Gee Whiz Geophysics…But What About the Log Data!

"Finding the hidden potential"

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by

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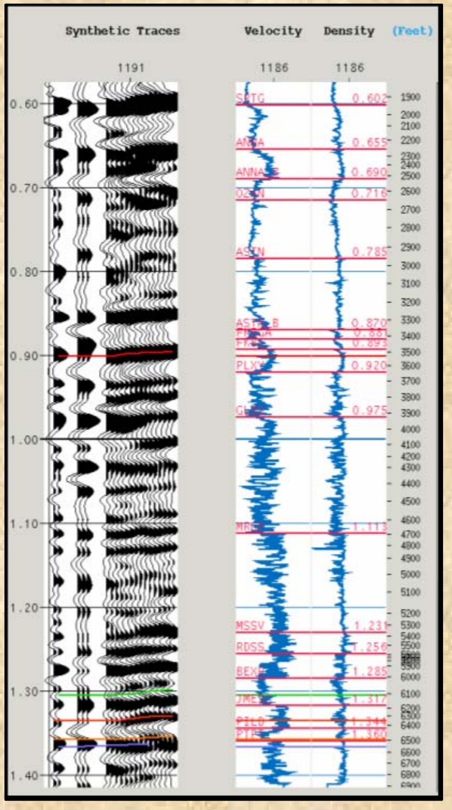
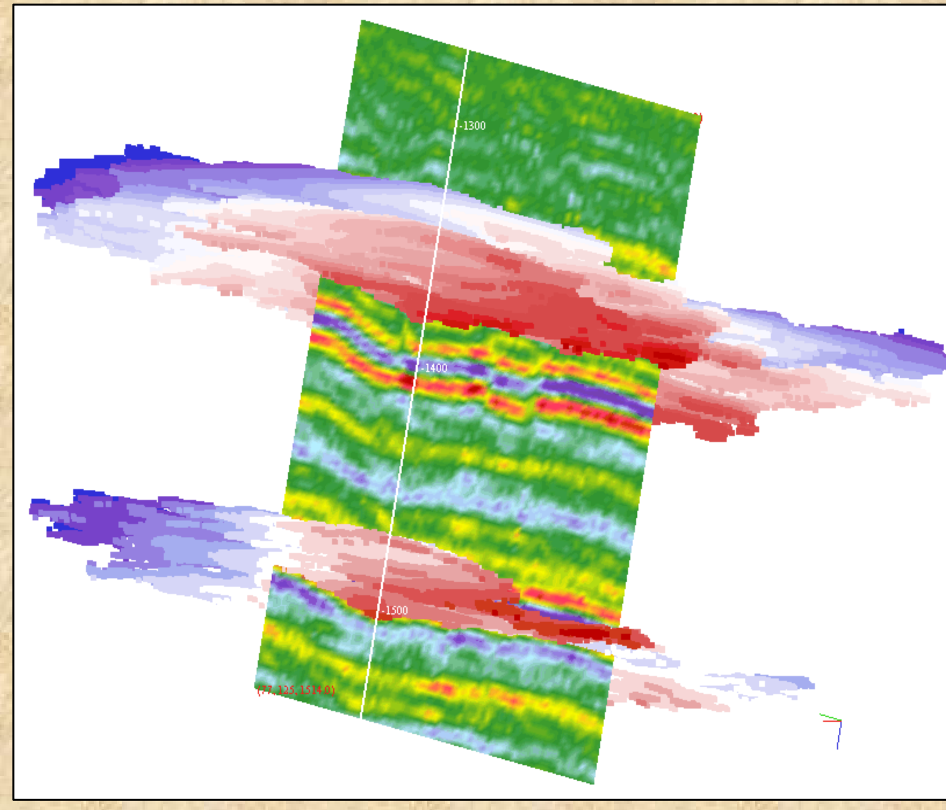
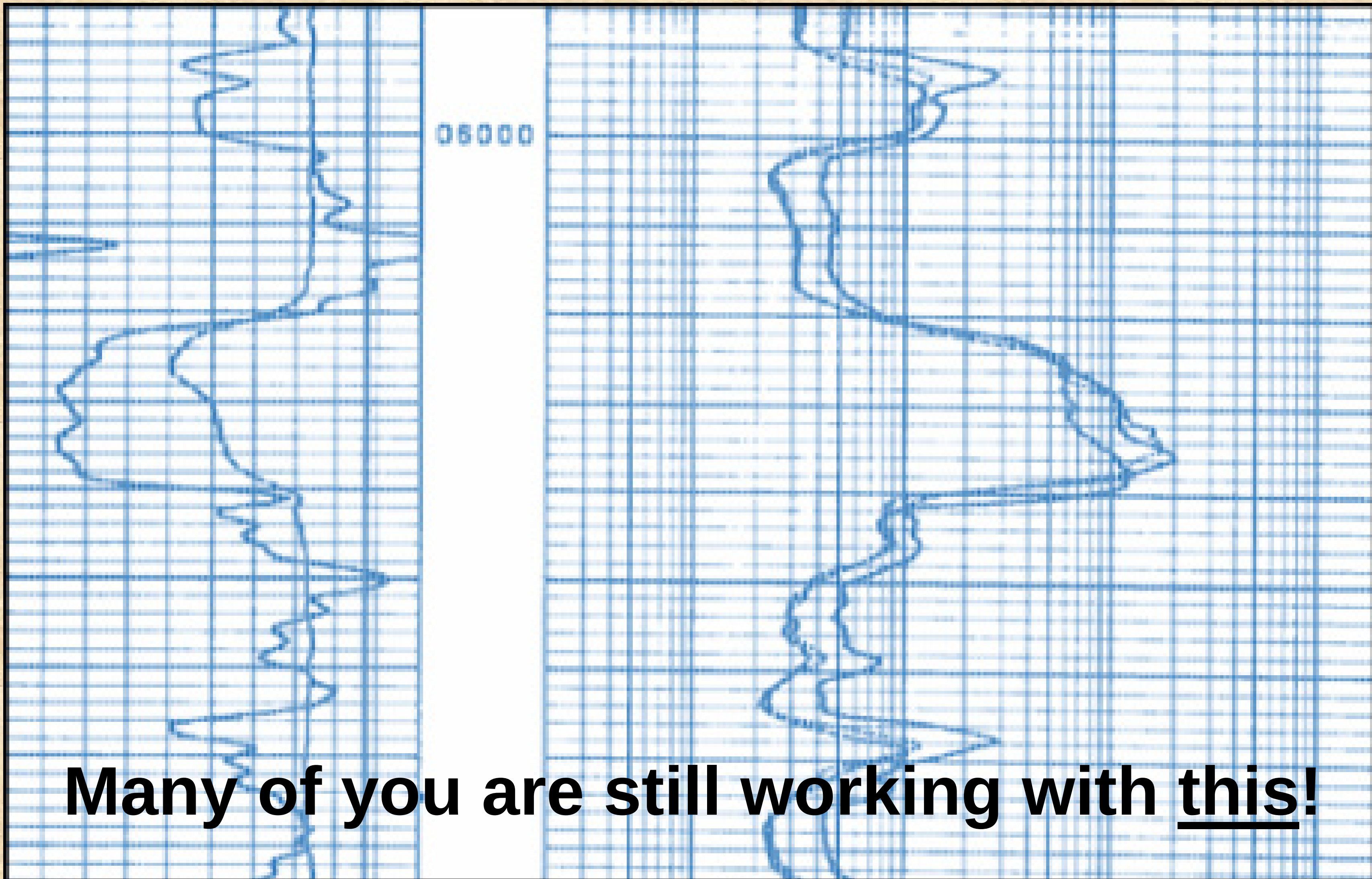
Gee Whiz Geophysics!





