THE UNCONVENTIONAL REVOLUTION IN EXPLORATION GEOPHYSICS

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During the last 25 years, 3-D seismic imaging has revolutionized hydrocarbon exploration by delivering an accurate 3-dimensional picture of the subsurface (Fig.1). The image is capable of detecting fluids within the reservoir and has significantly reduced the risk of locating and developing hydrocarbon deposits.

In the late 1990s, deregulation of natural gas prices allowed long-recognized deposits of natural gas locked in tight rocks to be economic. It sparked factory drilling (repeatable high-density evenly spaced) wells and hydraulic fracturing that would help unlock the reservoirs. All that was needed was a geologist to determine depths and limits of the reservoir and engineers to drill and complete the wells. If 3-D seismic data was available, it might have been used to define both the limits of the field and drilling hazards. Generally, the cost and time required to process and interpret 3D Seismic was considered too high to affect the perceived geologic risk of the Factory approach.

Completion costs in unconventional reservoirs account for over 50% of the well costs. It is therefore critical to understand the geometry of how the rock is fracturing and determine optimum well spacing to balance the cost of development with the value of the gas or oil being produced. By extending AVO (Amplitude Versus Offset) to the pre-stack domain, it's possible to simultaneously invert for Vp (pressure-wave velocity), Vs (shear-wave velocity), and density. Armed with these three fundamental rock properties that dictate elastic and inelastic rock response, researchers were able to combine those properties to tie directly to how well a rock will respond to hydraulic fracturing, or which rocks contain a higher Total Organic Carbon (TOC), or other rock properties that control how a rock responds to seismic waves or hydraulic fracturing. Combining these results allows interpreters to map areas of higher productivity and identify bypassed reserves.

Currently hundreds of different seismic attributes that are generated from 3-D seismic data are used to identify the highest productive areas and how to develop them. Micro-seismic mapping has made completion more efficient and safe. While the geophysics involved in unconventional resource development may not be the first thought in the board room, their data has become an accepted early development tool of successful oil and gas companies.