The Use of Seismic Technologies in Different Reserve Standards: Applications of 3D Seismic and 4D Seismic to the SEC, NI-51 and PRMS Reserve Categories*

Jeffrey B. Aldrich[1], Brandy M. Butler[1], and John P. Seidle[1]

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[1]MHA Petroleum Consultants, Denver, Colorado (jaldrich@mhausa.com)

Abstract

Use of seismic technology for estimating reserve volumes has been a continually evolving path which has not progressed at an even pace among different international standards. Currently the USA SEC guidance, the 2011 PRMS guidelines, and the Canadian COGEH NI-51-101 guidelines specify, to differing degrees, uses of seismic technology to estimate in-place hydrocarbon volumes. 3D volumes of seismic data, including various attribute analyses, are one common form of seismic technology widely used over large areas in both conventional and unconventional fields. Microseismic data is a 4D passive seismic method used on a limited areal scale to map detailed microseismic events triggered by the injection of stimulation fluids. While microseismic has been employed in conventional fields, its primary application has been to estimate the stimulated rock volume (SRV) in unconventional fields.

Accepted practices and workflows for inclusion of seismic technologies in reserve and resource evaluations are demonstrated; yet there are important differences depending on the standard under which the evaluation is being made. Guidelines and standards for determining the use in helping to define Proven, Probable, and Possible reserve categories are not straightforward and are subject to misapplications. Similarities and differences between the SEC, the PRMS, and the NI-51 standards are documented, and the applications of the best practices in the seismic work flow are detailed.

Selected References

Altamar, R.P., and K.J. Marfurt, 2015, Identification of brittle/ductile areas in unconventional reservoirs using seismic and microseismic data: Interpretation, v. 3/4, p. T233-243.

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52nd SPEE Annual Meeting, 2015, 3D Seismic data and its role in the estimation of resources—Shell Galleon Field, North Sea.

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The Use of Seismic Technologies in Different Reserves Standards

APPLICATIONS OF 3D SEISMIC AND 4D SEISMIC TO THE SEC, NI-51-101 AND PRMS RESERVE CATEGORIES

2016 AAPG Annual Convention
Calgary, Canada

Jeffrey B. Aldrich, Brandy M. Butler, John P. Seidle

Outline

- Introduction
- Definitions for Use of Seismic Data
  - PRMS
  - SEC
  - NI-51-101
- What constitutes “Reliable Technology”
- Practical Applications in Assessing Reserves
  - 3D Seismic Applications
  - 4D Seismic Applications
- Conclusions

USE OF SEISMIC DATA
PRMS / SEC / NI-51-101
GUIDELINES

SPE/AAPG Petroleum Reserves Management System (PRMS)

- **Resources** can be reported as both Prospective and Contingent
- **Reserves** can be reported as Proved, Probable, and Possible

- The PRMS (2007) and the PRMS Guidelines (2011) give detailed instructions.
- There is newer technology since both were written.

PRMS 2011 Guidance on Seismic Use

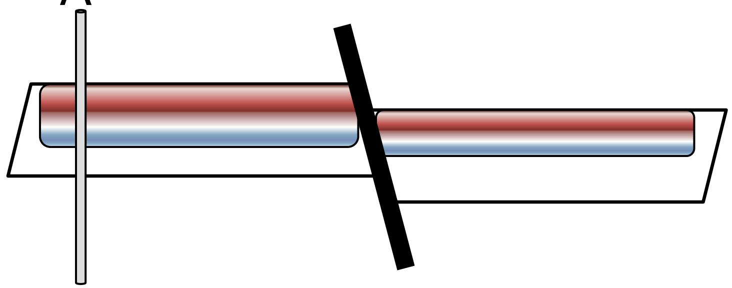
- 3D Seismic Data can be used to estimate
  - Areal Extents, Depths & Thickness for Gross Rock Volume (GRV)
  - Porosity, Lithology, Hydrocarbon Saturation (S_{hc}) & Pressure
- To be considered **reliable** the seismic data must
  - Be supported by reliable seismic-to-well tie at log scale
  - Demonstrate the same relationship exists at seismic scale
  - Have seismic-data quality which is satisfactory at reservoir scale

PRMS 2011 Guidance on Seismic Use

- To Substantiate or Extend Contacts
  - The contact or anomaly must be clearly visible and not related to imaging issues
  - Must be within the same fault block as well logs, pressure, well test and/or performance data AND demonstrate a strong tie between the calculated hydrocarbon/water contact and … the seismic anomaly
  - The spatial mapping of the…anomaly within the reservoir fairway fits a structural contour

What is an Appropriate Extension?

Conventional Field



Well A is a producer in Reservoir
3D seismic has mapped anomaly tied to well that crosses small fault.

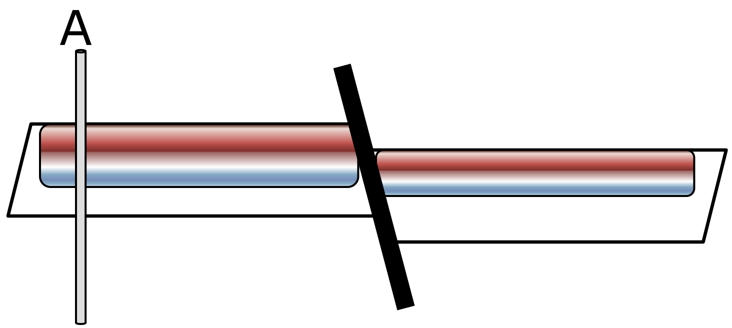
Is the downthrown block
Proved Reserve?
or Probable Reserve
or a Contingent Resource?

To be Proved, the Extension area must be

- Discovered (penetrated by a well in pressure communication) – a 'known reservoir'
- Must have demonstrated by testing, sampling and/or logging the existence of a significant quantity of moveable hydrocarbons
- Must meet commercial threshold
- Must have high confidence or 90% certainty that the volumes will be recovered.

What is an Appropriate Extension?

Conventional Field



Well A is a producer in Reservoir
3D seismic has mapped anomaly
tied to well that crosses small fault.

Is the downthrown block
Proved Reserve?
or Probable Reserve
or a Contingent Resource?

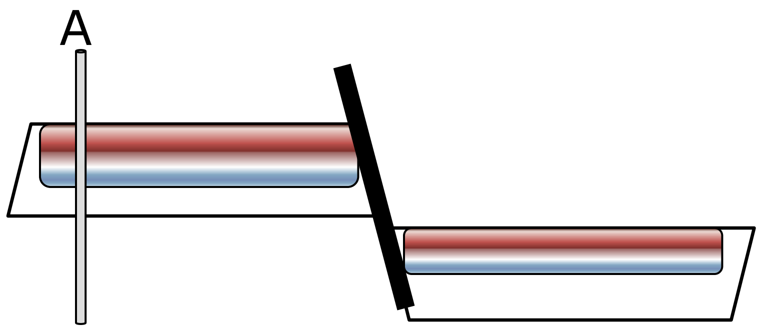
THUS Seismic Can Assist

- A determination of Proved if supported by
  - Pressure communication by another reliable technology
  - Can map a contact that conforms to structure
  - Meets Commercial Threshold
  - Has 90% Confidence level

- A determination of Probable or Possible by
  - Mapping a contact that conforms to structure
  - Meets Commercial Threshold
  - Has a 50% or 10% Confidence level

What is an Appropriate Extension?

Conventional Field



Well A is a producer in Reservoir 3D seismic has mapped anomaly tied to well that crosses a fault.

