"Diamonds in the Noise"
Treasures Lurking In Acoustic Data

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Senergy

Diamonds in the Noise

- Acoustic data are routinely acquired around the world, used for a single purpose, then the waveform data are relegated to the archives without a second glance.

- Waveform data recorded by modern sonic tools is full of hidden treasures, such as fracture characterisation, permeability, wellbore stability, hole size, production optimisation and much more.

- This presentation aims to review the types of acoustic tools on offer and consider the gems that can be mined from taking a second look at the data.

Treasures Lurking in Acoustics Data

- Did you know that the LWD sonic data you acquired for seismic correlation also contains a cement bond log and a "calliper"?

- Would you be surprised to learn that within the wireline crossed-dipole data you obtained for wellbore stability analysis lurk images of fractures 20 ft from the wellbore?

- Even though you ran a basic sonic tool for (sourceless) porosity, would you like to know the permeability as well?
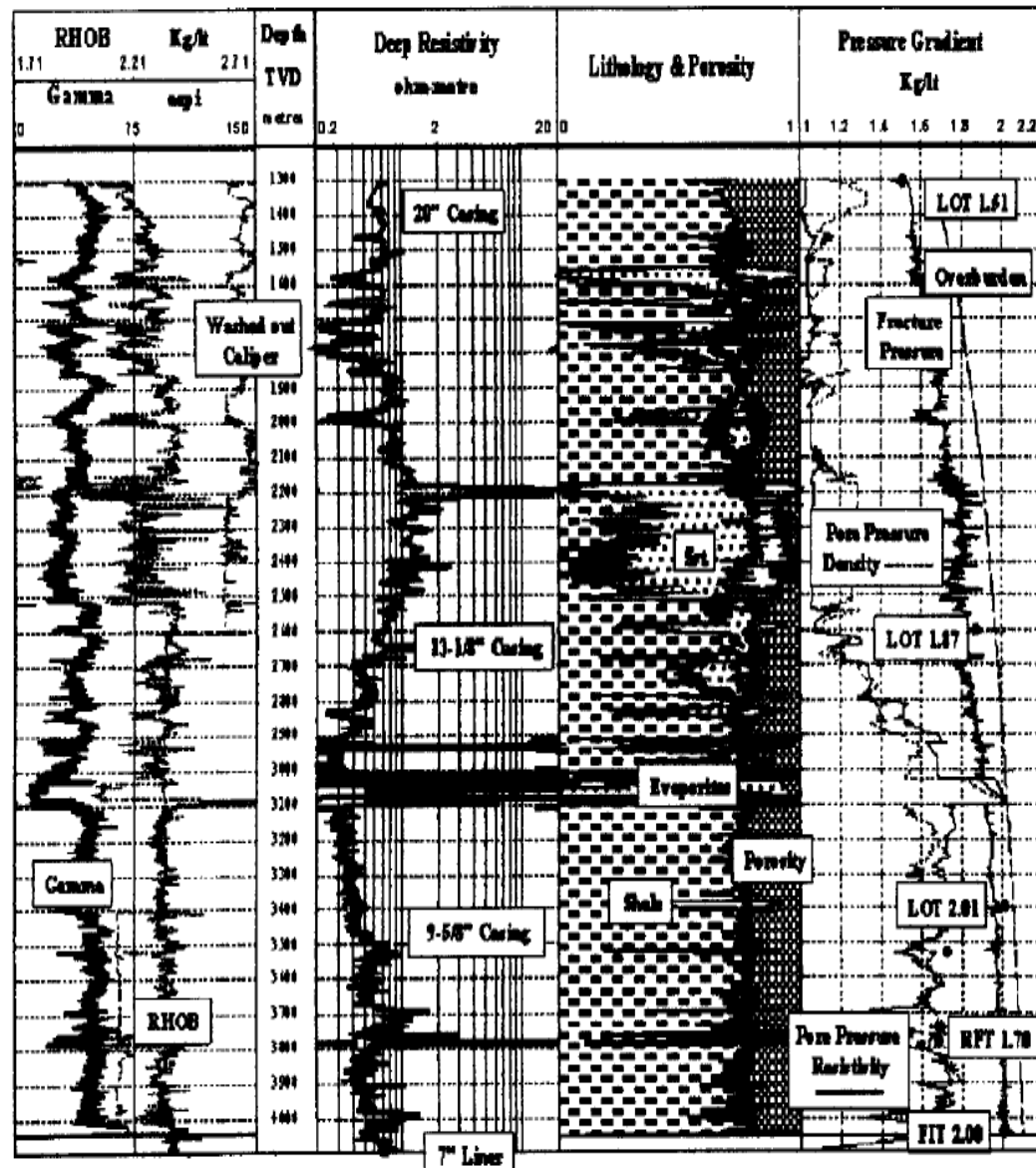
Overview