3D Acquisition, pre-stack depth migration, AVO, re-processing, 3D visualization…then interpretation!

But what about the log data?



Many of you are still working with this!

Geophysical Data

Acquired long before interpretation

Ancient data considered inferior – often ignored

New 3D data overlaps old data

3D visualization

Spectacular color graphics

Log Data

New data required “real time”

Ancient data could be <u>better</u> than modern data

Ancient/old data is often ignored

New data almost never overlaps old data

Oil & Gas Industry Challenges

Evaluating declining production in aging fields

Evaluating laminated, poor-quality, low permeability, fractured, or even unconventional reservoirs (shale gas and CBM)

Locating bypassed pay zones

To meet these challenges you need:

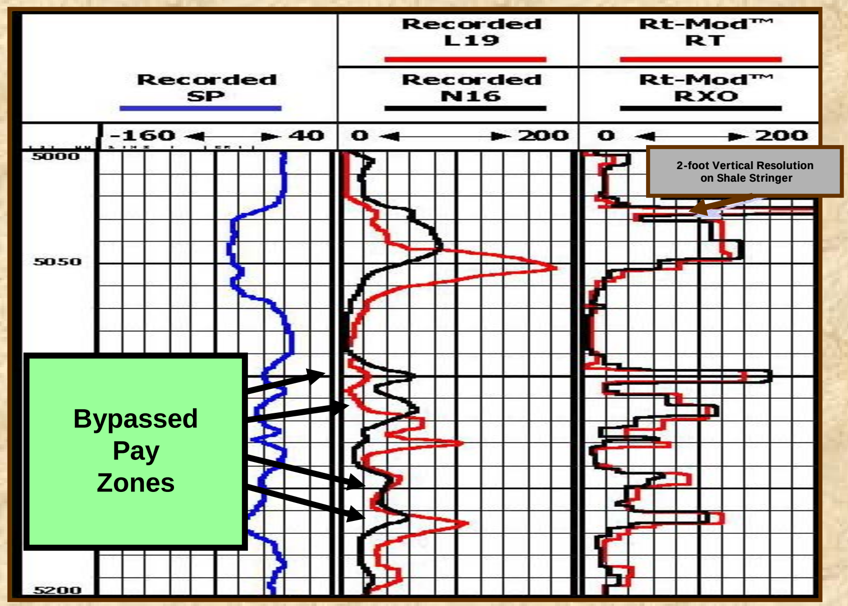
A complete suite of accurate, normalized high-resolution log, core and production data for <u>every</u> well in a study area

and,

A way to relate these data <u>quantitatively</u> to seismic, production and other log data

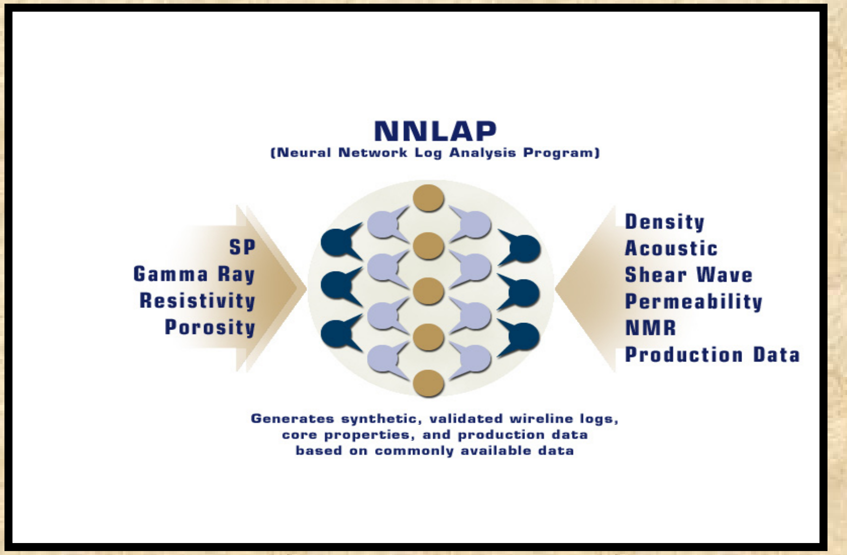
2 New Technologies

Inversion modeling of resistivity and SP measurements



and

Neural networks



Resistivity inversion…why bother?

