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A NOVEL APPROACH TO 3-D SEISMIC PROCESSING

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INTRODUCTION

Exploration seismology is based on analysis of seismic waves reflected from different layers in the earth's subsurface. Seismic energy, radiated by a seismic source into the subsurface, encounters discontinuities between the layers and is partially reflected back to the surface. The returning reflections, which contain indirect information on the elastic parameters of the subsurface, are detected and stored on magnetic tapes. Generally many seismic experiments are carried out for different positions of the seismic souce. The aim of seismic **migration** (a multi-dimensional seismic inversion technique) is to resolve a structural image of the subsurface from seismic measurements.

2-D VERSUS 3-D MIGRATION

In many practical situations seismic data acquisition is carried out along a straight line. Subsequently, seismic migration is carried out only for a vertical cross-section of the earth's subsurface below the acquisition line. In this case seismic inversion becomes a two-dimensional (2-D) technique. This may be very attractive from a computational point of view, however, the earth is three-dimensional (3-D). Particularly in areas with complicated structures 2-D migration techniques give a poor image of the subsurface. Actually, 2-D migration techniques may only be used when the subsurface model approximately satisfies the 2-D assumption, that is, when the elastic parameters depend on two spatial coordinates only. Unfortunately this assumption is rarely met in practice and therefore the reliability of many 2-D migration results is questionable.

POST-STACK VERSUS PRE-STACK MIGRATION

In the seventies and the early eighties much effort has been spent in the development of both 3-D data acquisition and 3-D inversion techniques. A typical 3-D marine survey is visualized in Figure 1.
Up to the present day, however, only the 3-D extension of the conventional migration approach has got serious attention, because conventional
migration is efficiently carried out after a so-called stacking process (post-stack migration), that is, after data reduction.

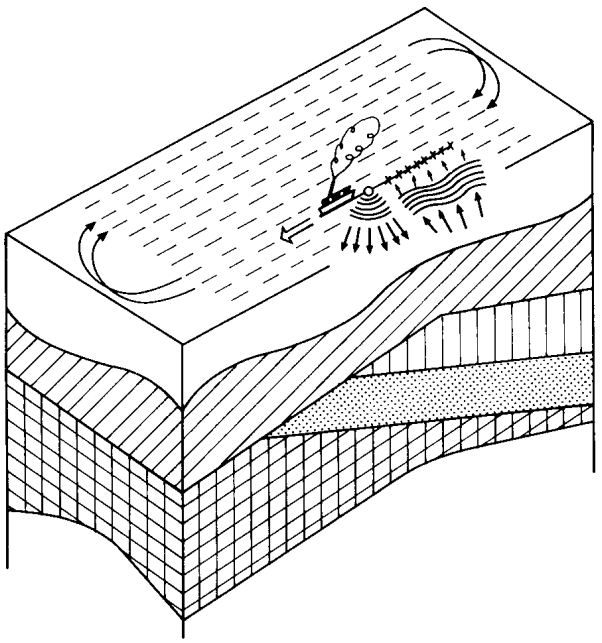

Figure 1: In 3-D marine seismics, data are often gathered along straight lines. Along each line many seismic experiments are carried out for different positions of the seismic source. In each seismic experiment many seismic signals are registered by the seismic detectors.

For a geologically complex subsurface, however, the resolution of 3-D post-stack migration techniques is far from optimum. A much better resolution may be expected from 3-D migration before stack (pre-stack migration), that is, before data reduction. However, even with nowadays fast vector computers full 3-D pre- stack migration is still unthinkable because of the enormous amount of data to be processed. For instance, a typical 3-D marine survey (see also Figure 1) consists of

200 seismic lines,
200 seismic experiments per seismic line,
100 traces per seismic experiment,
2000 samples per trace,
4 bytes per sample,

hence, the total survey contains 32 Gbyte of data. It is obvious that, given the limitations of computer hardware, a more practical approach to 3-D pre-stack migration is required.

TARGET ORIENTED 3-D PRE-STACK MIGRATION

In many practical situations seismic interpreters are mainly interested in a high resolution image of a pre-specified target zone. Hence, much work can be saved by the following two-stage procedure:

1. Apply conventional post-stack migration for an initial 3-D evaluation of the subsurface.
2. Apply full 3-D pre-stack migration to specific areas of interest ("target-oriented" stage).

During the presentation the details of target oriented 3-D processing will be discussed. Particularly the practical aspects of data-management will be emphasized. It will be shown that high quality 3-D images of the 'target zone' can be obtained in realistic processing times.