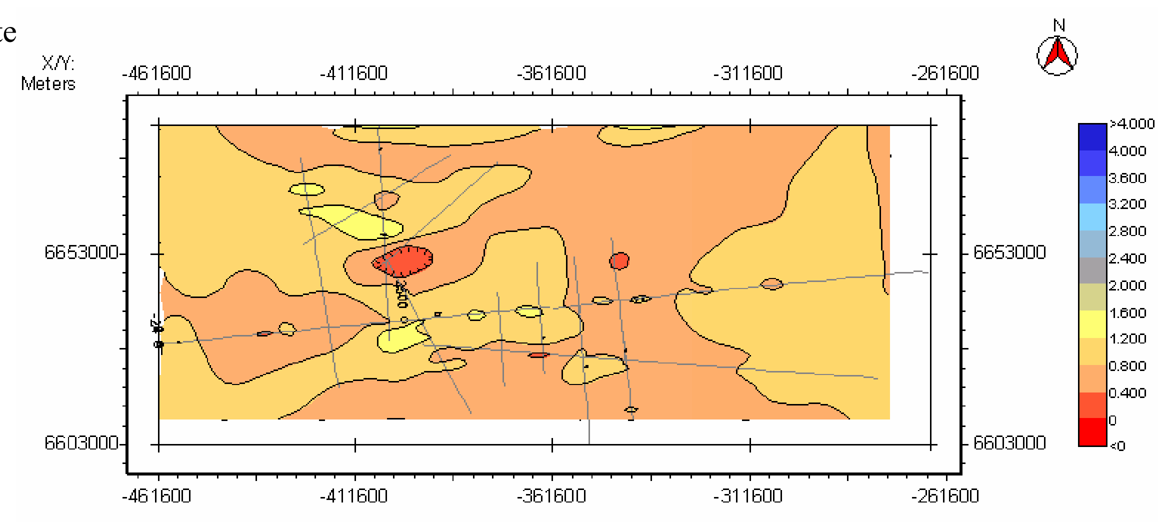


Figure 49: Isochron between horizons A and B.

Horizon C (blue)

Horizon C (figure 50) is below horizon B; the two-way travel time varies between 0.4 and 1.8 sec. The central region is relatively flat in time while depressions are observed in the weste



Here a pattern of thinning sediments is evident but when comparing it with figure 49, the parallel areas of sediment thickening have been shifted.

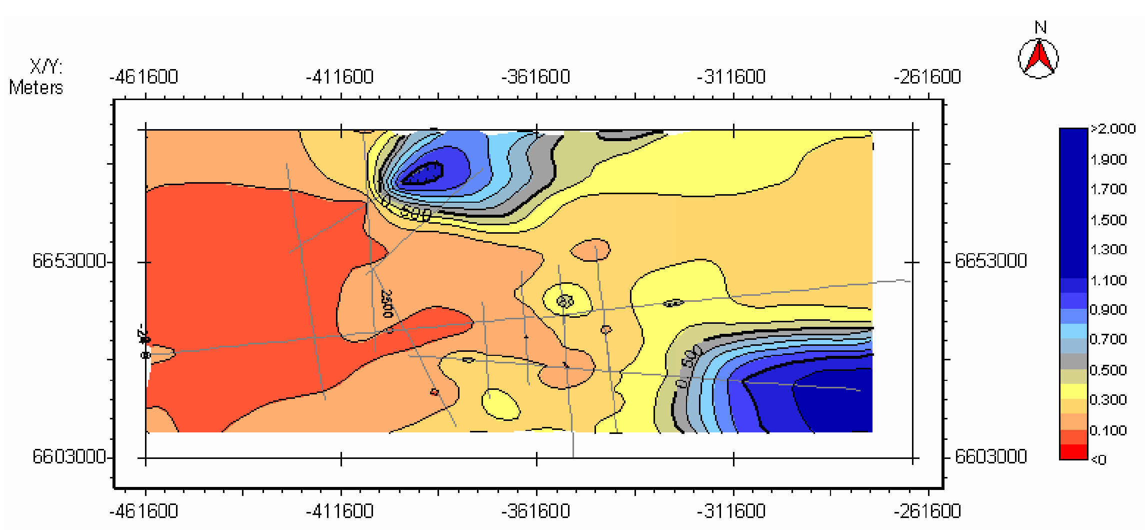


Figure 51: Isochron between horizons Band C.

Horizon D (brown)

Horizon D (figure 52) shows a major depression trending east below and northeast above to Kayak Island (compare figure 52 with figure 2). Between those two depressions an upwarp that could be related to a mayor fault system is observed tending northeastward.

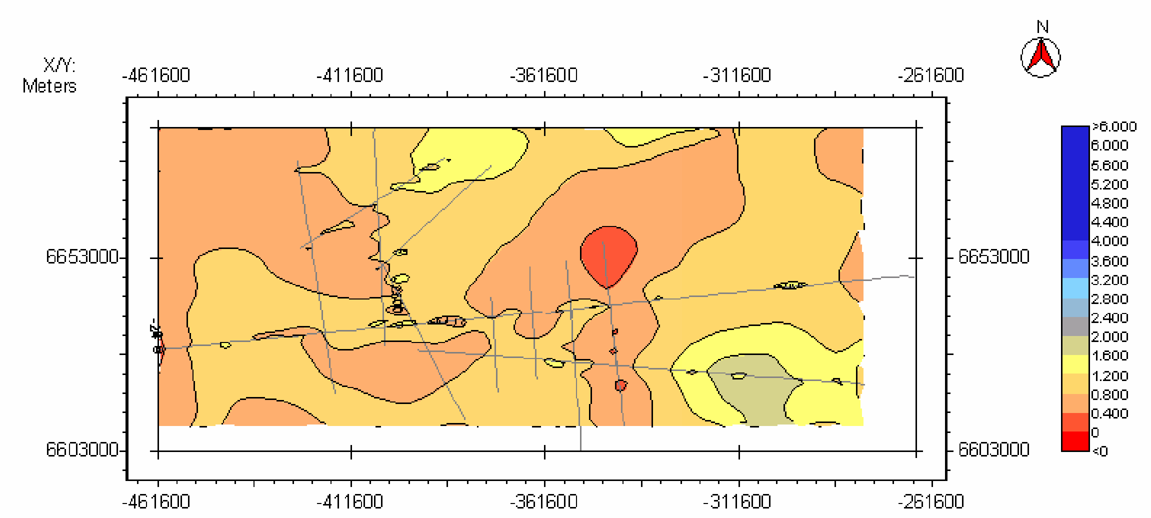


Figure 52: Contour map of horizon D.

The isochron of horizon C and D (figure 53) shows a concentration of thickening in the northwest side. The rest of the area is almost uniform in thickness. Comparison of this result to the previous horizon isochrones shows a change in pattern and direction of sediment deposition that has occurred in the evolutionary history.

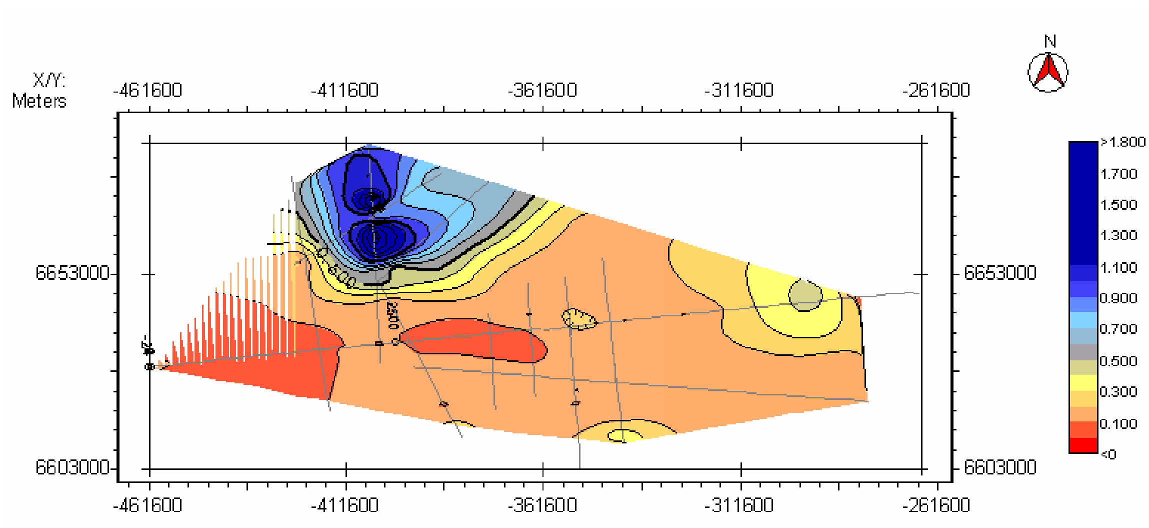


Figure 53: Isochron between horizons C and D.

Horizon E (Yellow)

The pattern observed on horizon D is more evident in horizon E (figure 54) where the central area tending northeast has high elevation.

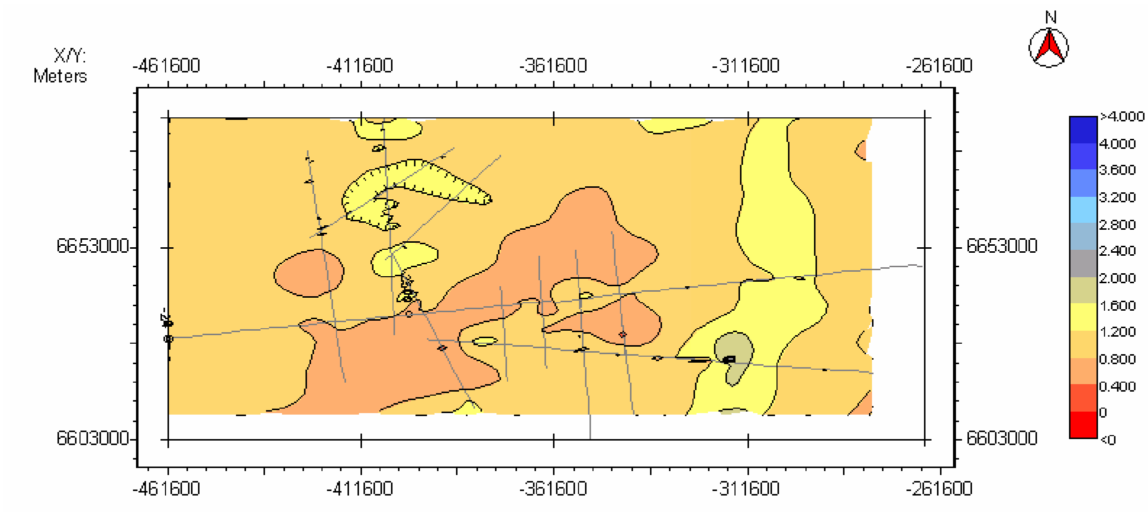


Figure 54: Contour map of horizon E.

Figure 55 shows that the pattern of thinning observed between horizon C and D (figure 53) has expanded to cover the whole northwestern region between the time of deposition of horizons D and E, while the southwest region deposition is more uniform.