- Applications

- Types of Sonic Tools and What Can Be Mined From Each

- Optimising Data Collection
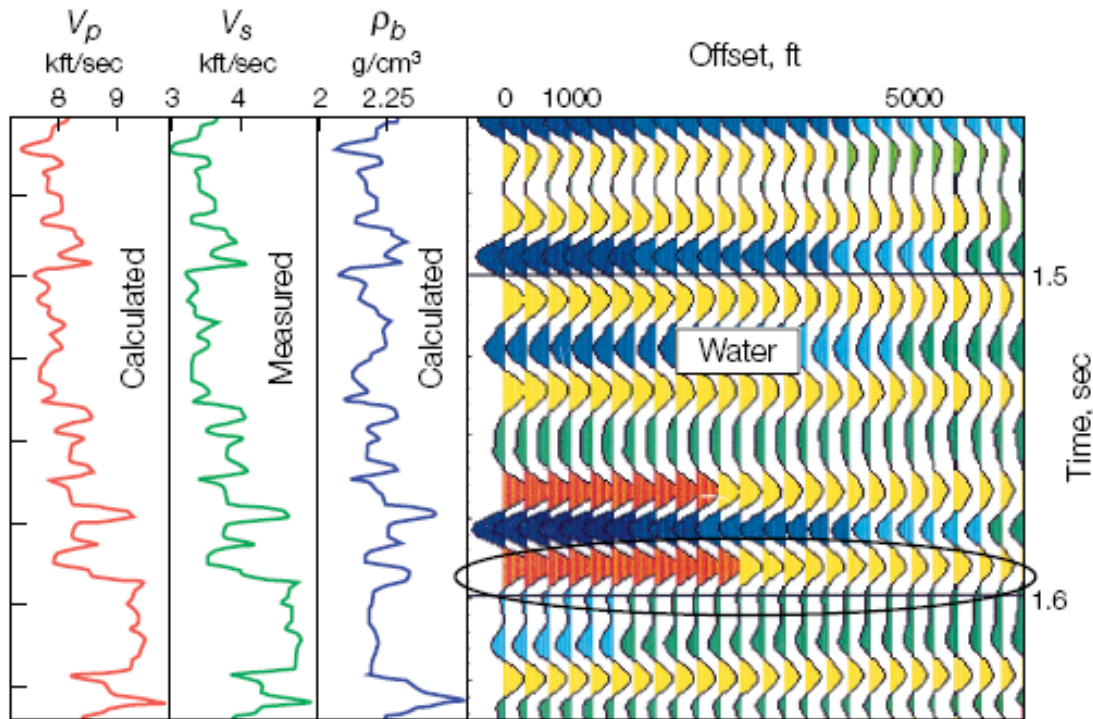
- Deliverables

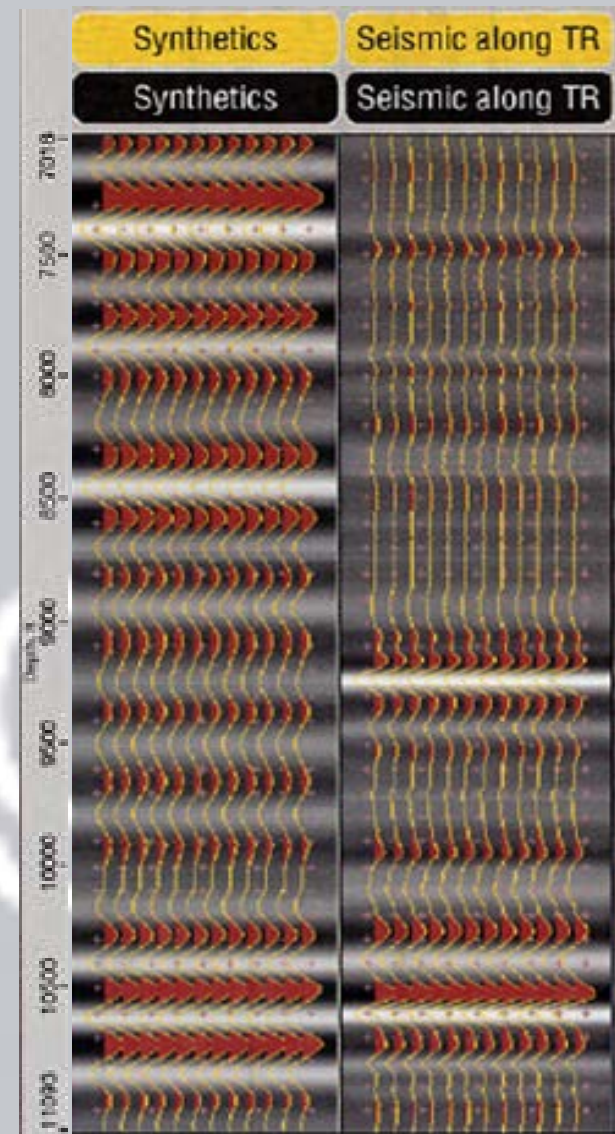# Classic Sonic Applications
Pore Pressure Prediction

