The Appropriate Use of Seismic Data for Estimating Petroleum Resources*

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Abstract

Seismic data is generally the key data source for resource evaluation in all categories except proved reserves. The use of seismic data for classification of proved reserves, in particular, is the subject of frequent disagreement because: 1) seismic quality, 3-D in particular, has advanced significantly and rapidly; 2) seismic data is generally precise but not accurate; and 3) reserves classification is historically an engineering discipline, and engineers are typically not well versed in seismic methodology. Seismic data is generally accurate enough for estimation of the areal geometry attributes such as dip and faulting for proved reserves. With comprehensive interpretation, seismic data may be accurate enough for estimating gross thickness. Seismic data is generally not accurate enough for the quantification of porosity or net-to-gross in the proved reserves category but often useful for the other resource categories. Seismic data is not accurate enough for the quantification of Sw within a hydrocarbon accumulation.

Fair quality data is more difficult to evaluate than good or poor data because judgment becomes more significant. Probabilistic estimations yield a specific numerical value for designating the resource category, but judgment is still significant in the estimation and less transparent. The consistency of resource estimation to which we aspire is aided by rules, standards, and guidelines. Neither the PRMS nor the SEC reserves definitions specifically address rules for the application of seismic data to resource estimation, except in the case of proved reserves and 3-D seismic data with a flat or bright spot. An attribute should be used for quantification of resources only when: The attribute is well defined (the data is good), the attribute is clearly correlated to well data (synthetics, analogs), and the basis of the attribute is known and can be modeled. Seismic data is commonly used with a bias, either too punitively or too optimistically. More definitive data sources such as petrophysics and well test data should be used to clip the high-side and low-side estimates from seismic data. No data, including seismic data should be used to classify resources unless that data clearly contributes to understanding the reservoir. Otherwise, generalized approximations and assignments are better because they are defined, repeatable and no less accurate. In particular, the reservoir parameters net-to-gross, porosity, and Sw are better defined by

other data sources unless the seismic data is of good quality, and considerable effort has gone into the interpretation and modeling of the attribute(s) used for the estimation. Individual judgment is essential in the resource estimation process and frequently results in a wide variation of results. The consistency and clarity sought by the application of standards are often at the expense of accuracy, but must be in place if resource estimations are going to be a relevant.

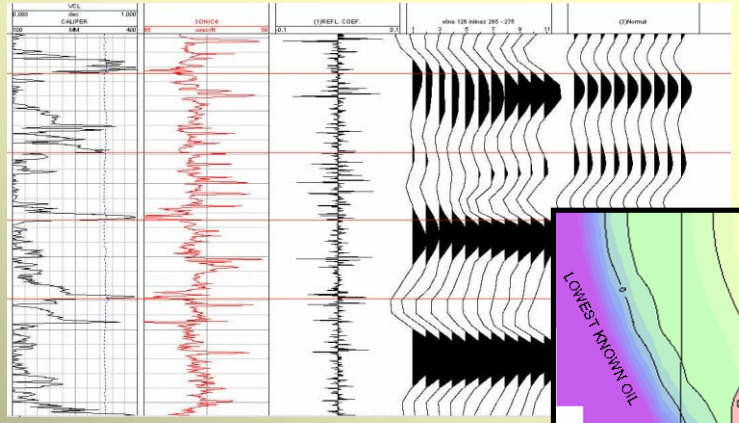
References

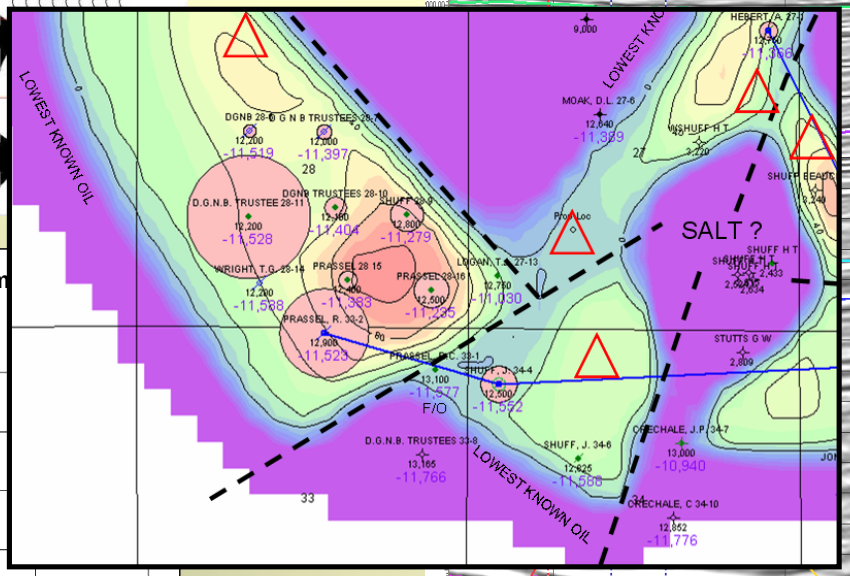
Brown, A.R., 1996, Seismic attributes and their classification: The Leading Edge, v. 15, p. 1090.

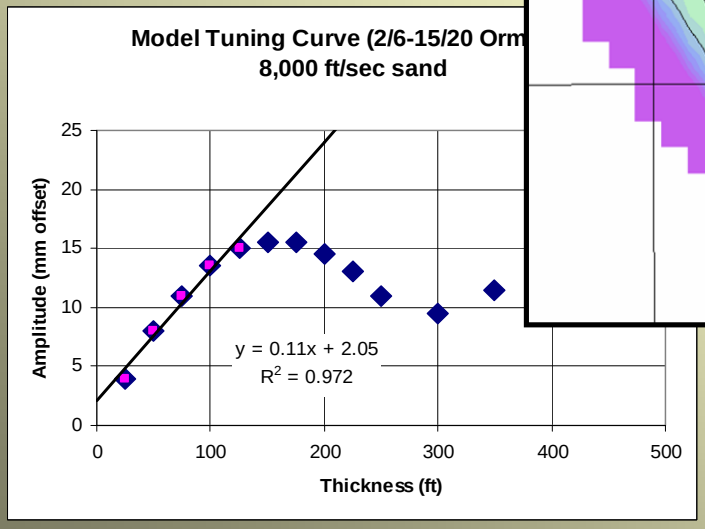
Brunei Shell Petroleum Co Sdn Bhd (BSP), Web accessed October 26 2009 (https://www.bsp.com.bn/main/index.asp

Singh, V., A.K. Srivastava, D.N. Tiwary, P.K. Painuly, and M. Chandra, 2007, Neural networks and their applications in lithostratigraphic interpretation of seismic data for reservoir characterization: The Leading Edge, v. 26/10, p. 1244-1260.

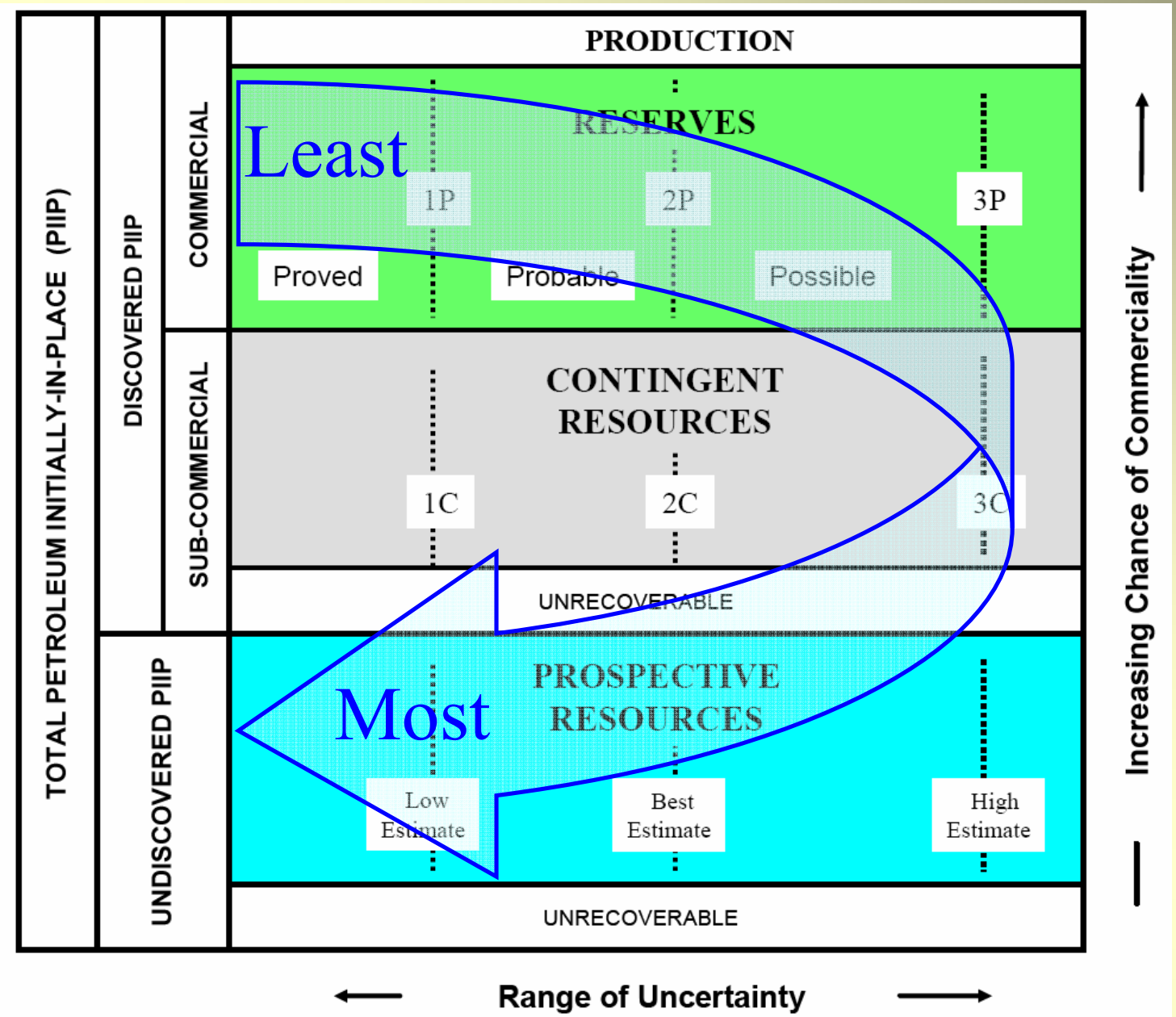
The Appropriate Use of Seismic Data for Estimating Petroleum Resources