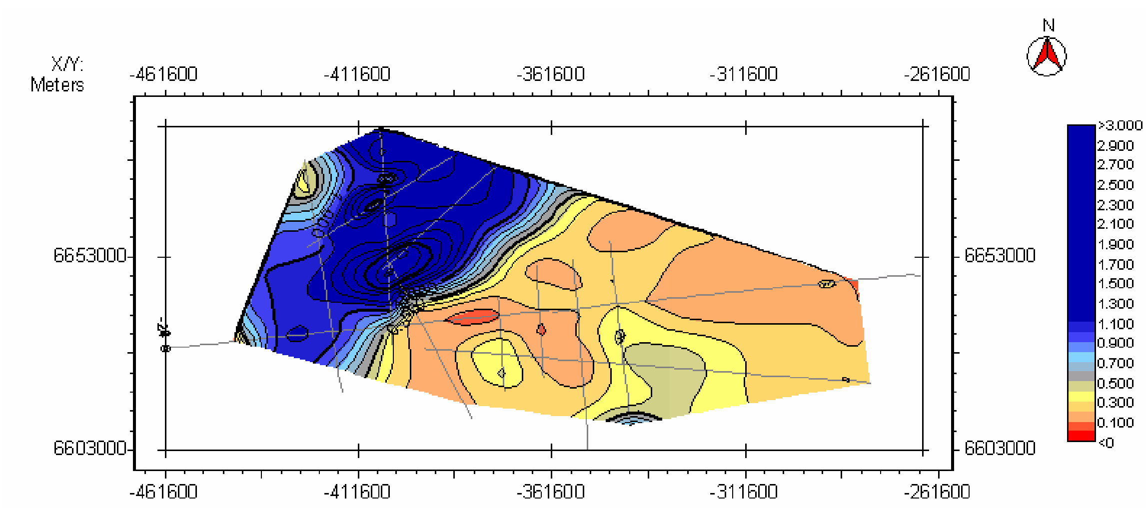


Figure 55: Isochron between horizons D and E.

Horizon F (green)

Horizon F is the deepest selected horizon here. The greatest depths for this horizon are located in the east and along a northwestward tending area in the west. This result, however; has to be interpreted with caution considering that in some areas the reflector was not well defined.

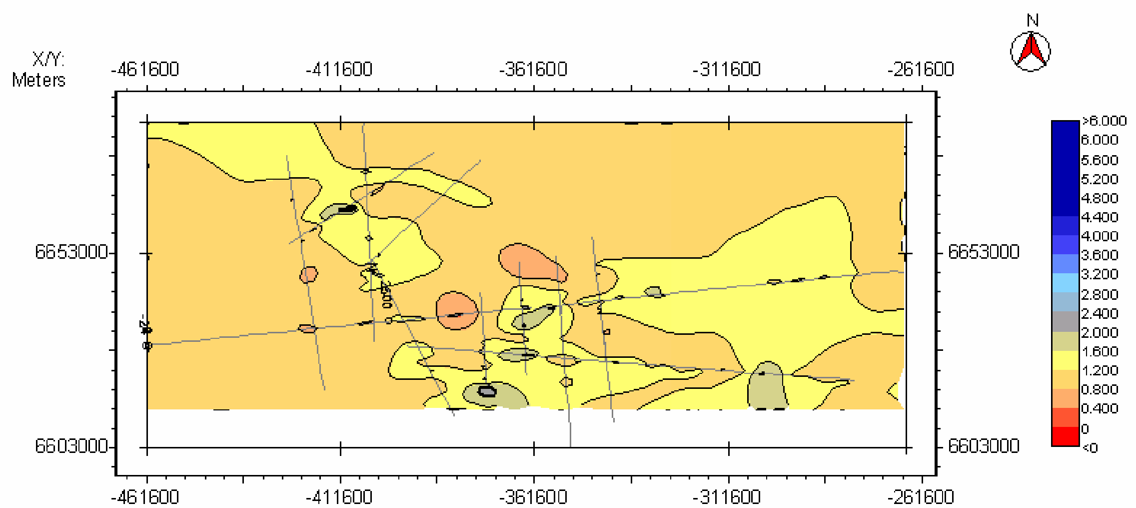


Figure 56: Contour map of horizon F.

The isochron between horizons E and F shows a thinning tending northwestward but concentrated only in the area below Kayak Island. This pattern is dramatically different from the observed above (i.e., figures 53-55) and may indicate a changing depositional pattern or a problem in mapping the deepest horizon.

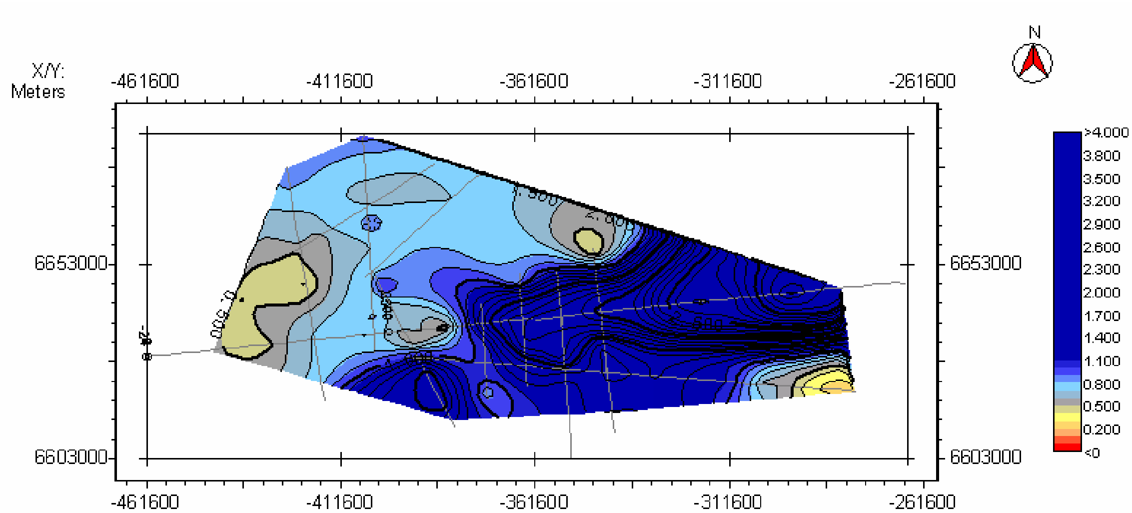


Figure 57: Isochron between horizons E and F.

DISCUSSION AND SUMMARY

Analysis of Sequence of Deposition from the Horizon and Isochron Maps

The information given by the horizon and isochron maps is useful to clarify many aspects of the tectonic evolution of the area. Certainly, by analyzing those maps, sediment depositional patterns where the deformation is concentrated and the behavior of deformation though time can be examined. The general pattern inferred from the horizon and isochron maps suggests that the area has been experiencing differential movement between the times of deposition. The fact that the isochron between horizon A and B is not flat suggests that the area has been active even in recent geological time.

Identification of Relevant Features on the Base Map

Figure 58 shows the location of the principal geological features observed though the seismic section studied here. A pattern of antiform structures is observed tending to the northeast. The upwarp pattern observed from line 413 to line 416 suggests the presence of a fault system in the region even though the faults are not directly observed on the seismic sections studied here. Finally a channel system is observed in the southeastern side, which may be the offshore continuation of a river system.

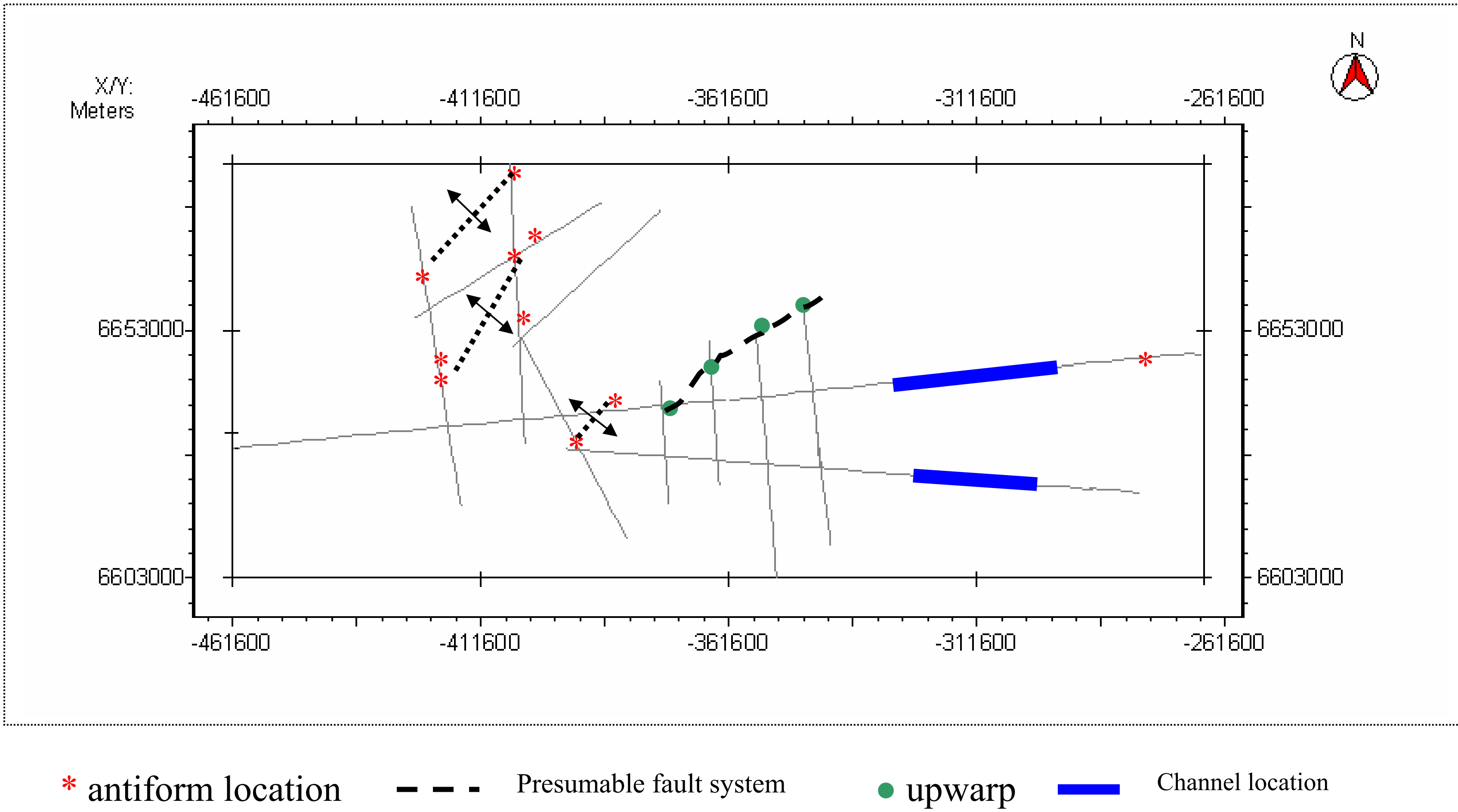


Figure 58: Identification of relevant features in the study area.

