Research Paper

3-D Land Seismic Data Acquisition And Processing

Science

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ABSTRACT | This paper reflects the application of Geophysics for studding the internal structure of the earth especially for '3-D Land Seismic Data Acquisition and Processing'. It is composed of general introduction about seismic, methods of seismic data acquisition, seismic data processing in different stages. Then finally I tried to summarized and conclude about the acquisition and processing of the seismic data and the results after processing. There are also graphs which represent the data before and after processing. The instruments that have been used for acquisition and the methods used have been stated in the summery and conclusion.

Introduction

The seismic method has three important/principal applications:

a. Delineation of near-surface geology for engineering studies, and coal and mineral exploration within a depth of up to 1km: the seismic method applied to the near surface *studies is known as* **engineering seismology**

b. Hydrocarbon exploration and development within a depth of up to 10 km: seismic method applied to the exploration and development of oil and gas fields is known as **exploration seismology.**

c. Investigation of the earth's crustal structure within a depth of up to 100 km: the seismic method applies to the crustal and earthquake studies are known as **Earthquake seismology/crustal seismic study.**

Robert E. Sheriff defines " Seismic survey is a program for mapping geologic structure by observation of seismic waves, especially by creating seismic waves with artificial sources and observing the arrival time of the waves reflected from acoustic impedance contrasts or refracted through high velocity members.

Seismic Data Acquisition

Subsurface geologic structures containing hydrocarbons are found beneath land, sea or Transition Zone. So there is a land data-acquisition method and a marine data-acquisition method. The two methods have a common-goal, imaging the earth. But because of the environmental difference, each method required unique technology and terminology.

1. Land Data Acquisition: In land acquisition, a shot is fired (i.e., energy is Transmitted) and reflections from the boundaries of various Litho logical units within the subsurface are recorded at a number of fixed receiver stations on the surface. These geophone stations are usually in-line although the shot source may not be. When the source is in-line with the receivers – at either end of the receiver line or positioned in the middle of the receiver line – a two-dimensional (2D) profile through the earth is generated. If the source moves around the receiver line causing reflections to be recorded form points out of the plane of the in line profile, then a three-dimensional (3D) image is possible (the third dimension being distance, orthogonal to the in-line receiver-line).

2. 2. Marine Data Acquisition: In a marine operation, a ship tows one or more Energy sources fastened parallel with one or more towed seismic receiver lines. In this case, the receiver lines take the form of cable called Steamer containing a number of hydrophones. The vessel moves along and fires a shot, with reflections recorded by the streamers. If as single streamer and a single source are used, a single seismic profile may be recorded in like manner to the land operation. If a number of parallel sources and/or streamers are towed at the same time, the result is a number of parallel lines recorded at the same time. If many closely spaced parallel lines are recorded, a 3D data volume is recorded. More

than one vessel may be employed to acquire data on 24-hour basis, since there is no need to curtail operations in nights.

3. 3 Transition Zone Recording: Because ships are limited by the water depth in which they safely can conduct operations, and because land operations must terminate when the source approaches the water edge, or shore lines, transition-zone recording techniques have been developed to provide a continuous seismic coverage required over the land and then into the sea.

Seismic data processing

The seismic method has been greatly improved in both the areas of data acquisition and processing. Till now we have seen only about data acquisition methods and procedures. From now on wards we will try to see the processing methods. Digital recording along with the CMP multi fold coverage was introduced during the early 60's. Data acquired from the field are prepared for processing by the field party itself and then it is send to the processing centre.

Processing is required because the data collected from the field is not a true representation of the subsurface and hence nothing of importance can be inferred from it. With the advent of high end computing systems modern day processing has become a lot easier than it really used to be. Turnaround times have therefore come down with lot of processing taking place in-field or on-board

2. Why Processing? Field record which we obtain contains:
- ❖ reflections,
- ❖ coherent noise, and
- ❖ Random ambient noise.

