FOUR REGIONAL SEISMIC LINES: NATIONAL PETROLEUM RESERVE—ALASKA (SUPPLEMENT TO U. S. Geological Survey Open-File Report 00-286)

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Four Regional Seismic Lines: National Petroleum Reserve—Alaska (Supplement To U. S. Geological Survey open-File Report 00-286)

ABSTRACT

This Internet site contains digital seismic data and associated support data for four regional seismic lines (736 line-miles) recorded in the National Petroleum Reserve – Alaska (NPRA). These lines were created as a supplement to the data set contained on USGS-Open File Report 00-286 (Miller et al, 2000) which is a CD-ROM publication that contains stacked, migrated, 2-dimensional seismic reflection data and associated support information for 22 regional seismic lines (3,470 line-miles) recorded in the NPRA from 1974 through 1981. These 22 regional lines, which form a grid covering the entire NPRA, were created by combining various individual lines recorded in different years using different recording parameters. The data were reprocessed by the USGS using modern, post-stack processing techniques, to create a data set suitable for interpretation on interactive seismic computer workstations. Reprocessing was done in support of ongoing petroleum resource studies by the USGS Energy Program. The grid of lines has a nominal spacing of 20 x 20 miles. However there are four intervals where the spacing between lines was much greater than 20 miles. To fill these grid spacing gaps, four additional regional lines (736 line-miles) were created using the same techniques as those used to create the lines on OFR 00-286. These lines and associated support data are contained on this internet site in the following files: 1) Four files containing the digital seismic data in standard, SEG-Y format; 2) One file containing navigation data for these 4 lines and for the original 22 lines contained on OFR 00-286, in standard SEG-P1 format; 3) Four small scale graphic images of the four seismic lines in Adobe Acrobat® PDF format; 4) a graphic image of the location map, generated from the navigation file, 5) an ASCII text file with cross-reference information for relating the sequential trace numbers on each regional line to the line number and shotpoint number of the original component lines; and 6) an explanation of the processing used to create the final seismic sections (this document).

The SEG-Y format seismic files and SEG-P1 format navigation file contain all the information necessary for loading the data onto a seismic interpretation workstation.

INTRODUCTION

The USGS reprocessed twenty-six 2-D regional seismic transects across the National Petroleum Reserve – Alaska (NPRA) using current seismic data processing techniques. Twenty-two (22) of these lines are contained on the CD-ROM publication USGS Open File Report 00-286 (Miller, et al, 2000). To order the CD-ROM, contact the USGS Earth Science Information Center: 1-888-ASK-USGS (1-888-275-8747) or write to: Box 25286, Building 810, Denver Federal Center, Denver, CO, 80225-0286. That CD-ROM includes the 20 original Regional Compressed Sections (RCS) (Ikelman, 1986) and 2 additional lines, totaling 3,470 line-miles in a nominal 20 x 20-mile grid that cover the whole of NPRA. However, the nominal 20-mile spacing was greatly exceeded between lines r-4 and r-5, r-6 and r-7, r-7 and r-8, and r-11 and r-13 (Figure 1). To fill these grid spacing gaps, four additional regional lines (736 line-miles) were created using the same methodology and processing sequence as that used for the first 22 lines, and these data are presented on this Internet site.

Although the complete NPRA seismic data set totals nearly 15,000 miles (Gryc, 1985, page C27) and is the largest public-domain onshore seismic data base in the United States, the 26 regional seismic lines presented here and on Open File Report 00-286 provide a useful summary of the NPRA data for understanding the overall geologic framework of the Brooks Range foreland basin and for assisting in research studies concerning the oil and gas potential of the region.

The remainder of this section and all of the next two sections are excerpted directly from CD-ROM publication OFR 00-286 and describe the methodology for creating the regional lines the problems encountered and our approach to solving those problems. This information also applies to the 4 additional lines presented on this internet site.

The original RCS lines were created by combining selected seismic lines into long regional lines that cover the whole of NPRA in a nominal 20 x 20-mile grid. Twelve (12) lines are oriented generally north-south and ten (10) lines are oriented generally east-west (Figure 1, Table 1). The seismic lines which composed each of the original RCS lines were the stacked, unmigrated, record sections that were processed by Geophysical Service, Incorporated (GSI) immediately after the data were collected (1974 through 1981.)