Achievement of this Study

Though this study, the quality of existent seismic data close to Kayak Island was improved. By applying time migration to the data the strongest shallow multiples were attenuated and the image was enhanced. Finally, evidence of folding patterns that may support a proposed model for the tectonic setting of the area was found.

Limitations

Even though the quality of the seismic data was improved in the shallow area the deepest region is still without a clear resolution. This may be due to problems inherent in the original data collection which cannot be corrected by processing. Another limitation in this study was the difficulty of identification of fault patterns. High angle faults are observed but it was not possible to correlate those faults and observe a pattern in the whole area.

Conclusions

From the analysis of the results obtained in this research it can be concluded that:

1) There is a clear differentiation in the deformation patterns between the southeastern side of Kayak Island, corresponding to a part of the Pamplona region, and the northwestern side of the Island. Event thought a degree of deformation is observed in

the southeastern side it is evident that the northwestern side of the Island is more active because the structures are more pronounced here than in the southeastern side.

2) The folding patterns suggest a northwest direction of compression consistent with the direction of motion between the North America and Pacific Plates.

3) Even though the major deformation observed in this research is greatest on the northwest side of the Kayak Island, limitations in the data quality made it difficult to determine weather or not the area is the locus of convergence of the Yakutat microplate. For this reason more research is needed in the area, especially on the northwest side of Kayak Island.

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APPENDICES

Appendix A: Principal Parameters Used in Geometry Assignment

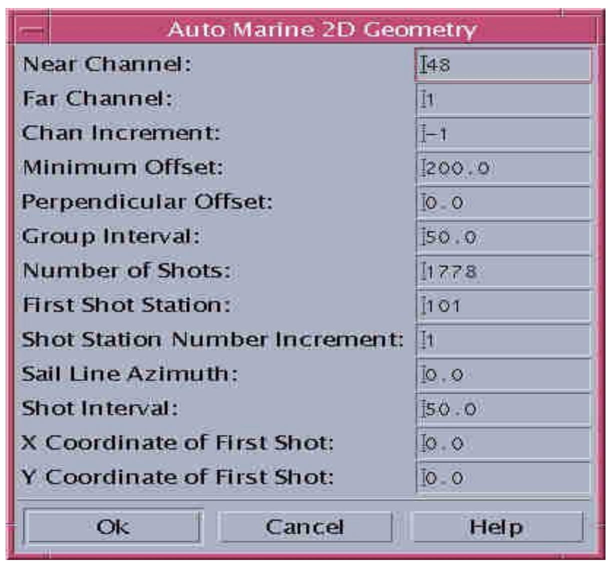

Figure 59: Auto Marine 2D Geometry parameters.
The number of shots was different for each section.

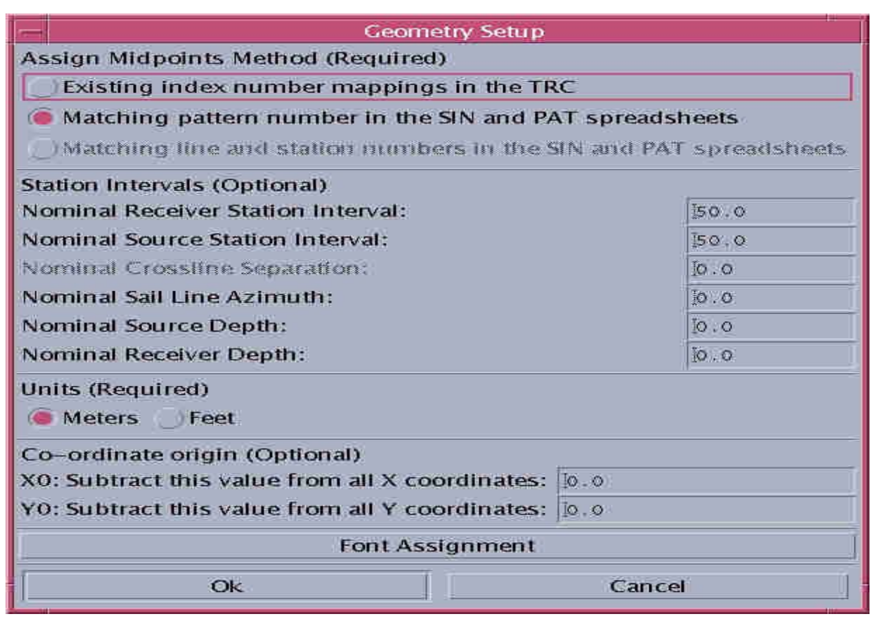

Figure 60: Geometry Setup parameters.