Classic Sonic Applications
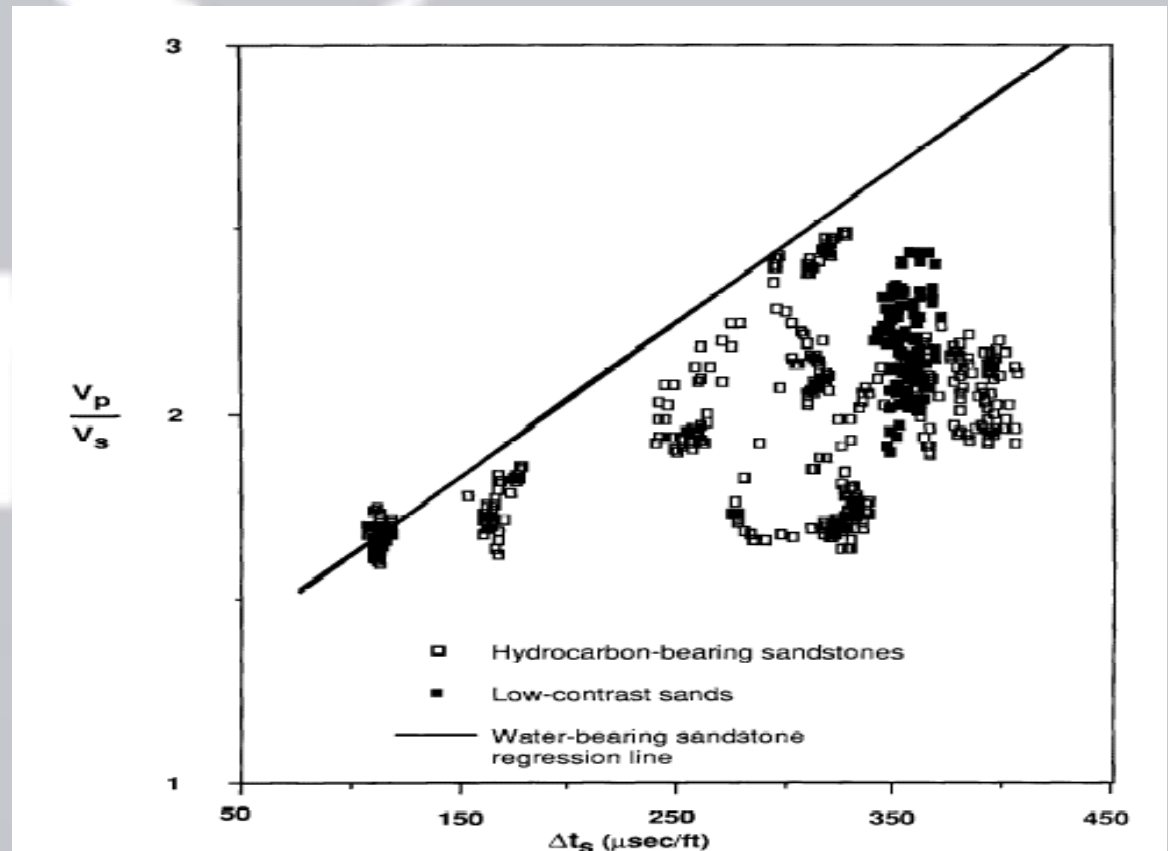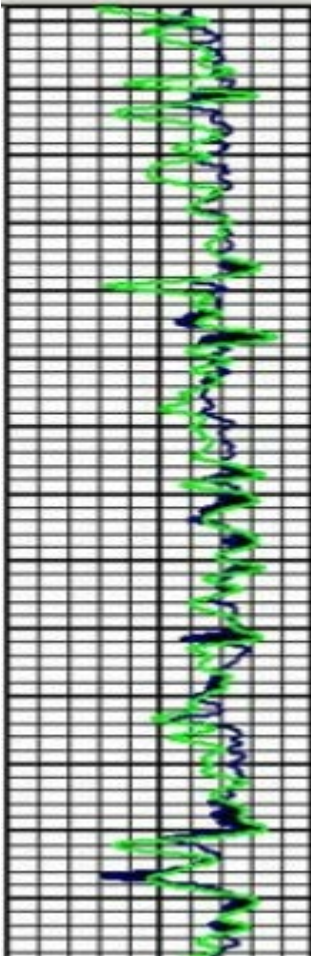## Seismic Correlation

Chiburis, 1993

Hashem, 1999

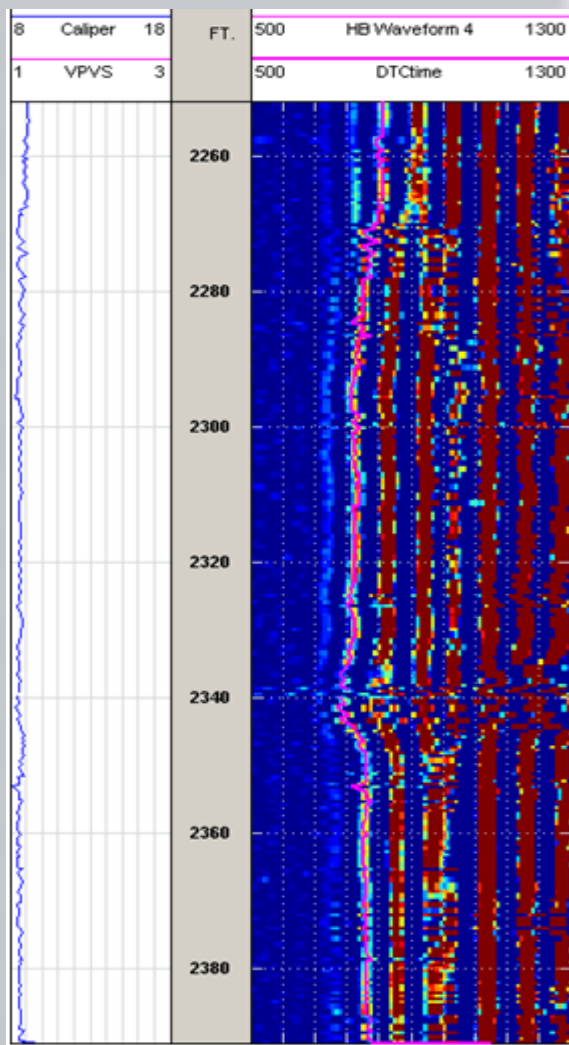# Classic Sonic Applications

Porosity

Hydrocarbon Indicator

Hydrocarbon-bearing sandstones
Low-contrast sands
Water-bearing sandstone regression line

