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Call: +61 8 8999 6443

Click: geoscience.info@nt.gov.au
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Visit: 3rd floor
Centrepoint Building
Smith Street Mall
Darwin
Northern Territory 0800

TECHNICAL REPORT
DIGITAL PROCESSING FOR 1981 HIGHWAY
SEISMIC SURVEY

OPEN FILE
PR81/031 D

RELATES TO
PR 80/33

SEISMIC DATA PROCESSORS LTD.
200, 1400 - 1st Street S.W.
Calgary, Alberta, Canada
T2R 0V8
Phone (403) 233-7830

Technical Report

Subject: Digital Processing of the 1980-1981 Alice, Highway and Walker Creek Surveys. (In the Amadeus Basin).

Client: Pancontinental Petroleums Ltd.

Processing Center: Seismic Data Processors Ltd.
200, 1400 - 1st Street S.W.
Calgary, Alberta
T2R 0V8

Processing Supervisor: Clay Hayes

PR81/31 A

Recording Parameters

Recording Contractor: Geophysical Services Incorporated
Client: Pancontinental Petroleums Ltd.

Energy Source: Vibroseis
Sweep Frequency: 12-80 Hz
Sweep Length: 16 seconds
Record Length: 20 seconds

Recording Instruments: Texas Instruments DFS V
Recording Format: SEG B
Recording Filter: 8-90 Hz
Recording Sample Rate: 4 Ms

Geophone Type: GSC 20 D, 10 Hz
Geophone Array: 24 phones, inline, 3 M spacing (Alice, Highway)
24 phones, inline, 4 M spacing (Walker Creek)

Group Interval: 50 Meters (Alice, Highway)
40 Meters (Walker Creek)
V.P. Interval: 100 Meters (Alice, Highway)
80 Meters (Walker Creek)
Near Offset: 175 Meters (Alice, Highway)
140 Meters (Walker Creek)
Far Offset: 1325 Meters (Alice, Highway)
1060 Meters (Walker Creek)
Traces/Record: 48
Trace Configuration: Split spread.

Processing Sequence

1. Demultiplex and removal of binary gain.
2. Spherical divergence correction.
3. Geometry specification.
4. Deconvolution and bandpass filtering.
5. Trace balance/CDP sort.
6. Weathering static calculation.
7. Velocity analysis.
8. Trace editing.
9. Normal moveout.
10. First break muting.
11. Datum and weathering static application.
12. Preliminary stack.
13. Surface consistent residual static calculation and application.
14. CDP trim statics calculation and application.
15. True relative amplitude stacking.
16. Bandpass filtering.
17. Trace equalization.

Analysis of the Processing Sequence

1. Demultiplex and binary gain removal:
Data is decoded from the multiplexed field recording format and converted to our internal 9 track, trace sequential format. Field recorded information such as field file numbers and trace numbers are retained in trace headers.

The field-applied binary gain is automatically removed by the program, recovering the true recorded signal amplitudes.

2. Spherical divergence gain:
The strength of the recorded signal decays with time due to spherical spreading of the wavefront as it passes through the earth, energy reflection at geologic boundaries, and energy loss due to inelastic attenuation of the signal by the earth. Consequently, gain is applied to compensate for these energy losses.

Poor data quality in this area precluded any complex data analysis and a simple T**2 gain curve was applied to the data.

3. Geometry specification:
Information on shot/spread and subsurface geometry, ie., source locations, station interval, elevations, etc. are entered into designated trace headers for future use.

4. Deconvolution and bandpass filtering:
As the source signal passes into the earth, it is altered through phase shifts and amplitude attenuation. Deconvolution is done to recover (A) the original signal amplitude levels over the input frequency band and (B) the proper phase relationships between frequencies, in the recorded signal.

Deconvolution tests were carried out on the data to assess the effectiveness of various operator design parameters. A predicitive deconvolution was selected with an operator length of 84 MS, pre-whitening of 3%, and a predicitive distance of 8 MS. This design was found to work quite well for the data from all three areas.

Following this, a zero-phase bandpass filter of corner points 12/16-80/100 Hz was convolved with the data to remove any low and high frequency noise boosted by the deconvolution.

5. Trace Balance, CDP sort:
Variations in the near surface low velocity layer, combined with variations in the quality of the coupling between the geophones and the earth, and/or coupling of the vibrator plate and the earth may drastically affect the energy recorded by the geophones. Such differences in recorded amplitudes contains little information and must be removed prior to further processing. This is accomplished by scaling over an offset-variant window, chosen over a zone of useful seismic information. The total energy in the window is calculated and then normalized to a mean level. If done over a sufficiently large data window, this method will effectively remove shot and geophone energy variations without destroying relevant amplitude relationships.