Appendix B: Seismic Section After Processing

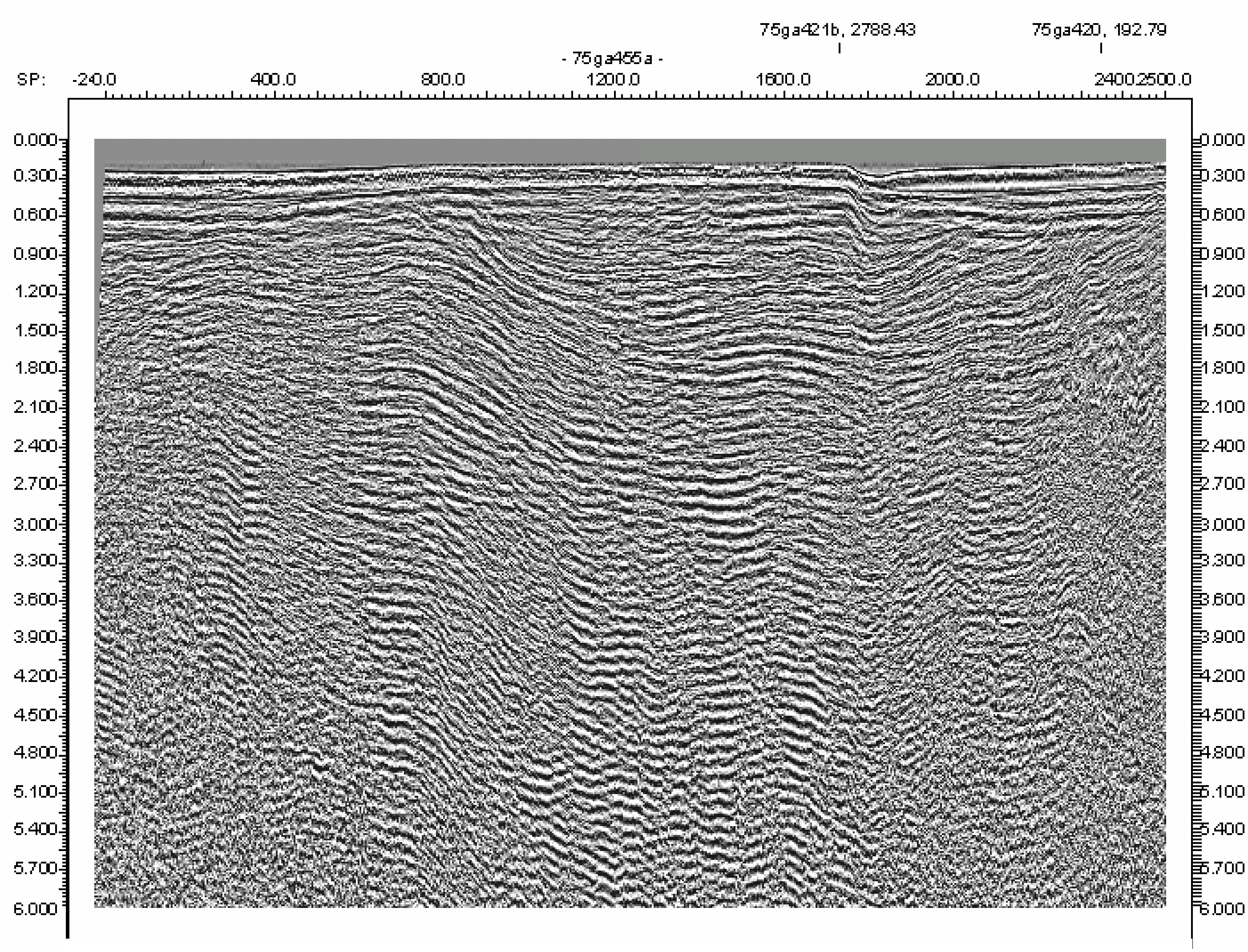

Figure 61: Seismic section 455a

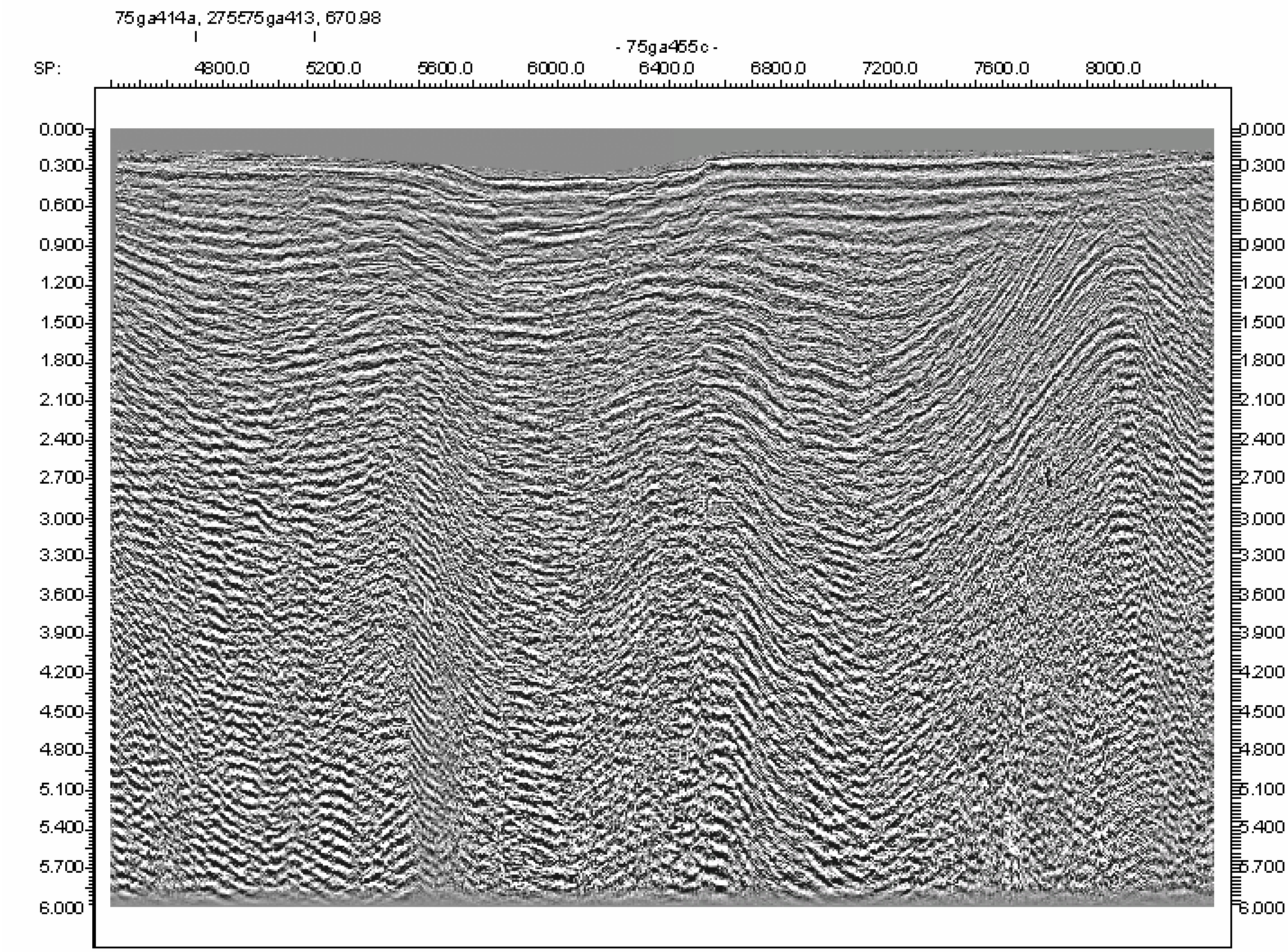

Figure 62: Seismic section 455c

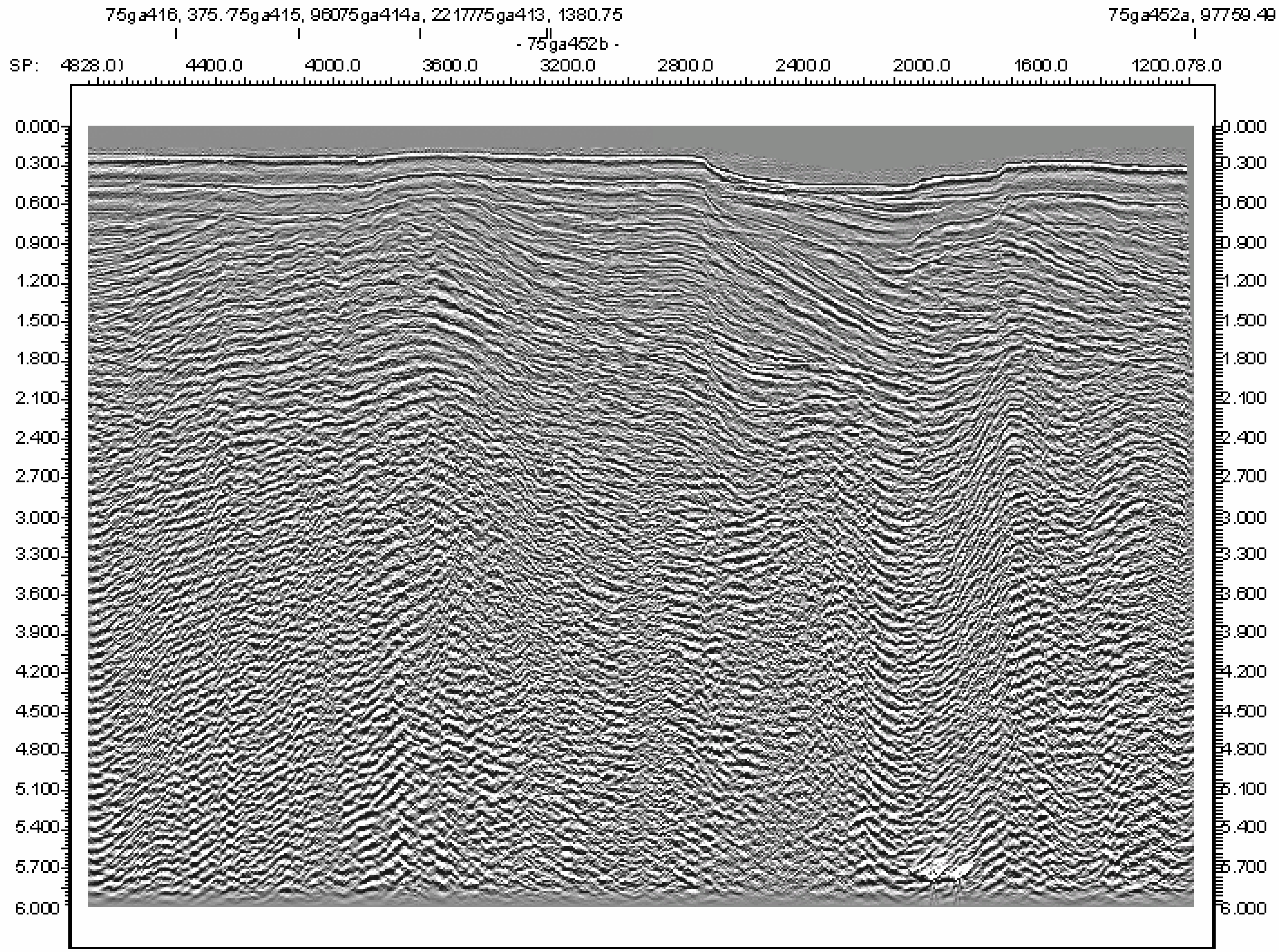

Figure 63: Seismic section 452b

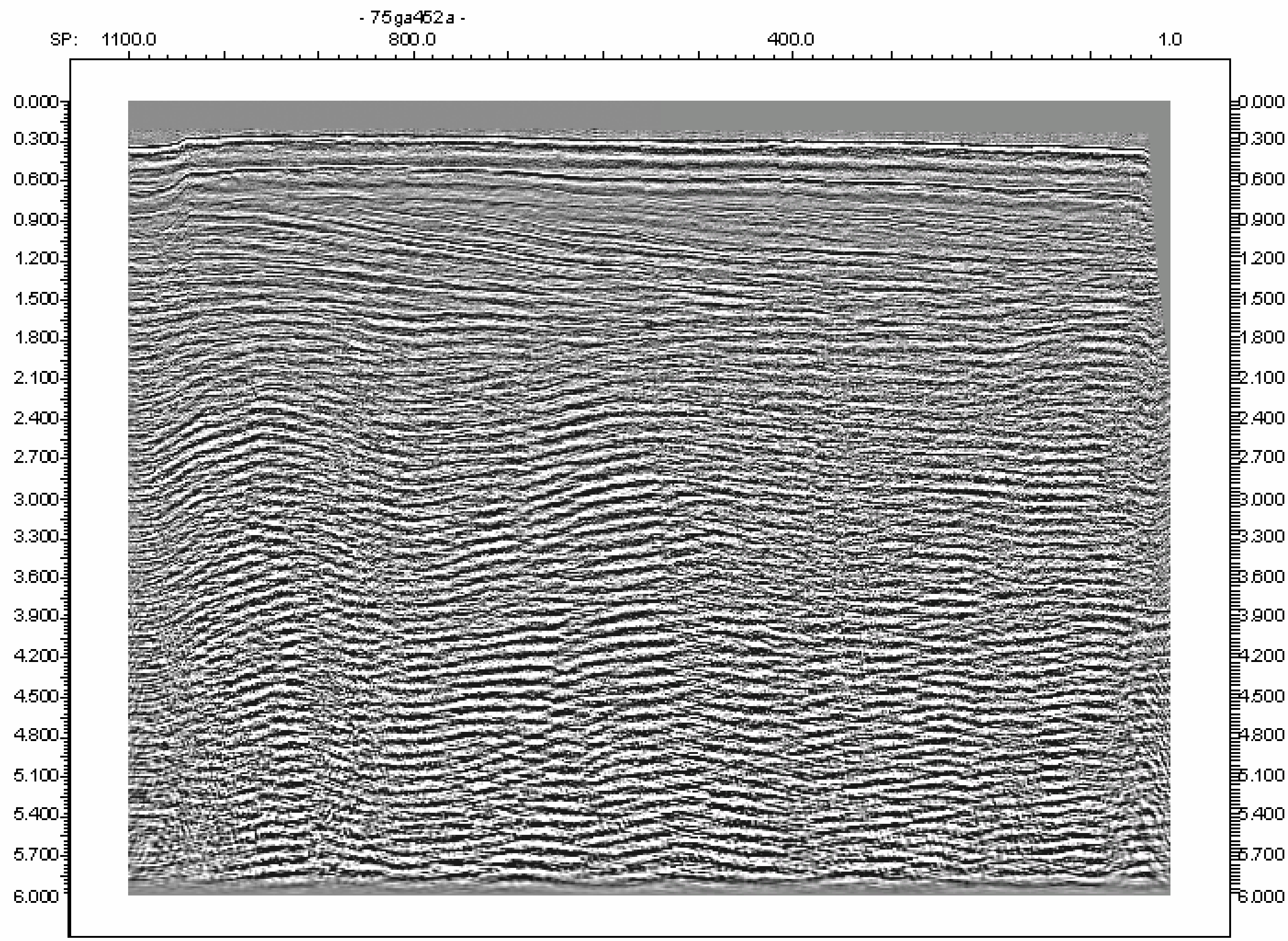

Figure 64: Seismic section 452a

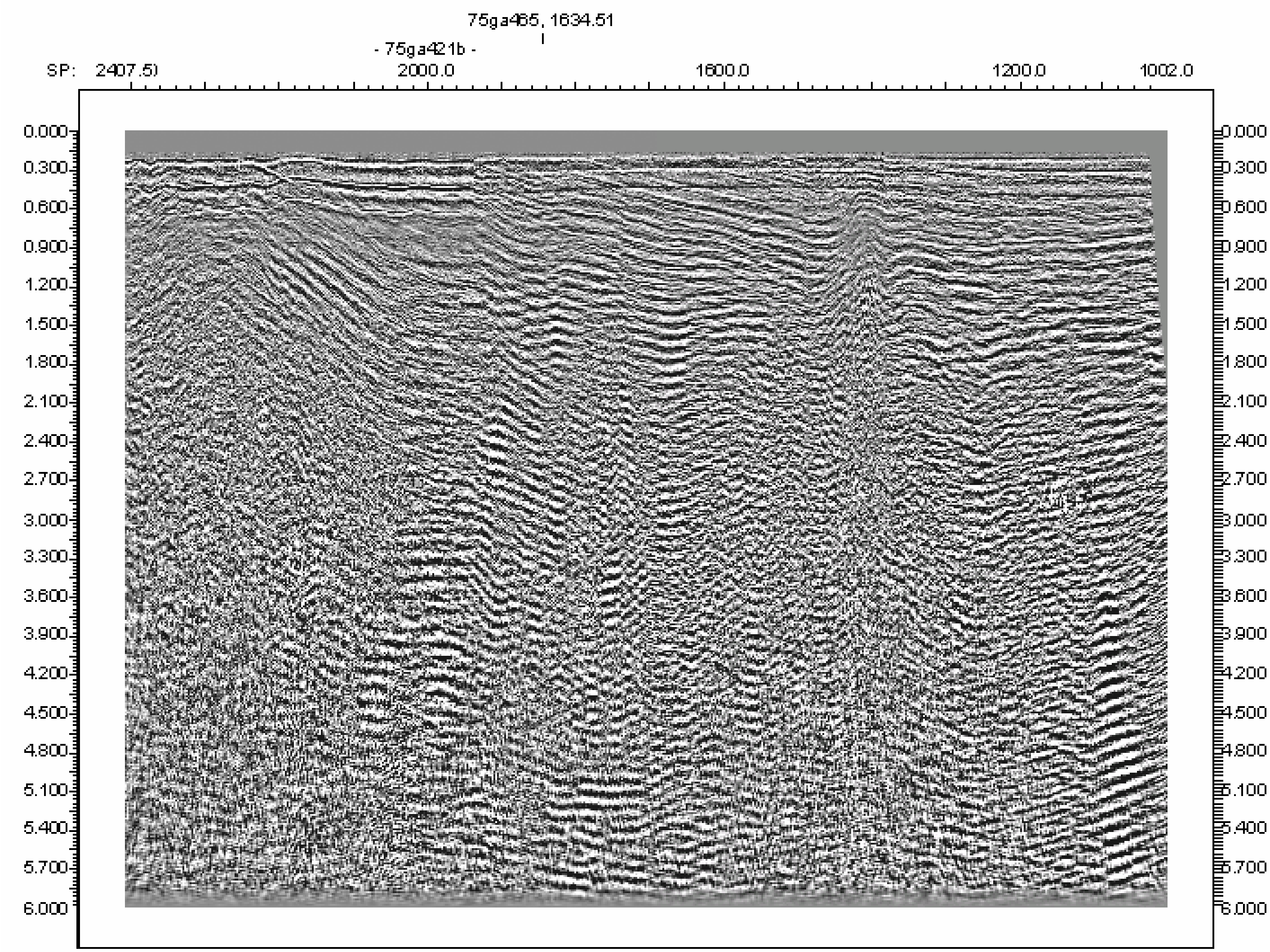

Figure 65: Seismic section 421

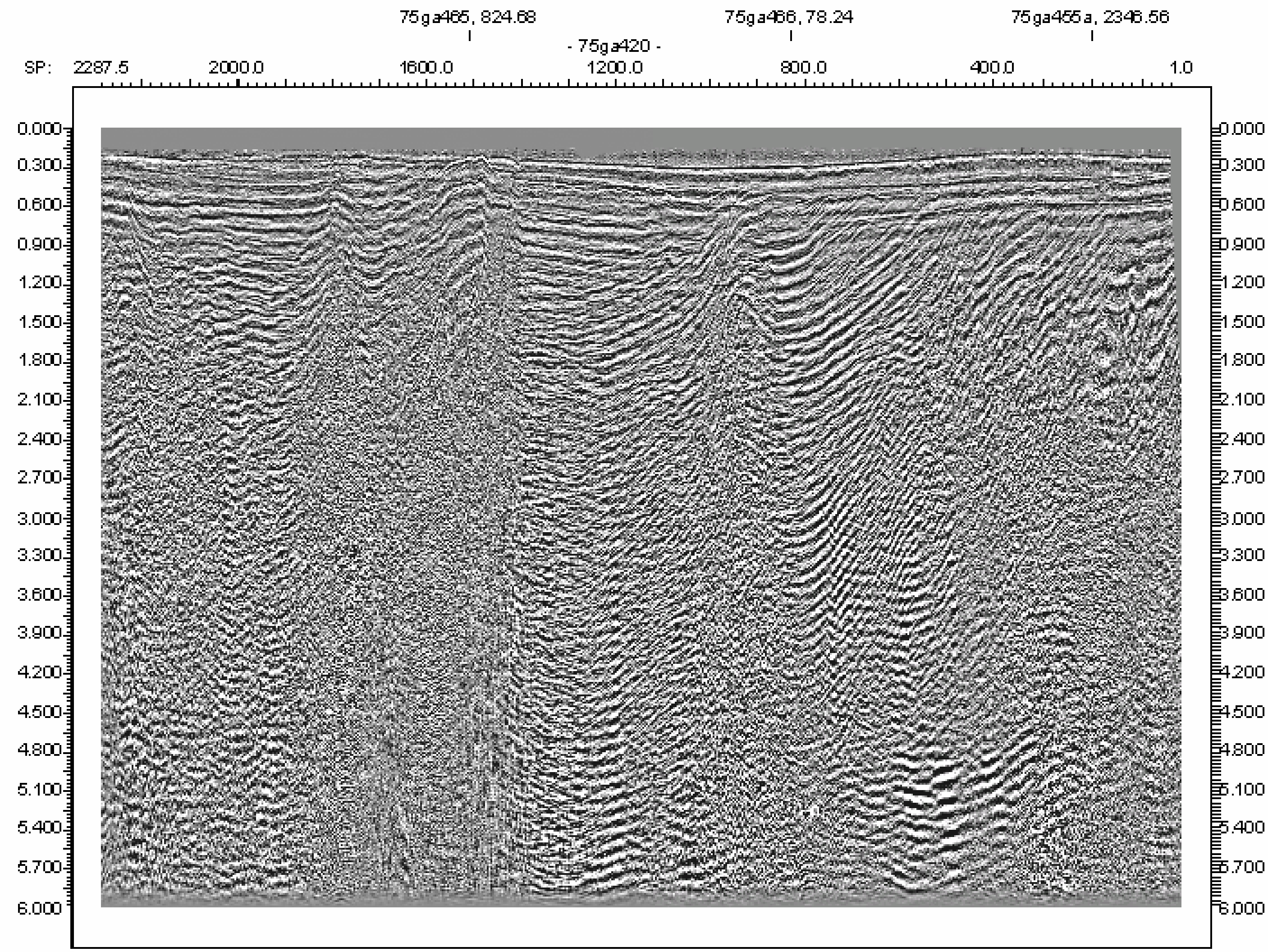

Figure 66: Seismic section 420

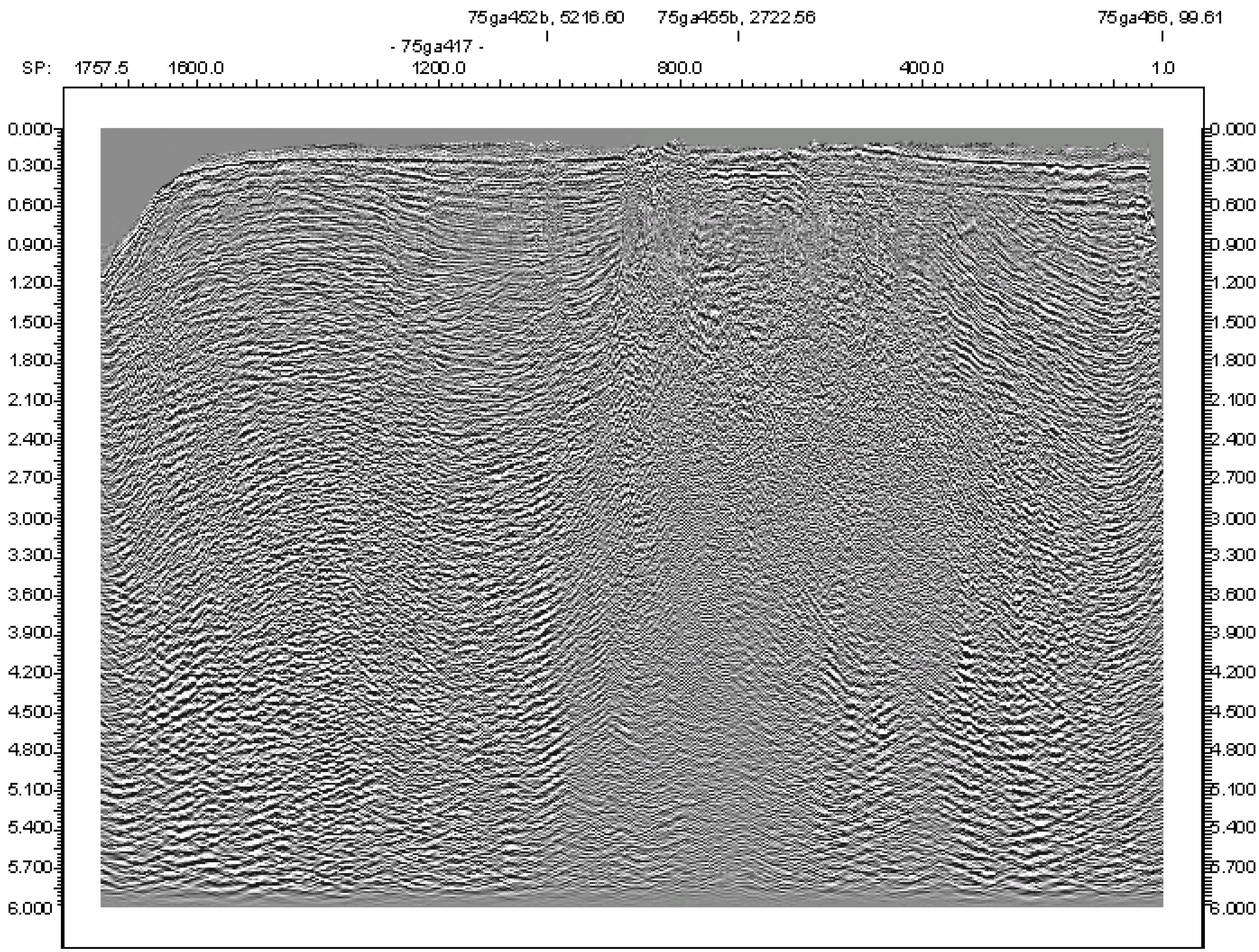

Figure 67: Seismic section 417

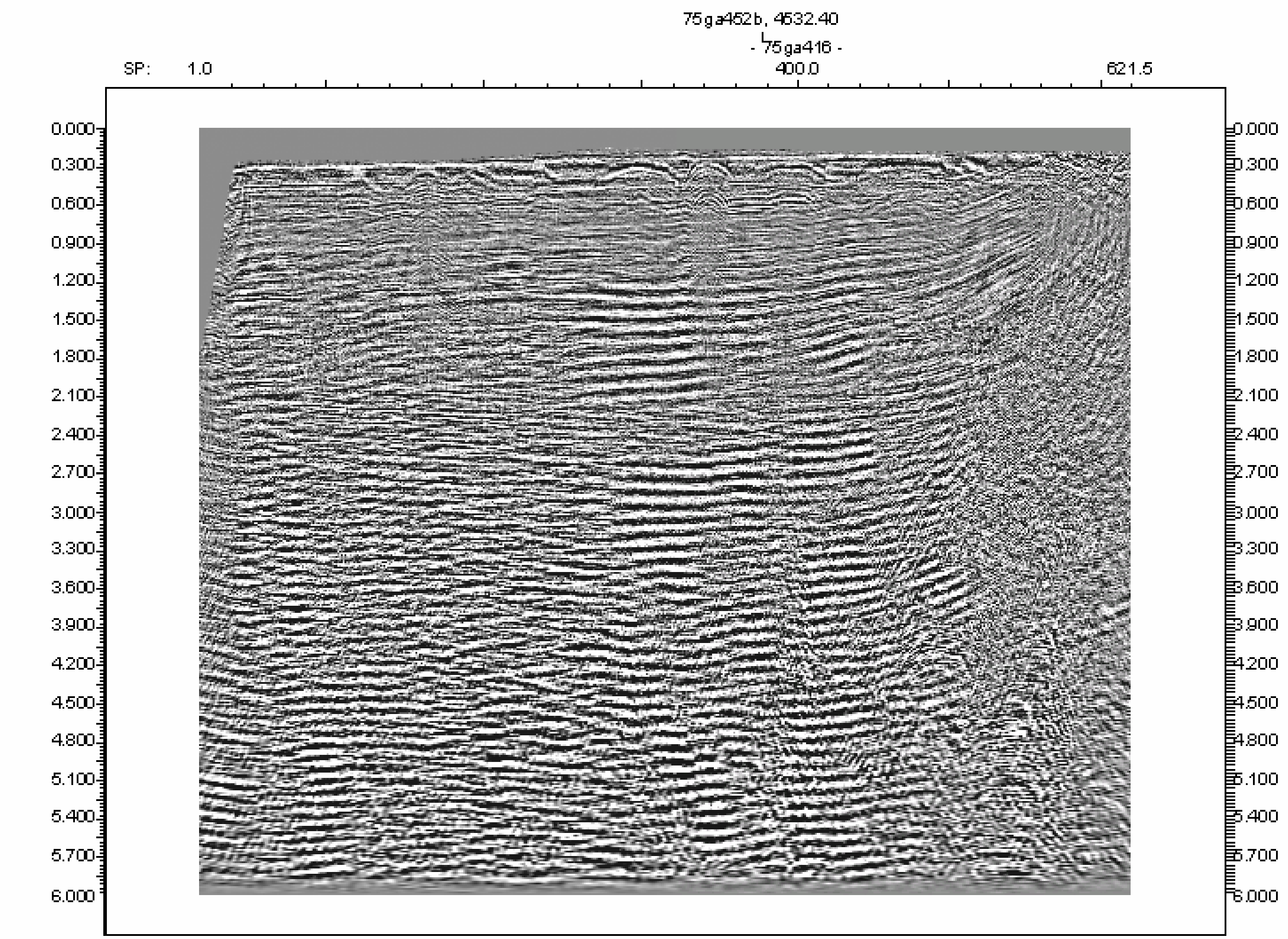

Figure 68: Seismic section 416