McCalmont, 2008

Williams, 1990

Classic Sonic Applications

Hole Size Indicator

8 Caliper 18	FT.	500 HB Waveform 4 1300
1 VPVS 3		500 DTCtime 1300

Top of Cement

Semb VDL 40 (µs/ft) 200	C SG Ener	Waveform VDL 500 (µs) 1200
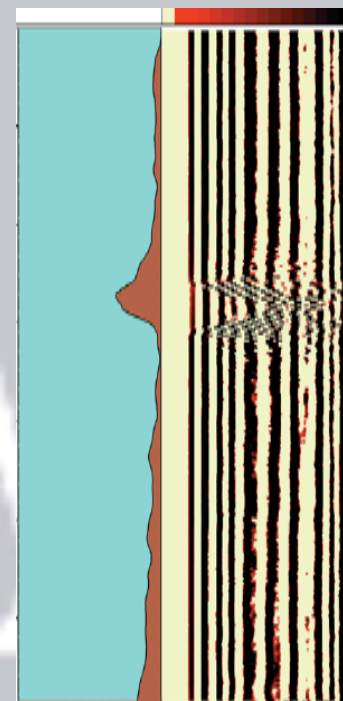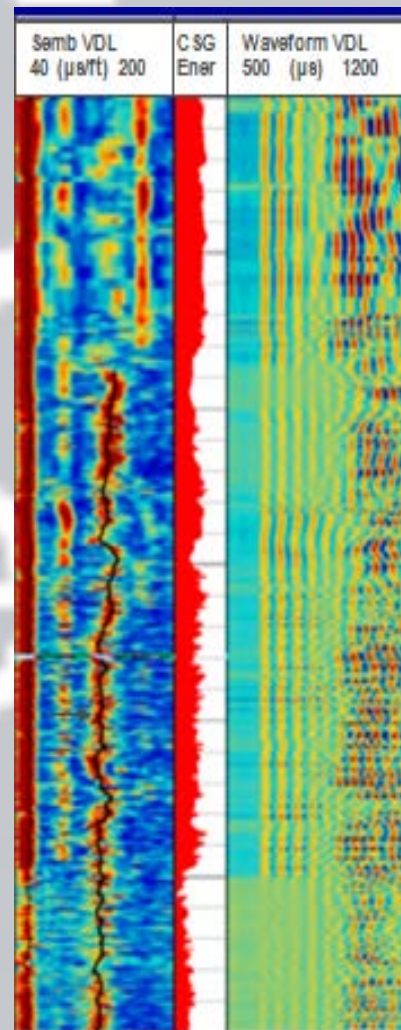
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Digging a Little Deeper

Permeability

Canady, 2005

Fracture Detection

Fogel, 2002

Digging a Little Deeper
Geosteering

Since LWD tools rotate, they acquire data at multiple azimuths. If the tool is properly equipped to track the angle, azimuthal images can be created and used to steer just as with other sensors (gamma ray, resistivity, etc.)

Several varieties of LWD azimuthal tools are commercially available.

Market, 2012
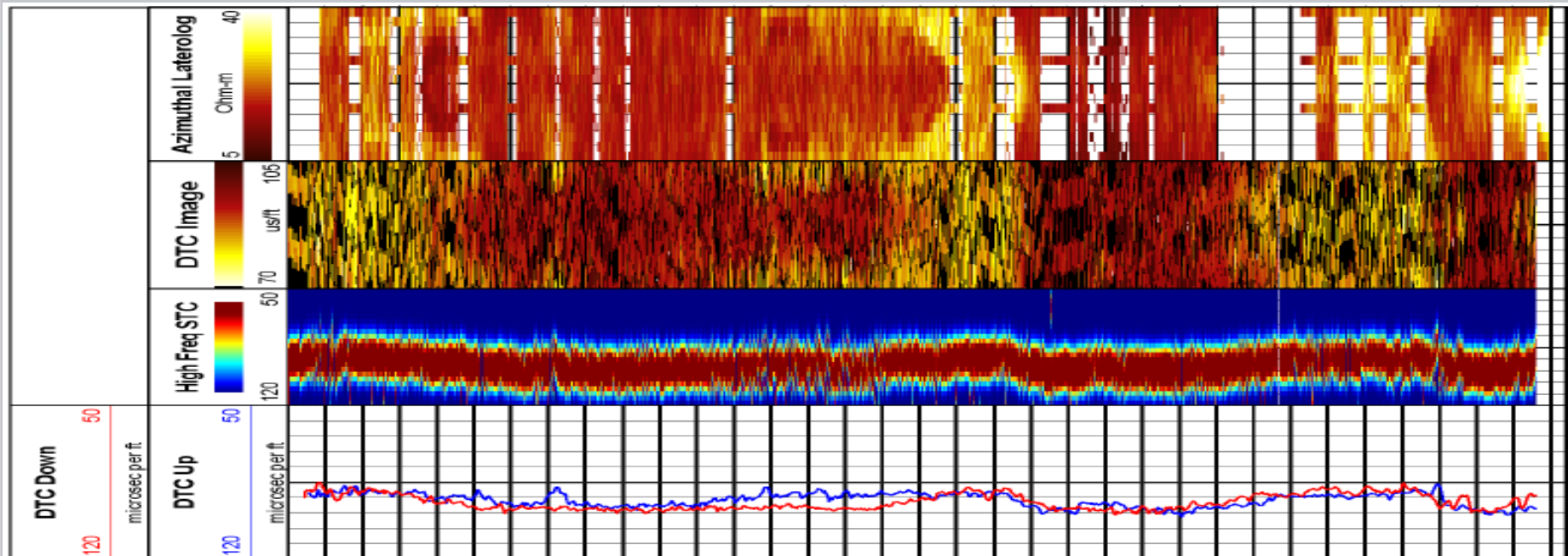
Digging a Little Deeper
Wellbore Stability and Mud Selection

Basic wellbore stability and mud properties can be calculated using standard DTC & DTS.

Azimuthal sonic velocities allow us to compute a more complete picture of wellbore stresses.
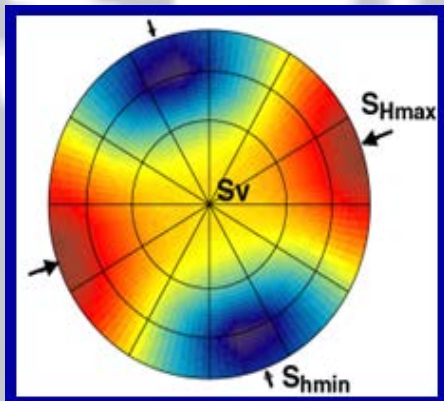
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Hidden Gems

