Recent Developments in 3D VSP Acquisition and Processing

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With the recent introduction of very long borehole seismic array tools in excess of 100 levels, better sources and source control and advances in imaging techniques 3D VSP can now better be used to provide subsurface images in challenging and complex geological environments.

Routine applications for 3D VSP have included the imaging and characterization of clastic reservoirs under various complex overburdens including shallow gas clouds, salt, carbonates and for reservoirs of generally low acoustic impedance contrast.

3D VSP acquisition remains however a logistical challenge. 3D VSP requires creative thinking for choice of source and source deployment and is bound by the operational constraints of drilling the well and the placement of a suitable receiver array. 3D ray trace modeling of the often complex subsurface is necessary to understand the subsurface coverage for any given acquisition geometry. The subsurface coverage can often be adversely affected particularly on land by surface conditions. It is usually not enough to simply perform ray trace modeling.

To understand and illustrate the challenges for 3D VSP imaging in complex geological settings, we use the SEG Advanced Modeling (SEAM) Phase I velocity model for 3D VSP finite difference synthetic data generation and imaging. The SEAM model simulates a complex geological environment; the model includes complex salt, grottoes, salt welds, sub-seismic resolution stratigraphic details, and even an overturned set of sediments.

For optimum survey design we recommend an iterative flow of ray trace modeling, 3D finite difference synthetic data generation and imaging. With recent advances in tool and source technology the acquisition time for 3D VSPs has been significantly reduced. In complex geological environments, better model building and calibration methods and more accurate imaging algorithms such as RTM will lead to successful 3D VSP surveys.