Schlumberger

3D Far-Field Sonic Service Acoustically Confirms Well Locations in Salt, Gulf of Mexico

Advanced active acoustic ranging accurately estimates distance and direction in relief well interception test for BP

CHALLENGE

From an openhole well in a salt formation, locate two nearby wells (one cased hole and one open hole) in the same formation.

SOLUTION

Perform active acoustic ranging (AAR) with 3D far-field sonic service to overcome the limitations of magnetic ranging technology and enable location of both the cased hole and openhole wells.

RESULTS

- Located both wells at a maximum distance of approximately 160 ft [49 m] in salt—beyond expectations for this type of formation.
- Analyzed salt quality, a factor that would be critical for evaluating interception locations for kill operations.

Overcoming limitations in locating relief well targets

Relief wells are an important contingency response in the event of a loss of well control. The basic concept involves intercepting the target well at a particular depth and then pumping kill fluid from the relief well. To achieve this, operators need a reliable and robust method of locating, tracking, and intercepting the target.

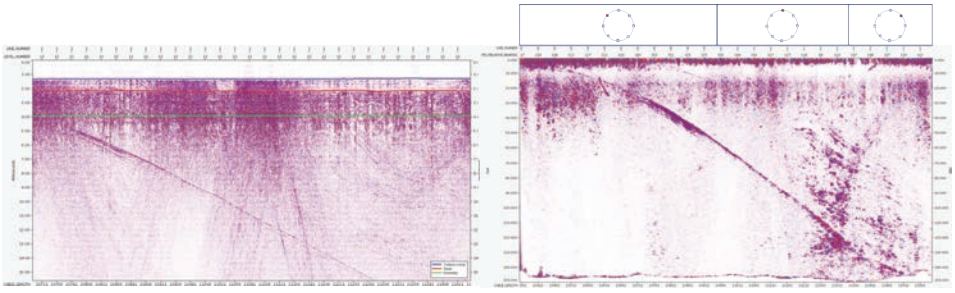
Current directional survey technologies present a high cumulative uncertainty in the absolute location of the target well, posing the need for a direct and accurate locating technique. For example, magnetic ranging technologies are helpful but not optimal for this purpose, especially in salt formations, where active systems are sensitive to the salt resistivity and passive systems are limited by target wellbore residual magnetism.

For a contingency application in the Gulf of Mexico, BP was concerned about these limitations and wanted to test another solution to locate two target wellbores—one open hole and one cased hole—from an openhole wellbore.

Interpreting acoustic signals to enable ranging in salt

Schlumberger recommended 3D far-field sonic service, which uses AAR technology to identify formation features. The service employs reflected compressional and shear waveforms from the target wellbore as well as the acoustic properties of the formation rock to detect nearby wellbores and formation features and determine their distance, dip, and azimuthal direction.

Initially, the workflow used for 3D far-field sonic service manually identified the reflection from the wellbore that was ranged on eight azimuthal images, each covering a 45° sector, obtained at each of the Sonic Scanner* acoustic scanning platform's 13 receiver stations. As processing techniques have evolved, the dataset has been reprocessed using an automated sonic imaging technique that enables a more accurate and consistent azimuth and range estimate. Automation also reduces turnaround time and the bias that can be introduced by manual interpretation.



In the monopole data (left) acquired by a single sensor for determining distance and azimuth with the sonic imaging workflow, the target cased hole well slopes from upper left down toward the right. A migrated view of the monopole data (right) clearly shows the cased target well out to 140 ft. The openhole target well is seen as a faint curved feature on the middle left at a range of 5 to 10 ft. This is a composite of three azimuthal receivers. Prior to development of the automated sonic imaging workflow, the reflector would have been manually picked on the azimuthal receiver at the strongest observed reflection amplitude.

Accurately acoustically determining wellbore locations and salt quality

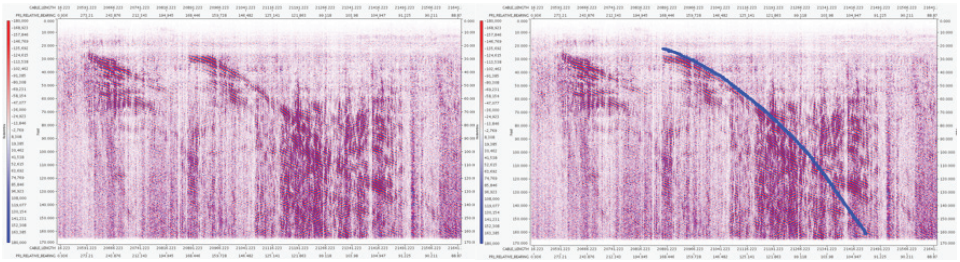
For the test operation, the Sonic Scanner platform was run in an openhole sidetrack of a well to locate the cased main bore of the well and another openhole sidetrack of the same well. Although BP knew the relative positions of the intercept wells, these were not shared with the acoustic imaging team to ensure a realistic interception simulation.