2.1. Reflections: Reflections are recognized by the hyperbolic travel times. If the reflection interface is horizontally flat, the reflection hyperbola is symmetric with respect to zero offset. On the other hand if it is dipping interface, then the reflection hyperbola is skewed in the up dip direction.

2.2. Coherent Noise: Under the coherent noise category there are several wave types.

- Ground roll is recognized by its low frequency, strong amplitude and low group velocity. It is the vertical component of dispersive surface waves i.e. Raleigh waves. Typically we try to eliminate ground roll in the field itself by array forming of receivers.
- Guided waves are persistent, especially in shallow marine records in areas with hard water bottom. Guided waves also are found in the land records. These waves are largely attenuated by CMP stacking. Because of their prominently linear move-out, in principle they also can be suppressed by dip filtering techniques. One such filtering technique is based on 2D Fourier transformation of the shot record. Side Scattered noise commonly occurs at the water bottom, where

there is no flat, smooth topography.

- Cable noise is another form of coherent noise which is linear and low in amplitude and frequency. It appears on shot records as late arrivals.
- Another form of coherent noise is the air wave which has a velocity of 300 m/s. It can be a serious problem when shooting with surface charges. Notch muting is the only way of removing them. Power lines also give rise to noisy traces in the form of a mono frequency wave (50 or 60 Hz).
- Multiples are another type of coherent noise. They are secondary reflections having inter- or intra- bed ray paths. They propagate both in sub and supercritical regions.
- Power lines also cause noisy traces in the form of a mono-frequency wave. A mono-frequency way may be 50 or 60 Hz, depending on where the field survey was conducted. Notch filters often are used in the field to suppress such energy.

2.3. Random Noise: Random noise has various sources. Poor planting of geophone, wind, transient movements in the vicinity, wave motion in the water (marine) and finally electrical noise of the recording instrument.

One important aspect of data processing is to uncover genuine reflections by suppressing all unwanted energies (noise of various types) .The objective of seismic data processing is to convert the information recorded in the field to a form that can be used for geological interpretation.

Through processing we are enhancing the signal to noise ratio, removing the seismic impulse from the trace (inverse filtering) and repositioning the reflectors to its true location (NMO, DMO and migration), thereby making it into a more palatable form.

The following tables give an idea on various types of noises & methods to attenuate them.

Table 1. *Noise Attenuation Techniques*

Random	Coherent
Band pass filtering	Band pass filtering
Notch filtering	Velocity filtering,eg FK filtering
K-filtering i.e tracing/shot gathering	Muting
FK-filtering	Coherency filtering
Stacking	
De-spike	
F-X filtering	
Coherency filtering	
Editing (i.e killing)	

Table 2: *Land Data – Additional Type of Noises*

Noise/problem	Nature	Solution
Hi-line	Random	Kill, notch filter
Ground roll	Coherence	F_K filter
Air wave	Coherence	HI-cut filter , surgical filter
Correlation noise	Random	Mute
Traffic (vehicles, animals ,people)	Random	Filter, stack
Wind noise	Random	Filter ,stack
Falling materials	Random	Filter ,stack

Different Stages of seismic data processing
Stage I-Pre- processing
Pre-processing is the first and foremost step in the processing sequence and it commences with the reception of field tapes and observers log. Field tape contains seismic data and observers log contains geographical data (shot/receiver numbers, elevations, latitude, longitude etc).It includes: de-Multiplexing, re-formatting, re-sampling, editing, geometry Merging (Labelling), Static Corrections, amplitude Recovery (Geometric Spreading Correction) and muting.

