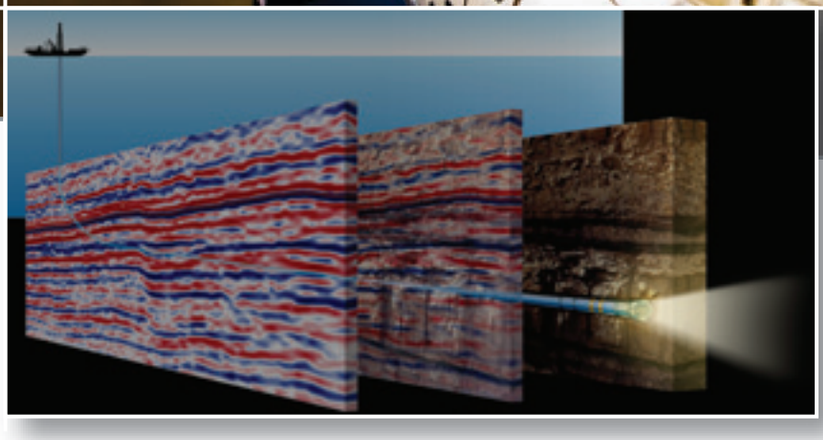
Schlumberger



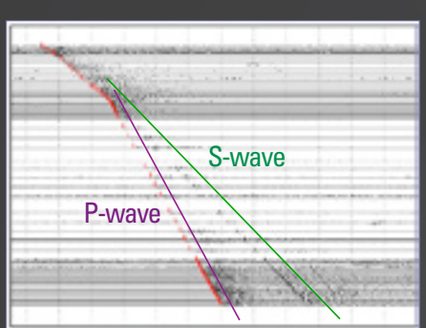
seismicVISION

Real-time borehole seismic imaging for productive drilling

Seismic-while-drilling service
accomplishes the world's first successful real-time salt proximity survey

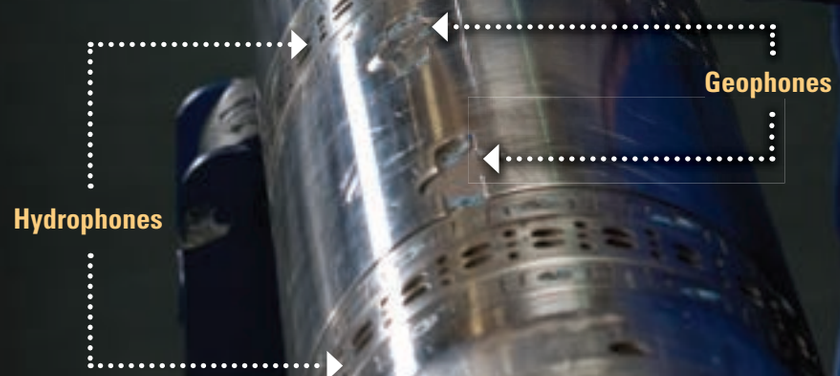
BENEFITS

- Saves rig time and cost
- Improves safety
- Reduces depth uncertainty
- Reduces casing runs
- Reduces sidetracks and pilot holes



Velocity approximately 8,400 ft/s

Rotated horizontal shows S-wave from top of salt.



seismicVISION

Award-winning technology with real-time waveforms delivers accurate time-depth-velocity information. With minimum impact on drilling operations, the service optimizes drilling decisions, reduces risk and well costs, and improves safety.

The seismicVISION* seismic-while-drilling service was developed from 15 years of Schlumberger research and engineering. Synchronized downhole clocks invented by Schlumberger are accurate enough to measure milliseconds—the standard timing in seismic surveys—and robust enough to survive the rigors of drilling. Since 2003, this service has continually demonstrated its ability to create value by helping the oil and gas industry put wells in the best place in less time.

The seismicVISION service has been named Best Exploration Technology by *World Oil*. It has also received a Special Meritorious Award for Engineering Innovation from Hart's *E&P* and an OTC Spotlight on Technology Award.

The service delivers time-depth-velocity information to optimize drilling decisions, reduce costs, and improve safety during the drilling process. In environments where both risk and well costs are high, this system offers measurements that can significantly reduce drilling uncertainty. Unlike a conventional wireline survey, these measurements do not normally interfere with drilling operations or consume rig time.