Seismic Impact on Classification



Seismic Contribution as a Data Source

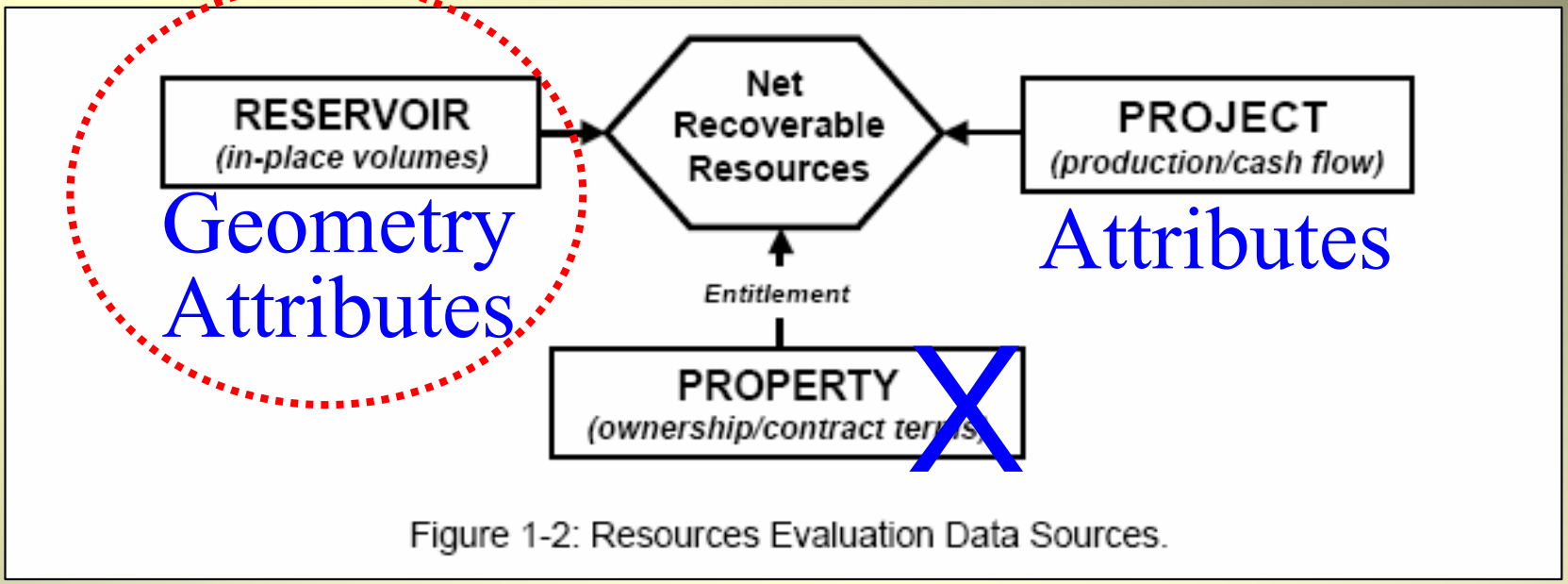


Figure 1-2: Resources Evaluation Data Sources.

In-Place = Area x Thickness x Phi x S_{hc} x fvf

Increasing Importance

Goals for Resource Estimation

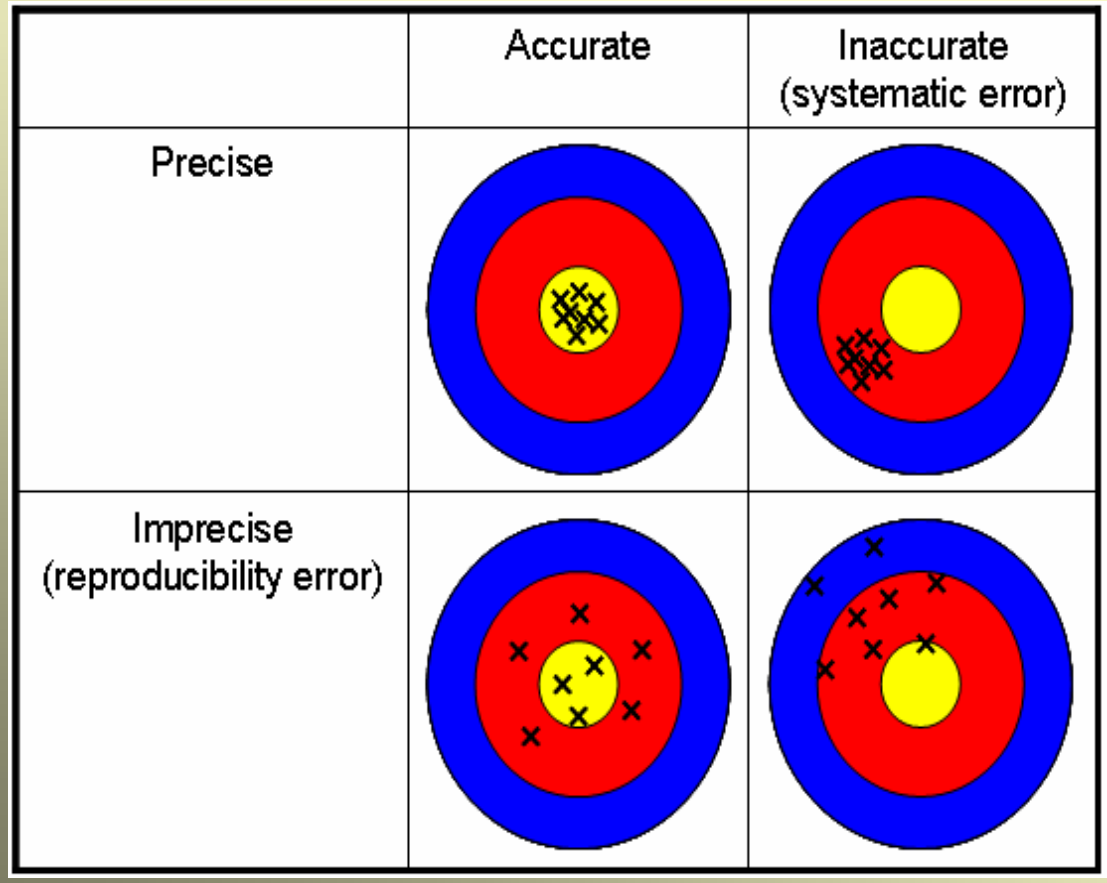
- Accuracy for valuation
- Consistency to allow comparison
- Transparency for repeatability

Seismic data should not be used to classify resources unless that data clearly contributes to the accuracy of the estimation