Is the downthrown block
Proved Reserve?
or Probable Reserve
or a Contingent Resource?

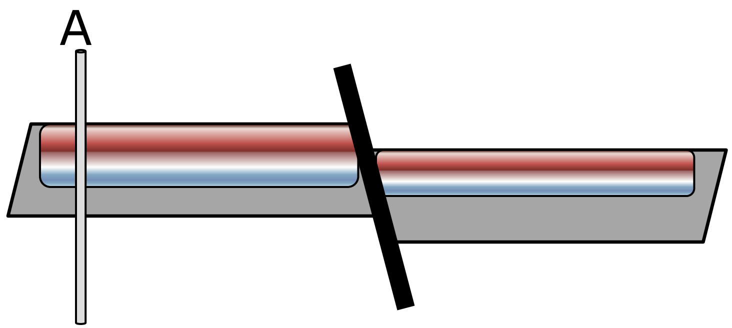
Here there is clear separation

- Even if twenty of twenty times the anomaly is HC bearing, the new fault block is NOT a reserve by SEC rules

- There is latitude in the PRMS if there is sufficient evidence to demonstrate “reliable technology” for Possible Reserves – not Proved Reserves.

What is an Appropriate Extension?

Unconventional Field



Well A is a producer in Reservoir
3D seismic has mapped anomaly tied to well that crosses small fault.

Is the downthrown block
Proved Reserve?
or Probable Reserve
or a Contingent Resource?

- In an Unconventional Field the migration of hydrocarbons may not be a risk (self-sourced), and thus pressure communication is no longer an issue.
- Proving Reservoir Heterogeneity is the critical factor. Do you have a "reliable technology" to demonstrate similar reservoir characteristics?

PRMS 2011 Guidance on Seismic Use

- 4D Seismic can be used to monitor
  - Temperature, Pressure, Fluid Flow, Fluid Contact Depths
- Requires the acquisition of
  - A baseline 3D seismic survey
  - One or more additional 3D seismic surveys over the same or similar footprint with the same or similar acquisition parameters at later times
  - Processing of the datasets to determine the differences within the reservoir

Seismic Data and Uncertainties with the PRMS

- The PRMS 2011 Guidance counsels that all volumetric estimates should include statements of the uncertainties. Seismic uncertainties are seen as a factor of:
  - The quality of the **seismic data** (bandwidth, frequency content, signal-to-noise ratio, acquisition and processing parameters, overburden effects, etc.)
  - Uncertainties of the **rock and fluid properties**
  - Errors in the **Time to Depth conversion**
  - Errors in the **positioning of structural elements** during processing (migration)
  - Errors and Uncertainties in the **Interpretation**

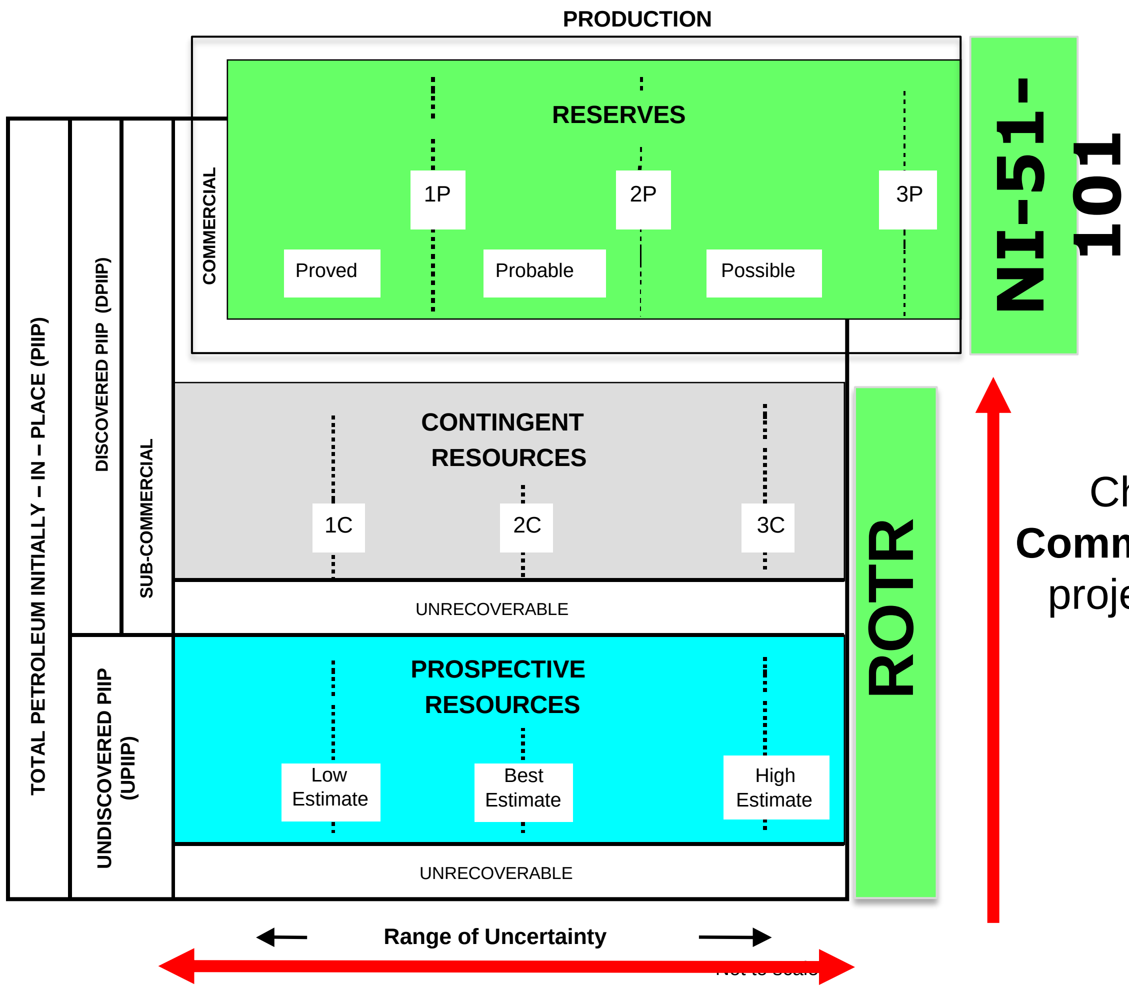
Securities and Exchange Commission (SEC)

- The SEC rules and guidelines do not allow for reporting of resources.
- SEC allows for the reporting of proved, probable and possible reserves only.
- The SEC provides most guidelines through the use of case studies. They have yet to address the latest in seismic technology.

NI-51-101 and COGEH

- The Canadian Security rules for Oil and Gas reporting are detailed in the National Instrument Section 51-101 (NI-51-101)
- The complete set of standards and guidelines are published by the Society of Petroleum Evaluation Engineers (SPEE) and the Petroleum Society of Canada (PSC) as the Canadian Oil and Gas Evaluation Handbook (COGEH), a 3-volume set.
- It is under revision.

COGEH NI-51-101 & ROTR
(Resources Other than Reserves)



Chance of **Commerciality** of project applied

Estimates based on **uncertainty** of sales quantities associated with a project

ROTR – Economics at all levels!

- Like reserves reports, **risked NPV** is shown before and after tax at the designated discount rates.