Although the processing of the original RCS lines was done well, we encountered the following limitations when attempting to interpret the data:

1. The data were not migrated. The probable reason for not migrating the data is that at the time of the original processing, migration was a time-consuming and expensive process.

2. Except for a few lines, the magnetic tapes containing the original RCS lines could not be located and therefore we were unable to perform the migration process or to load these data into a modern seismic interpretation workstation for on-screen interpretation. We had digital versions of most of the stacked, unmigrated line segments which made up the RCS lines, but these had been processed by widely varying means and needed additional processing before being combined (discussed below.)

3. The individual seismic lines which made up a single RCS line were recorded in different years using different recording parameters, the most significant parameter being different distances between geophones on the surface ("group intervals".) These different group intervals meant that the horizontal resolution along each RCS line could change at the line segment boundaries. Within a single RCS line, the distance between seismic traces could be 165 ft. for one line segment, 110 ft. for another segment and 55 ft. for a third segment. To compensate for this difference in trace spacing, the original line segments were displayed on mylar film at different horizontal trace spacing scales and then physically spliced together by hand. The result was an RCS line having a constant horizontal scale which was sufficient for visual inspection of the data. However, in order to digitally process a seismic line through migration, the actual distance between traces must be constant.

4. The data were processed using a "floating" datum that was a smoothed approximation of the surface elevations. The datum values used at line intersections were not always the same and therefore, the reflections did not tie in two-way travel time.

REPROCESSING

Because of the limitations described in the previous section, and in order to properly prepare the data set for migration and for interpretation on a computer workstation, we performed the processing steps described below. Two of the processing algorithms used were developed in-house and are noted below. All other processing was performed using the industry-standard ProMAX® seismic data processing system developed by Landmark Graphics®.

1. We reconstructed the RCS lines from the individual stacked, unmigrated seismic lines for which we had digital data (table 2). This "post stack" processing included amplitude scaling, frequency filtering, and noise burst editing, in order to create versions of the data that were relatively consistent in character from line to line.

2. For those line segments for which we had no digital stacked data (table 2), we started with the raw field data and completely reprocessed each line through the steps described in #1, immediately above. The processing performed prior to stacking included editing of noisy data, amplitude scaling, spiking deconvolution, datum statics, Normal Moveout (NMO) corrections using velocities determined by interactive velocity analysis, and residual static corrections calculated by a surface consistent residual statics routine.

3. For all the lines, we adjusted the datum to a common horizontal sea level datum.

4. We converted the distance between traces to a constant of 110 ft., either by interpolation or decimation. A constant trace-to-trace interval is necessary in order to perform migration using the algorithms commonly available in commercial seismic data processing systems.

5. We migrated the data using smoothed stacking velocities adjusted to the sea level datum. For the line segments that were processed using post-stack methods only, we used the stacking velocities that were printed at the top of each segment's mylar display. For those line-segments that were processed beginning with the field tapes, we used the stacking velocities that we determined (refer to step #2, above.)

6. After migration we applied post stack predictive deconvolution (using the 2^{nd} zero crossing of the autocorrelation function as the predictive distance) in order to increase the temporal resolution of the data. The software used for this process was developed in-house.

7. After predictive deconvolution, we applied a signature deconvolution process (sometimes referred to as wavelet deconvolution) to compensate for changes in the source waveform between lines and to further increase the temporal resolution of the data. The software used was developed in-house and was a version of Gray's (1979) Variable Norm deconvolution method, adapted for post-stack data.

This processing produced a data set that is well-suited for analysis on a seismic interpretation workstation. Reflections on the seismic lines tie in both travel-time and waveform at all line intersections and the distance between individual traces on all seismic lines is a constant 110 ft.

Line	Line-Miles	Orientation
R-1	96	N-S
R1-ALT	137	N-S
R-2	116	N-S
R-3	129	N-S
R-4	145	N-S
R-5	190	N-S
R-6	215	N-S
R-7	149	N-S
R-8	135	N-S
R-9	125	N-S
R-10	84	N-S
R-11	109	E-W
R-12	159	E-W
R-13	203	E-W
R-13ALT	26	E-W
R-14	259	E-W
R-15	292	E-W
R-16	238	E-W
R-17	180	E-W
R-18	163	E-W
R-19	88	N-S
R-20	232	E-W
R-21	166	N-S
R-22	210	N-S
R-23	140	N-S
R-24	220	E-W
Total:	4206	

Table 1. List of seismic lines contained in the data set with total mileage and geographic orientation of each line..