Precision vs. Accuracy

- Precision—repeatability
- Accuracy—correctness

Resource Evaluation Strives for Accuracy

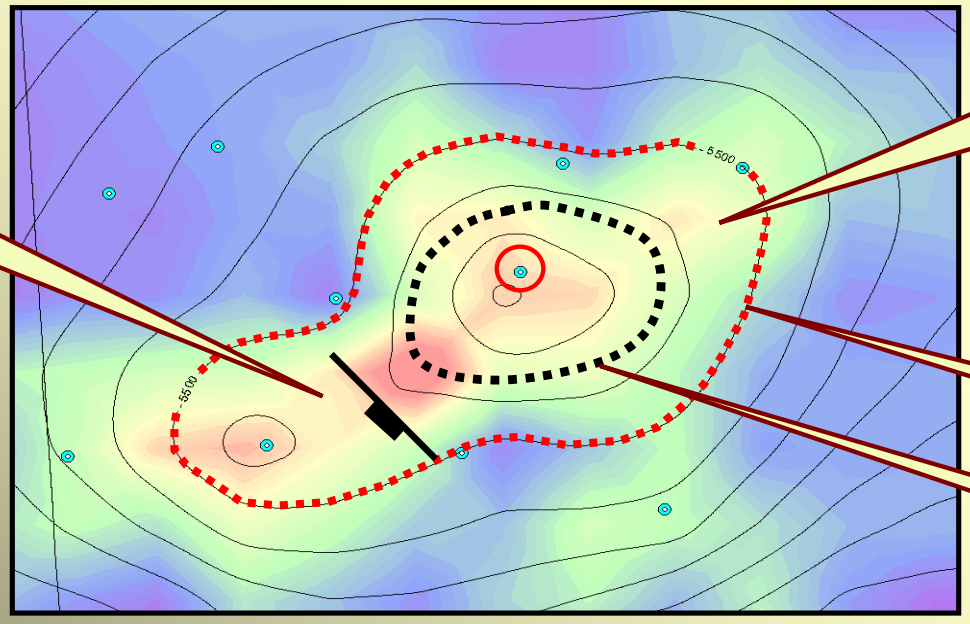


- Area ~Always
- Thickness Often
- Porosity Rare
- Sw Very Rare
- Pressure ~Never

Rules

- *In the absence of fluid contacts, **Proved** quantities are limited by the **lowest known hydrocarbon** (LKH) being the deepest structural level of well penetration **unless otherwise indicated by** definitive geological, **geophysical**, engineering or performance data. Such definitive information may include pressure gradient analysis and seismic indicators. **Seismic data alone may <u>not</u> be sufficient to define fluid contacts for Proved reserves.***

- *…Interpretations of available geological, **geophysical** and engineering data indicate with reasonable certainty that the objective formation is **laterally continuous with drilled Proved locations**.* *See Guidelines



Lateral Continuity Attributes and Structure

LKG Structure and Attributes

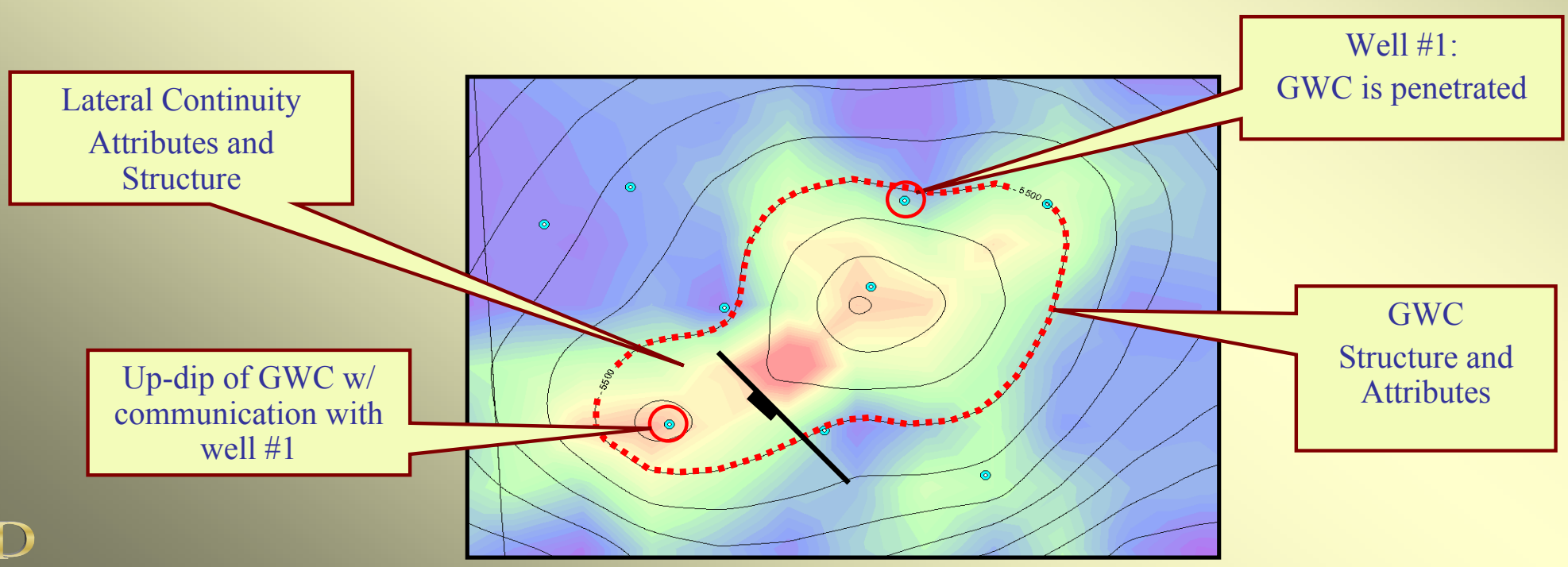
LKG amplitude

LKG in well

Guidelines

Seismic flat spots and/or bright spots are definitive for Proved below LKG when:

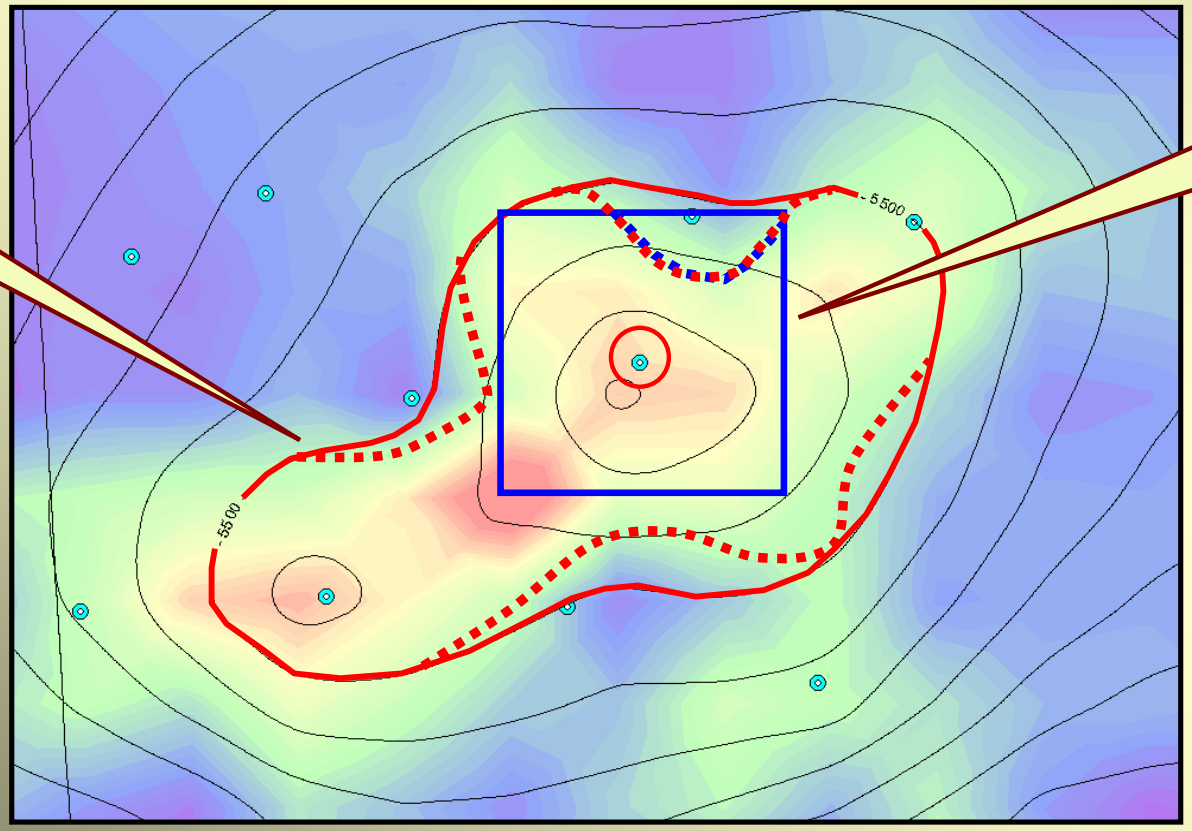
- Clearly visible
- Conformance of amplitude and structure (*between the segments*)
- The GWC is penetrated and reservoir is tested
- A well penetrates the segment in question up-dip from the GWC and pressure data shows communication



