Reduce Depth Uncertainty with Real-Time Borehole Seismic

Wade McCutcheon
Vice President, Schlumberger North America

Innovative and Integrated Solutions
Transfer of Technology to Drilling Ops

Wireline Borehole Seismic

seismicVISION

Sea floor

Wireline tool

Seismic reflector

Surface system

Source

MWD telemetry

Seismic reflector

Surface system

Source

seismicVISION
Principle of Operation

- Surface air gun source
- Downhole geophones and hydrophone
- Synchronized high precision clocks
- Waveforms recorded in downhole memory
- Downhole processing
- Time check shot via MWD telemetry
Time Waveforms

- Improved quality control on first arrival
- Improved interval velocities
- Industry first seismic look-ahead capability in real time
Source fired according to a predetermined time schedule

15 secs

15 secs

Downhole system records data on predetermined time schedule synchronized with surface.

Surface and downhole are synchronized and cycles begin transit time every 15 seconds.

Coherent records are stacked downhole and a time pick taken from the stacked result, sent uphole once pumps resume.
Benefits and Applications

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

- Put the bit on the seismic
- Casing and coring point selection
- Target depth prediction
- Landing well without pilot holes
- Pore pressure prediction
- Salt proximity
SeismicVISION Used to Select Casing Point

Problem:
Setting casing below and above target.
Uncertainties overlap.

Check shots taken in real-time reduce uncertainty.
Uncertainties reduced:
Clear area to set casing.
Case Study—Real-Time Seismic Steering with seismic in the Gulf of Mexico

Plan
Steer well to intersect two targets at optimal locations at each stratigraphic trap
Location critical to identify reservoir size/flank and economic hydrocarbon volume

Problem
Seismic velocity uncertainty between nearest seismic lines
The Solution—seismicVISION

Trace number

Target intersected at 14,180 TVD@3.986s TWT from Res

Updated target 2: 16,060 ft TVDSS

Original target 2: 14,950 ft

TVD (true vertical depth) [ft]
t-On-Seismic Plot

- **Pre-drill well plan**
- **Approx. KOP**
- **Casing Target 1**
- **Casing**
- **Target**
- **Intermediate well plan**
- **Final well path**

Trace number

TVD (true vertical depth) [ft]

- 29
- 4.414
- 16143.6

Trace number
Structure on a South Caspian Well

- Complicated structure, dips up to 40 degrees
- Deviated to avoid high pressure and faulting at crest of structure
- Depth uncertainty on target reservoir up to 700 m
- SeismicVISION used to reduce depth uncertainty/geosteering

Fasila reservoir target
Faulting and high porpressures over crest structure
Stacks COMP BP (10-75 HZ) Grouped Rcvrs: 4
Lookahead Results

- Pressure ramp
- Trend shift
- SVWD data
- Pereriv Target
- Pressure ramp
- Current TD

**Key Points:**
- Trend shift observed at 2 km
- SVWD data indicating reservoir changes
- Pereriv Target highlighted in blue
- Pressure ramp indicated in green

**Legend:**
- Lookahead trend at 2 km
- SVWD data
- Pereriv Target
Combined Hydrophone VSP—Vertical

- 8,000 ft lookahead to unconformity
- 3,000 ft lookahead to unconformity
VISION/sonicVISION

Surface seismic

Current bit position

sonicVISION Synthetic – real time (corrected by real-time checkshot)
Riserless Drilling for Gas Hydrates, Japan
No Drilling Surprises — Exploration

- T5 is overpredicted.
- Objective was above T5 and achieved.
- No drilling surprises.
- SVWD in real-time up to T5 velocity and accurate.
- SVWD in real-time indicates that T5 is accurately predicted.
- Casing set—no surprises.
The time is coming when we will not drill without looking ahead of the bit—any more than we would drive at night without headlights, occasionally shining a lamp behind us to see what we had hit."

– Mike Tweedy, Drilling Advisor, Chevron
Waveforms with RT picks made by the tool shown
Target reflector may be seen approaching on the Real-Time VSP. VSP is updated with checkshot data prior to the next checkshot level (shooting at connections while drilling, ROP < 100 ft/hr)

Velocities increased significantly over pre-drill model

300 ft TVD deeper than the pre-drill