Invasion Profiling

Sinha, 2005
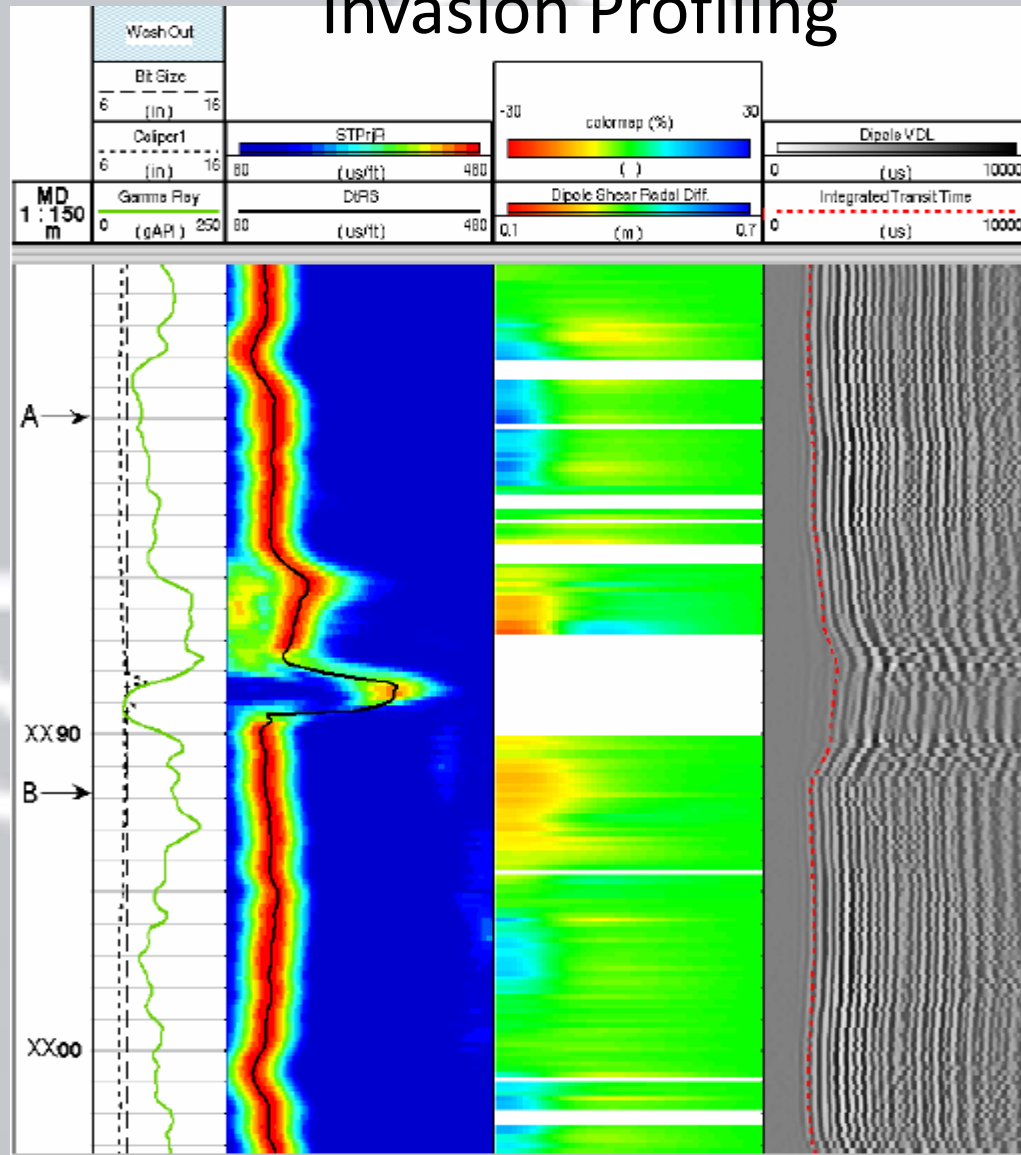
Hidden Gems

Unconventional Reservoir Production Enhancement
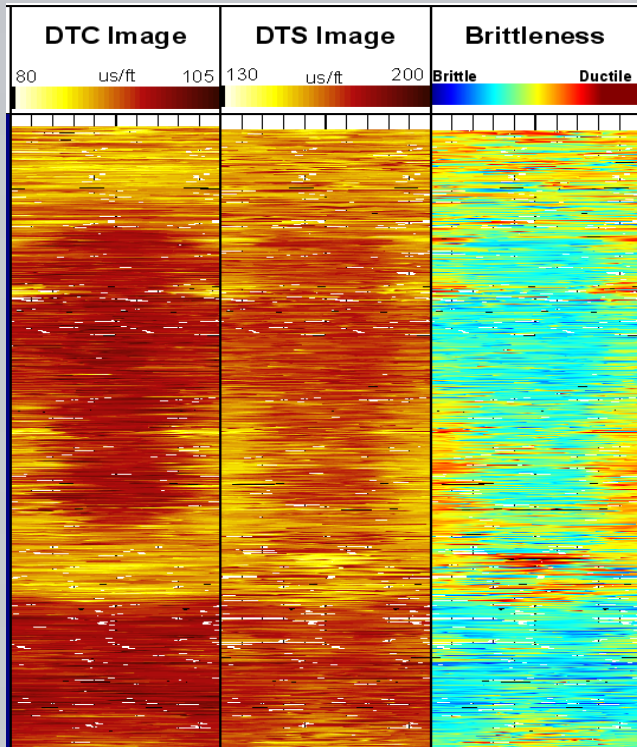
Pitcher, 2011
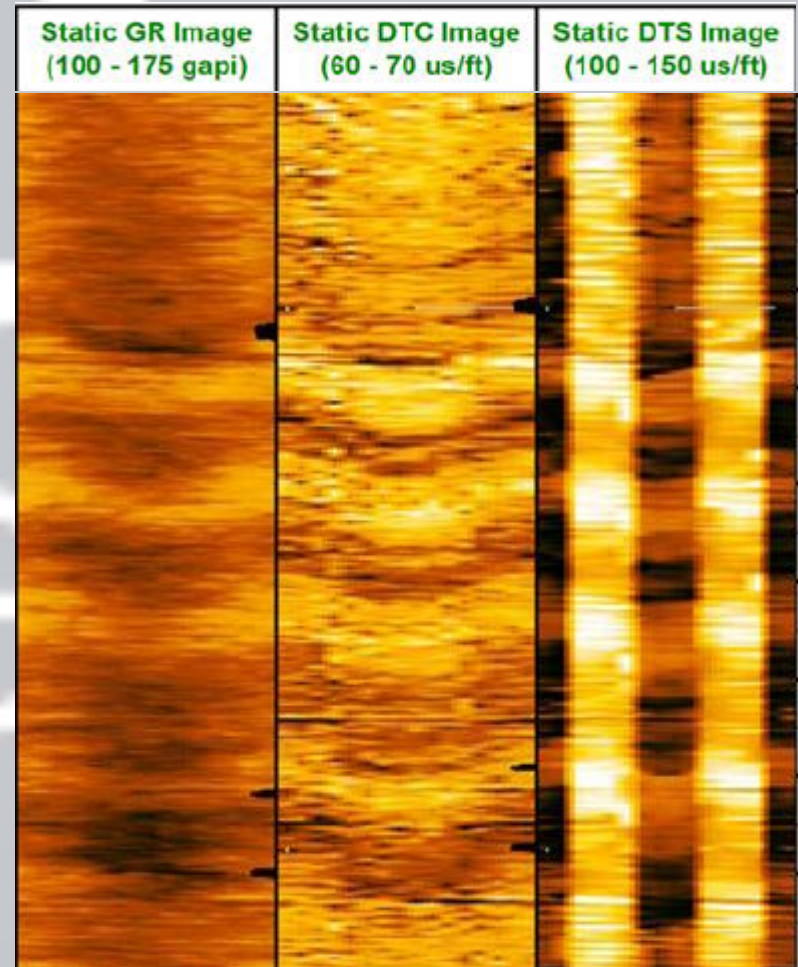
Barnett, 2012