Borehole environment

Transmitter/receiver configurations

Different tool types over 70 years

Different service companies

Normalization Problems

Tedious Chartbook Corrections

Resistivity Inversion Modeling History

Available and considered valuable for more than 25 years

Long processing times

Expensive hardware

Restricted use

Not a practical solution for multi-zone, multi-well applications

Resistivity Inversion Today

Required input:

Tool type; bit size, deep resistivity curve

Processing speed:

100’ of log in 20 seconds on a PC

The Objective:

To convert old (even ancient) logs into logs with the vertical resolution of modern logs

The Results:

Accurate Rt, Rxo and bed thickness (h)

Resistivity Inversion Applications

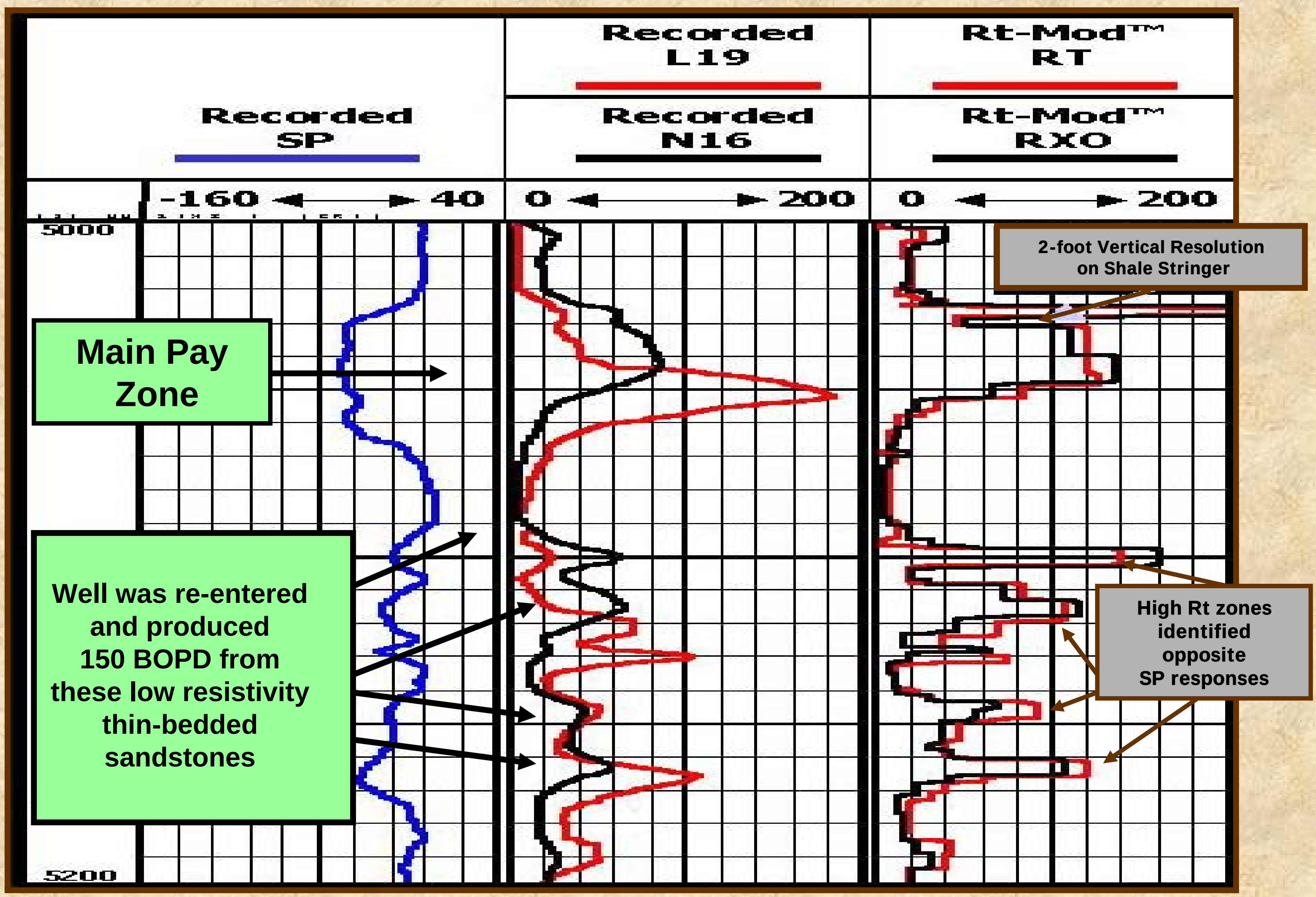
More accurate Sw and volumetric reserve calculations