- This is an estimate of **expected monetary value adjusted for risk**; it should not be viewed in the same manner as a NPV for reserves; it is to assist in reaching an opinion of the relative merit versus similar projects, and the **likelihood that the company would proceed with investments in this project.**

- At the Resource level, **Volumes** are always one of the largest uncertainties, and seismic is almost always the key technology to reduce that uncertainty.

WHAT CONSTITUTES “RELIABLE TECHNOLOGY”

What is "Reliable Technology"?

- SEC "Final Rule" (Dec 2008) Definition #25
  - **RELIABLE TECHNOLOGY** is a grouping of one or more technologies (including computational methods) that have been field tested and have been demonstrated to provide reasonably certain results with consistency and repeatability in the formation being evaluated or in an analogous formation.
- USES
  - **Highest Known Oil** (Definition 17- Possible Reserves, Definition 22 -Proved Reserves)
  - **Lowest Known Oil** (Definition 22 Proved Reserves)
  - **Undeveloped Reserves** – any category (Definition 31)

What is "Reliable Technology"?

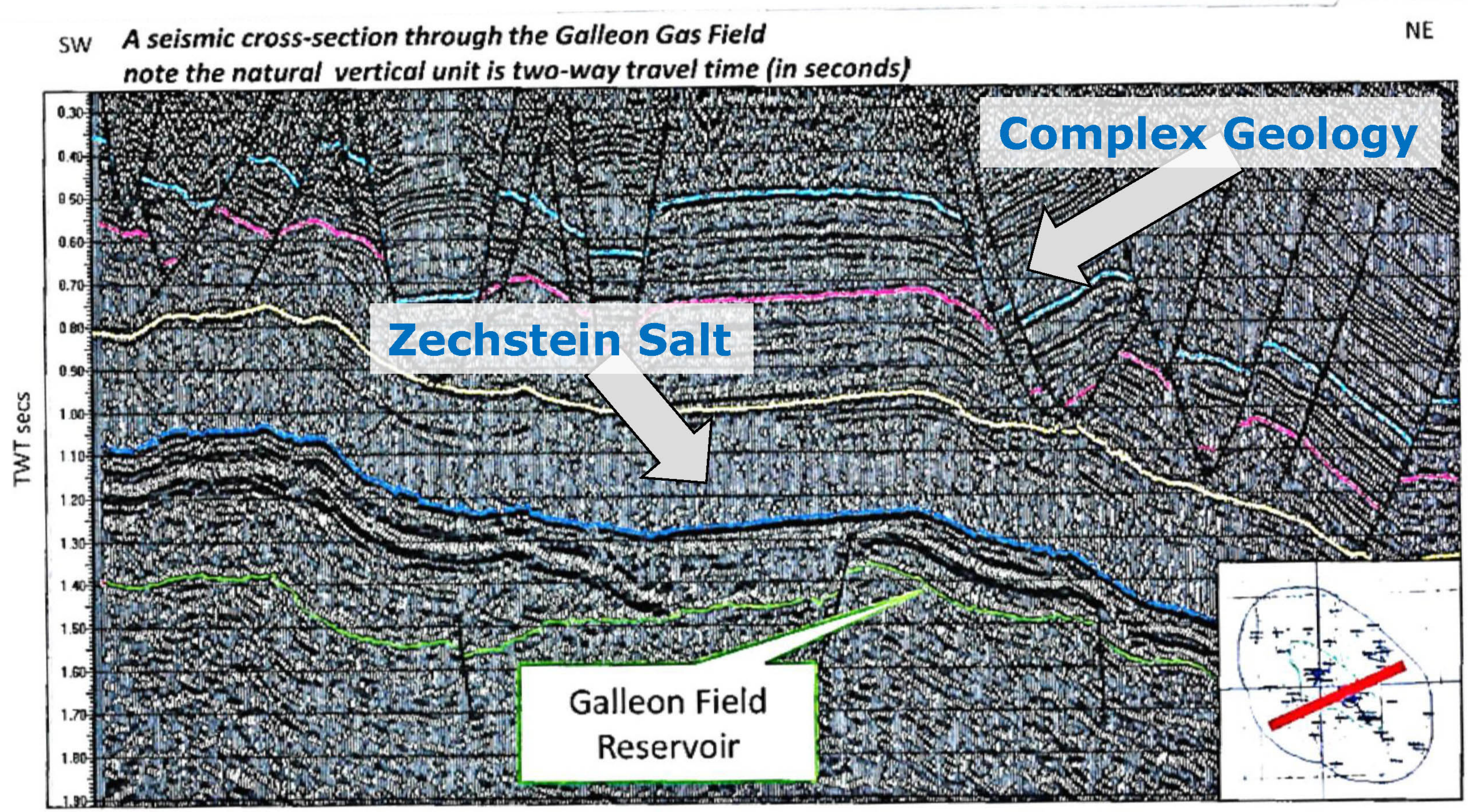
- Do not ask "Can I show how it could work?"
- It is better to ask "Can I demonstrate how it could fail and then show that it does NOT fail?"
  - A harder and more rigorous challenge but doable

(Modified from the 2015 SPEE Presentation by R.Smith, & R.Sidle, Satisfying the Requirement for Establishing Reliable Technology. Does the Argument Meet the Criteria?")

PRACTICAL APPLICATIONS AND CASE STUDIES IN ASSESSING RESERVES

3D Applications

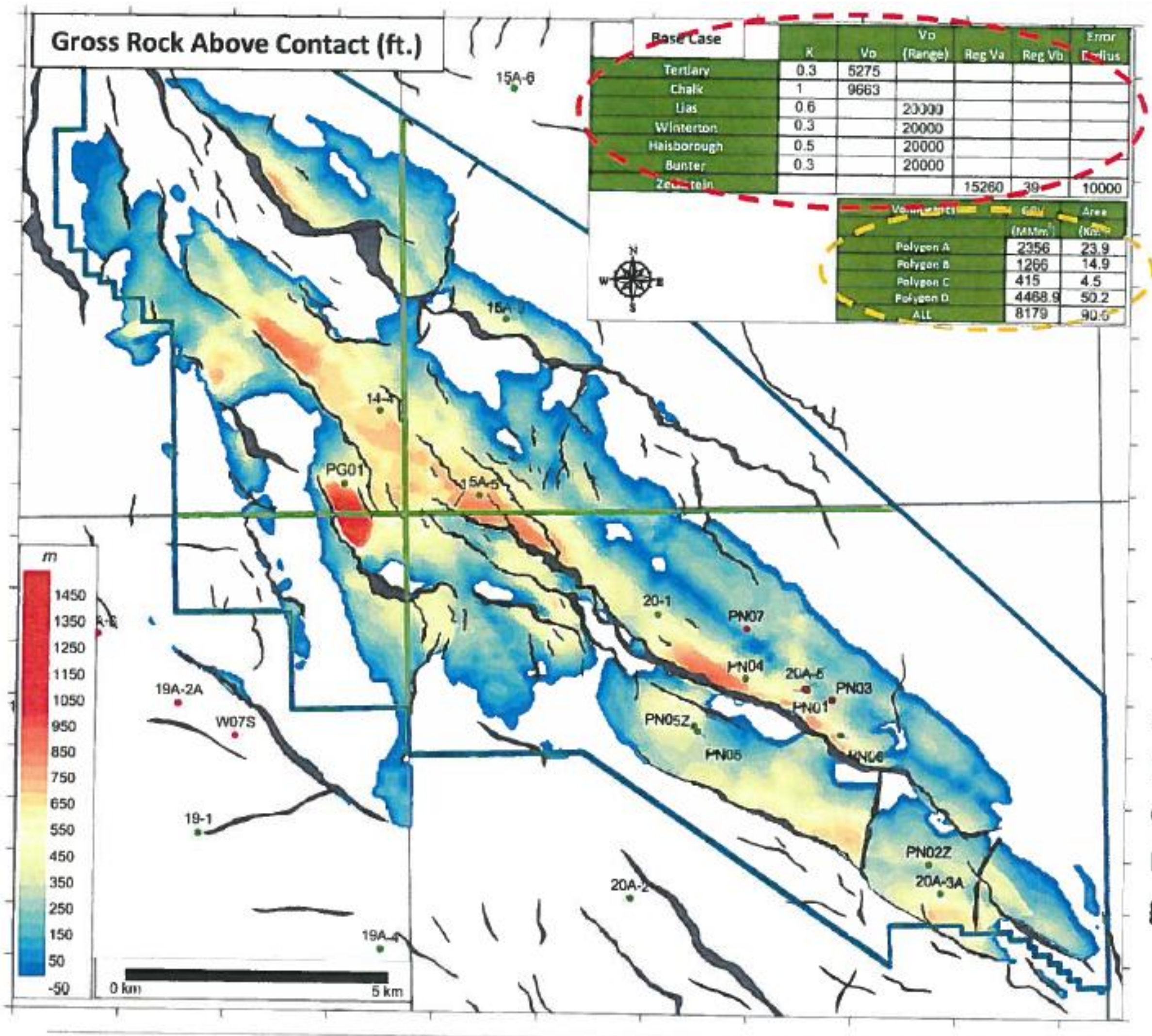
Shell Galleon Field – Example of Depth Uncertainty