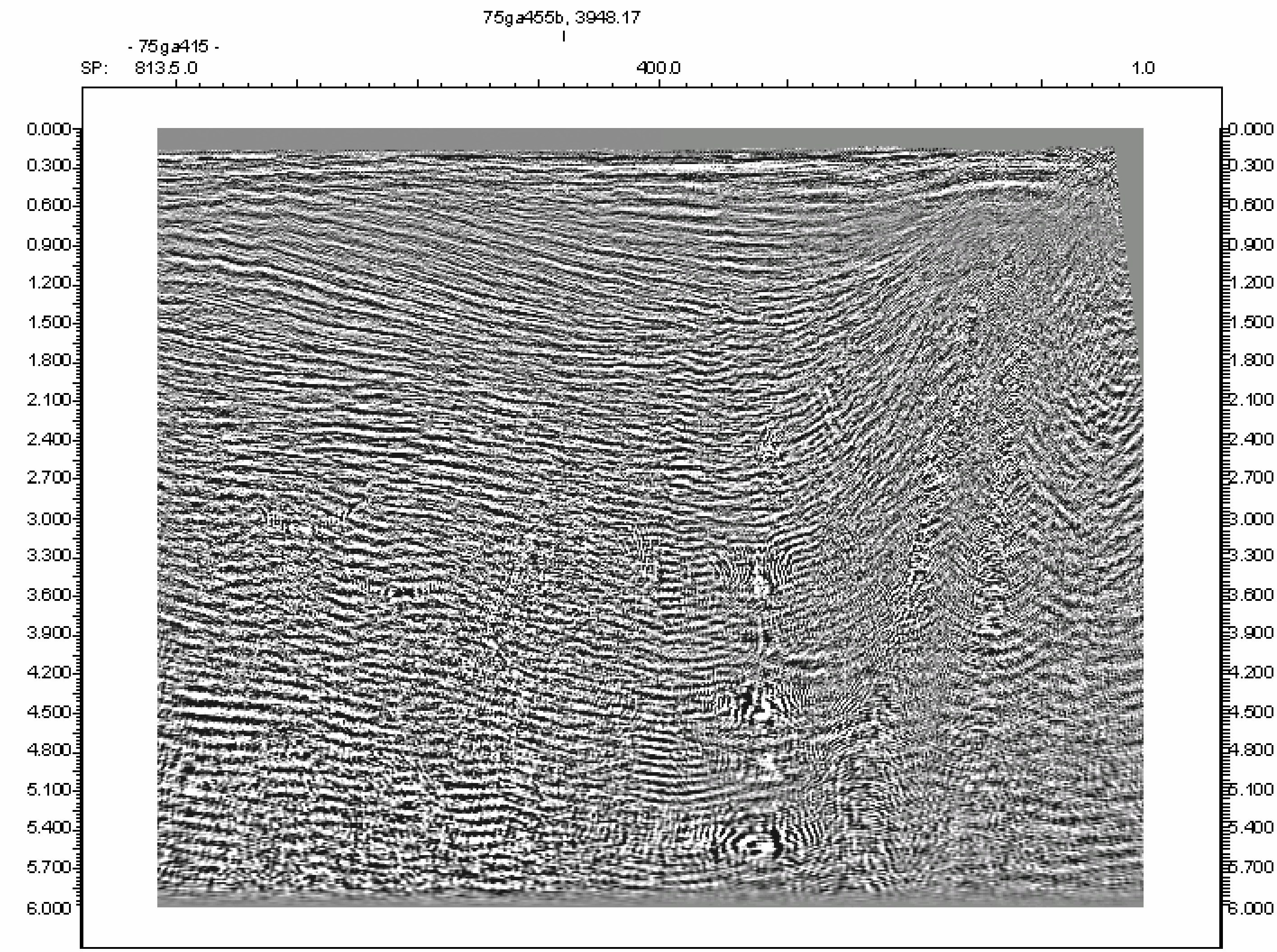

Figure 69: Seismic section 415

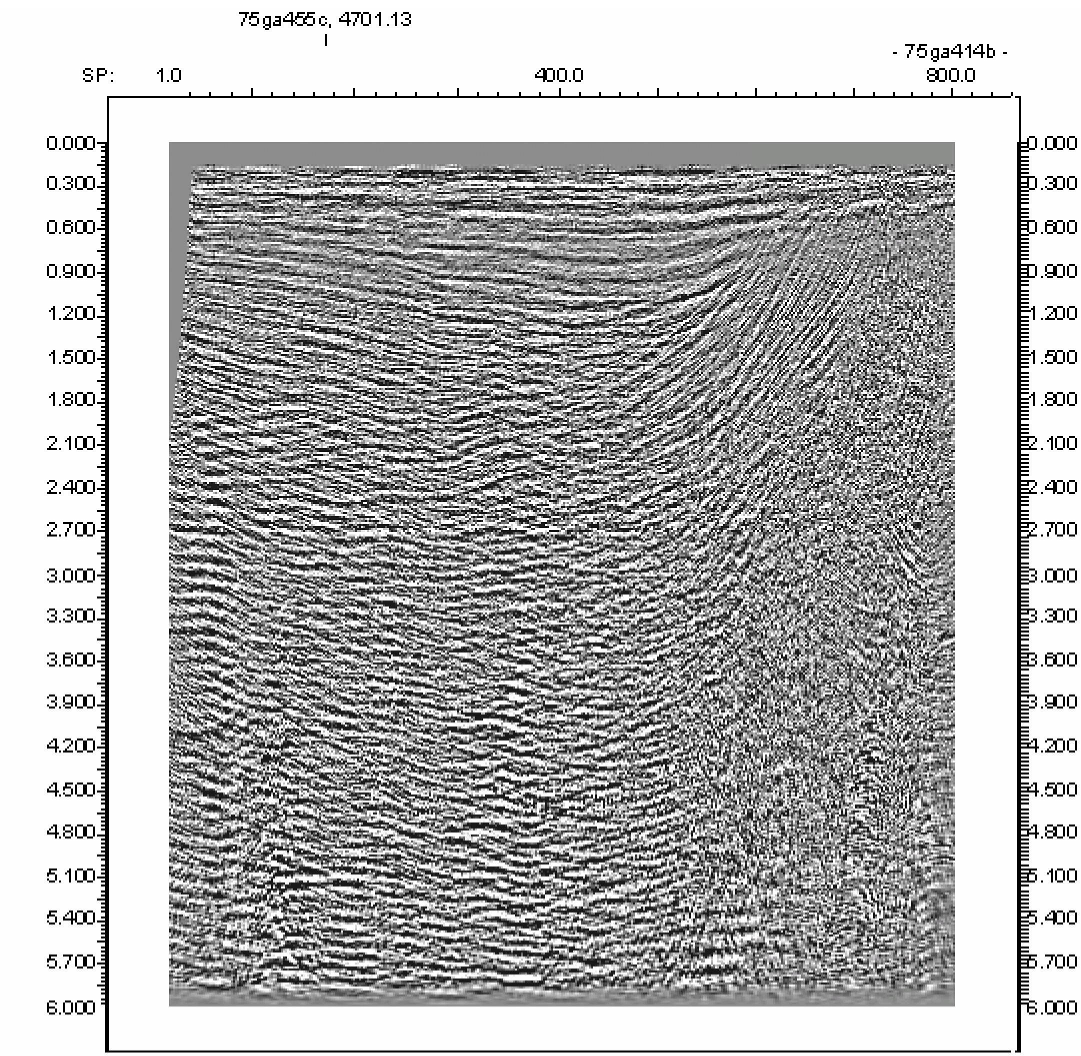

Figure 70: Seismic section 414b

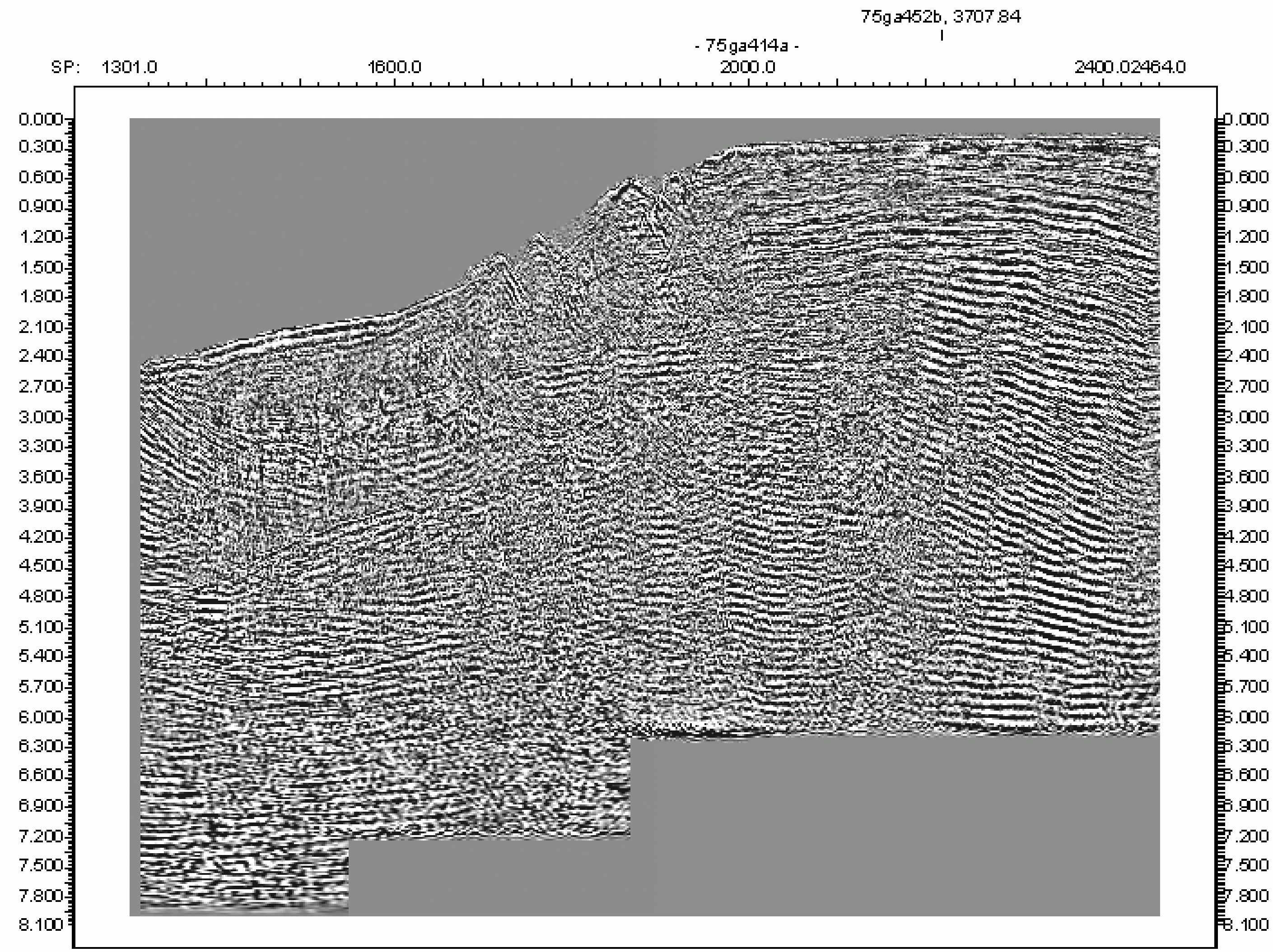

Figure 71: Seismic section 414a

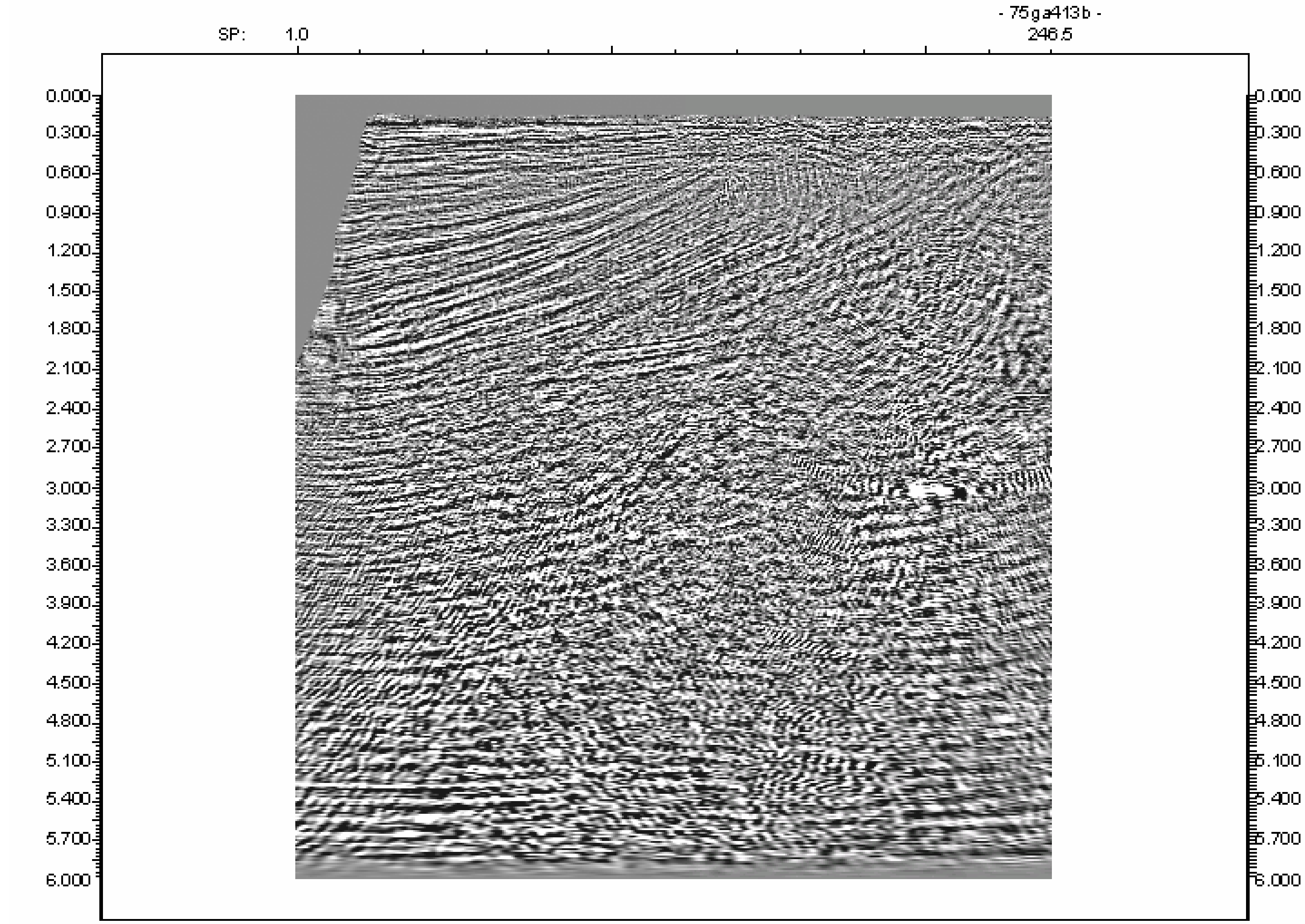

Figure 72: Seismic section 413b

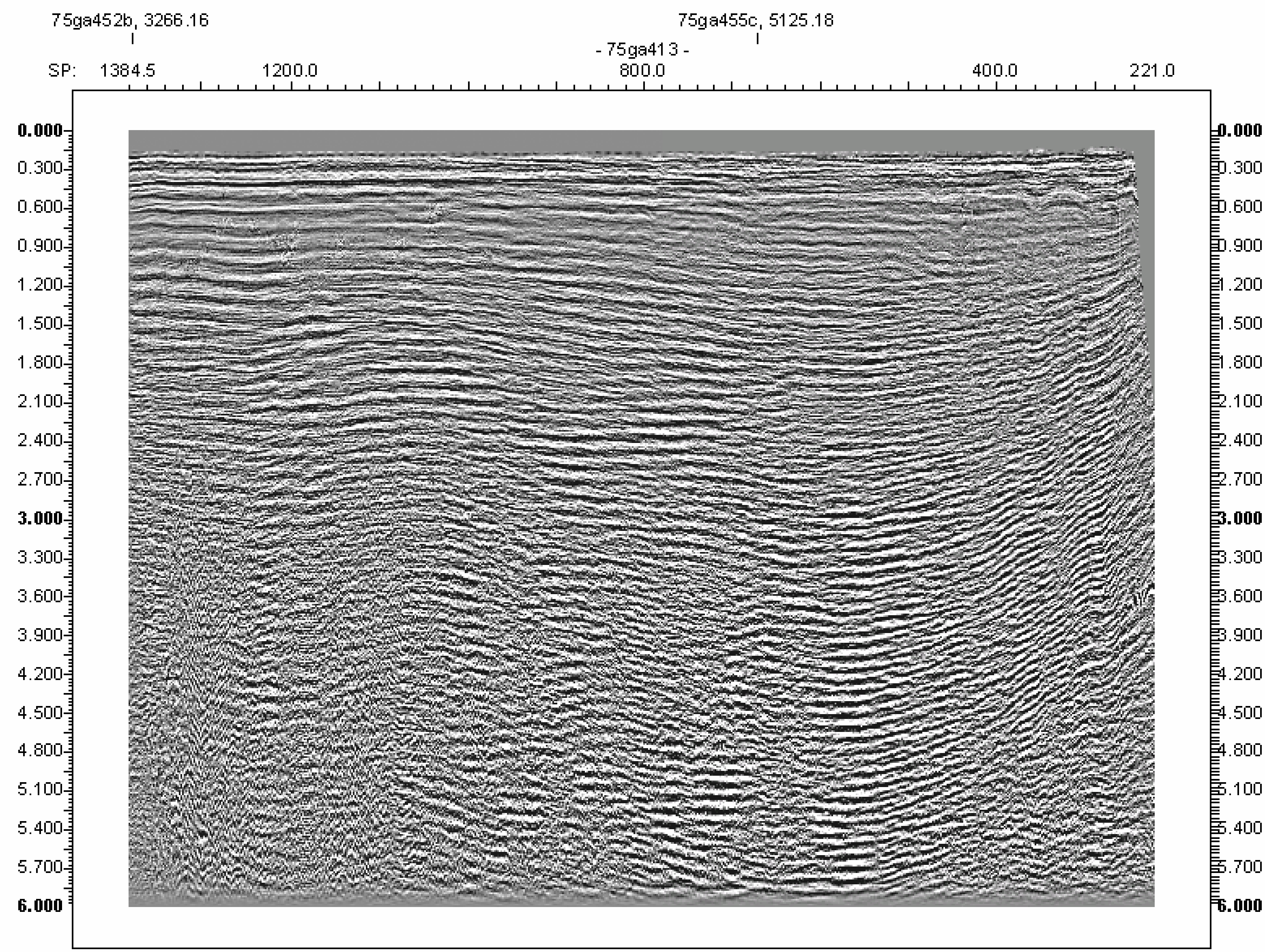

Figure 73: Seismic section 413

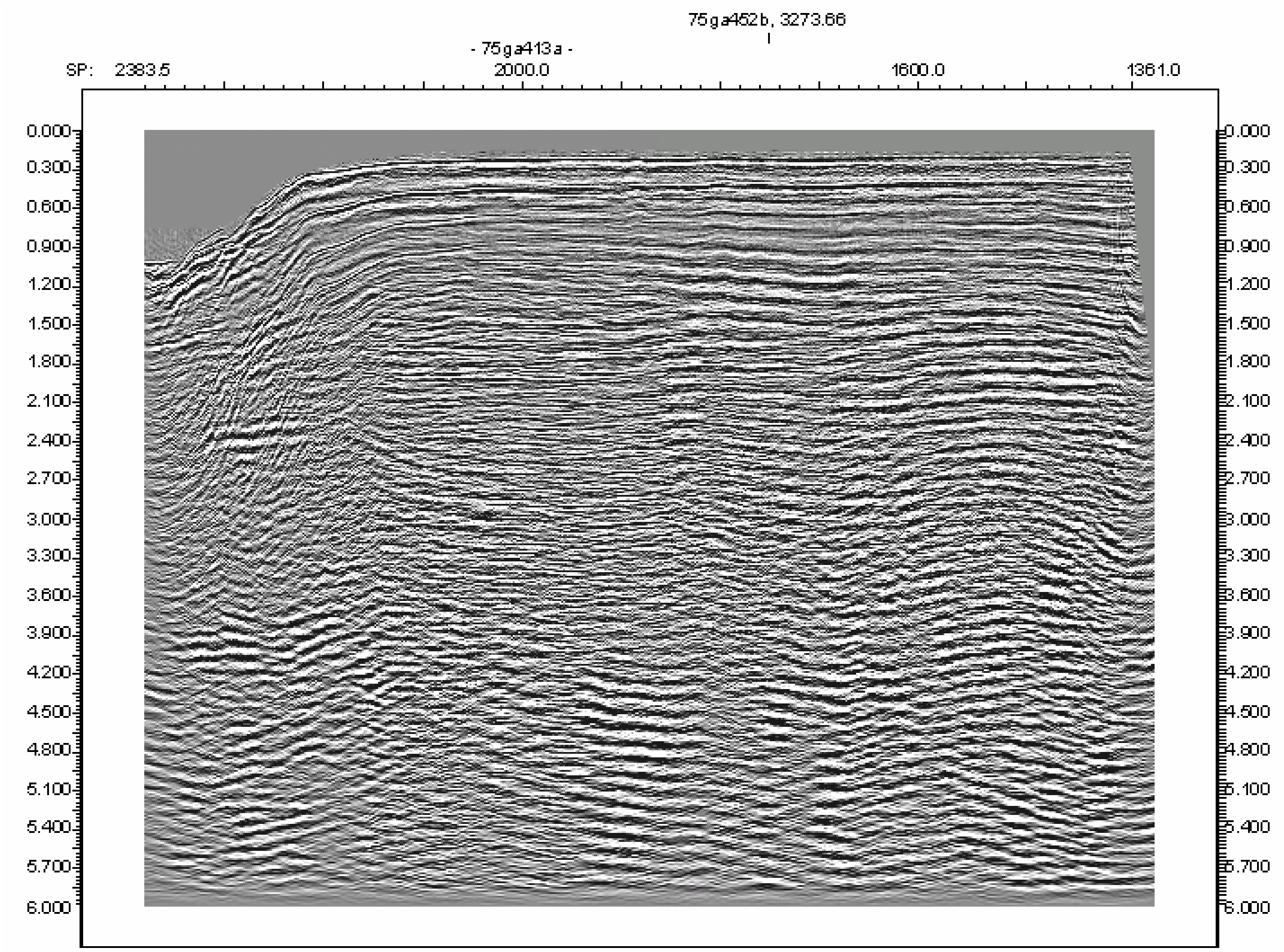

Figure 74: Seismic section 413a

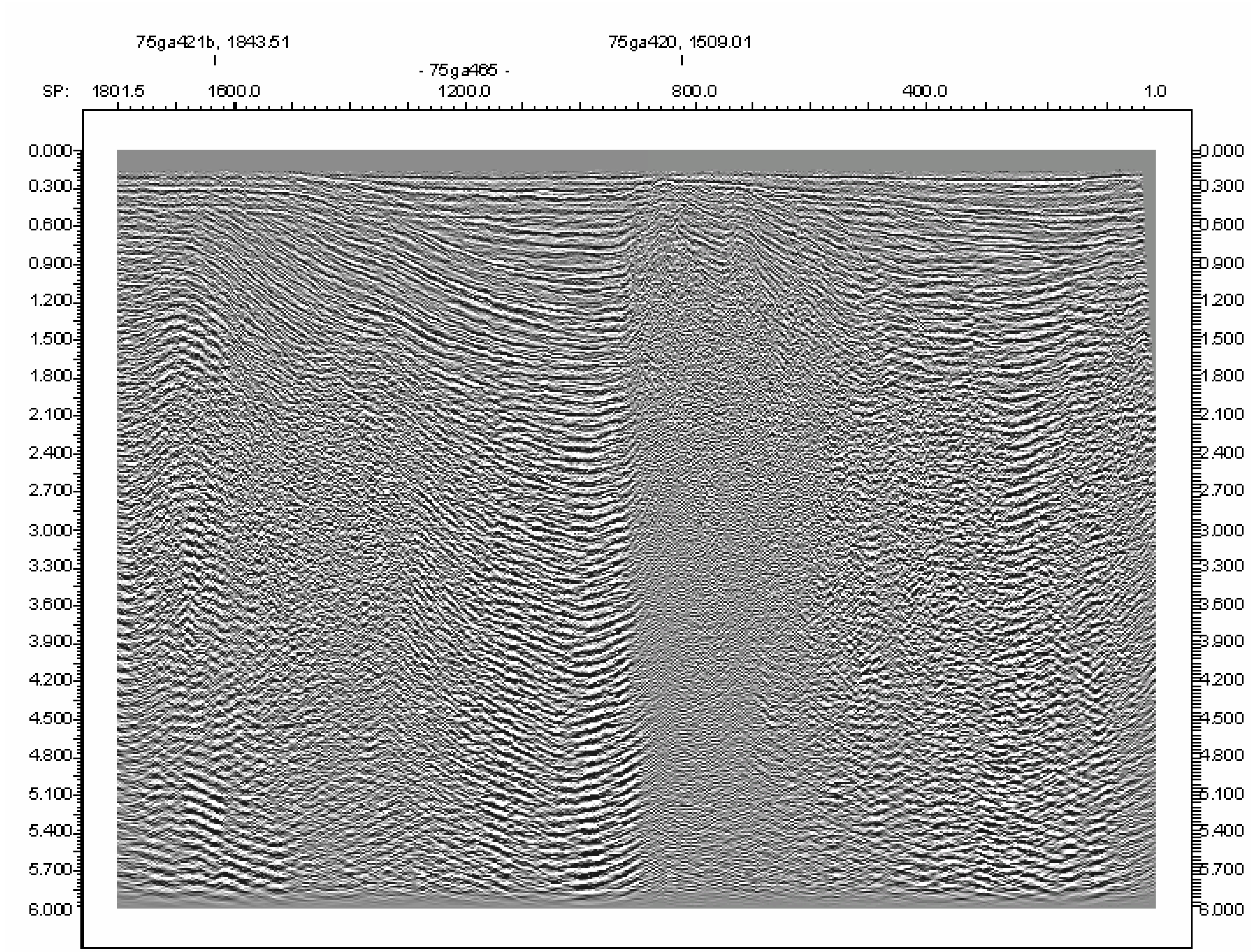

Figure 75: Seismic section 465

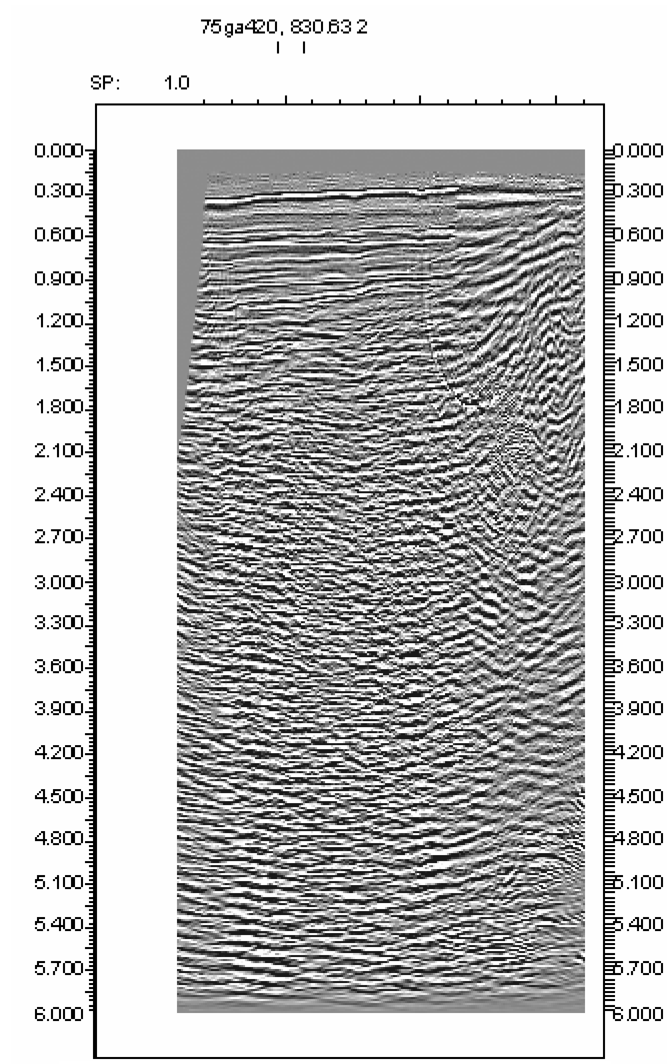

Figure 76: Seismic section 466

VITA