Next, the data is sorted from shot ordered format into CDP ordered format.

6. Weathering static calculation:
A very critical part of seismic processing is proper compensation for travel of the seismic energy through the near-surface low velocity layer or layers. If the variations in velocity and thickness of this material layer are not properly compensated for, the result will be a structurally

incorrect section.

Compensation for this weathering layer is done by application of shot and geophone time shifts calculated from arrival times and weathering velocities. The arrival times and weathering velocities are interpreted from refraction arrivals on weathering records taken from dynamite shots spaced 400 M apart, shot split spread with a far offset of 1200 M.

Weathering statics were calculated using the following formulae:

$$\text{Shot static} = TUH - \left(\frac{(T1+TUH)}{2}\sqrt{\frac{VR-VO}{VR+VO}}\right) - \left(\frac{(T2-T1)}{2}\sqrt{\frac{VR-V1}{VR+V1}}\right) - \left(\frac{(T3-T2)}{2}\sqrt{\frac{VR-V2}{VR+V2}}\right)$$

Geophone static = shot static - TUH

Where TUH - uphole time, T1 = first layer intercept time, T2 = second layer intercept time, T3 = third layer intercept time, VO - first layer velocity, V1 = second layer velocity, V2 = third layer velocity and VR = replacement velocity.

In general, three weathering layers were observed, with some localized fluctuations in thickness and velocity occuring in the layers. Disappearance of one or more of the layers was observed on some lines, as deeper layers approached surface.

7. Velocity analysis:
Due to the variable data quality in these areas the velocity analysis were carried out as a 3 step procedure.

The first step was to produce a brute stack of each line using a single velocity function for the area. This stack, although lacking good velocity control and statics, was used to assess the most favorable locations on each line for velocity analysis control points.

The second step is to produce a series of constant velocity stack (CVS) displays, over a selected velocity range, at the control point is picked from these CVS displays.

The third step is a quality control check of the picked velocities. This is done by producing common offset stacks, using the velocity functions picked in step 2, on the same data traces used in the CVS sections. Any existing residual NMO may be observed in the events on these displays, and corrected for at this point.

The highly complex geology and the occurence of poor data zones made identification of residual NMO difficult, limiting the effectiveness of this step.

8. Trace edit:
Noisy and erratic traces, which would degrade the quality of the stack, are omitted from further processing at this stage. The standard procedure is to do the edit by visual inspection of the deconvolved shot records.

9. Normal moveout:
The velocity functions determined previously are applied to the data in this stage. The velocities are linearly interpolated both spatially and temporally between control points.

10. First break muting:
To prevent deterioration of the shallow section of the stack, the first break refraction energy and overstretched reflection energy is deleted using an offset-dependent, spatially variant mute. The effect this has is to zero the unwanted part of the traces.

11. Datum and weathering statics application:
The data is now time shifted by the previously calculated shot and receiver elevation and weathering statics.

12. Preliminary stack:
The data is CDP stacked for a quality control check of the processing up to this point and to facilitate selection of processing parameters for the following processing steps.

13. Surface consistent residual static calculation and application:
In this stage, residual source and receiver statics are calculated, based on relative time shifts between the traces in each CDP. The calculation is done for each CDP by iterative cross-correlations between the individual data traces and model traces generated from the traces in each CDP.

Processing control parameters such as correlation window length, maximum allowable static, and correlation search windows are determined by the user through prior inspection of the preliminary stack section.

The calculated statics are applied as shot and geophone statics and are also stored in trace headers for possible future use.

This step was found to be effective in resolving most residual static problems, where the signal to noise ratio was good, although care had to be taken to prevent effects such as cycle skipping.

14. CDP trim static calculation and application:
A trim static pass is done at this point to improve the alignment of events. The statics are calculated on a CDP basis by cross-correlation of the data with a pilot trace,

generated from the data, over a specified window. A new pilot trace is created for each CDP, preventing any alteration of structure.

These static values are applied as CDP statics and are also stored in a trace header, for possible future use.

15. True relative amplitude stacking:
After the CDP gathers have been corrected for residual statics and the mute application checked, the CDP gathers are stacked with the objective being to attenuate ambient random noise and some forms of coherent noise.

16. Bandpass filtering:
After stacking, the data was then convolved with a zero phase bandpass filter possessing corner points of 12/16-60/70 Hz. Filtering the data post-stack serves to enhance shallow data with a low cut filter to remove the remaining elements of ground roll, NMO stretch and any smearing caused by the stacking. While the deep data can be enhanced by use of a high cut filter to remove high frequency random noise.

17. Trace equalization:
Before displaying the stacked section on film the data was scaled to suppress the high energy first breaks and to emphasize geological continuity.

Sincerely yours,

Marc Roulston
B.Sc.