The shallower geology is quite complex; this creates significant uncertainty when time is turned into depth.

Depth Conversion using Multi-layers

Shell Galleon Field – Example of Depth Uncertainty

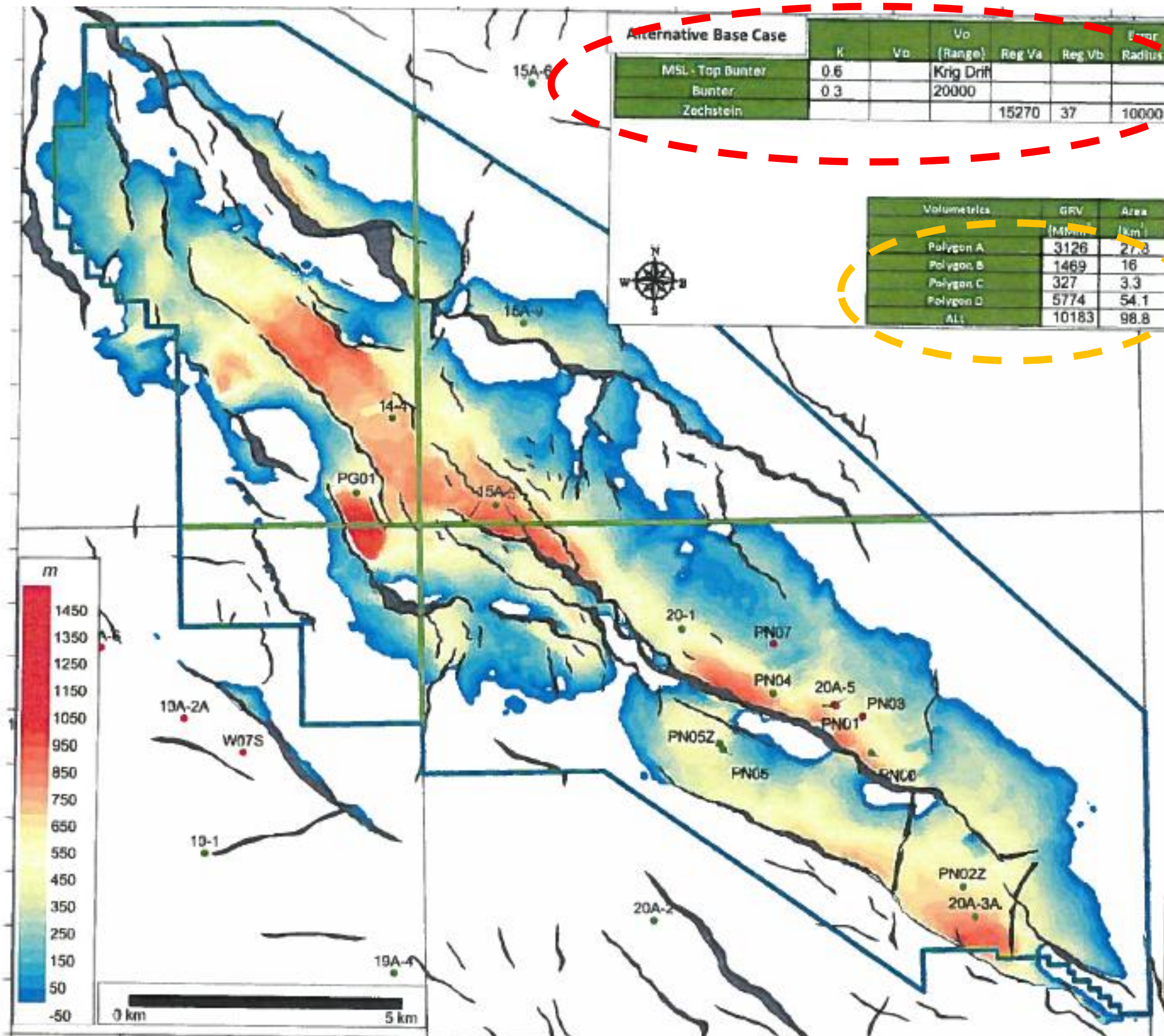


GRV= 8179 MMm3

3D Seismic Data and its Role in the Estimation of Resources, 52nd SPEE Annual Meeting, 2015

Different Velocity Model Through Salt

Shell Galleon Field – Example of Depth Uncertainty



Alternative Base Case	K	Vo	Vo (Range)	Reg Va	Reg Vb	Error Radius
MSL - Top Bunter	0.6		Krig Drift			
Bunter	0.3		20000			
Zechstein				15270	37	10000

Volumetrics	GRV (MMm³)	Area (km²)
Polygon A	3126	27.8
Polygon B	1469	16
Polygon C	327	3.3
Polygon D	5774	54.1
ALL	10183	98.8