Bypassed pay identification

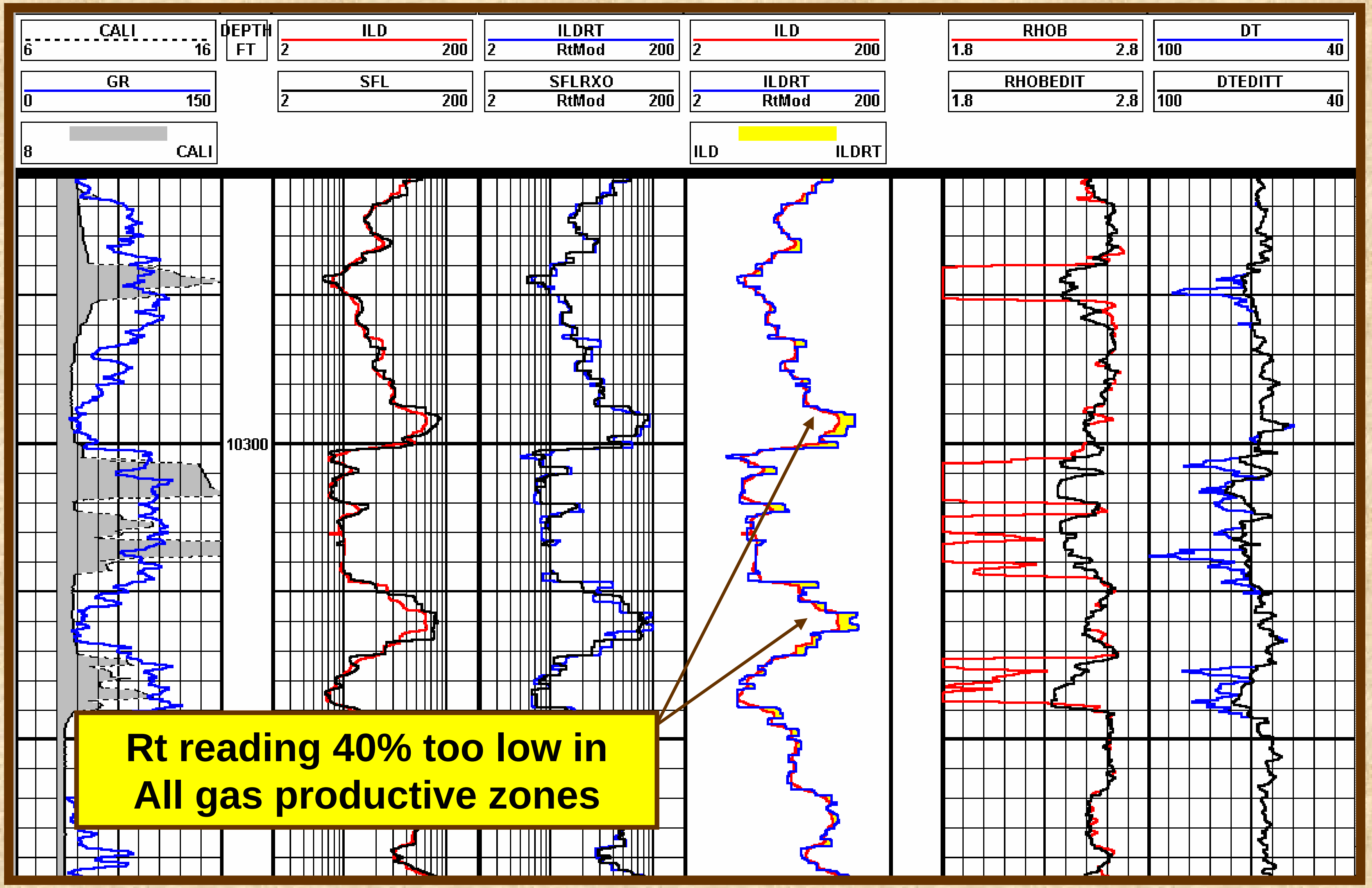
Thin bed evaluation

Acquisitions and divestitures

Oklahoma ES Log



Induction Log: Jonah Field, Wyoming



Conventional Use of the SP Log

Qualitatively

- Correlation
- Lithology
- Shaliness
- Porosity/ Permeability
- Bed boundaries

Quantitatively

- Rw calculation

5 Effects on the Electrochemical SP Response

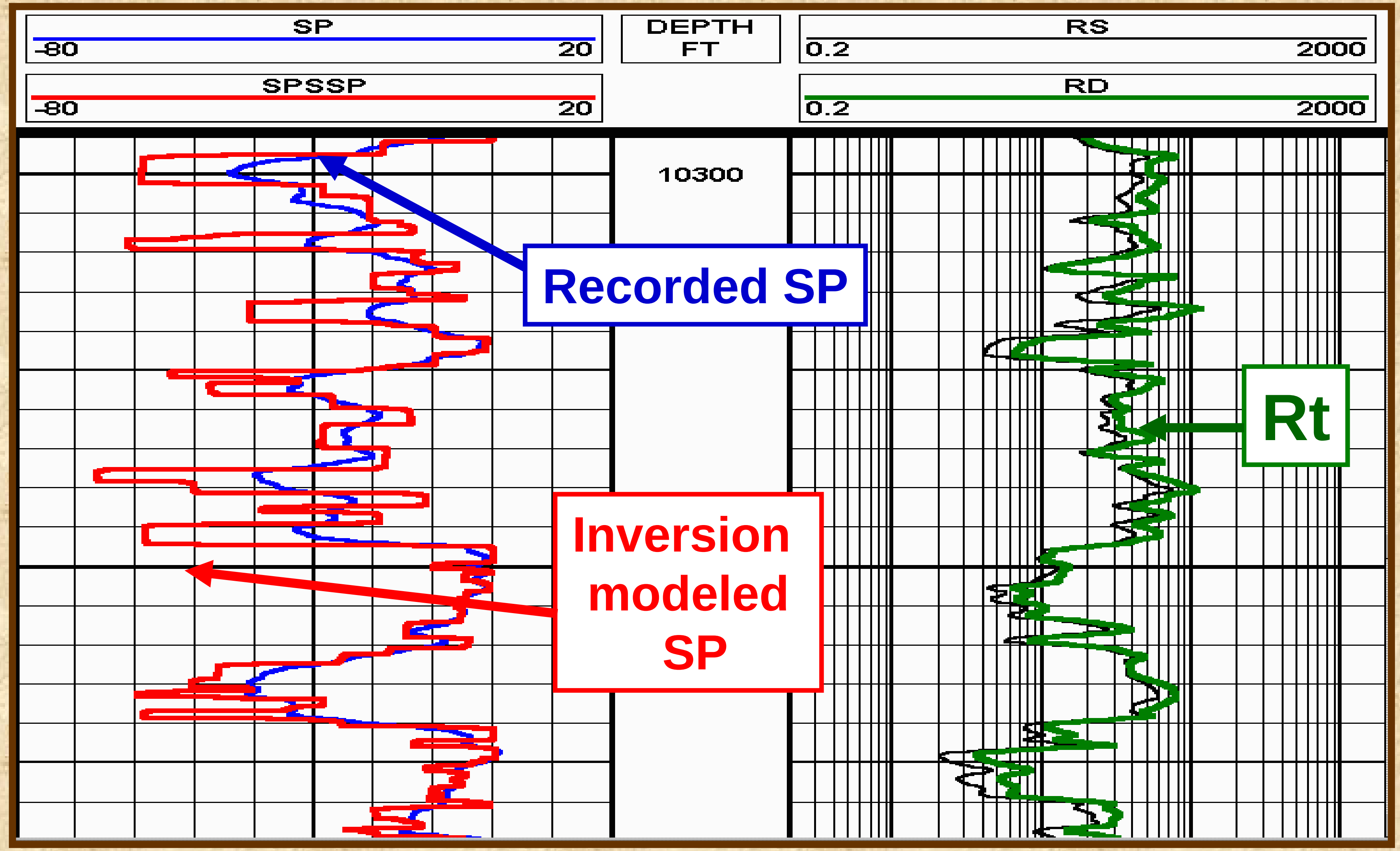
***Bed Thickness**
***Rmud/Rt Ratio**
****Rw**
****Rmf**
Clay in the Permeable Zone (Rock Quality)