The four lines contained on this internet site are R-21 through R-24. Click on any of these four line names to display a graphic image in PDF-format of the stacked, migrated record sections.

R line	**Original Line**
R-21	65-76
R-21	60-75
R-21	66-75
R-21	88-77
R-22	45X-78
R-22	45-77 *
R-22	45-75
R-22	678-79
R-22	41-74 *
R-22	42-74 *
R-22	DS3-76 *
R-22	672L-79
R-22	628N-79
R-23	U3-78
R-23	70-75
R-23	5X-75
R-23	22-81
R-23	35-74
R-23	35-75
R-23	684-79
R-24	55-76
R-24	55-75
R-24	B22-78
R-24	B19-78
R-24	667-79
R-24	77-75
R-24	3-75
R-24	32-75
R-24	74-75
R-24	75-75
R-24	17-74 *
R-24	18-74

Table 2: List of the component lines that make up the 4 regional lines presented on this internet site. Asterisks (*) indicate those lines which were completely reprocessed from the field tapes. All other line segments were reprocessed from the stacked, unmigrated data previously processed by industry.

NAVIGATION CONVENTION

Interactive seismic interpretation software requires a unique index number to relate each seismic trace in a line to a surface position on a map. Further, migration algorithms assume that for each seismic line, the distance between consecutive traces is at some regular, constant interval and as described above, we reprocessed the data to meet this requirement, making the distance between any two seismic traces a constant of 110 ft. For many 2-D seismic surveys, the unique index number used is the line's shotpoint number, but because the regional lines were created by combining different line segments, the original shotpoint numbers for any given regional line are not necessarily unique. For example, the first line segment of a regional line might have shotpoint numbers 10 through 50 and another line segment of the same regional line might have shotpoints 30 though 80. In order to have a unique number for each trace in a regional line, we renumbered the traces starting at 1 for the first trace in the line and then increased the number by one, sequentially through the last trace in the line. We stored this unique number in the header of each seismic trace in the location ("trace-header word") reserved for the Common Depth Point (CDP) number, and used this unique number as the index number for the navigation data.

For each line segment, Latitude and Longitude coordinates for the surface position of each shotpoint were available. For each regional line, we combined the navigation data for the various line segments together and changed the shotpoint numbers to the associated, unique, CDP (index) number. The file NPRANAV.SEG contains location coordinates for all of the regional lines contained on both this Internet site and on OFR 00-286's CD-ROM. The location map (figure 1) was generated directly from this file. Users loading these data into their own interpretation workstation should consider the unique CDP number to be the "shotpoint" number.

There is no consistent formula to relate the original shotpoint number of each line segment to the CDP number of the regional line. Depending on the line and the interpolation needed, there could be 16, 12, 8, 4, or 2 CDP's (traces) between shotpoints. However, file CDP_SP.TXT contains a table giving a cross-referenced list relating regional line number, to original line number, to original shotpoint number, and to CDP number for each regional line.

DESCRIPTION OF THE DATA FILES CONTAINED ON THIS INTERNET SITE

The following information is provided on this Internet site

Seismic Data Files (Files R_21.SGY to R_24.SGY): These are the processed seismic data in SEG-Y format. The SEG-Y seismic data format standard was developed by the Society of Exploration Geophysicists (SEG) in 1975 and has been in common use throughout the geophysical industry since that time. A complete description of the SEG-Y format is given in Barry and others (1975). All of the seismic data files in this publication are disc-images of the SEG-Y data format described therein. That document assumes 9-track, magnetic tape recording media; naturally, the inter-record and inter-block gaps described for magnetic tape media will not exist on the disc-image. The disc-image is therefore a continuous file composed of a 3200-byte EBCDIC header, a 400-byte binary header, and data traces, each composed of a 240-byte trace-header followed by a fixed number of seismic data samples. The data samples are type 2: fixed-point integer (2 bytes (16-bits) per sample). The SEG-Y format provides a large number of trace header-words for the purpose of recording information related to each trace. Because the data are stacked, processed data, only the following two header words have valid information:

1) CDP number: bytes 21-24, the standard trace header word reserved for the Common Depth Point (CDP) number. This CDP number begins at 1 for the first trace of each line and increases by 1 sequentially to the end of each line. These are the reference numbers used in the navigation file to define the location of each trace.