Bias *aka. Judgment*

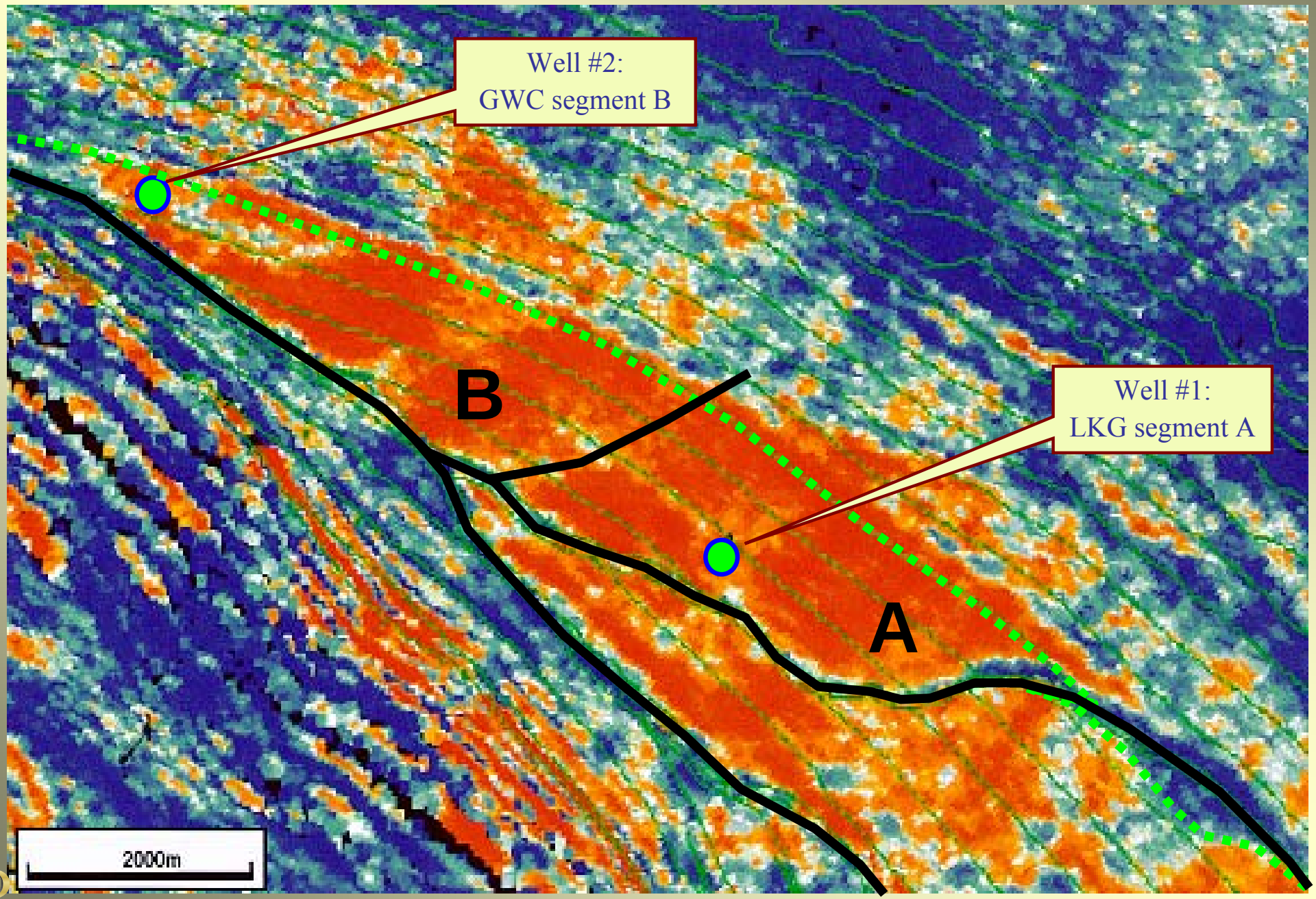
- We all have it
- We should try to apply it equally (consistency)

Positive Bias:
P1 = 1000 acres amplitude above LKG



Negative Bias:
P1 = 320 acres less the area of low amplitude

Rules and Guidelines



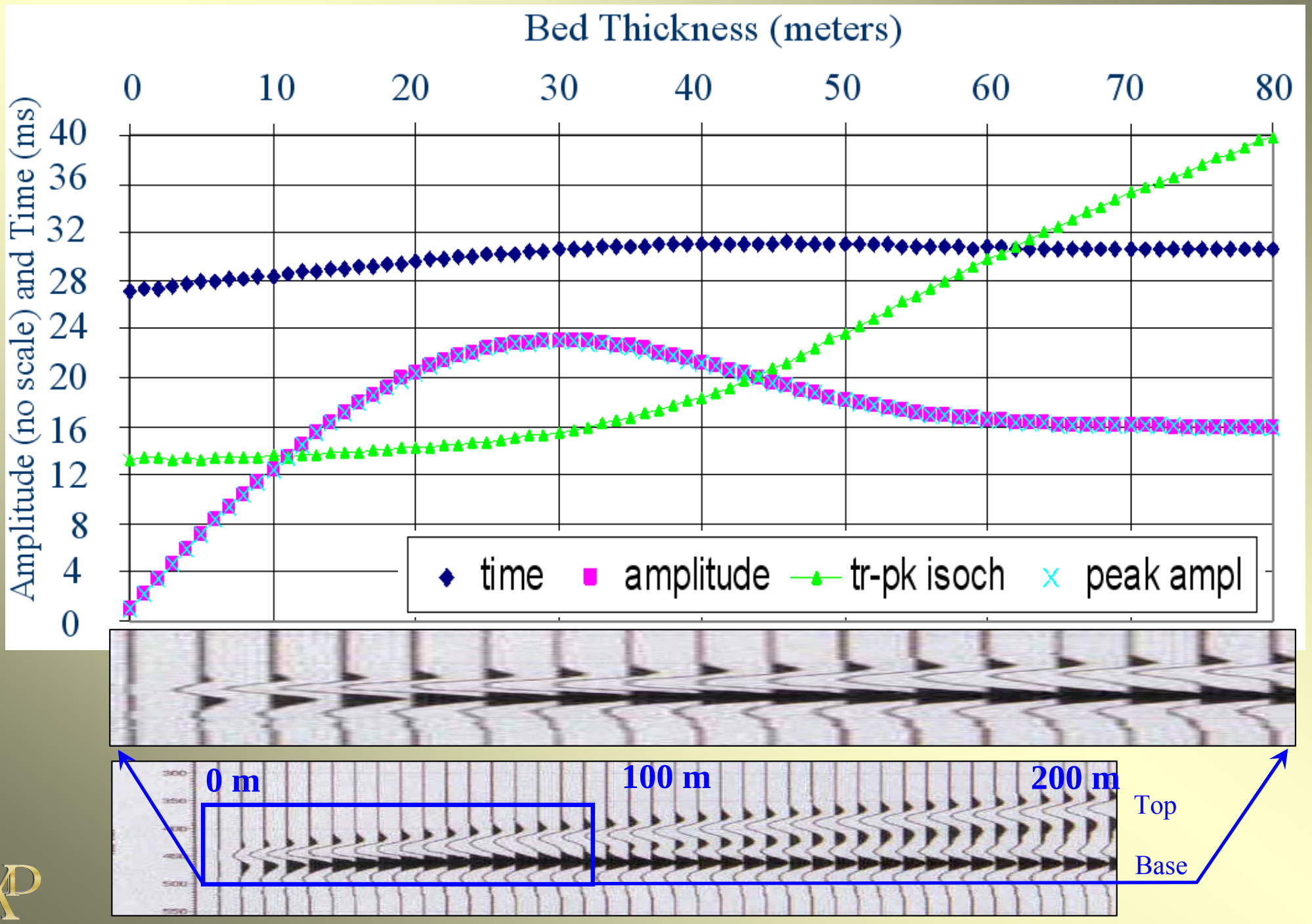
•https://www.bsp.com.bn/panagaclub/pnhs/Geology/pics/29856s.jpg