REAL-TIME CHECKSHOT DATA AND SEISMIC VELOCITIES

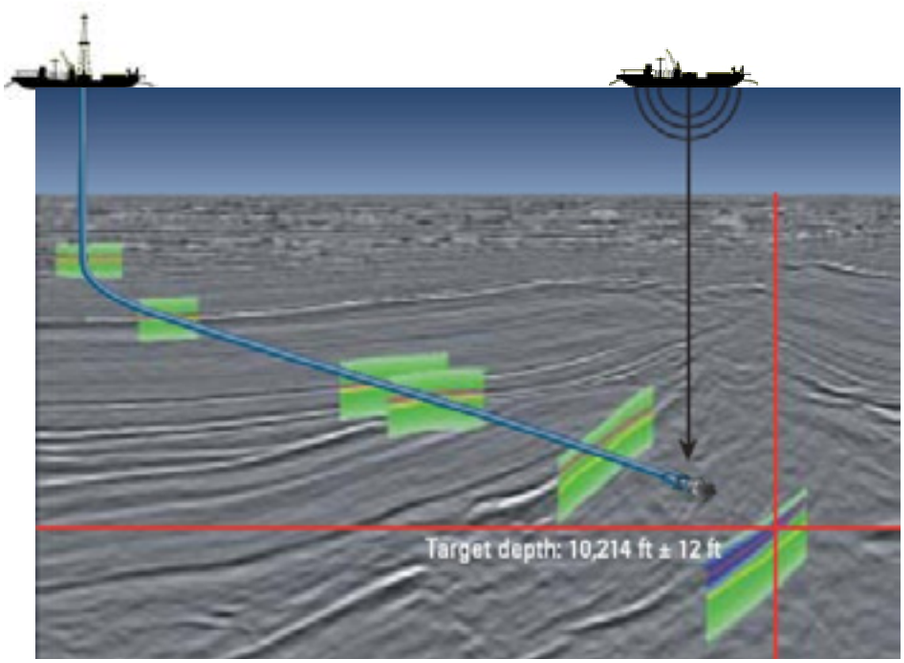
Using Bit On Seismic* software, real-time seismicVISION checkshot data can be used to place the bit on the surface seismic map to select casing points, place the well, and predict hazards ahead of the bit, such as faults or pore-pressure changes. Incorporating seismicVISION real-time checkshot data and real-time waveforms in the latest borehole seismic software allows easy visualization to facilitate communication and cooperation at the wellsite or remote offices, and converts complex information to an easy-to-understand wellbore placement path. Real-time seismic velocities are used to update pore-pressure predictions and improve hazard depth predictions.

APPLICATIONS

- Placing the bit on the seismic map while drilling
- Predicting target depths and adjusting well trajectory
- Identifying salt proximity in real time
- Landing the well in the best place in the reservoir
- Updating coring and casing points while drilling
- Providing input data to constrain pore-pressure models while drilling
- Optimizing mud weight
- Providing information for salt proximity and preparation for salt exits

Hart's *E&P* Special Meritorious Award for Engineering Innovation

World Oil Best Exploration Technology Award



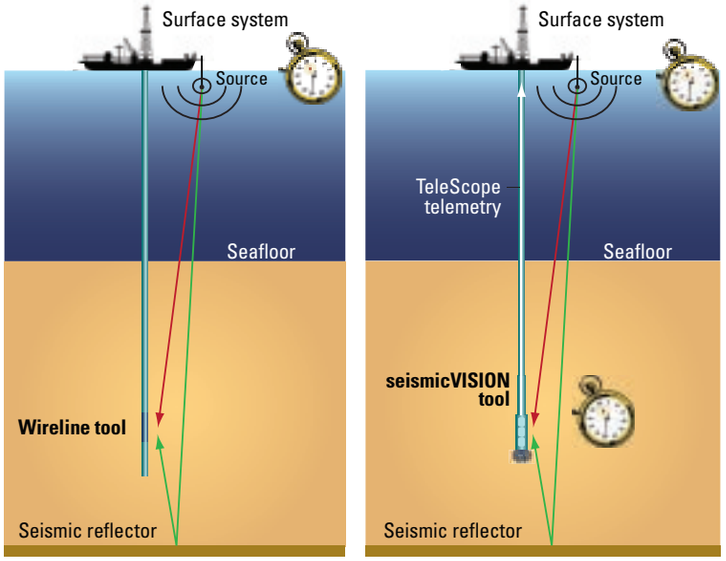
The seismicVISION system reduces well placement uncertainty.