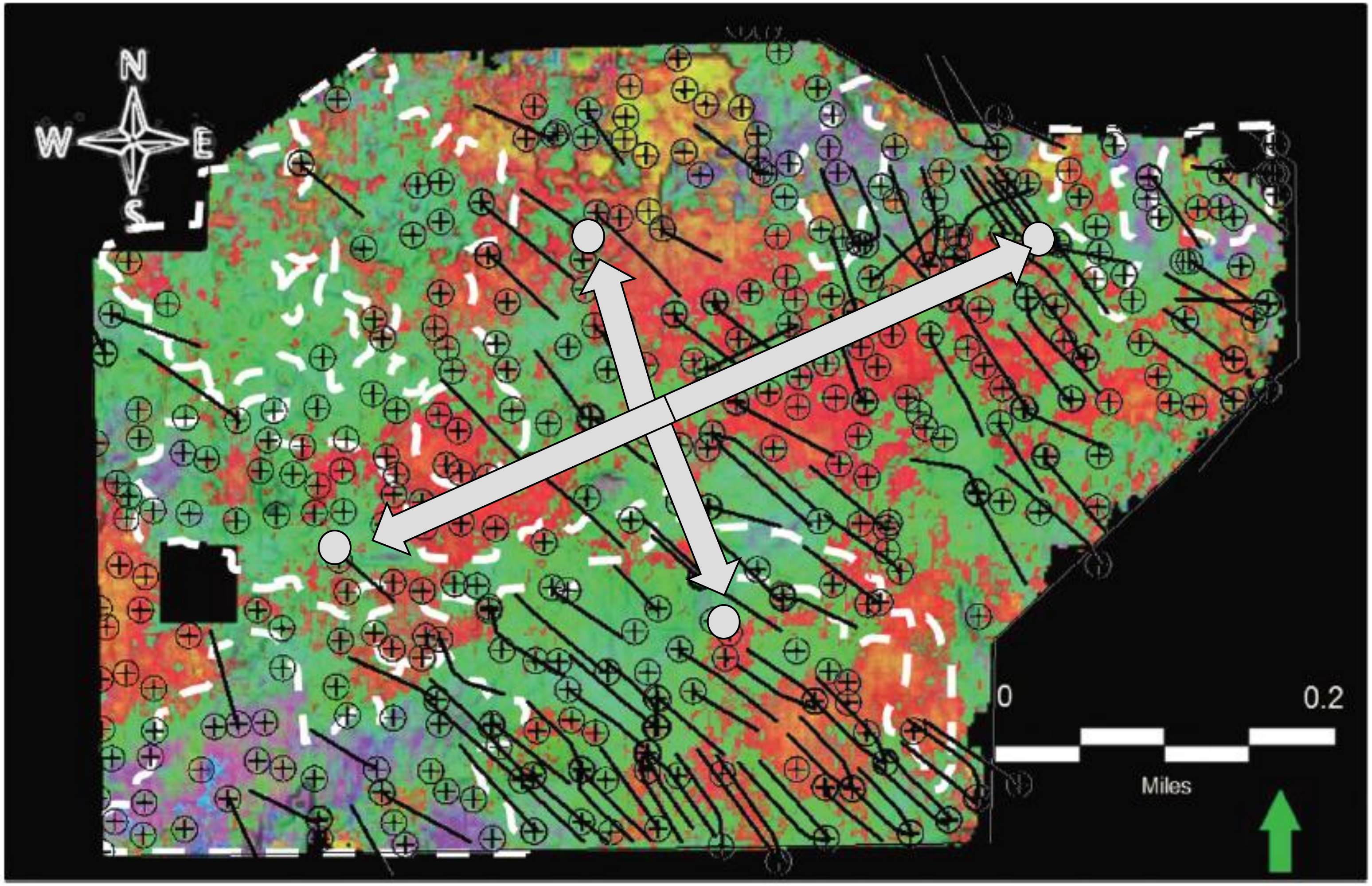
GRV= 10183 MMm3

20% Increase in GRV!

3D Seismic Data and its Role in the Estimation of Resources, 52nd SPEE Annual Meeting, 2015