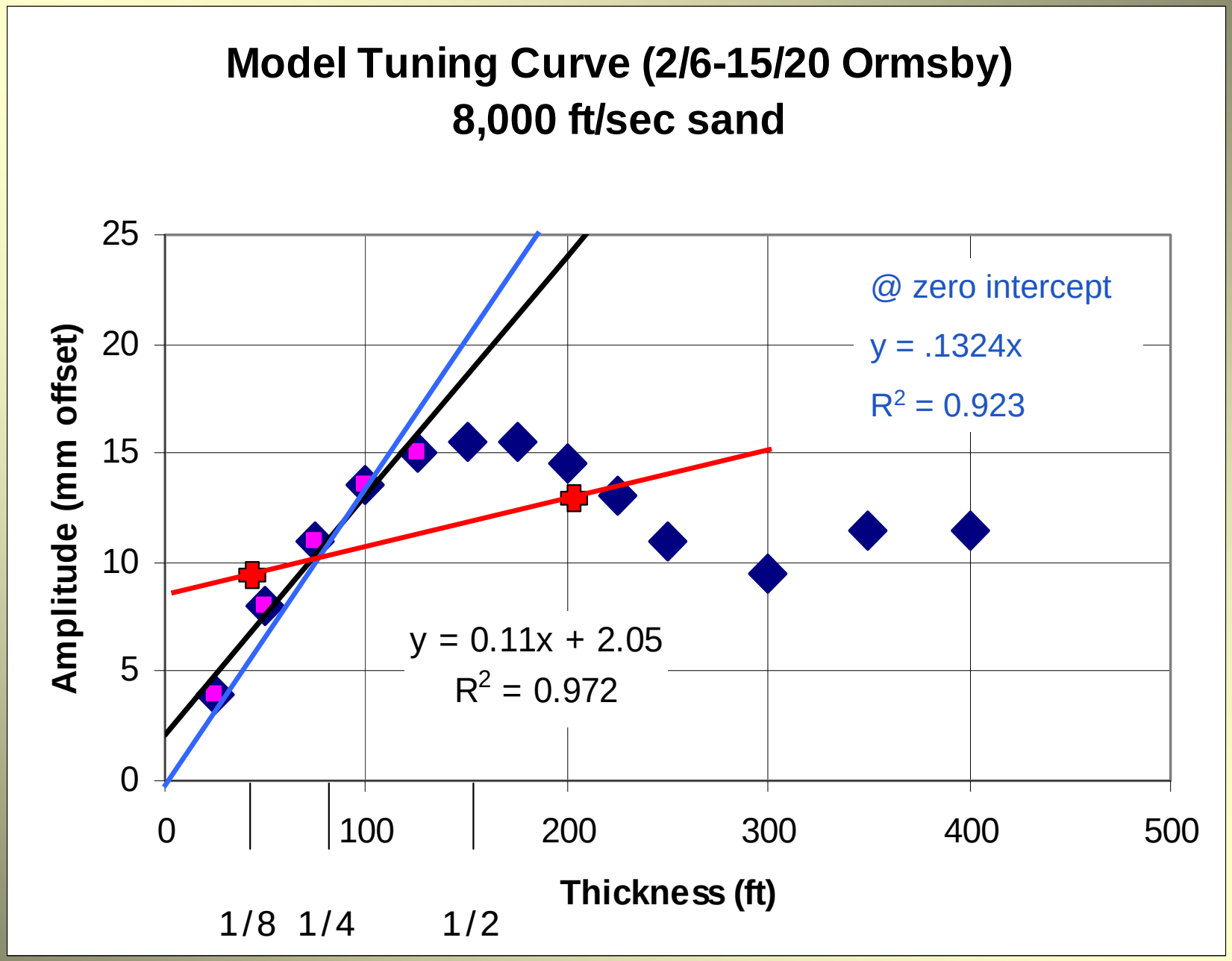
Attributes for Parameter Estimation of Proved Reserves

- Attribute is Well Defined and Quantifiable
- Attribute is Correlated to well data
- The Basis of the Attribute is understood and can be Modeled– Correlation and Causation

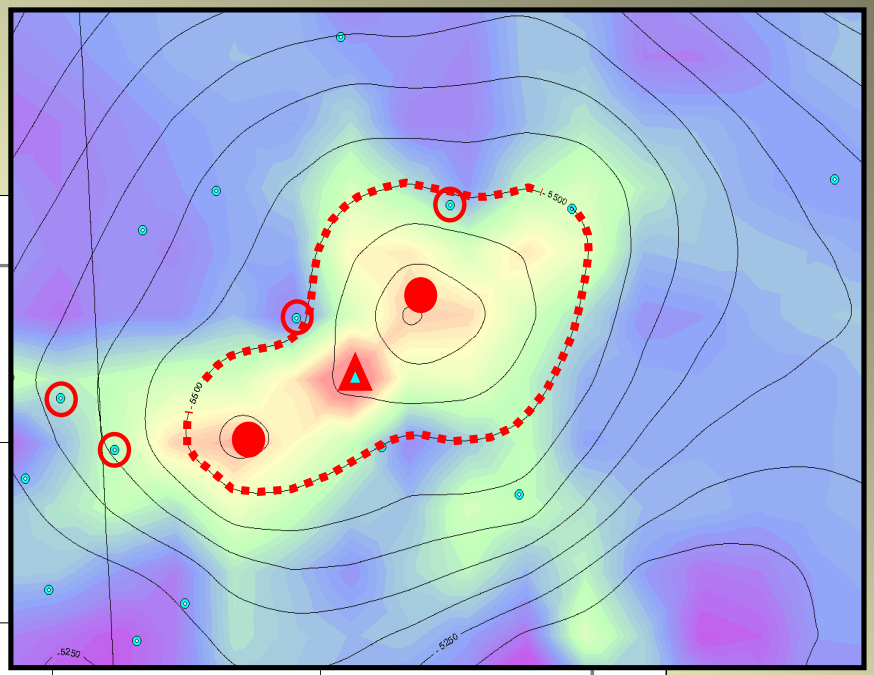
Boutique Attributes have no place in reserves estimation

Tuning Curve (wedge model)



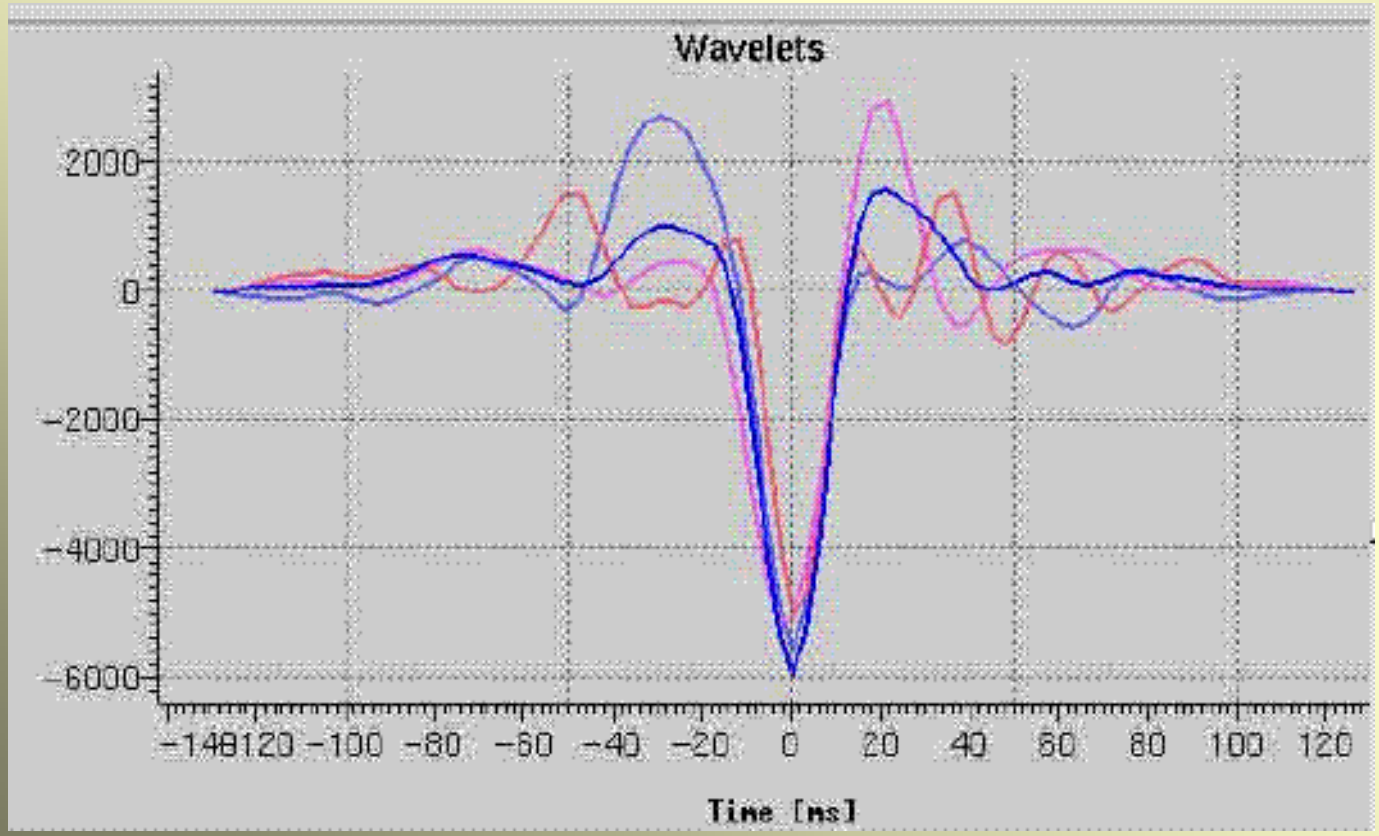

Model Tuning Curve (2/6-15/20 Ormsby)
8,000 ft/sec sand
Amplitude (mm offset)
25
20
15
10
5
0
0
100
200
300
400
500
Thickness (ft)
1/8
1/4
1/2
@ zero intercept
y = .1324x
R2 = 0.923
y = 0.11x + 2.05
R2 = 0.972

