

Geology and Geophysics in Reserve Estimates

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for

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Geology and Geophysics in Reserve Estimates

Outline

Overview, Perspective & Context
Recent Changes & Trends -Geology
Recent Changes & Trends - Geophysics
Reservoir Characterization
Reliability of Predictions & Rock Properties
Conclusions
Summary



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Overview, Perspective and Context

Reserve auditors are really no different than financial auditors.

Switching reserve auditors every year would be frowned upon in North American business circles.

Just as a financial auditor does not want to see discrepancies and wishes to see everything in order according to standard accounting practices, the reserve auditor wishes to find the same thing.

As properties evolve over the years from an exploratory mode, through an exploitation mode to a development mode, the amount of data and information typically increases, resulting in a narrowing of the error bars associated with defining the reserve.

Auditors are less inclined to support aggressively a minimalist technical approach.

The quality of technical rigor applied should be given more weighting in the reserve audit process.



Overview, Perspective & Context

- Historically, reserves reporting for the oil & gas industry have been predominantly driven by the engineering discipline.
- U.S. Securities and Exchange Commission (SEC) reserves reporting guidelines were revised in 2008
- The revisions were based upon the Petroleum Resources Management System (PRMS), most recently published in April 2007, which emphasized the importance of utilizing all geo-science and engineering data.
- Subsequently, heightened geo-science input for the reporting of reserves has been increasing.



Overview, Perspective & Context

- PRMS is sponsored by; the Society of Petroleum Engineers (SPE), The Society of Evaluation Engineers (SPEE), the World Petroleum Council (WPC), the American Society of Petroleum Geologists (AAPG) and the Society of Exploration Geophysicists (SEG)
- In November 2011, working with the SPE Oil and Gas Reserves Committee (SPE ORGC) published guidelines for the application of PRMS with chapter 3 dealing with Seismic Applications
- The SEG Oil & Gas Reserves Committee (SEG OGRC) is actively supporting the roll-out of the application guidelines of PRMS, hosting workshops in Lima Peru (May 2012), Mexico (September 2012) with other SPE workshops held in 2013.



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Recent Trends & Changes – Geology

Reservoirs are not a “tank”, they can have considerable heterogeneity...

Lithologic variations, petrography (thin section analysis and mineralogy) along with core descriptions and laboratory analysis are being reviewed more frequently when such data and information is available, hence reservoir description is becoming more detailed.

Paleospastic restorations are being used to substantiate if a complex structural interpretation is technically viable.

The depositional model and structural evolution of the reservoir are additional elements being reviewed with greater frequency.

A well described geologic model is often being requested by reserve auditors.



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Recent Trends & Changes – Geophysics

Historically, the contribution of geophysics through the use of seismic data has had limited impact, often just defining the areal extent of the reserve for volumetric analysis.

Technological developments during the past couple of decades suggest that it is possible for seismic data to be used to predict reservoir properties through reservoir characterization.

These predictions, if well calibrated geologically, can materially impact reserve bookings, particularly probable and possible reserves, not to mention resource potential.

The level of technical rigor applied by the client company becomes a key component of the geophysical contribution to reserve analysis exercise.

In this regard, effective reserve auditors will guide their clients with key measures to undertake for next year's audit.



Recent Trends & Changes – Geophysics

For some new exploration plays with perhaps a single discovery well and no production history, the geophysical data may be the most valuable science for assessing the Original Oil In Place (OOIP).

For more mature plays, considerable reservoir characterization work could have been conducted resulting in descriptions of the reservoir in the form of rock properties.

However, not all plays are conducive to seismic contribution as vertical resolution may be an issue to the seismic method.

Not all long-time producing properties even have any seismic data or if they do, it may only be 2D data. This may restrict the geophysical contribution to define a reserve.



