Vecta Exploration, Inc. - “Shear Wave Seismic Study: Comparing 9C-3D SV and SH Images with 3C-3D C-Wave Images”

Sound waves generated at or near the surface of the earth travel downward through the earth, reflecting back to the surface when they encounter a discontinuity or change in the acoustic properties of the subsurface rock layers through which they are traveling. Discontinuities are created when there is a change in rock properties (such as a change in mineralogy that occurs at the boundary between two rock layers or a change in porosity within a rock layer) and/or when there is a change in the fluids (oil, gas, or water) contained within the rock layers. These reflection events, when properly recorded and interpreted, are used to produce an image or “picture” of the subsurface rock layers. This information is used extensively in the exploration for oil and gas to identify potential subsurface oil and gas bearing formations.

Conventional 3D seismic survey methods commonly in use today utilize only compressional (P) waves (sound waves traveling in the direction of the original seismic signal) to generate the seismic data. Usually, P-wave data alone is sufficient to identify subsurface structure (shape). However, 3D seismic imaging using only P-wave data sometimes does not provide enough information about the subsurface to reliably identify “good” drilling prospects. Some formations do not always generate sufficient reflected P-wave energy to produce an image clear enough to define the structure and P-wave data alone provides very little information about the stratigraphy (rock character) which often determines whether or not the formation contains or is capable of producing hydrocarbons.

The sound waves generated at or near the surface of the earth by explosives or vertical vibrators (thumper trucks) consist of P-wave and shear (S) wave (sound waves traveling perpendicular to the direction of the original seismic signal) components, but only the P-wave reflections are typically recorded due to cost considerations. Each of these wave types, P-waves and S-waves, react to the rock and fluid properties in a different way and thus each provides different information about the rock system (i.e., the stratified layers of rock and fluids) it is traveling through. The differences in the way each of these wave forms reacts to the rock system creates differences in their respective seismic reflections, depending on the petrophysical properties of the rock system.

If defining the subsurface structure is all that is needed to identify drilling prospects in a geographical area, then 3D P-wave data is sufficient. However, if successful drilling depends on locating fractures, detecting porosity trends, mapping lateral variations in the composition, or defining subtle stratigraphic traps, then acquiring and combining the P and S-wave seismic reflection data provides additional valuable geologic information about these subsurface features.

Sear wave seismic reflection data can be acquired in either of two ways. The first and more common practice is to use three-component (3C) geophones, an instrument designed to detect vibrations, to acquire 3C-3D seismic data which consists of both the P-wave and S-wave signals. The 3C data can then be used to “create” the shear wave mode, called a C-wave, by converting the S-wave signal using a P-to-S mode conversion algorithm technique. The second method involves an emerging seismic technology which uses multiple sound wave generation techniques (a vertical vibrator, an inline horizontal vibrator, and a crossline horizontal vibrator) in conjunction with 3C geophones, to acquire multi-component (9C-3D) seismic data which “records” S-wave reflections consisting of a horizontal (SH) mode and a vertical (SV) mode along with the P-wave reflections. The 9C-3D data then has the added advantage of acquiring three fundamental sound wave mode reflections (P, SH, and SV) in addition to the fourth converted C-wave reflection, each of which can be used for imaging. Each of these wave modes has a different reflectivity behavior and thus produces a different image of the subsurface geology. 3C seismic data provides only two imaging options, P and C-wave, whereas 9C seismic data provides all four imaging options, but is considerably more expensive to acquire and process. The cost of acquiring multi-component 9C-3D seismic data is approximately twice the cost of conventional 3C-3D seismic acquisition, however the improved imaging and additional information is expected to reduce drilling risks, result in more discoveries, and improve the recovery of bypassed oil, thereby significantly offsetting the higher initial cost. The added costs of obtaining 9C-3D S-wave seismic data and the lack of perceived benefits have thus far precluded the wide-spread application of this important technology among cost-conscious independent oil and gas producers.

Vetca Exploration, Inc. (Vecta) will subcontract the Exploration Geophysics Laboratory (EGL) at the Bureau of Economic Geology at The University of Texas at Austin to assist in research to document the differences in imaging quality between lower-cost C-wave images from 3C data and higher-cost SH and SV images from 9C data in identifying subsurface features. EGL will process both 3C-3D and 9C-3D seismic data which was acquired over the same survey area and create SH, SV, and C-wave images. Vetca will then drill a new well inside the seismic survey area and acquire a comprehensive set of well log data to aid in and verify the evaluation and interpretation of each of the seismic images. Vetca and EGL will compare the three sets of shear wave images to determine the relative merits of each S-wave imaging option. The results will be made available to the oil and gas industry to inform operators about the advantages and disadvantages of each S-wave imaging technique.

Few independent operators are aware of the significance of S-wave seismic data, and those who are familiar with 3C-3D C-wave seismic data will have access to the comparative merits and information about the differences, similarities, advantages, and disadvantages of the S-wave imaging options. Wide-spread industry acceptance and application of S-wave imaging technology could result in the discovery of significant additional barrels of oil reserves across the oil-producing regions of the United States.

Total Project Cost: $ 329,239
DOE Share: $ 75,000
Vecta Exploration Inc.:$ 254,239 (Cost share 77 %)
Length of Project: 12 months.

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