Hidden Gems
Deep Imaging

Tang, 2010
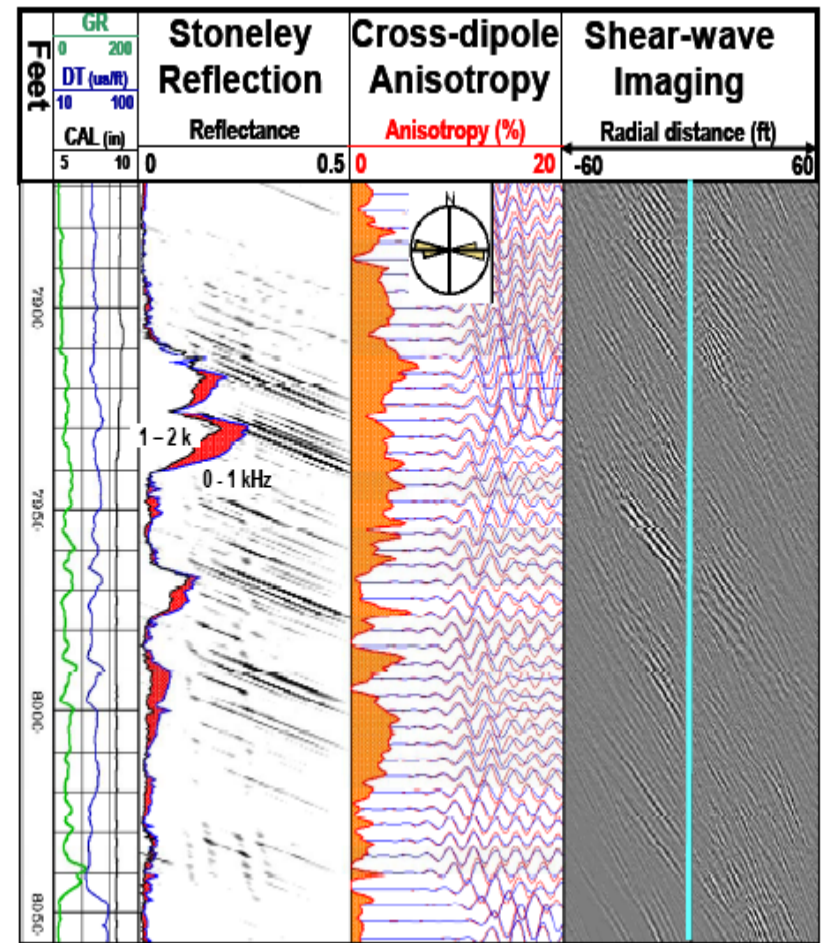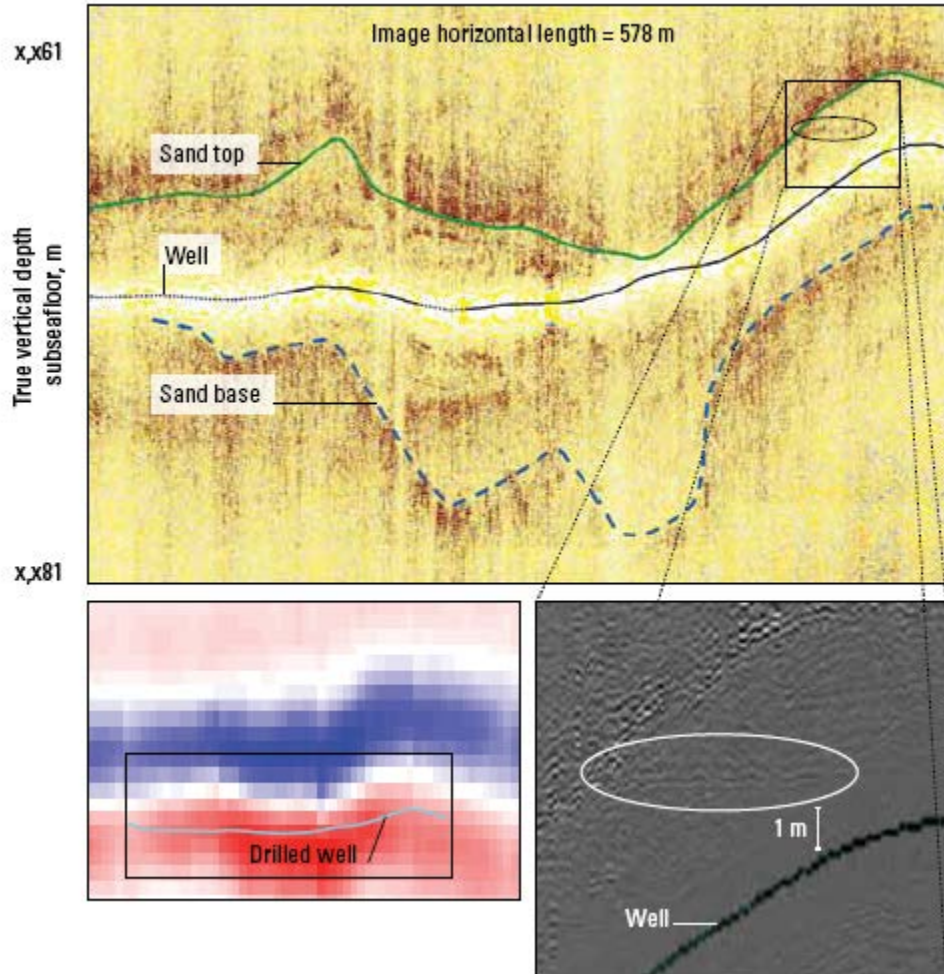
Wireline Tool Flavours