Correlation of Amplitude and Thickness



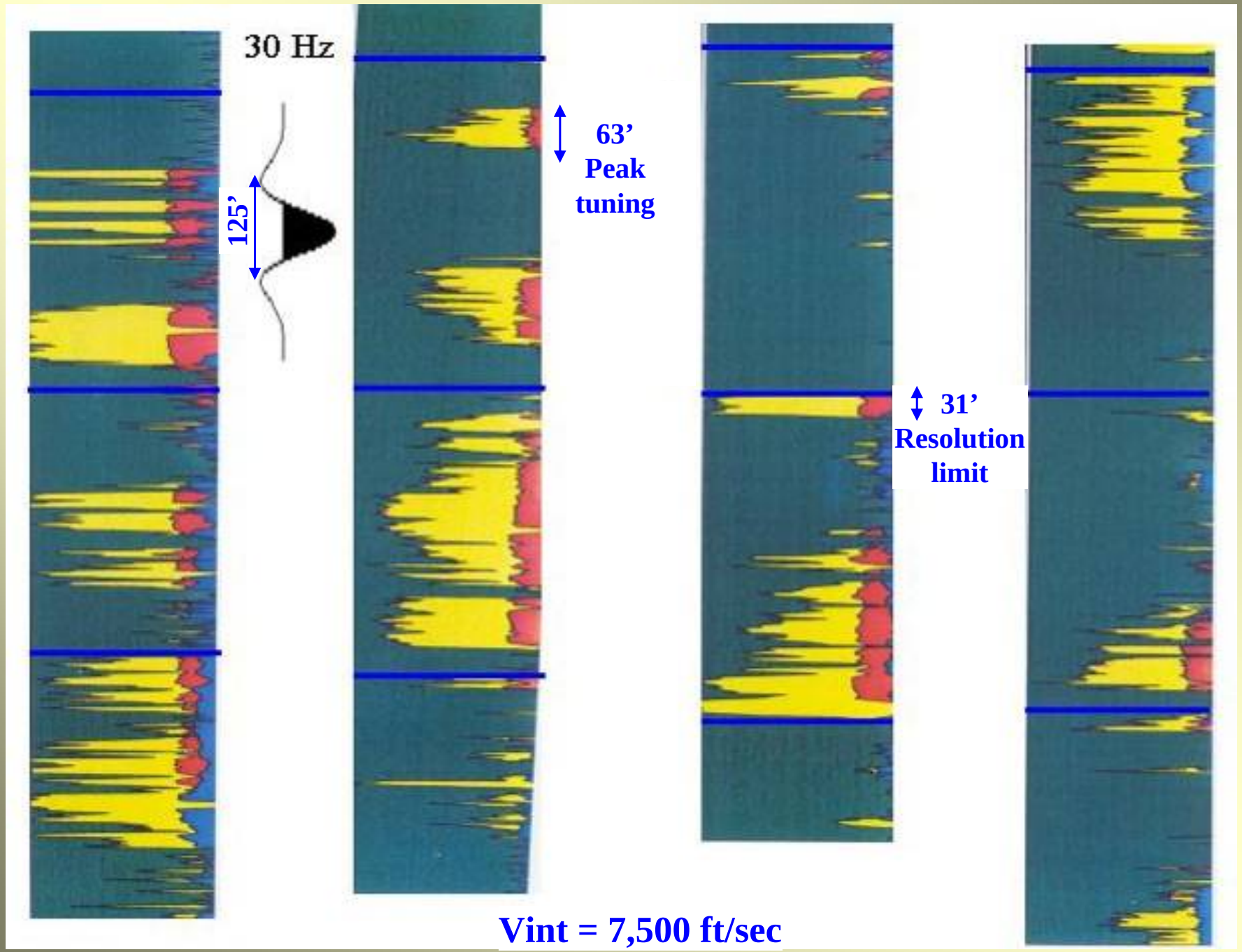
Seismic generally has insufficient accuracy for estimating porosity, saturation, and pressure

The result of a calculation can't be more precise than the least precise item used in the calculation.