The seismicVISION service has been used successfully in a **wide range of offshore environments.**

DOWNHOLE PROCESSING

The seismicVISION downhole tool, which has a processor and memory, receives seismic energy from a conventional airgun array located either on the rig or on a source vessel. Acquired seismic signals are stored and processed, and checkshot data and quality indicators are transmitted uphole in real time by the TeleScope* high-speed telemetry-while-drilling service. The time-depth data are used to position the well on the seismic map—at the wellsite or remote offices.

The TeleScope service can also send real-time waveforms to the surface for quality control of downhole data. These real-time waveforms have the resolution and sufficient length to allow look-ahead vertical seismic profile (VSP) processing.



The seismicVISION service saves rig time by acquiring data while drilling.

Continuous transmission of data via the InterACT* connectivity, collaboration, and information system allows experts at data consulting centers to provide quality control of the data, update the target locations, and process look-ahead VSPs while drilling.

TRANSPARENT ACQUISITION

A patented technique enables source activation and data acquisition during drilling pauses when the downhole environment is quiet, such as making pipe connections while drilling or tripping. Typically, source activation does not interfere with operations and is triggered automatically by dedicated logic implemented downhole.

VERSATILE AND RELIABLE

Previous real-time seismic systems that used noise generated by the drill bit as a source were ineffective in deep wells, were difficult to deploy offshore, and were not compatible with polycrystalline diamond compact (PDC) bits. The seismicVISION service has been designed to overcome those limitations. It can be combined with all other Schlumberger LWD tools and services, and it has been used successfully in a wide range of environments and operating conditions, including

- all well geometries
- vertical depths greater than 30,000 ft
- open and cased holes
- hard and soft formations
- deep and shallow water
- moored and dynamically positioned rigs
- zero-offset and vertical incidence VSPs
- flow rates to 2,000 galUS/min
- pressures to 25,000 psi.

WELLSITE QUICKLOOK

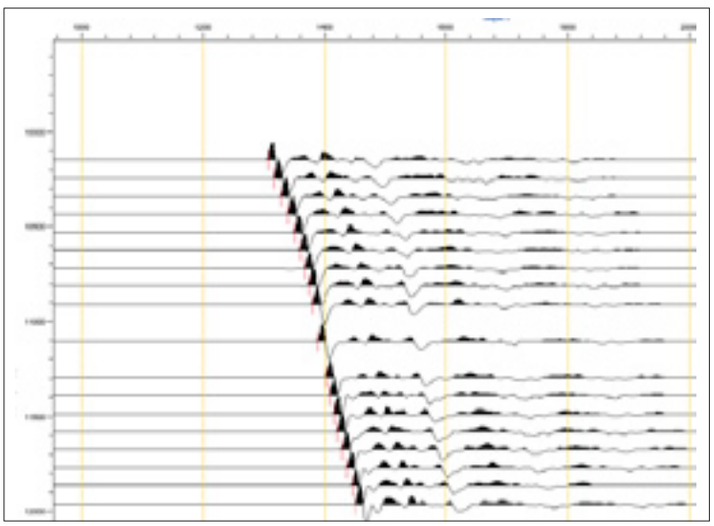
The seismicVISION service uses the latest Q-Borehole* integrated borehole seismic system technology—a total-concept approach in which borehole seismic interpretation experts use Q-Technology* single-sensor seismic hardware and software to deliver optimized and innovative solutions. Q-Technology software used for the seismicVISION service includes the SWINGS* seismic navigation and positioning system and the WAVE* Q-Borehole field processing system, which allows quicklook seismic processing at the wellsite for basic quality control and simple imaging applications. The seismicVISION service also uses TRISOR* acoustic source control to provide highly predictable and consistent seismic source quality signals.