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Reservoir Characterization

More integrated studies are more common for key core producing properties with production history



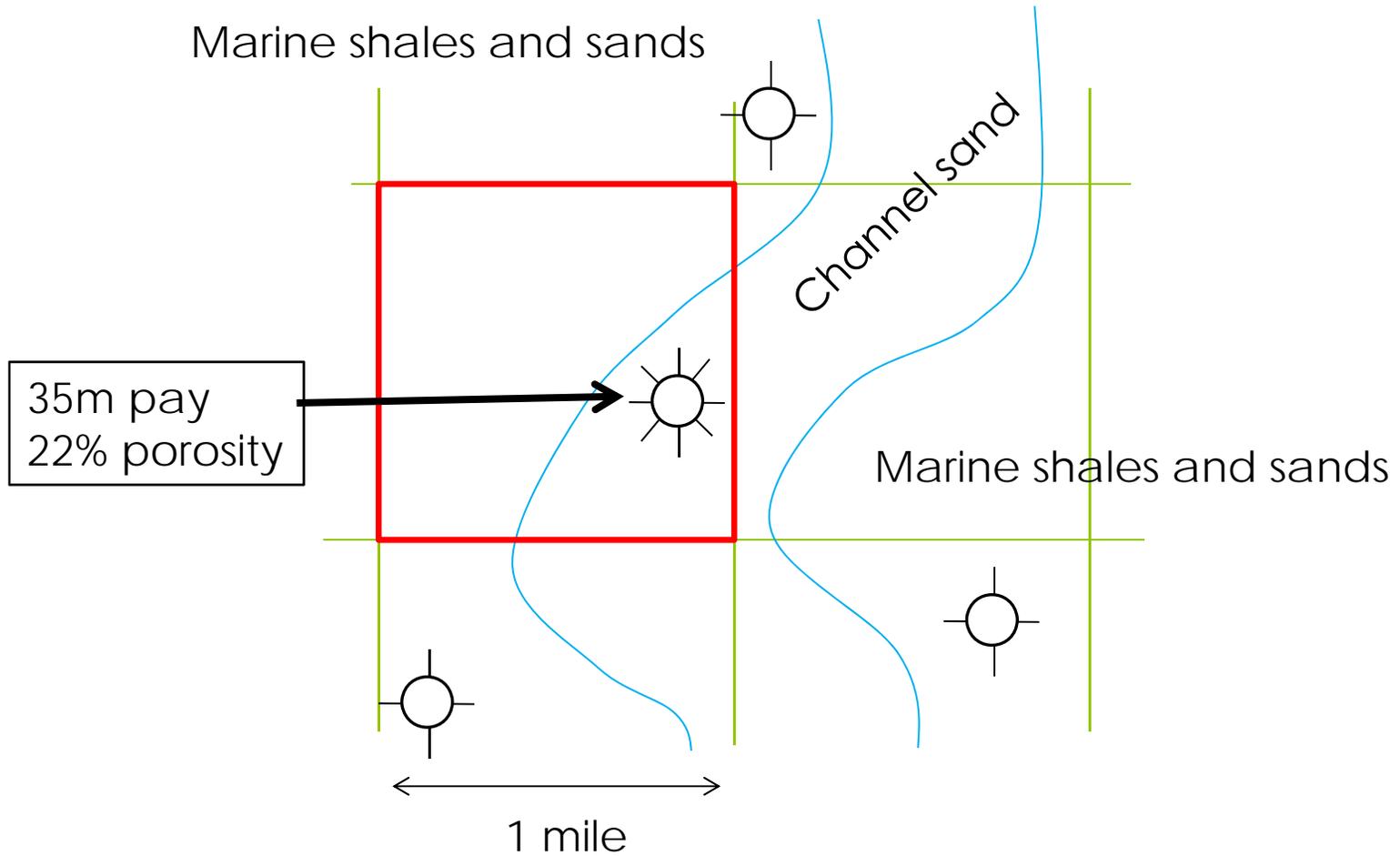
Heterogeneity is being described in terms of geobodies, each with its own rock properties and parameters

Properties being investigated more thoroughly are: porosity, vertical & horizontal permeability, mineralogy, diagenesis and faulting.

Seismic data has the advantage of looking between the wells (advantage is more pronounced for 3D data) but with poorer vertical resolution than well-logs yet combined together, spatial and vertical resolutions can be enhanced.