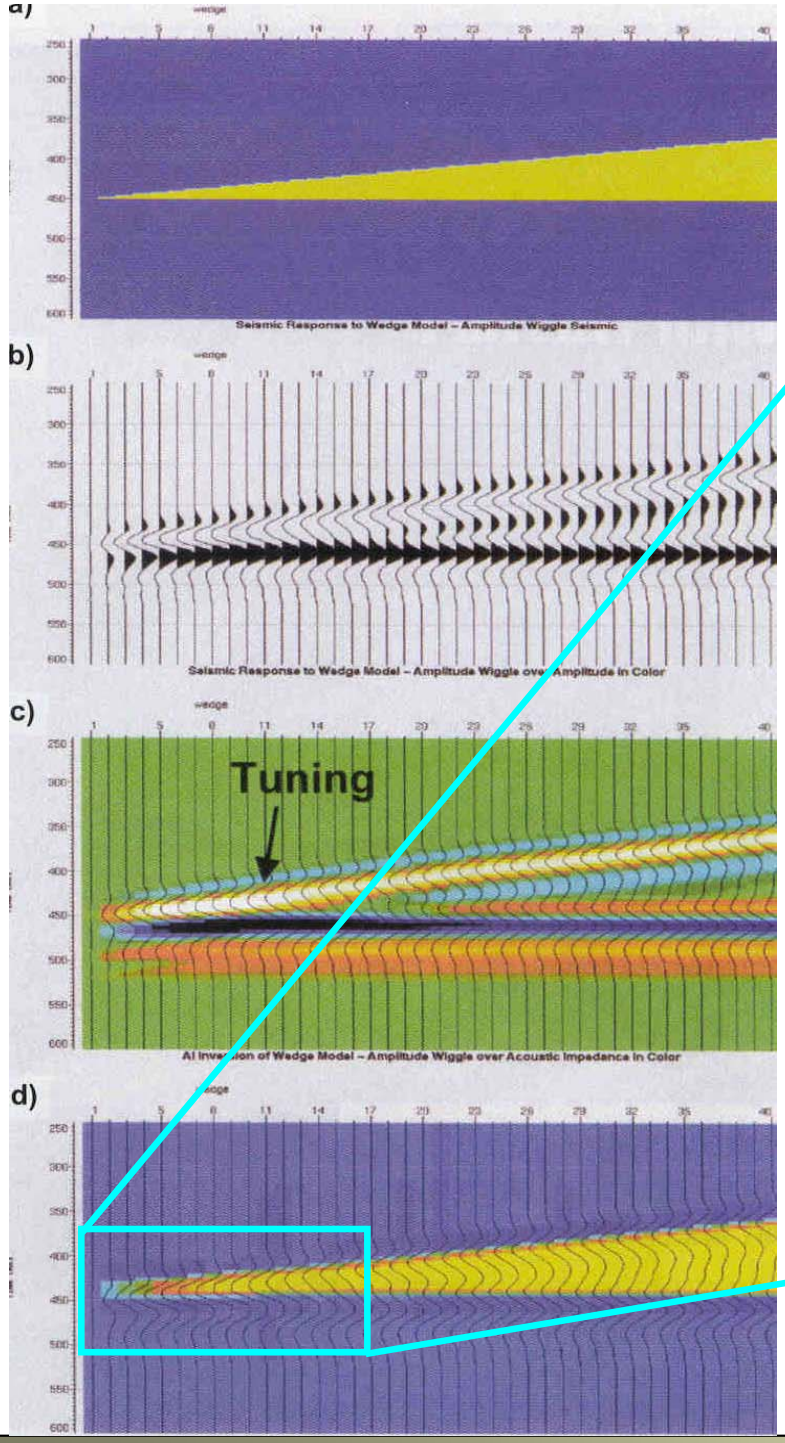


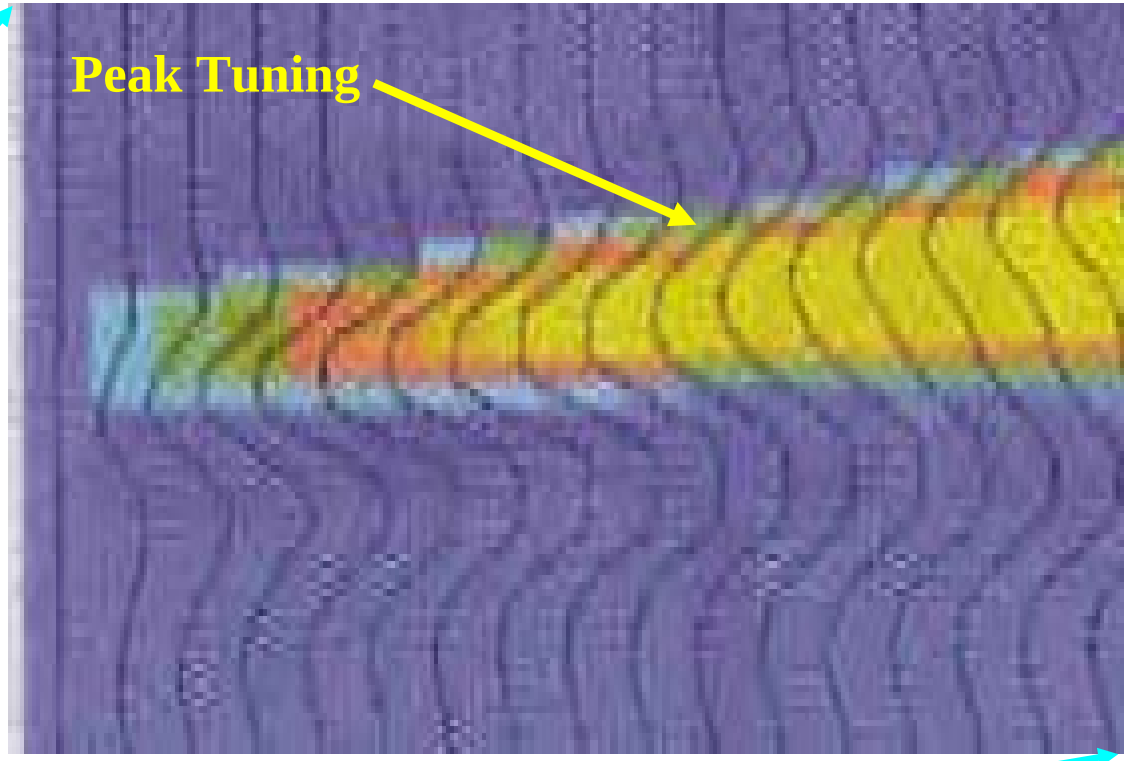
- The Wavelet
- Layering

Typical Gulf of Mexico Resolution



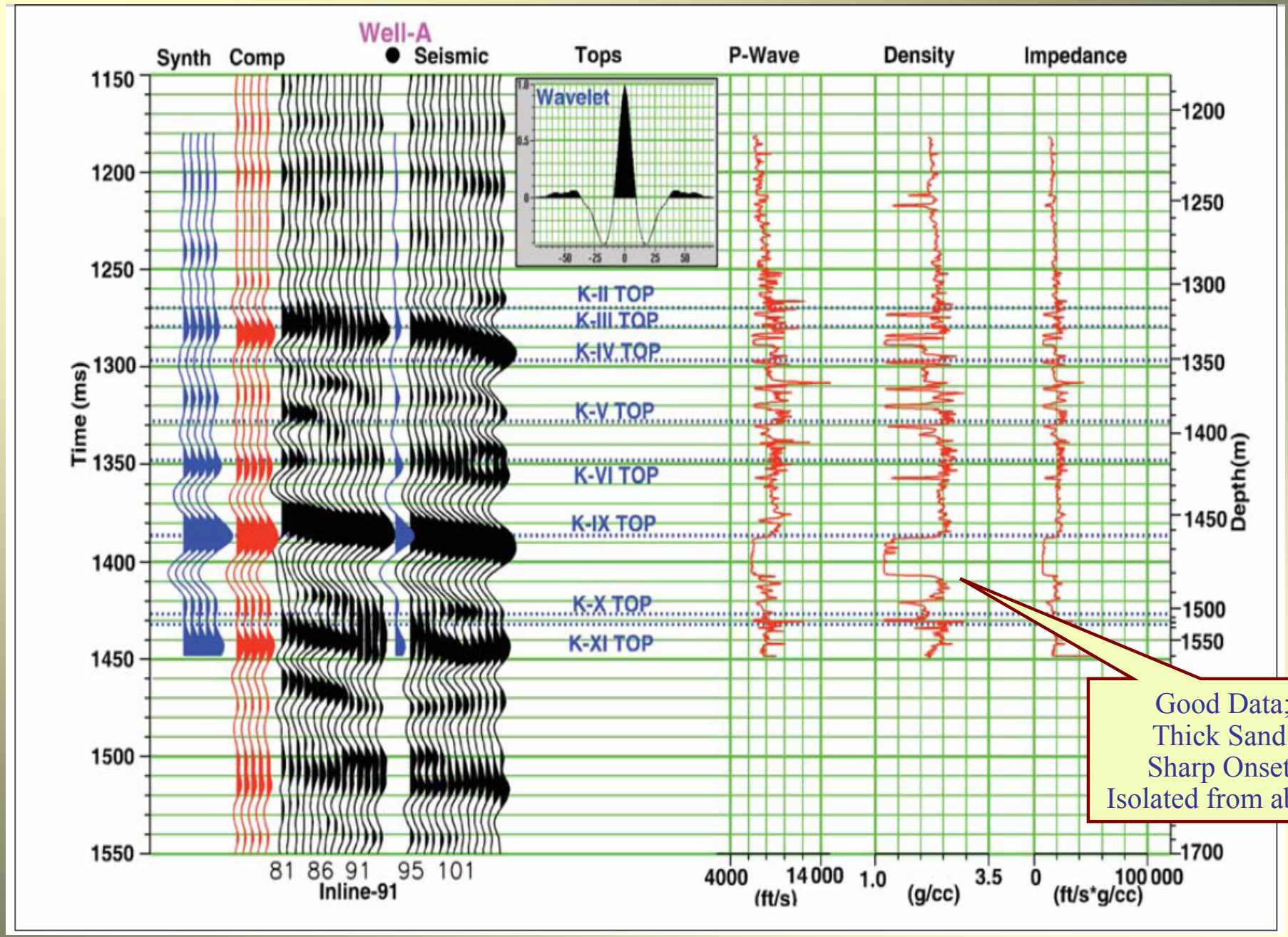
Inversion Wedge Model





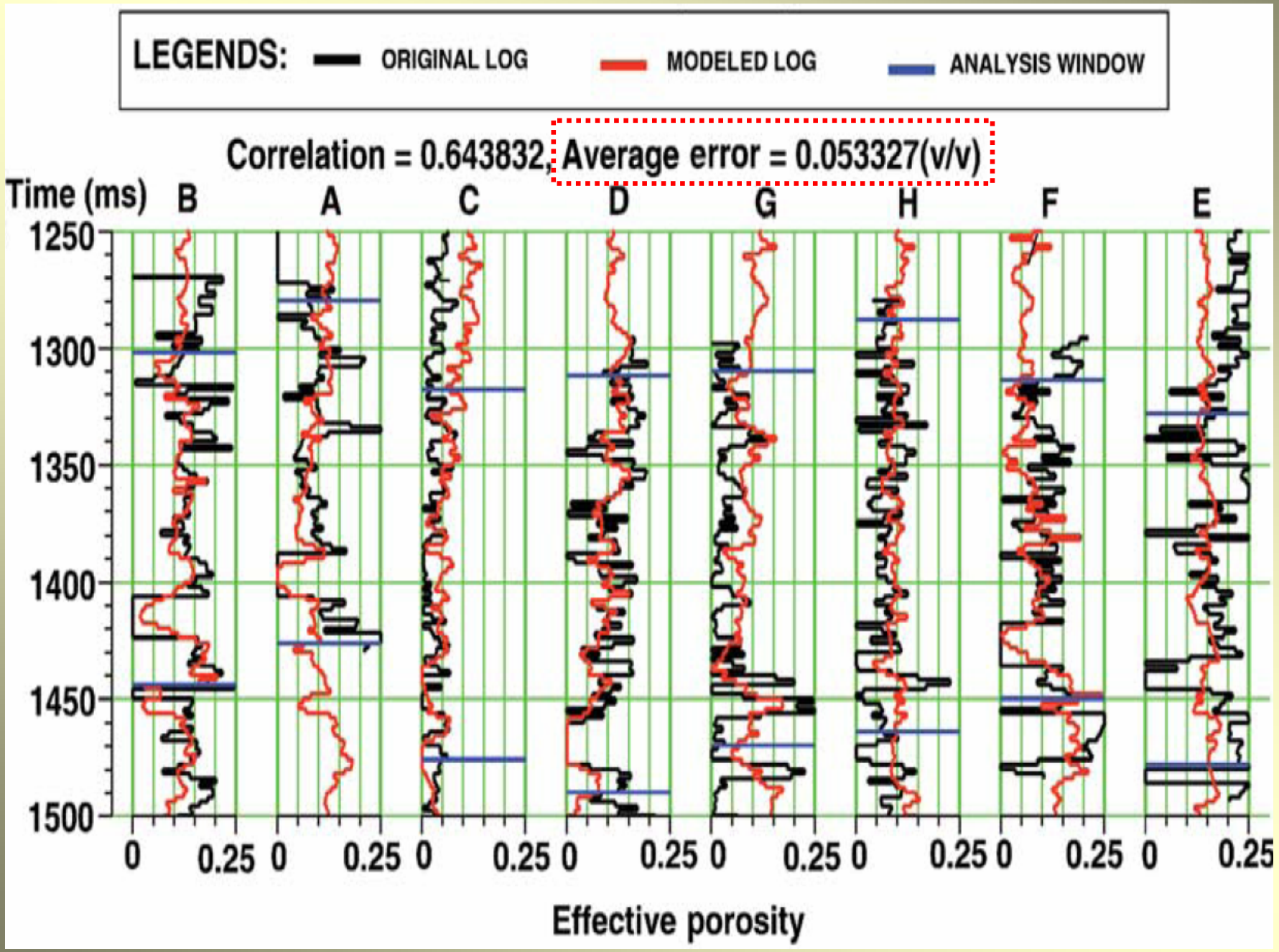
Brown, 1996

Porosity Determination from Seismic



Singh et al., The Leading Edge Vol. 26, #10; March 2007

Porosity Determination from Seismic