Stage II-Velocity Analysis:
Velocity analysis is an interactive tool used to interpret Stacking or normal move out velocities (MOV) on 2D & 3D pre stack seismic data.
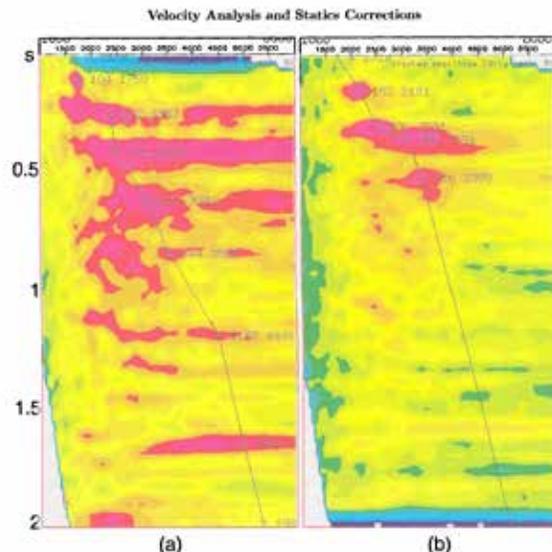

Fig1. *Velocity spectra derived from the CMP gather*
(a) Without static correction (b) with static correction

Stage III - Migration:
Is a process which attempts to correct the directions of the geological structures inherent in the seismic section?
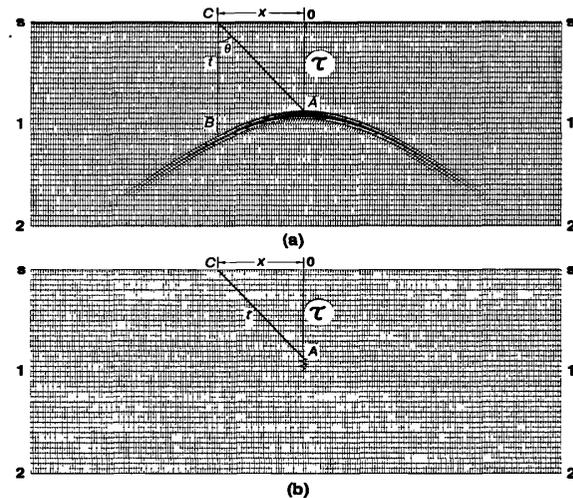

FIG2. *Principles of migration based on diffraction summation.(a) Zero-offset section (trace travel ,25m;constant velocity,2500m/s) (b) migration.*

The amplitude at input trace location B along the flank of the travel time hyperbola is mapped on to output trace location A at the apex of the hyperbola.

Summery and Conclusion
Seismic data acquisition consists of gathering and recording of continuous seismic signals from seismic stations. Process of automatic acquisition, detection, processing and dissemination of seismic data at Observatory's acquisition center is performed on three parallel acquisition systems: DASP (B. Glavatovic, MSO, Montenegro), SeisComP3 (GFZ, Potsdam, Germany) and Smart-

GeoHub (Geotech Instruments,Dallas,TX).

Acquisition of analogue signals is executed on DASP acquisition system, developed by director of Montenegro Seismological Observatory Prof. Branislav Glavatovic and collaborators. This system is constituted in the beginning of seismic signal acquisition era on PC computers in the World and it has been in operation more than20years.Digital seismic signal acquisition is supported by two acquisition platforms (SeisComP3 and SMART Geo Hub servers), for fully automated earthquake data processing and analyzing of earthquake information, along with simultaneous application of dozens of programs for those purposes. Average time of automatic system reaction on earthquake occurrence on the Montenegro territory and its surroundings, with processing and distribution of earthquake data via Internet and SMS messages is three minutes.

Processing is required because the data collected from the field is not a true representation of the subsurface and hence nothing of importance can be inferred from it. So for that we have used different stages of processing.

REFERENCE

[1] Canales, L., 1984, Random noise reduction: 54th Ann. Internat. Mtg., Soc. Expl. Geophysics, Expanded Abstracts, 525. | [2] Claerbout, J. F., 1985, imaging the earth's interior: Blackwell Scientific Publications. | [3] Aki, K. I. and Richards, P. G., 1980, Quantitative seismology: W. H. Freeman and Co. | [4] Alkhalifah, T. and Larner, K., 1994, Migration error in transversely isotropic media: Geophysics, 59, 1405-1418. |