****SP Modeling removes these effects***
*****Normalization removes these effects***

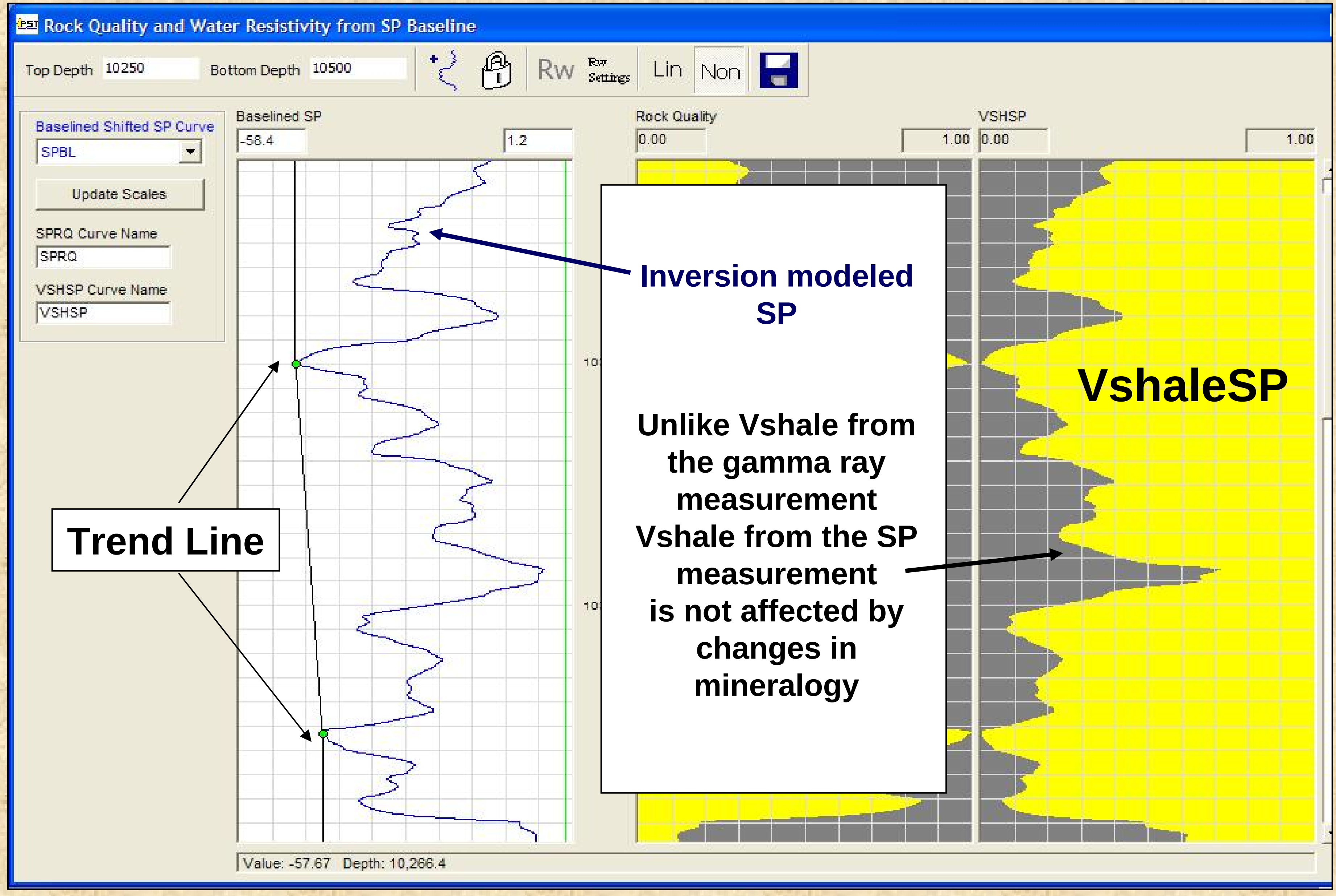
You are left with <u>rock quality</u> (permeability)