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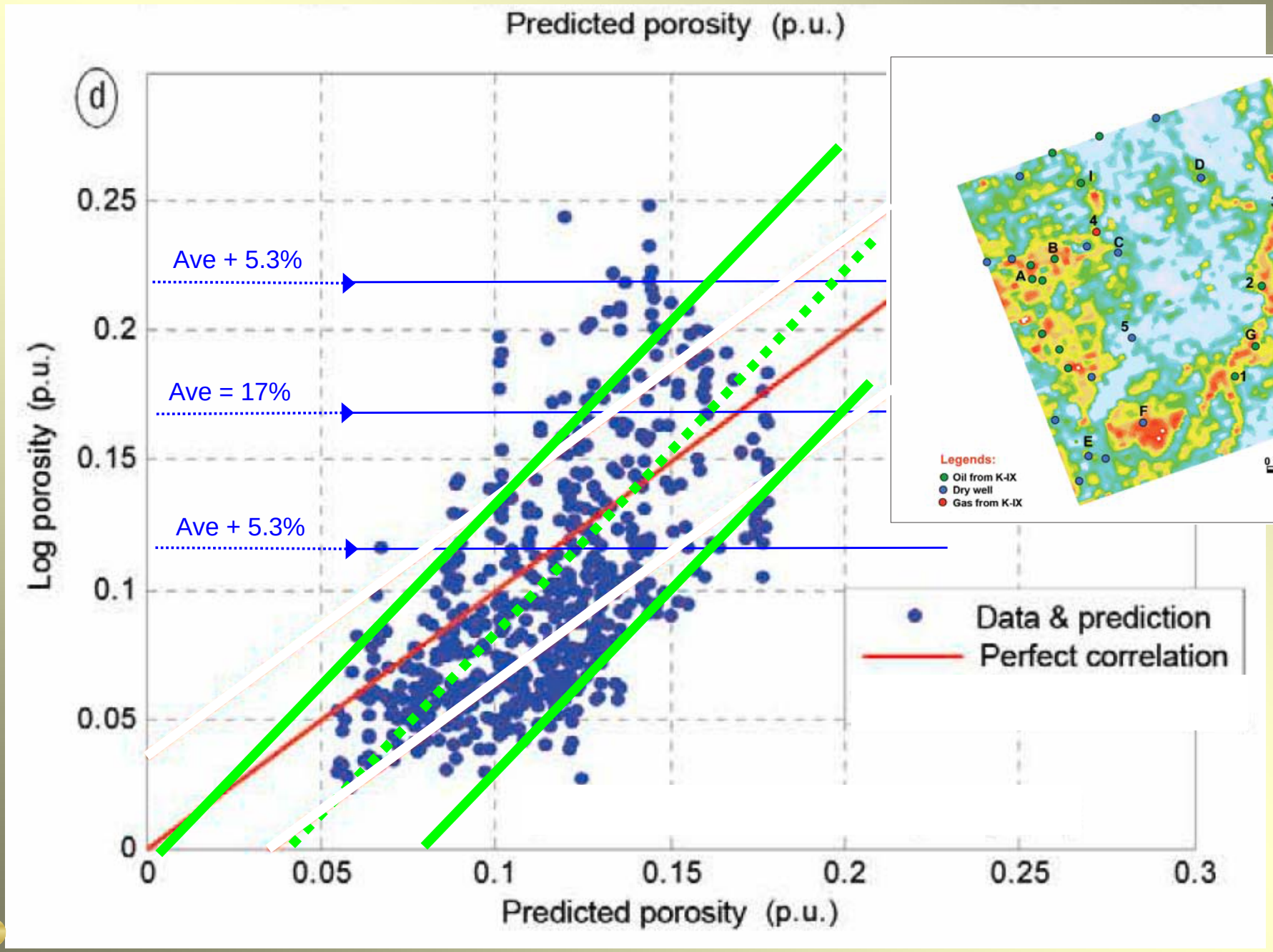

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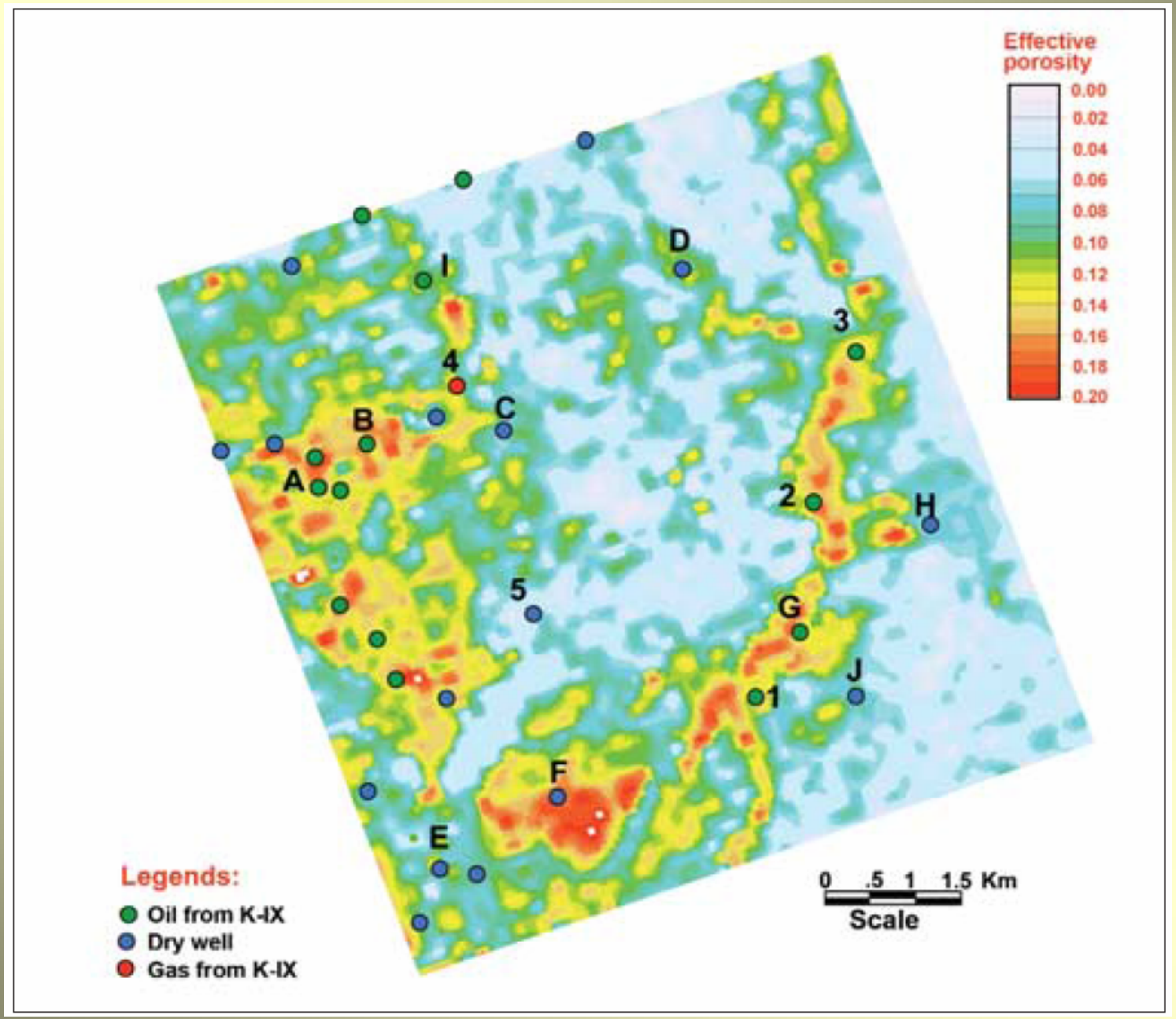
Porosity Determination from Seismic



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Seismic Interpretation

"Technology is so much fun but
we can drown in our technology.
The fog of information can drive out knowledge"

Daniel Boorstin