Monopole

- The primary measurements are DTC and DTRS (shear in fast formations).

- These tools are usually short with high frequency sources, so the measurements are relatively shallow.

- Some varieties have Stoneley capabilities.
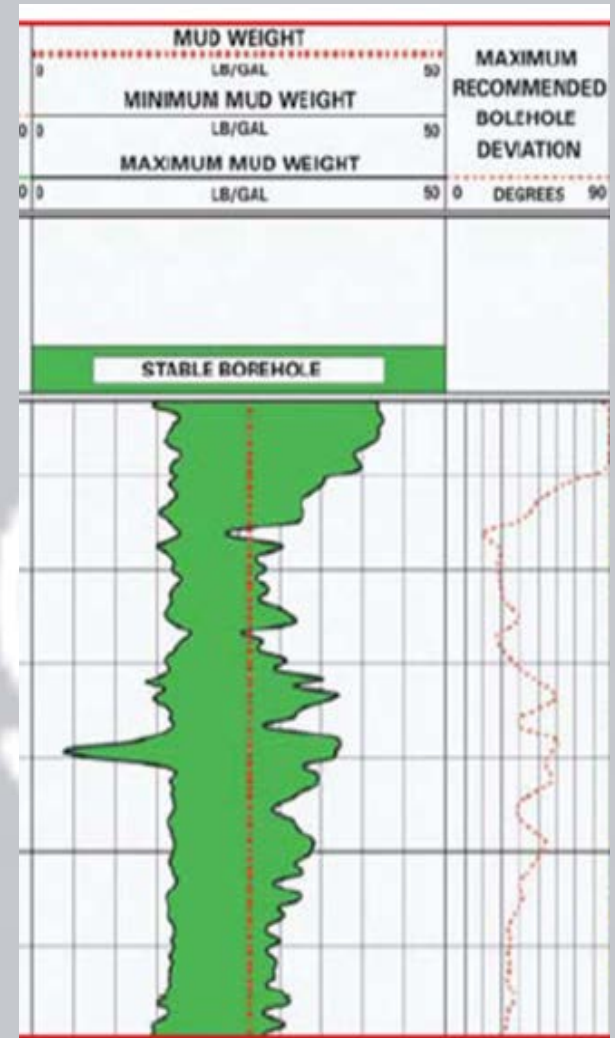
Crossed-Dipole

- Modern tools have both monopole and crossed-dipole sources.

- Measurement capabilities include DTC, DTRS, DTS in slow formations, anisotropy and Stoneley waves.

- These are long-spaced tools (with 8+ receiver arrays) and broad frequencies. This makes them capable of deep measurements.

Pistre, 2005
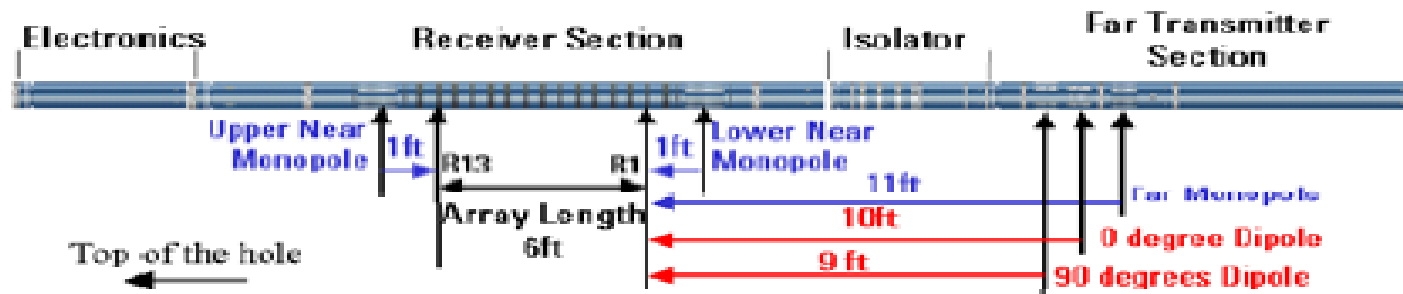
LWD Tool Flavours

Unipole/Monopole

- Like wireline monopole tools, these are designed primarily for DTC and DTRS. Some have Stoneley capabilities.