Jonah Field, Wyoming

SP inversion modeling removes the effects of Rt and bed thickness



Vshale from the inversion modeled SP



Critical SP Inversion Applications

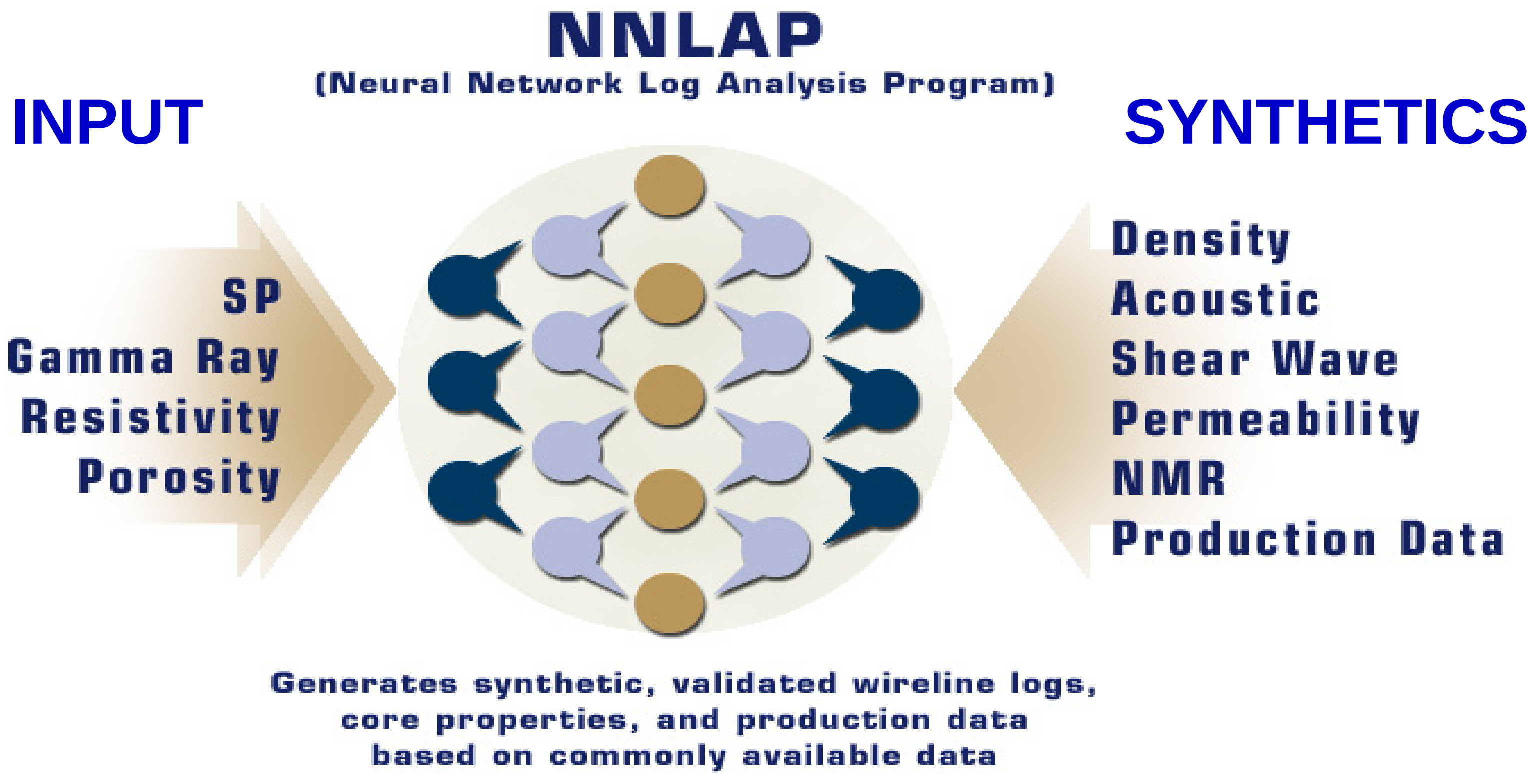
VshaleSP

excellent quantitative predictor of permeability at a 1-foot vertical resolution

SPRQ

calculate Rw, even in hydrocarbon-bearing zones that do not produce measurable water samples

Neural Networks



Neural Network Process

Train the network in a training well

Blind test the results in confirmation wells

Validate models on a foot-by-foot basis through automatic back-prediction of predictor curve values