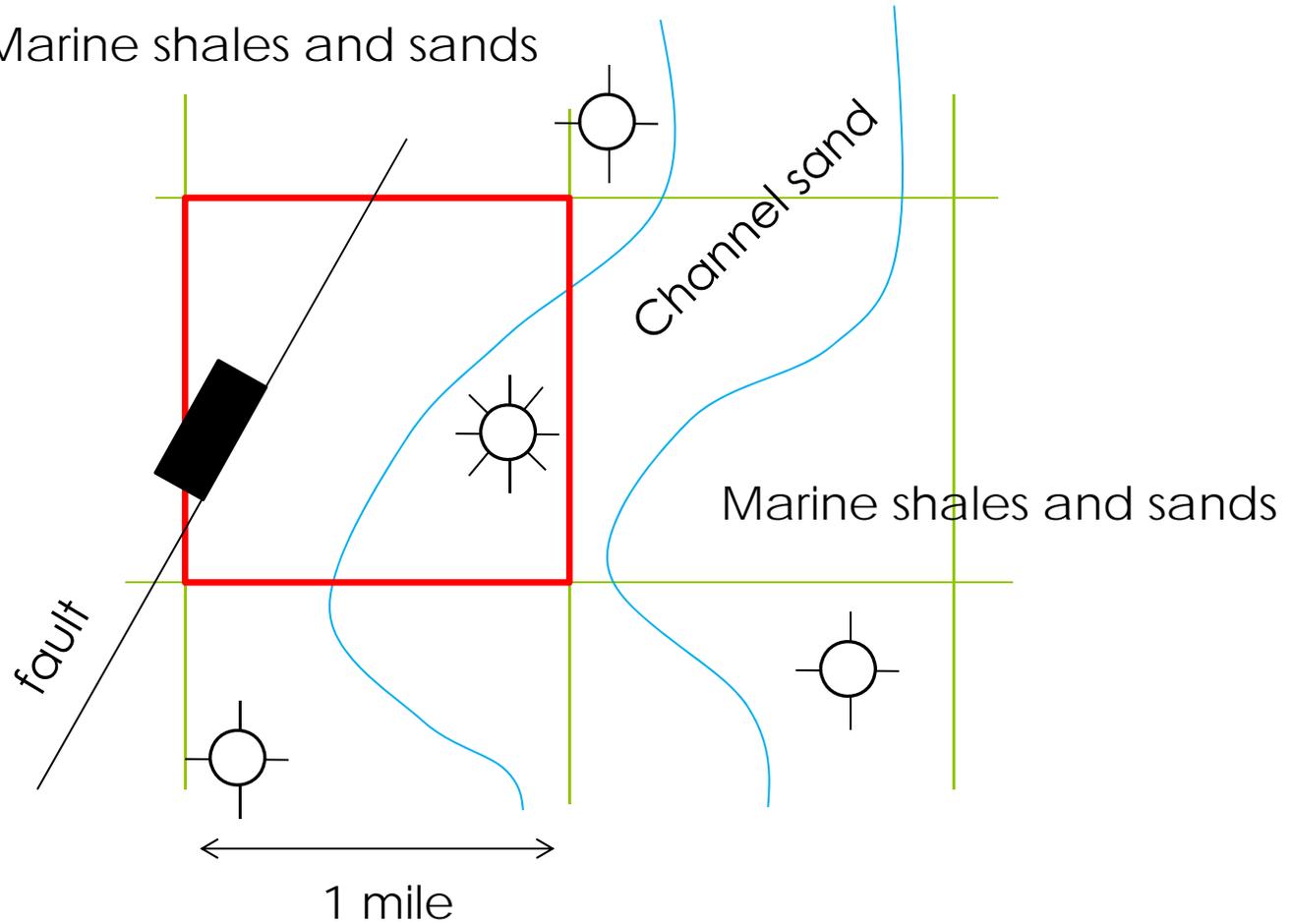


Example



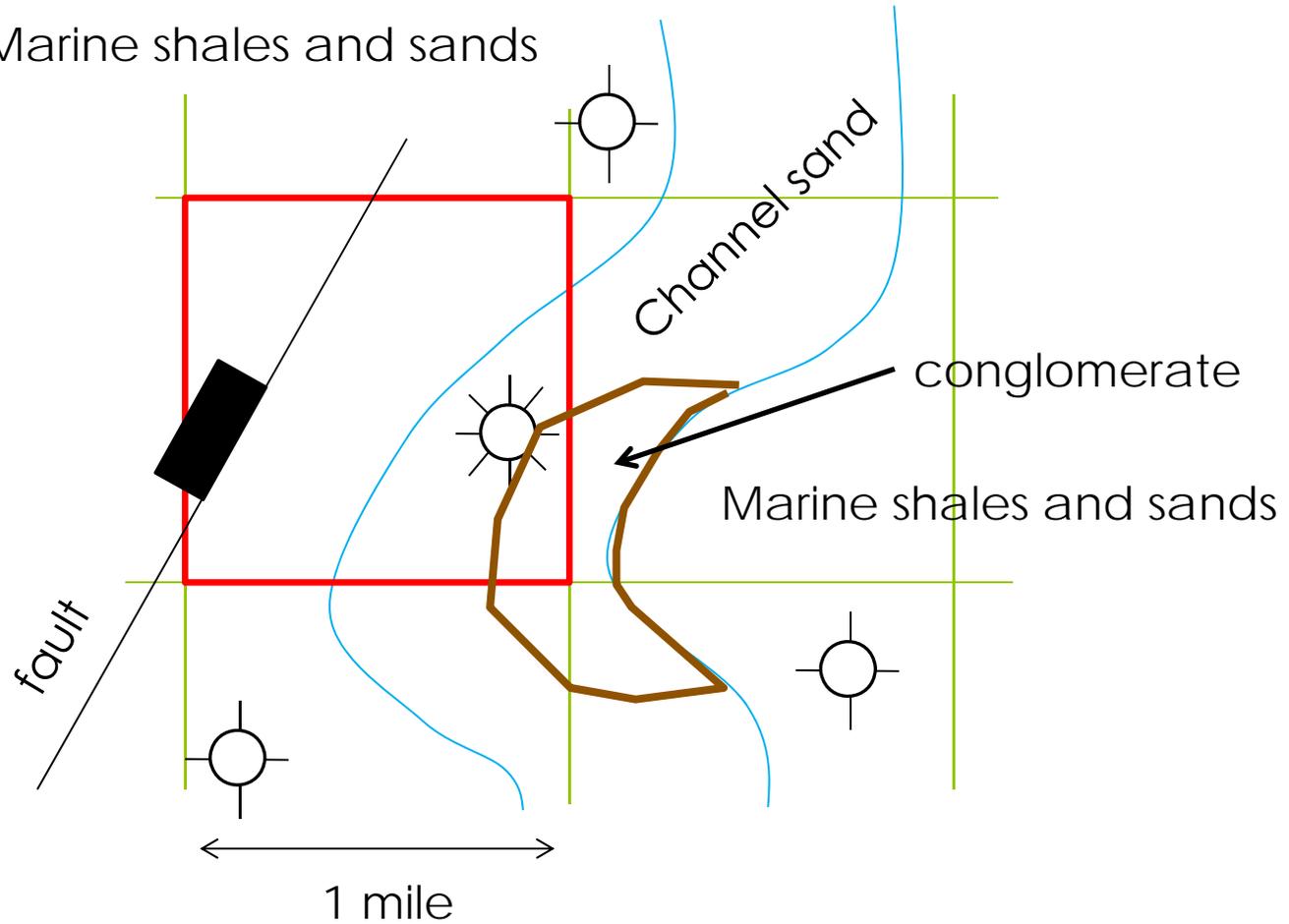
Example

Marine shales and sands

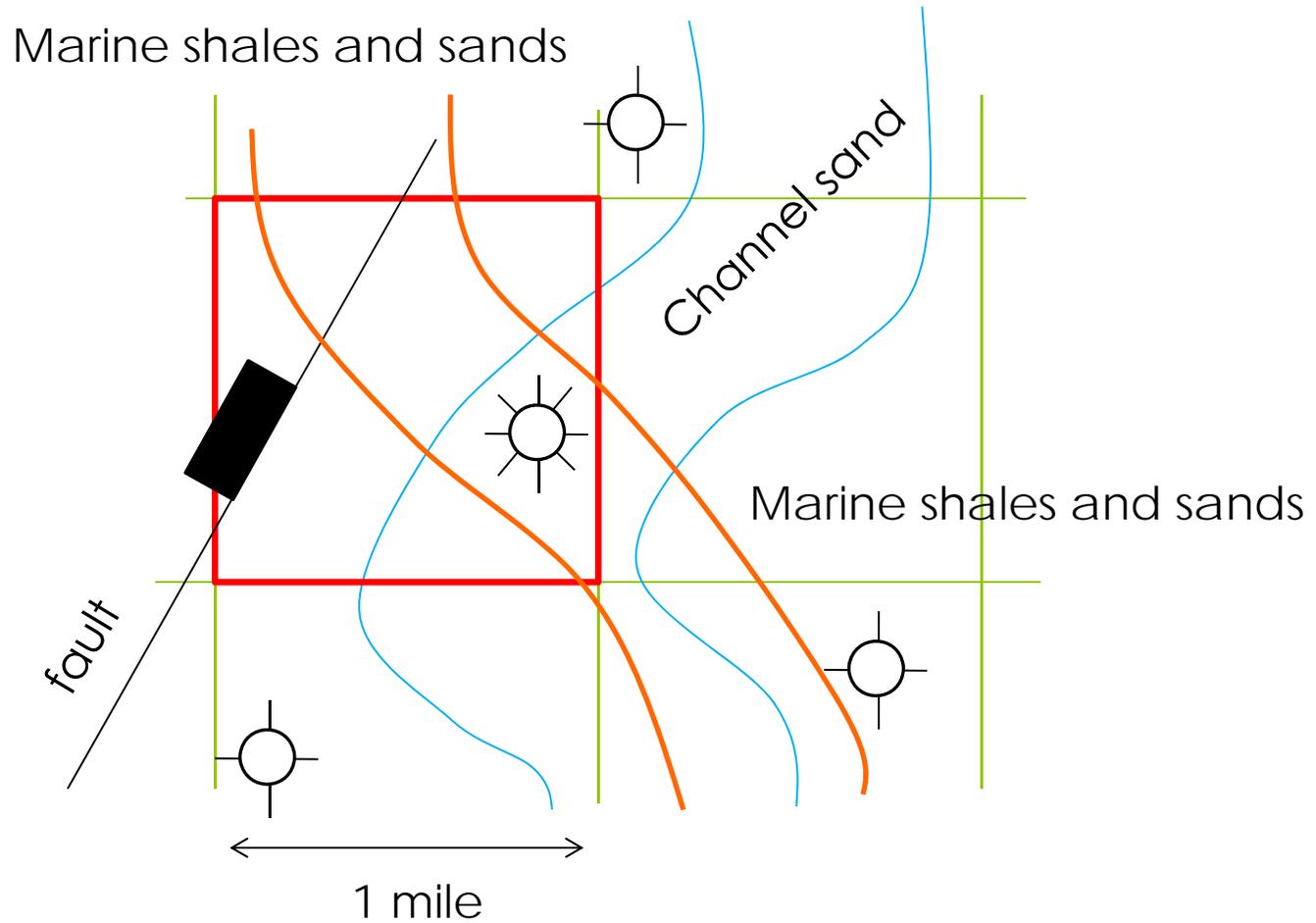


Example

Marine shales and sands



Example



Actually a 15m channel on top of a 20m channel

Porosity variations are common place predictions.

When the relationship between porosity and permeability is linear, permeability maps can be made from seismic data.

Lithologic variations, stress orientations, fault definition and variances in Poisson's Ratio and Young's modulus can all be inferred from seismic data, given the right conditions for resolution.

Cross-plotting these log parameters can lead to enhanced definition of reservoir properties.

Quantitative interpretation is the term to describe this integrated approach of geophysics, rock physics, geophysics and geology.

Seismic attributes used for calibration can include parameters such as M_{μ} , ρ , density, V_{Clay} , Poisson's Ratio, curvature, coherence, P-wave velocity, S-Wave velocity, AVO, AVAZ, etc....

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Reliability of Predictions of Rock Properties

Accuracy of predictions vary according to...

- data quality
- vertical & horizontal resolution limits
- quantity of data available
- degree of rigor associated with scientific calibration
- quality of calibration
- quantity of data
- etc...

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The general trend is for greater G&G technical rigor to be applied to fields by clients and in turn to be supplied to reserve auditors for review.

Not only all data but all information and knowledge as well should be supplied to abet the process.

Innovations in seismic technology to permit the characterization of the reservoir and potentially describe rock properties can help define a reserve, particularly affecting probable, possible and resource potential categories.

Quantitative interpretation and integrated studies make for the creation of better geo-models of the reservoir.

The level of technical rigor applied in addition to the quality of calibration is critical to extracting subtle detail

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