2) Shotpoint Number: bytes 17-20, the standard trace header word reserved for the energy source point number. These shotpoint numbers are those from the original seismic lines which make up each regional line. As mentioned previously, file CDP_SP.TXT contains a table giving a cross-referenced list relating regional line number, to original line number, to original shotpoint number, and to CDP number for each regional line.

Navigation File (NPRANAV.SEG): This is the location data in SEG-P1 format, the standard format for latitude, longitude, x, and y coordinates, and surface elevation, as defined by the Society of Exploration Geophysicists. Navigation information is given for the first and last trace of each line segment and traces within each line at an interval of 10 shotpoints.

Digital Map Image (MAP.PDF): This file is a digital image in Adobe Acrobat® PDF format, containing a map view of the trace locations, generated directly from file NPRANAV.SEG. The label for each line number presented on this internet site (R-21 through R-24) is also a hyperlink that allows the user to view the associated digital image of the seismic line (see below).

Cross Reference File (CDP_SP.TXT): A table giving a cross-referenced list relating regional line number, to original line number, to original shotpoint number, and to CDP number for each regional line. A printout of the first few lines in this file is given below:

Line No.	Original Line No.	Original Shotpoint	CDP No.
R-21	65-76	290	2
R-21	65-76	280	122
R-21	65-76	270	242
R-21	65-76	260	362
R-21	65-76	250	482
R-21	65-76	240	602
R-21	65-76	230	722
R-21	65-76	220	842
R-21	65-76	210	962

Digital Images of Seismic Displays (Files R21MT.PDF through R24MT.PDF): Small scale displays of each line, generated from a GEOGRAPHIX/SEISVISION® work station at a horizontal scale of 1:250,000 for distance and 1.5 inches/second for two-way travel time ("PRN" files). Although the vertical exaggeration of these displays is approximately 6:1 (assuming an average velocity of 10,000 ft/sec), the longest line (R-15) is about 78 inches long. The PRN files from SEISVISION were converted to compressed Adobe Acrobat® PDF files using the "Distiller" function in Adobe Illustrator®. The PDF files can be opened, viewed, and printed using the free downloadable version of Adobe Acrobat® Reader 4.0, which can be obtained from http://www.adobe.com.

Notes on display annotation: There are two sets of numbers at the top of each display, one labeled Shot indicating Shotpoint number, the other CMP which is an acronym for Common Mid Point and is equivalent to the term CDP used elsewhere in this document. On the displays, these numbers are the same because as described above, we made the Shotpoint number equal to the CDP number in order to have a unique index number for each trace within a line.

Display Software: No display software is provided on this Internet site. However, Open File Report 00-286 contains an IBM P/C compatible seismic display program, PLOTSEIS.EXE and associated documentation for the purpose of displaying the SEG-Y data files. This display program is also published separately by Zihlman (1996).

DISCLAIMER

SYSTEM REQUIREMENTS

Minimum hardware/software requirements are as follows:

All platforms: Software capable of reading SEG-Y format data files, ASCII text files, and PDF-format graphics files.

FIGURES

Figure 1. Digital image in Adobe Acrobat® PDF format, containing a map view of the trace locations, generated directly from file NPRANAV.SEG. The label for each line number presented on this internet site (R-21 through R-24) is also a hyperlink that allows the user to view the associated digital image of the seismic line in Adobe Acrobat® PDF format.

TABLES

Table 1. List of seismic lines contained in the data set with total mileage and geographic orientation of each line. The four lines contained on this Internet site are R-21 through R-24. Click on any of these four line names to display a graphic image in PDF-format of the stacked, migrated record sections.

Table 2: List of the component lines that make up the 4 regional lines presented on this Internet site. Asterisks (*) indicate those lines which were completely reprocessed from the field tapes. All other line segments were reprocessed from the stacked, unmigrated data previously processed by industry.

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