Elisabeth Espinoza Canales grew up in El Eden, a small village close to the Yojoa Lake in Honduras. She is the older daughter of a family of teachers. From childhood her most precious dream was to become a teacher. After she finished high school in her village, she moved to Tegucigalpa, the capital of Honduras, where she enrolled in the "Universidad Pedagogica Nacional Fracincisco Morazan" (UNPFM) with the science education department. She graduated with the equivalent of bachelor in education, concentration in natural science in 1989.

In 1990 Elisabeth enrolled in the department of physics at the "Universidad Nacional Autonoma de Honduras" (UNAH) where she obtained a bachelors degree in physics in July of 1995. In 1991 while pursuing her bachelor in physics she worked as laboratory assistant at the UPNFM. In October of 1995 she received a scholarship to perform graduate studies in Japan. She enrolled at the Aichi University of Education, where she joined a teacher training program for a year, after which she continued with a graduate studies in Science Education. In 1999 she obtained a master in education oriented to natural science education. In March of 1999 she returned to Honduras to continue her work as a instructor at the UPNFM and at the UNAH.

In 2002 she received a scholarship to performed studies in Geophysics under the sponsorship of the UNPFM and the Fulbright-LASPAU program. From January to August 2002, she attended an intensive English course at Arkansas State University. Finally, she enrolled in the Geology and Geophysics department at UNO in the fall of 2002.

Upon graduation, Elisabeth plans to return to Honduras where she is going to continue teaching at the Universidad Pedagogica Nacional Francisco Morazan and the Universidad Nacional Autonoma de Honduras. She hopes to apply the knowledge acquired to contribute to the improvement of the Earth Science education in Honduras.

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