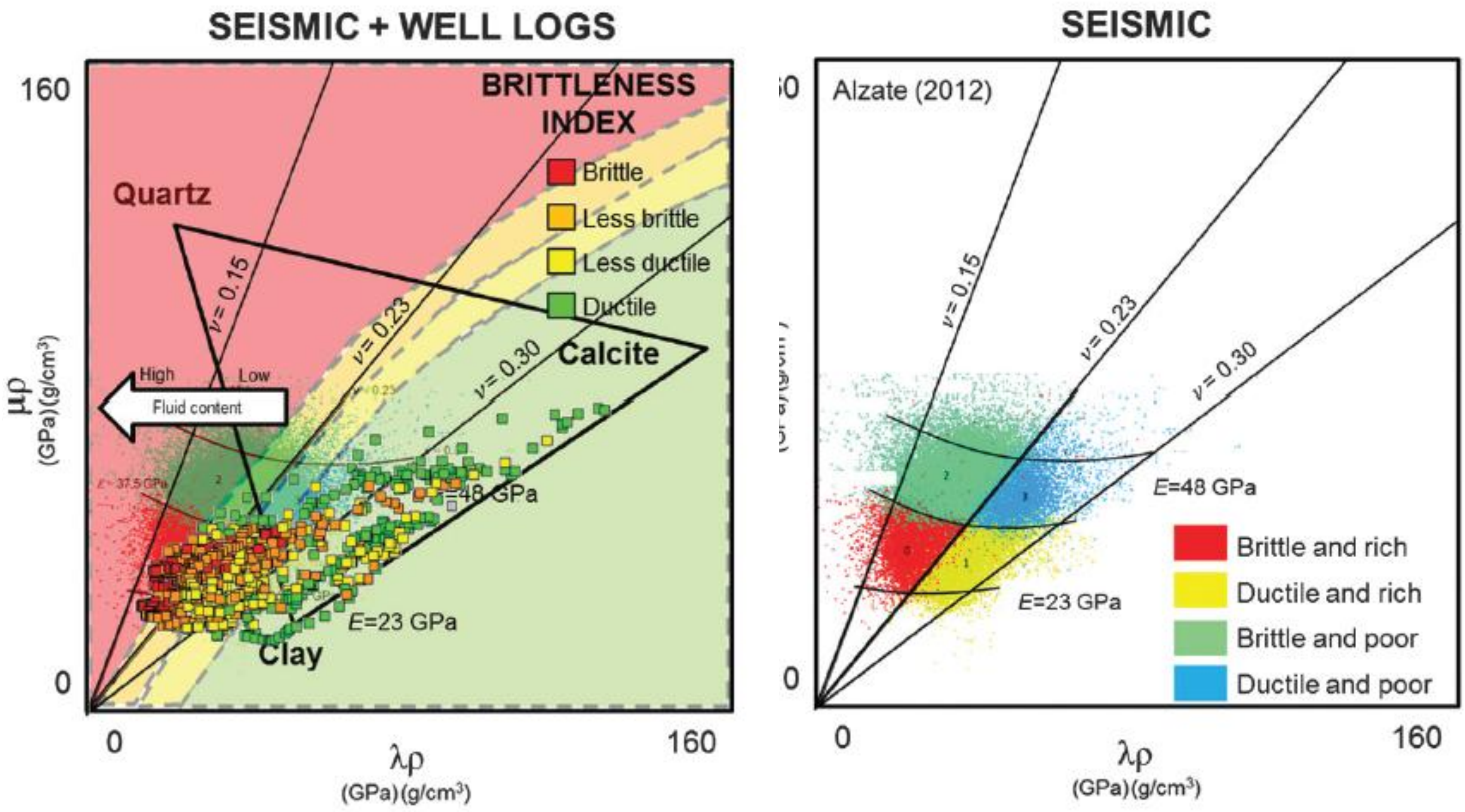
3D Applications

Use of 3D for Reservoir Prediction in the Barnett Shale



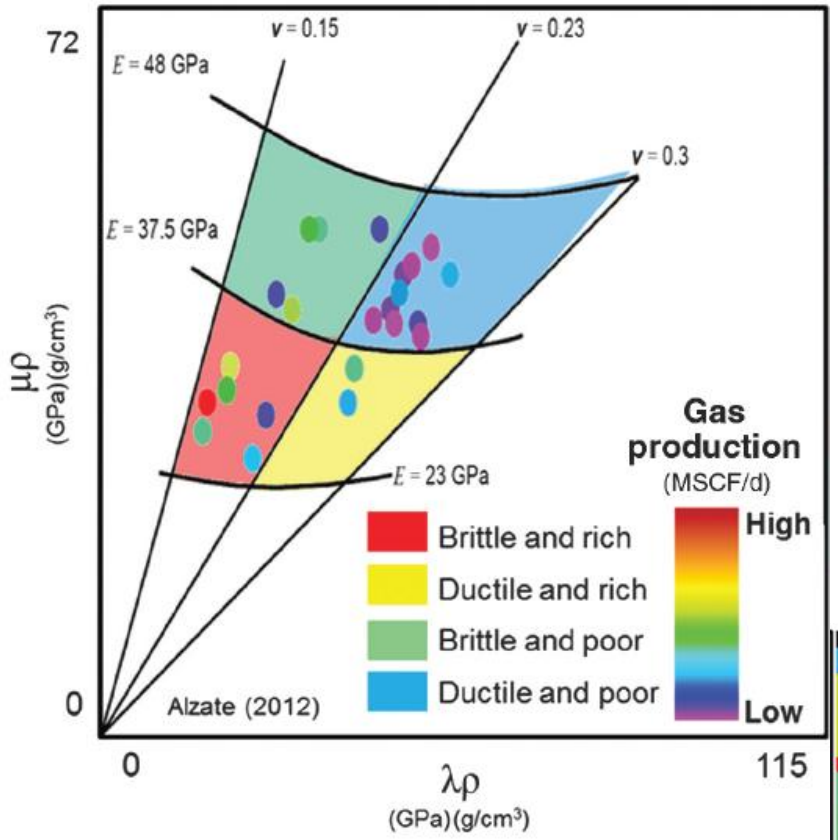
Altamar, R.P., & Marfurt, K.J., 2015, Identification of brittle/ductile areas in unconventional reservoirs using seismic and microseismic data, Interpretation T233-243.

Tying 3D to Well Petrophysics for Reservoir Prediction



Altamar, R.P., & Marfurt, K.J., 2015, Identification of brittle/ductile areas in unconventional reservoirs using seismic and microseismic data, Interpretation T233-243.

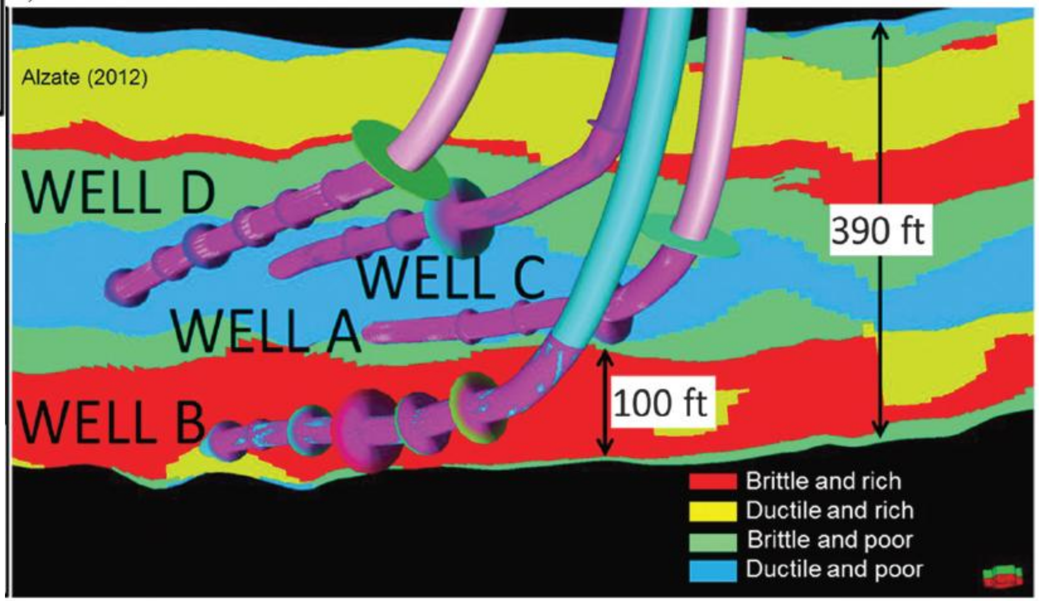
Log, Seismic and Production Match



Seismic prediction of production “rock types”

Have a good correlation against gas production

Seismic Rock Types are matched at Log and Reservoir Scale.



Altamar, R.P., & Marfurt, K.J., 2015, Identification of brittle/ductile areas in unconventional reservoirs using seismic and microseismic data, Interpretation T233-243.