Common Neural Network Applications

Fill in the gaps

Edit poor quality data

Compressional and shear velocity

Extend core perm data to all wells

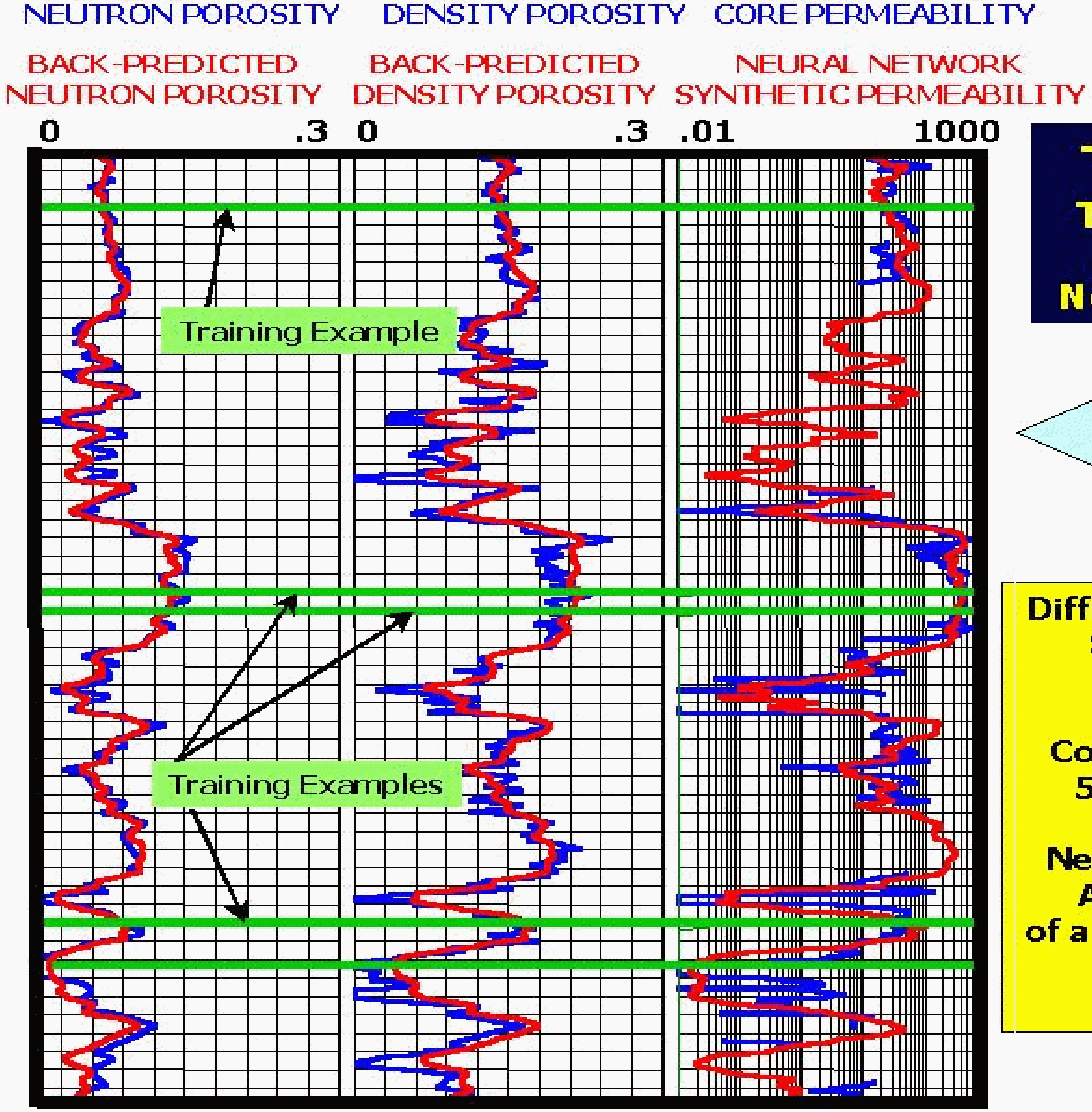
Extend expensive NMR data to all wells

Save up to 40% on logging costs

Effectively design frac stimulation projects

Identify bypassed pay zones

Training the Neural Network



TRAINING WELL
TENSLEEP FM, WYOMING
Core Permeability from Neutron & Density Porosity

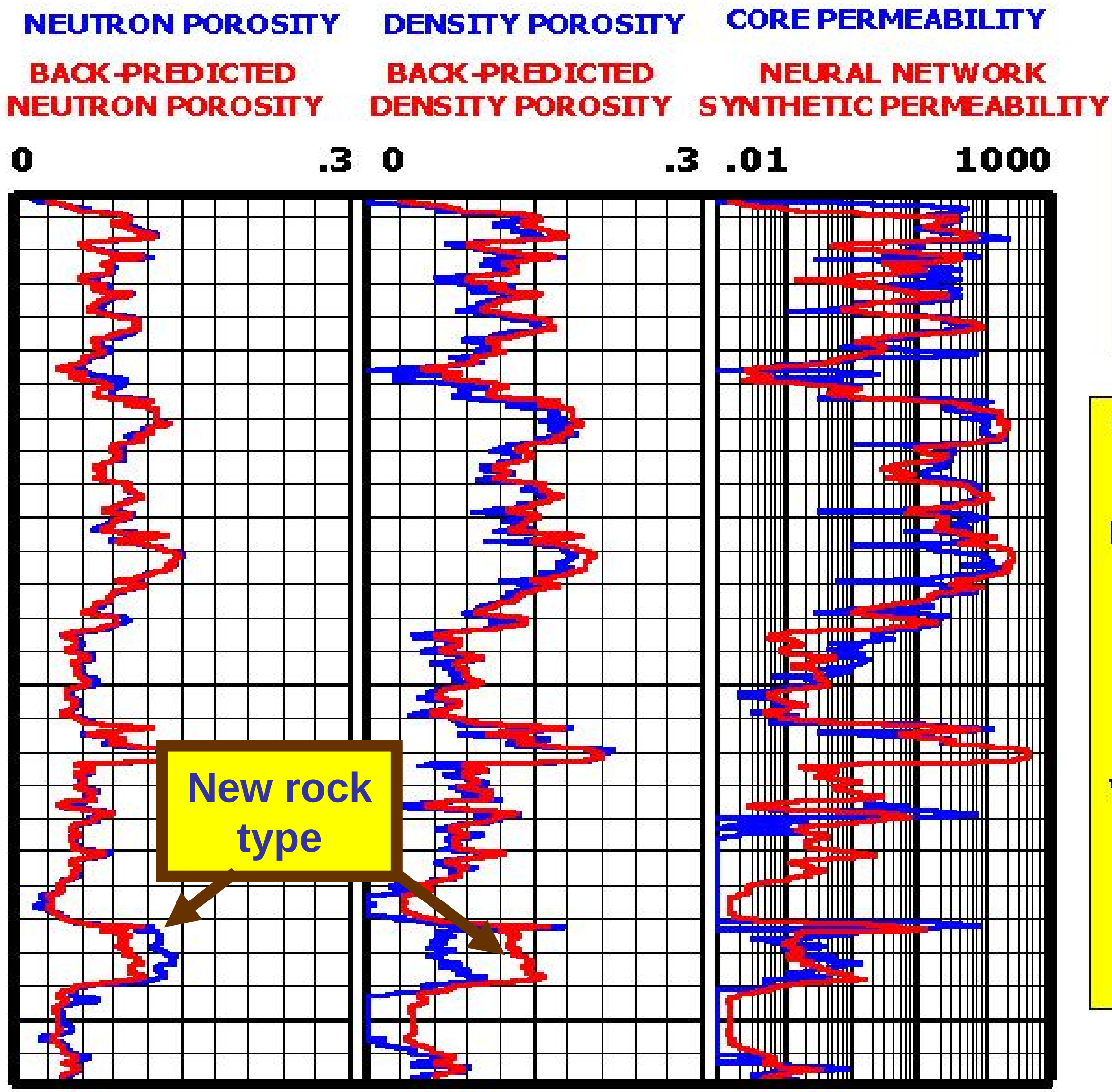
PERMEABILITY DATA WHERE NO CORE WAS RECOVERED

