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Wide-Azimuth Streamer Acquisition for Gulf of Mexico Subsalt Imaging

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Abstract

A 3D wide-azimuth (WAZ) marine streamer survey was designed to image deep objectives below a complex salt structure in a deepwater area of the Gulf of Mexico. Numerous technical and logistical challenges were considered in developing the design for this survey. The final selected wide-azimuth design was used for a survey acquired over the Friesian prospect in the Gulf of Mexico. We summarize some of the modeling studies supporting the wide-azimuth survey design and present the acquisition and processing results from the Friesian WAZ pilot project. We will also make some observations on the data-subsetting studies that have been done to identify more efficient wide-azimuth acquisition methods.

This project was intended to demonstrate the value of the WAZ technology to exploration in complex subsalt settings. The data we will show here were from the first phase of a two-part acquisition effort. The successful imaging results from Phase 1 alone were sufficiently convincing to allow the deferral or cancellation of Phase 2. Shell Exploration then initiated an effort to acquire a large multiclient exploration survey in a complex salt-canopied area of the Gulf of Mexico.

Introduction

Over the past twenty years, there are many examples showing the benefit of varying the azimuth of conventional streamer acquisition to illuminate sedimentary structures below or adjacent to complex salt bodies. The first dedicated multiazimuth streamer acquisition we are aware of was the 1988 dual-azimuth survey at Bullwinkle that was reported by O'Connell, Kohli, and Amos (1). The Bullwinkle survey results clearly demonstrated that different areas of the survey were imaged better with one azimuth or another. In most cases, these results were understandably related to the interaction of the imaging algorithms employed, typically some form of Kirchhoff time migration, with the proximity of fast salt bodies to the objective. It is important to recognize that acquisition does not stand on its own, but must be thought of in the context of the processes that will be applied to the data.

The desirability of wide-azimuth acquisition was suggested by Padhi and Holley (2), wherein they described the minimal dataset concept for analyzing the benefits of such designs. There are a number of ways to achieve a greater azimuth distribution in marine data beyond just acquiring several conventional narrow-azimuth surveys in different directions, which we refer to as multiple-azimuth (MAZ) data. Ocean-bottom cable or ocean-bottom seismometer surveys offer another way to achieve a more complete azimuth distribution. But, while we have had a longstanding interest in this type of data, we will not enter into that discussion in this paper. We are also now beginning to see alternative marine streamer survey designs, such as the helix design described by Sukup (3) that employ repeated inline source locations while moving the streamer pattern around to achieve greater crossline coverage.

We emphasize a distinction between this type of sparse (repeated) shot, uniform receiver wide-azimuth design, and the multiple-azimuth designs more commonly used in marine environments. It is the sparse-shot wide-azimuth style of acquisition, which we refer to as WAZ, that we will consider here.

Defining acquisition design requirements is simple: we want a survey that fully illuminates the subsurface, optimally suppresses coherent noise, is easy to process, and is cheap. It is perhaps not so easy to achieve all of those, but what we will try to keep in mind are a few basic principles:

- We need a range of azimuths to illuminate under complex salt.
- We want relatively uniform sampling in some domain for processing.
- High-fold sparse-shot survey designs allow efficient wave equation migration (WEM). From a WEM imaging point of view, we would like to have full area receiver coverage for each shot, but by reciprocity, we know that such a survey has a redundancy in the offset azimuth distribution, which is an inefficiency we may want to remove in the final design.