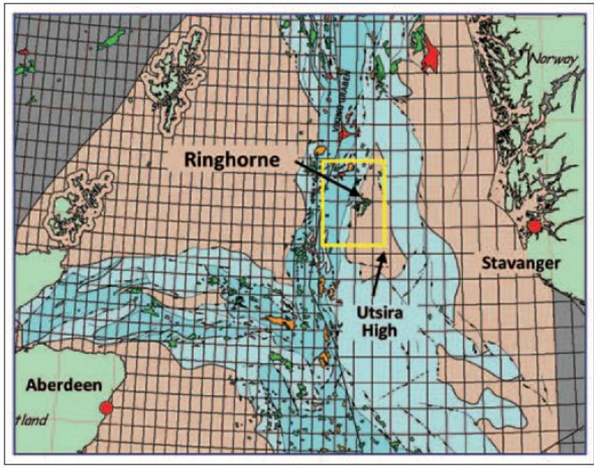
4D Applications

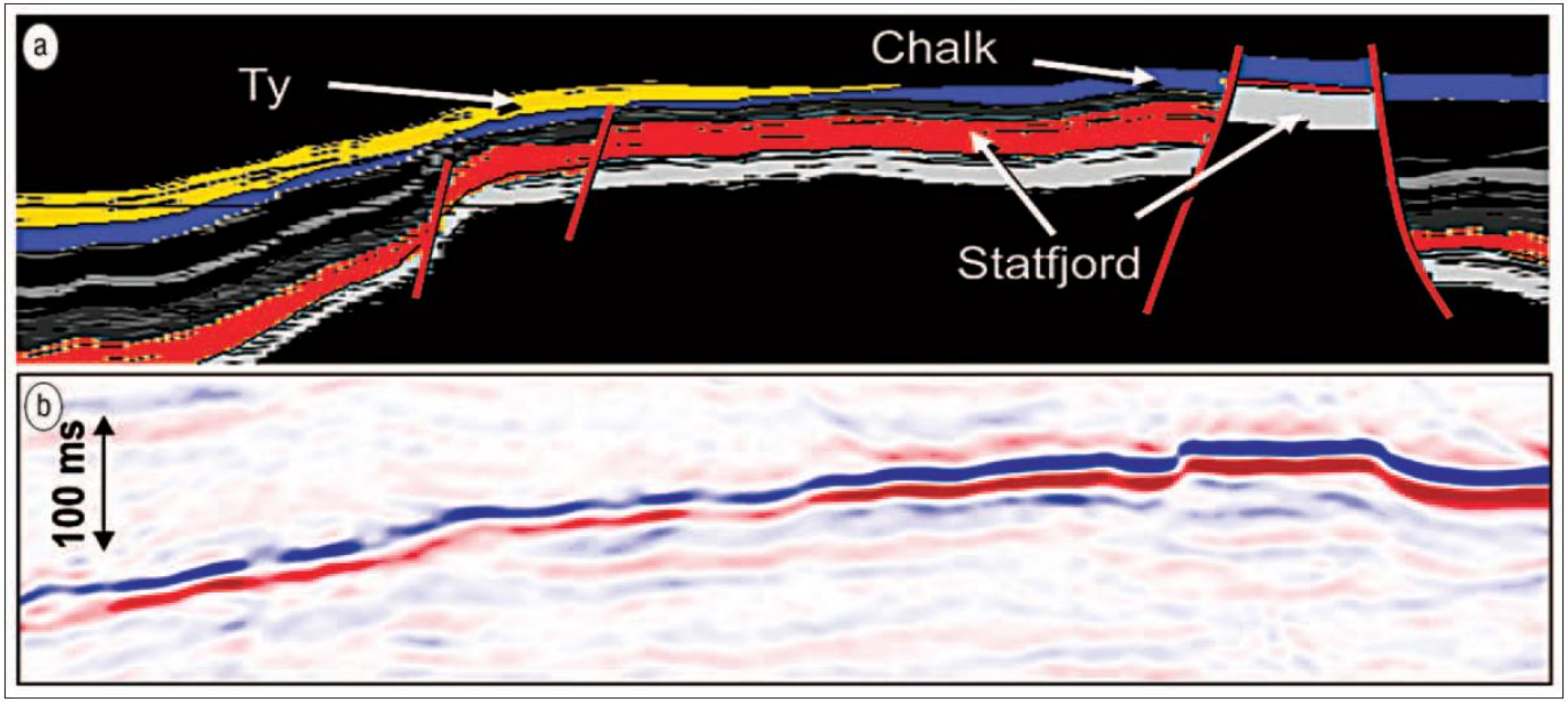
Ringhorne Field discovered in 1997

Main Production from Statfjord Fluvial reservoirs

Secondary Reservoir is Post Chalk Ty Deep Water clastics

Natural water Drive, light oil, 30% Ø, single wavelet

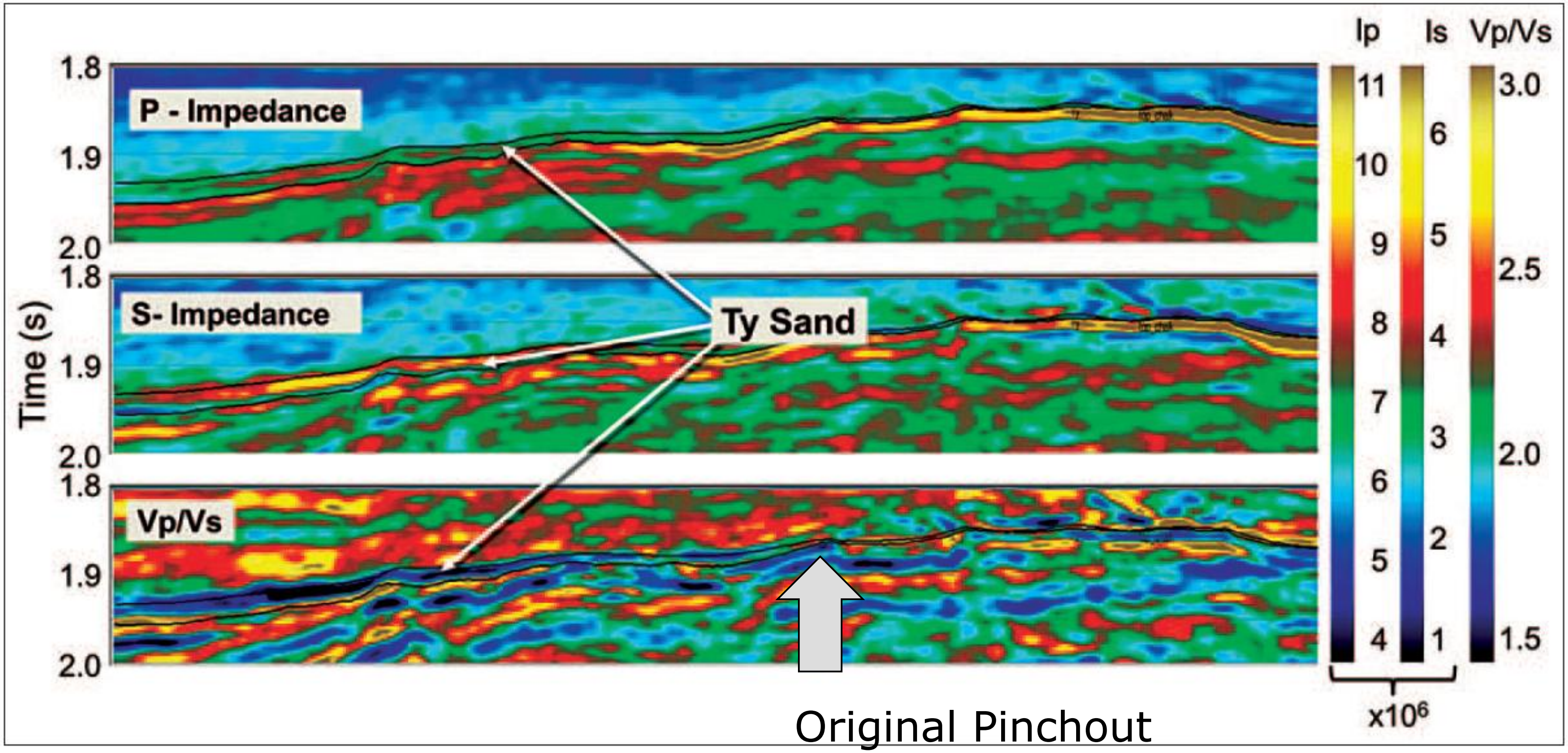




Johnston, D. & Laugier, B., 2012, Resource assessment based on 4D seismic and inversion at Ringhorne Field, Norwegian North Sea, TLE Sept. 2012.

