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Depth processing – practical aspects

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Abstract

As the use of depth processing is rapidly expanding, the industry is gaining experience in correct implementation of this evolving technology. Although the core of depth processing is in construction of velocity models and application of prestack depth migration, other important issues need to be carefully considered during each project. These involve selection of correct velocity analysis tool, correct prestack depth migration algorithm, and correct processing aimed to enhance the final image. Integration of all of the above will secure correct result. The paper presented here will discuss how a combination of the above factors is needed in order to successfully execute a depth processing project.

INTRODUCTION

The objective of depth processing is to construct a depth domain seismic volume where geological formations are correctly positioned in both vertical as well as lateral locations. This is mainly achieved through construction of velocity models and application of depth migration. However, in order to successfully apply imaging techniques, interpretation needs to start during the processing phase rather than after its completion. More importantly, specific attention needs to be paid to velocity analysis techniques, interpretation and modeling of complex structures, and the selection of imaging algorithms.

Application of depth processing results in a depth seismic volume, as well as a depth velocity volume. The latter can be used to enhance processing techniques when used as a guide. Model based processing enlarges the scope of imaging into what we call depth processing. Finally, time to depth conversion can be applied as part of imaging, resulting in a very accurate depth seismic volume.

The objectives of this paper are:

* To describe the tools used for depth processing that exists in the marketplace today
* To explain the correct selection of these tools in different geological settings
* To demonstrate the limitations of different procedures, and
* To present case studies that show how the correct combination of imaging and interpretation results in successful exploration programs.

VELOCITY ANALYSIS TECHNIQUES

Four main velocity analysis techniques are used today in depth processing. These are coherency analysis, tomographic optimization, image gather analysis and full waveform inversion. The first two techniques are based on traveltime calculation and are thus called kinematic techniques. The third and fourth techniques are based on wave equation calculation (for modeling and migration) and are thus called dynamic techniques.

Kinematic methods are generally faster to execute, but are based on pre selection of only portions of the data for analysis. Dynamic methods are more expensive to use, but contain fewer predefined conditions. How should we decide which tool to use in any one specific case? There are some cases where one tool will serve the purpose. However, in most cases only a combination of several tools will result in the correct velocity model needed to assure a correct migration result.

IMAGING ALGORITHMS

3D prestack depth migration is the most expensive algorithm applied in processing today. For each prestack trace, a full 3D volume of traveltime function is calculated. The tremendous increase in computing power enables us to apply this technique in the production environment, but we still have to tie the computing algorithms to the existing hardware, which is not unlimited. In order to be able to execute 3D prestack depth migration within a reasonable time frame, a few issues need to be addressed.

The most economical algorithm in use is the Kirchhoff summation method. The core of this algorithm relies on computation of traveltime functions. Recent advances in this area have resulted in new algorithms that are both fast and accurate.

The future of imaging relies on the progress of 3D prestack depth migration technology. Successful full volume 3D prestack depth migration can be achieved by further development in computer technology that will allow use of more complicated geophysical algorithms.

MODEL BASED TECHNIQUES

Application of depth processing focuses on construction of velocity models and application of depth migration. Nevertheless, depth-processing covers a larger area of processing that can be described as model based techniques. Having a velocity model, seismic processing algorithms can be greatly improved. Model based stacking, model based AVO and model based gaining are some examples. Model based techniques that are closely related to imaging are model-based aperture selection, model-based muting and model-based multiple elimination.

Model based multiple elimination is one of the most important considerations when imaging subsalt formations. In many cases, top salt peg leg as well as (salt related) converted waves migrate to a depth close to the real salt base and below. This fact poses difficulties in both identification of the salt base as well as the ability to image subsalt reflections. The ability to model these ray paths using a model provides a tool to predict those multiple arrivals and to remove them from the time domain data.

As depth processing techniques develop, more model-based solutions will emerge, enhancing the capabilities of seismic data processing. This is one of the main reasons why we call imaging (and beyond) Depth Processing.

TIME TO DEPTH CONVERSION

The objective of depth processing is to construct a depth seismic volume in which events are positioned correctly in both lateral as well as vertical directions. "Depthing" can be applied after depth migration, but in order to maintain the integrity of the seismic volume, it is preferable to correctly convert the data from time to depth during the process of model building. In cases of anisotropy, an anisotropic algorithm can be used for depth migration. Using a case study from the Mississippi salt basin, we will demonstrate a technique where velocity analysis and construction of the depth model are done using seismic methods as well as well data (see Figure 1).

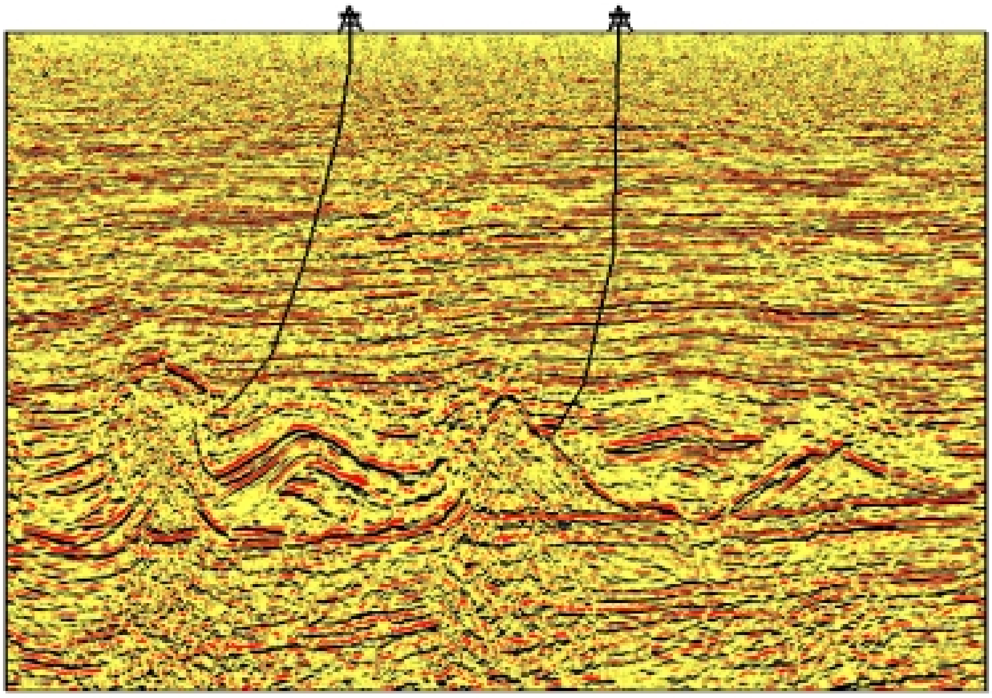

Figure 1. Depth image and well locations targeted at deep producing formations. The combination of clear image together with accurate positioning of seismic events is necessary in order to choose optimal well locations.

CONCLUSIONS

Depth processing is “the neww way” of processing seismic data in which both superior imaging as well as time to depth conversions are applied in one step. However, the only way to accomplish this task is by starting the interpretation process during the early processing phase.

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