To determine the ranging distance, the salt compression and shear slowness were logged during a data acquisition run. The Q-factor was determined from a generic salt property for Gulf of Mexico offsets, and its attenuation was determined from vertical seismic profile (VSP) data.

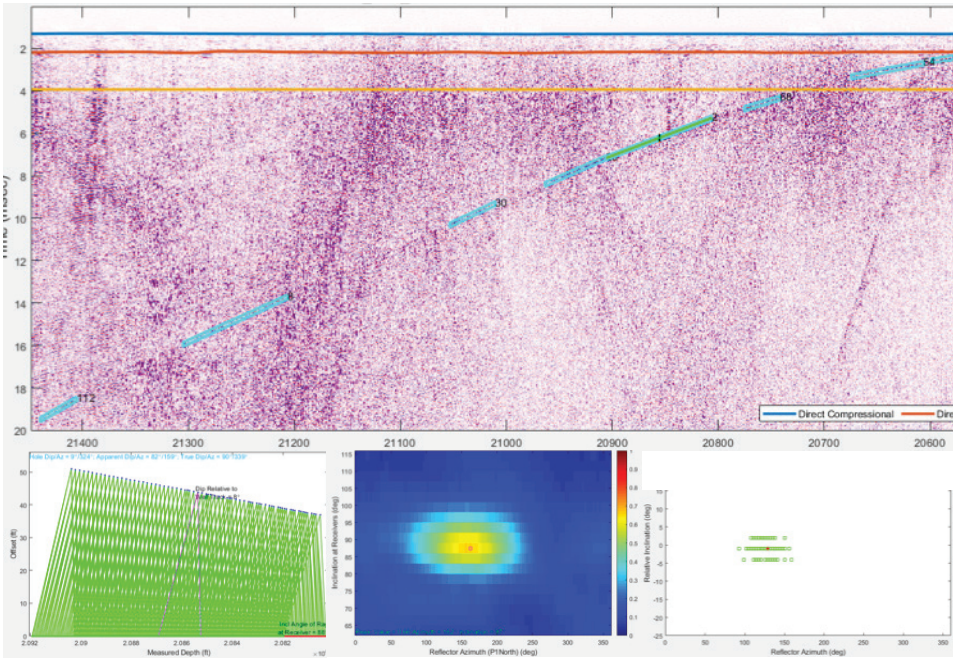
The reflected compression and shear signals were processed to determine distance and relative direction of significant formation features—in this case, the two wellbores. The cased hole wellbore was optimally detected using the monopole source, and the openhole wellbore using the dipole source. Probability analysis determined the ranging distance, uncertainties, and a best direction estimate, indicating the maximum ranging distance based on the tool setting as run is approximately 160 ft [49 m] with ±11.75° in direction using existing advanced sonic logging settings.

The test run generated additional information in terms of salt homogeneity, an important consideration in evaluating formation compressive strength as a selection criteria for interception and kill operations.

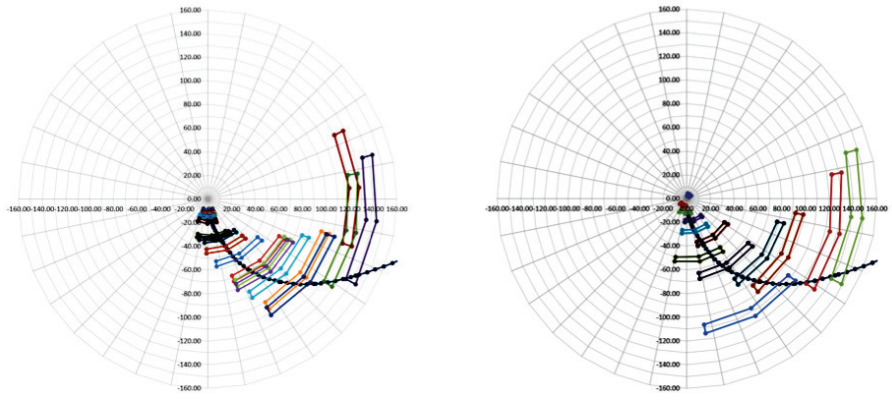
For more details, see SPE-187313.



The migrated Y dipole data shows a short section of the cased hole target to the left (25- to 50-ft range) and a clear view of the openhole target from 20 ft out to 160 ft, as highlighted with the blue curve on the right.



Three quality control plots for the single-sensor monopole data with time picks from the sonic imaging workflow at the top are (left to right) ray tracing results for each sample point along the reflector time pick, 3D slowness-time-coherence plot for one point (shown with purple rays on the left plot), and the reflector azimuth and inclination estimate for every point along the reflector.



The 3D far-field sonic service determined the acoustic ranging distance and direction for the cased hole well on the traveling cylinder with corresponding uncertainties in colored boxes. The well survey from BP is represented by the blue curve. On the left are picks from the automated workflow, and to the right are picks from the initial manual approach.

slb.com/3DSonic

Schlumberger