Difficult Problem in Cross-bedded Sandstone with Carbonate Cement

Core Permeability Ranges Over 5 Decades (0.01 to 500 md.)

Neural Network Predictions are Accurate to Within One Half of a Decade Using Only 5 Training Examples (Plus the Depth Interval Sample).

Confirming the Neural Network Solution



CONFIRMATION WELL

TENSLEEP FM, WYOMING

Core Permeability from Neutron & Density Porosity

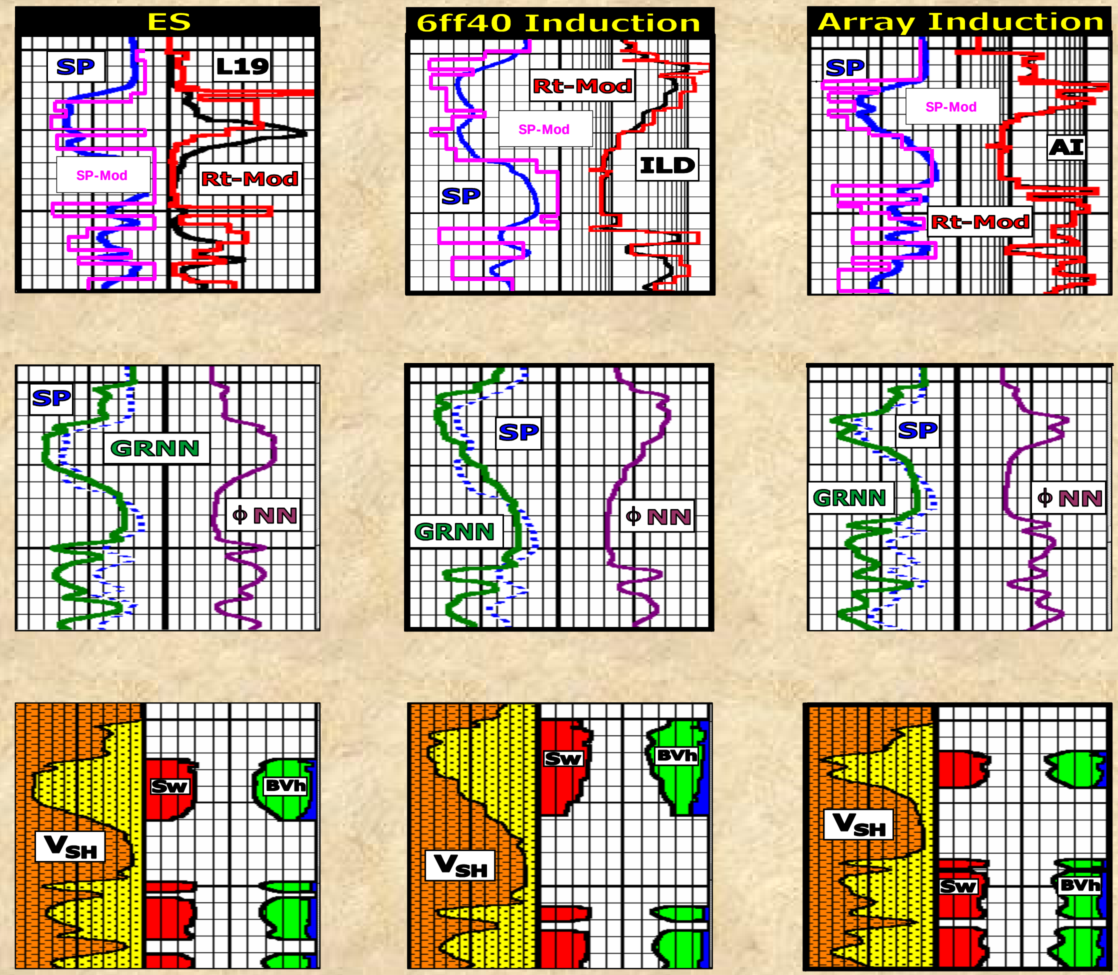
Neural Network Solution from the Training Well was Applied to Another Well Which Had Core Permeability Data and the Results Were Compared

The Favorable Match Indicates That We Have a Robust Solution

We Can Now Feel Confident That We Can Apply the Neural Network Solution to Other Wells (Located Between Our Training and Confirmation Well) Which Do Not Have Core Data

Using resistivity and SP inversion modeling and neural networks together

1940's 1980's 2005



First

Optimize all resistivity and SP measurements with modeling

Then

Synthesize missing logs and core properties with neural networks

Finally

Calculate reservoir fluid content