Multi-pole tools

- These tools are designed to acquire DTC, DTRS, and use Stoneley, flexural, or quadrupole modes to determine shear in slow formations.

Azimuthal

- The rotation of the LWD toolstring allows for azimuthal images to be created while drilling

Receiver Array

Attenuator

Unipole Transmitter

Barnett, 2012

Transmitter

Receivers

Transmitter

Receivers

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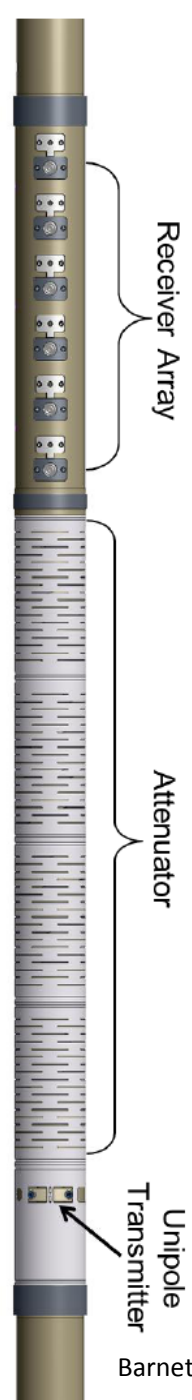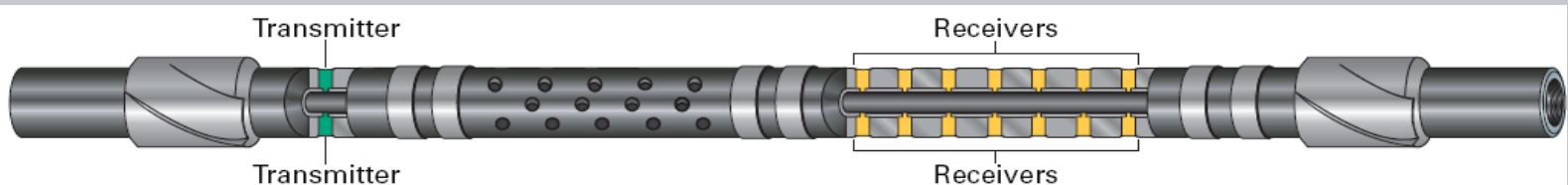
What Can We Mine From Each Tool?

	Classic Monopole (WL/LWD)	WL Crossed-Dipole	LWD Multipole	Azimuthal LWD
Pore Pressure Prediction	✓✓	✓✓✓	✓✓✓	✓✓✓
Seismic Correlation/AVO	✓	✓✓✓	✓✓	✓✓
Hydrocarbon detection	✓	✓✓✓	✓✓	✓✓
Lithology Indicator	✓	✓✓✓	✓✓	✓✓
Porosity	✓✓	✓✓✓	✓✓✓	✓✓✓
Top of Cement	✓✓✓	✓✓✓	✓✓✓	✓✓✓
Permeability	✓	✓✓✓	✓✓	✓✓
Fracture Characterisation	✓	✓✓✓	✓	✓✓
Wellbore Stability	✓✓	✓✓✓	✓✓	✓✓✓
Production Optimisation	✓	✓✓✓	✓✓	✓✓✓
Hole Size Indicator	✓✓	✓✓	✓✓	✓✓
Geosteering	✓		✓	✓✓✓
Invasion Profiling		✓✓✓	✓✓	✓✓

Optimising Data Collection

- Ensure that the tool is "healthy" – i.e. operating at full specifications with all of the transmitters, receivers, and isolation working properly.

- Good depth tracking is essential (even on the trip out!)

- Centralise the tool if possible.

- Some LWD tools are affected by "drilling noise". Placing them away from the bit or reamer can increase data quality.

- LWD - consider "wiping" over intervals if interest with the pumps off to increase signal quality.
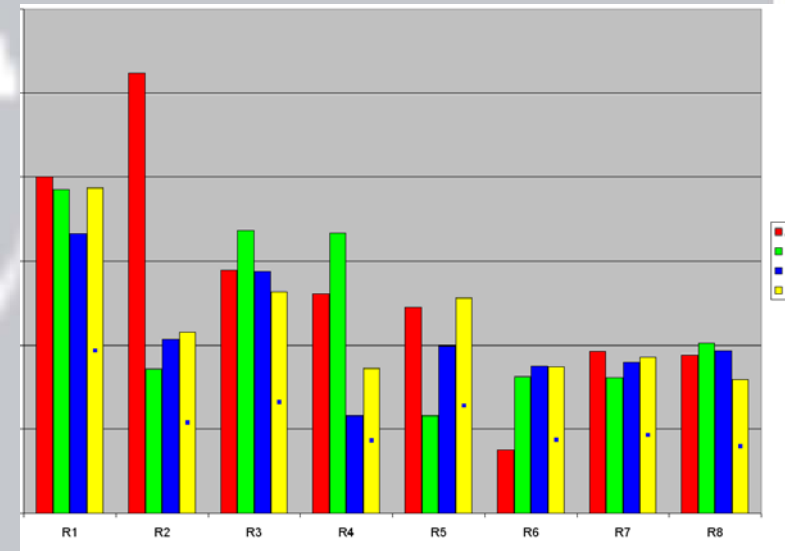
Market, 2009

Deliverables

- Regardless of the primary purpose of sonic data acquisition, always request/ archive the full waveform data (raw format) for all modes the tool acquired. This enables later data mining for other applications –including applications developed in the future.

- For LWD, obtain the non-drilling data in addition to the drilling data. This can be used for CBL, hole size indicators, time-lapse logging and more.

Summary

- With the wealth of acoustic data acquired today, there are many opportunities to "mine" the data for additional applications.

- Optimising the data collection will maximise the amount of information that can be extracted from the waveforms.

- Archive the full dataset. Who knows what new applications will be developed next year?

Thank You!

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