DRILLING OPTIMIZATION

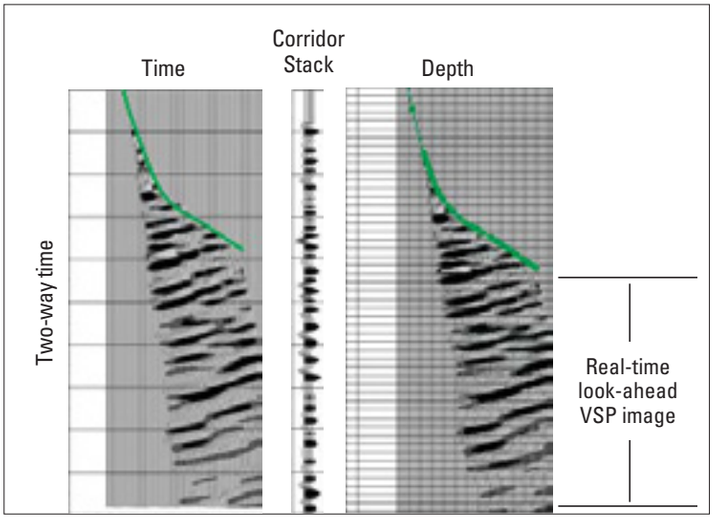
By continually updating the well with real-time seismicVISION information, wellbore pressure and stability challenges can be managed while drilling and placing the well on target. In addition, the updating improves casing point selection, reduces pore-pressure uncertainty, eliminates the need for pilot holes, and, ultimately, reduces drilling cost. The seismicVISION service also provides valuable information for salt proximity solutions, predicting drilling hazard depths and planning exits.

RIG-TIME AND COST SAVINGS

Operators have eliminated the cost of sidetracks in offshore wells by using the seismicVISION service to acquire real-time depth and velocity input for Bit On Seismic software and using the Bit On Seismic information to land wells—in many cases modifying the original trajectories by more than 100 ft. The seismicVISION service has also enabled operators to acquire seismic data in boreholes where stability issues made wireline runs risky or even impossible.



Real-time waveforms from the seismicVISION service.



Real-time waveforms allow look-ahead VSP processing.

seismicVISION

SEISMIC-WHILE-DRILLING SERVICE

Specifications	seismicVISION675* Tool	seismicVISION825* Tool	seismicVISION900* Tool
Nominal OD[†], in [mm]	6¾ [171]	8¼ [210]	9 [229]
Max. OD, with wear bands, in [mm]	7.50 [190.5]	9.10 [231.14]	10 [254]
Pressure drop, psi	[mud weight (lbm/galUS) × flow rate^2 (galUS/min)^2] / 217,000	[mud weight (lbm/galUS) × flow rate^2 (galUS/min)^2] / 769,000	[mud weight (lbm/galUS) × flow rate^2 (galUS/min)^2] / 769,000
Upset type	1 wear band	1 wear band	1 wear band
Fishing neck			
OD[‡], in [mm]	7.50 [190.5]	9.10 [231.14]	10 [254]
Length with new collar[§], in [mm]	71.3 [1,811]	78.9 [2,004]	78.9 [2,004]
Nominal length without subs[††], ft [m]	14 [4.267]	13.84 [4.218]	13.84 [4.218]
Length including 2 crossover subs, ft [m]	16.39 [4.996]	15.94 [4.859]	na[‡‡]
Loaded weight, lbm [kg]	1,500 [680]	2,000 [907]	2,500 [1,134]
Top thread connection	5½ FH box	6⅝ FH box	7⅝ H90 box
Bottom thread connection	5½ FH box	6⅝ FH box	7⅝ H90 box
Joint makeup torque, ft.lbf [N.m]	23,000 [31,184]	56,000 [75,926]	65,000 [88,128]
Joint yield torque, ft.lbf [N.m]	42,700 [57,893]	67,000 [90,840]	120,000 [162,698]
Average moment of inertia, in^4	85	191	296
Bending strength ratio[§§]	2.17	2.37	2.23
Equivalent bending stiffness[†††], ft [m]	13.8 [4.206]	14.4 [4.389]	14.8 [4.511]
Max. dogleg severity[‡‡‡]			
Rotating, °/100 ft [°/m]	8/100 [8/30]	7/100 [7/30]	4/100 [4/30]
Sliding, °/100 ft [°/m]	16/100 [16/30]	14/100 [14/30]	12/100 [12/30
Operations			
Max. weight on bit[§§§], lbf/L^2 [N/L^2]	74,000,000 [329,168,398]	164,000,000 [729,508,342]	261,400,000 [1,162,765,126]
Max. operating torque, lbf.ft [N/L^2]	16,000 [21,693]	23,000 [31,184]	35,000 [47,454]
Surface speed, rpm	200	200	200
Stick/slip amplitude	±100% of mean speed sustained for more than 30 min	±100% of mean speed sustained for more than 30 min	±100% of mean speed sustained for more than 30 min
Lateral vibrations	30 min at shock level 3 (50-*g* threshold) or 200,000 shocks above 50 *g*	30 min at shock level 3 (50-*g* threshold) or 200,000 shocks above 50 *g*	30 min at shock level 3 (50-*g* threshold) or 200,000 shocks above 50 *g*
Max. operating pressure, psi [MPa]	25,000 [172.369]	23,000 [158.579]	23,000 [158.579]
Max. differential pressure[††††]			
Internal-external difference, psi [MPa]	5,000 [34.474]	5,000 [34.474]	5,000 [34.474]
External-internal difference, psi [MPa]	5,000 [34.474]	5,000 [34.474]	5,000 [34.474]
Max. operating temperature, degC [degF]	150 [302]	150 [302]	150 [302]
Max. flow rate, galUS/min [L/min]	800 [3,028]	2,000 [7,571]	2,000 [7,571]
Max. sand content of mud solids, %	3	3	3
Max. dissolved solids content	No limit	No limit	No limit
Lost circulation material[‡‡‡‡]			
Max. size	No limit	No limit	No limit
Max. concentration	No limit	No limit	No limit
Magnetic sub	No	No	No