4D Applications

Use of Vp\Vs Inversion to interpret the updip pinchout of the reservoir

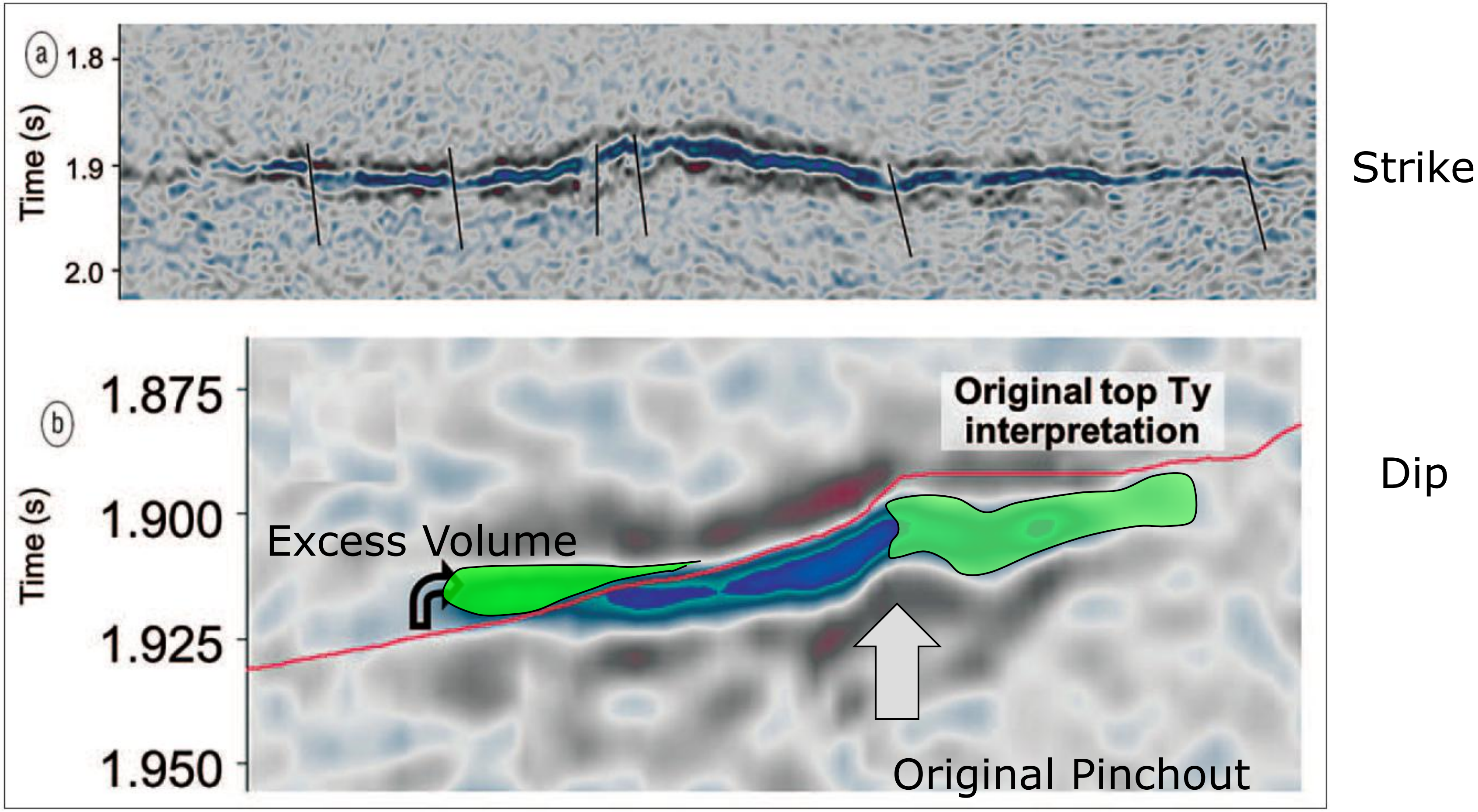


Johnston, D. & Laugier, B., 2012, Resource assessment based on 4D seismic and inversion at Ringhorne Field, Norwegian North Sea, TLE Sept. 2012.

4D Applications

3 New 4D volumes, acquired 3 years apart, with excellent acquisition overlap parameters

Processing with Quadrature-Phase 4D difference Volumes



Johnston, D. & Laugier, B., 2012, Resource assessment based on 4D seismic and inversion at Ringhorne Field, Norwegian North Sea, TLE Sept. 2012.

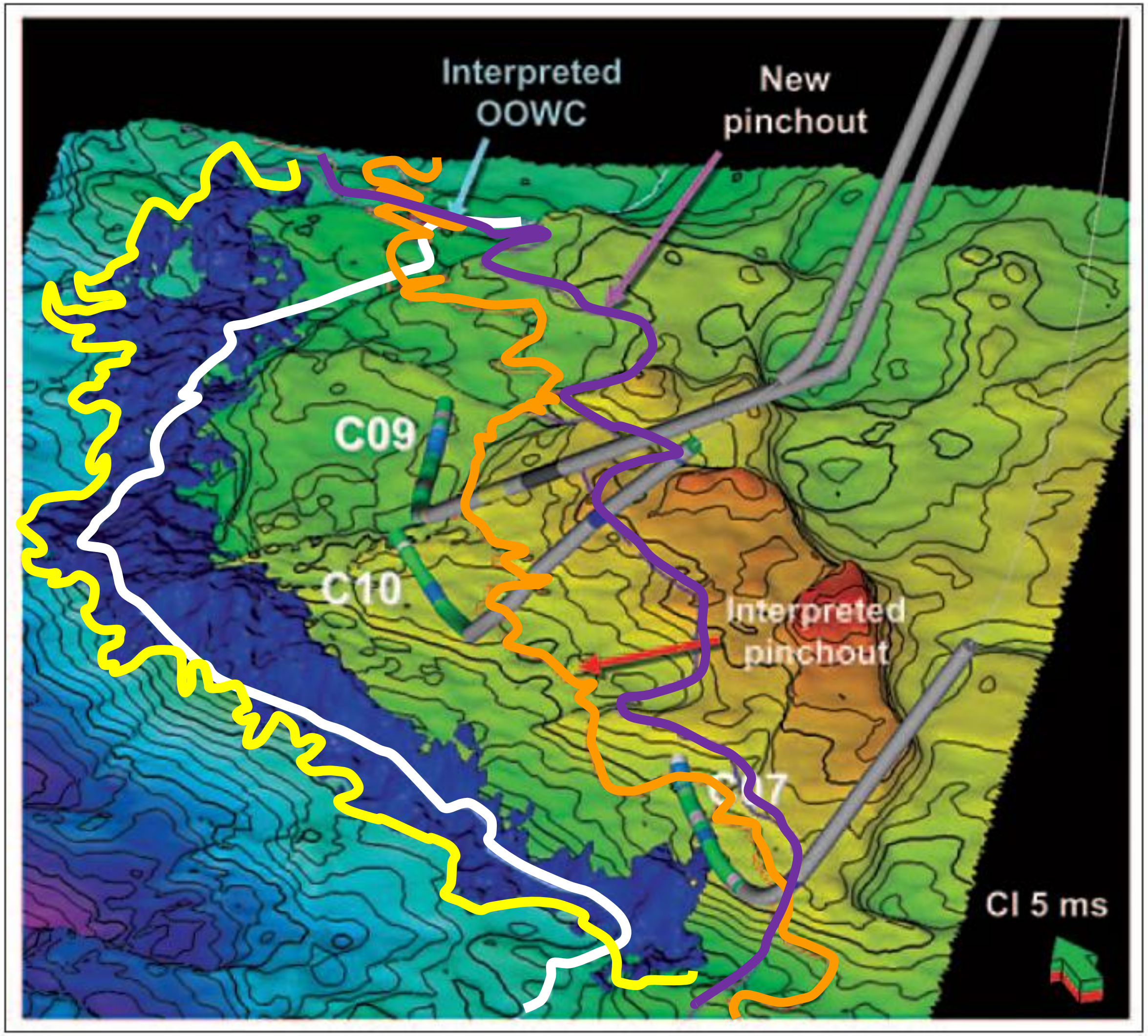
4D Applications

The 4D inversions explained

A) Why water breakthrough was not being seen

B) Why pressures were being maintained

C) Allowed a 40% increases in Reserves!



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CONCLUSIONS

Conclusions

- The PRMS, NI-51-101 and SEC have SIMILAR but slightly DIFFERENT Rules with respect to Seismic usage.
- The PRMS and NI-51-101 have more written guidance, but the SEC has more case studies (examples).
- Increasing acceptance as reservoir evaluation tool
- All refer to out of date technology but allow for new “reliable technology.”
- **Any seismic method must be combined with other technology to satisfy “reliable technology.”**

Acknowledgements

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The authors also acknowledge the authors of several papers we have cited in this presentation and have listed their full publication on the references slide.

References

- 3D Seismic Data and its Role in the Estimation of Resources, 52nd SPEE Annual Meeting, 2015
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