[†] American Petroleum Institute (API) specification.

[‡] See tool drawing in appropriate manual for details.

[§] Specification assumes new collar. Fishing neck is measured from the face of the uphole box to the start of the first external upset.

[††] The sub length is that of the minimum self-contained operating configuration, excluding crossovers, saver subs, pony subs, etc.

[‡‡] Not applicable.

[§§] Bending strength ratios are determined by the API connection and tool OD at the connection box. Check the bending stress ratio for any particular connection in your string.

[†††] Equivalent bending stiffness is the length of a standard API collar that would act in an equivalent manner to the bending stiffness of the subject collar. The equivalent bending stiffness is calculated as follows: $L_{equivalent} = L_{tool} \times \frac{I_{APIcollar}}{I_{tool}}$. Here, L means length, and I is the moment of inertia, in^4.

[‡‡‡] This is the maximum recommended dogleg severity (DLS) to which the tool should be subjected, which is not necessarily the DLS of the borehole.

[§§§] Maximum allowable weight on bit (WOB) is calculated from the equation WOB = 917,000 × $\frac{I_{tool}}{L_2}$. The maximum WOB depends on the unsupported length of collar, L, which is the distance between the stabilizers above and below the sub. I is the moment of inertia, in^4.

[††††] These values represent the maximum safe differential pressure in each direction prior to fluid leakage across the joints. The mechanical integrity of the joints should hold at least up to the maximum tool pressure rating (23,000 to 25,000 psi). However, if the maximum safe differential pressure is exceeded, pressure and fluid can be lost across the metal-to-metal face seal at the tool joint.

[‡‡‡‡] These tools should pass any size of commercially available lost circulation material. However, always check tool diagrams for minimum tool bore diameters and annular clearances.

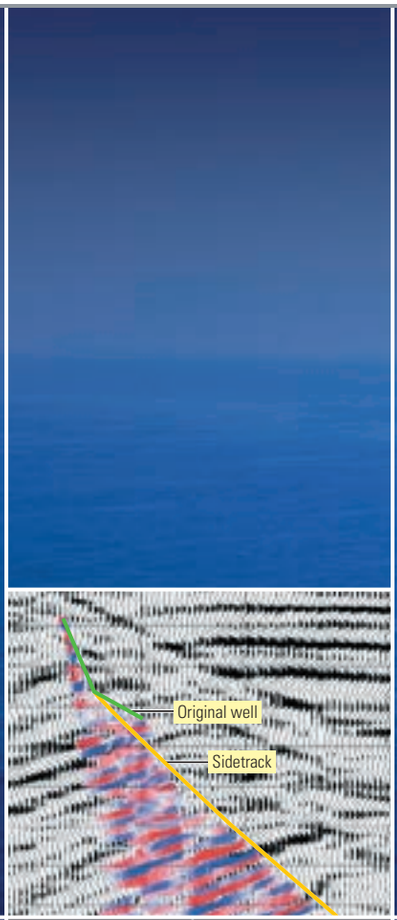


Image acquired from original well

Image acquired from sidetrack

seismicVISION

- Real-time checkshot data
- Real-time, high-resolution waveforms for look-ahead VSPs
- Recorded multicomponent waveforms
- Ruggedized high-precision clock
- Tools in 6¾-, 8¼-, and 9-in diameters for hole sizes from 8½ to 26 in
- Multicomponent measurements
- High flow rate
- Pressure ratings up to 25,000 psi
- Combinable with all other Schlumberger LWD tools
- Compatible with the latest Q-Borehole integrated borehole seismic system

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Schlumberger