[PS]"3-D Close-the-Loop" Modeling of the Grosmont Reservoir*

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Search and Discovery Article #41661 (2015)**
Posted August 17, 2015

*Adapted from poster presentation given at AAPG 2015 Annual Convention and Exhibition, Denver, Colorado, May 31 – June 3, 2015

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Abstract

The Grosmont platform in Alberta, Canada, holds one of the largest heavy oil accumulations in the world (400Bboe), of which 90Bboe are within Shell's current leasehold. Grosmont is a highly prolific, heterogeneous, fractured carbonate reservoir below an angular unconformity with well-developed sinkholes on the top of the carbonate. Shell's primary target zone within the Grosmont platform is the Upper Ireton formation, a Late Devonian, Frasnian, intertidal platform dolomite. The reservoir depth of less than 400 meters provided the ability to acquire high resolution seismic. Using this seismic data in a "3D Close-the-Loop" study enabled us to check the validity of the existing reservoir model and to better understand spatial distribution of porosity in the Upper Ireton formation. This work integrated an existing static reservoir model from Petrel, with high-resolution seismic data and well logs, calibrated with a carbonate rock physics model. The main purpose of this study was to use the best match between the synthetic seismic response from the existing static reservoir model and re-processed seismic data for future Petrel model updates. The work was executed in three steps: (1) 3D Check-the-Loop: comparison between the synthetic response of the original 3D static reservoir model from Petrel with the re-processed seismic data. (2) 3D Close-the-Loop: adjustment of various rock physics parameters using Shell proprietary inversion software in order to get the best match/fit between generated synthetic and re-processed seismic volumes. (3) QC and application of the results: update of porosity and layer thickness properties in the static reservoir model. After multiple iterations, we successfully executed a "3D Close-the-Loop" workflow using our Probabilistic Seismic Inversion (PSI) algorithm. The subsequent QC step showed a reasonable match between the porosities derived from XStream PSI inversion and the measured porosities at the available vertical and lateral blind wells within the seismic volume. High resolution, multiple trend porosity maps of each single zone were then used as new spatial porosity distributions in the static model instead of the old, single trend maps covering several zones.

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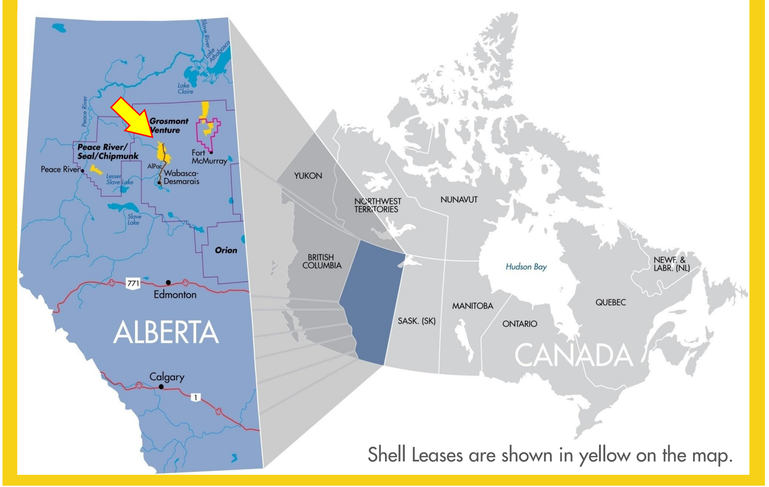
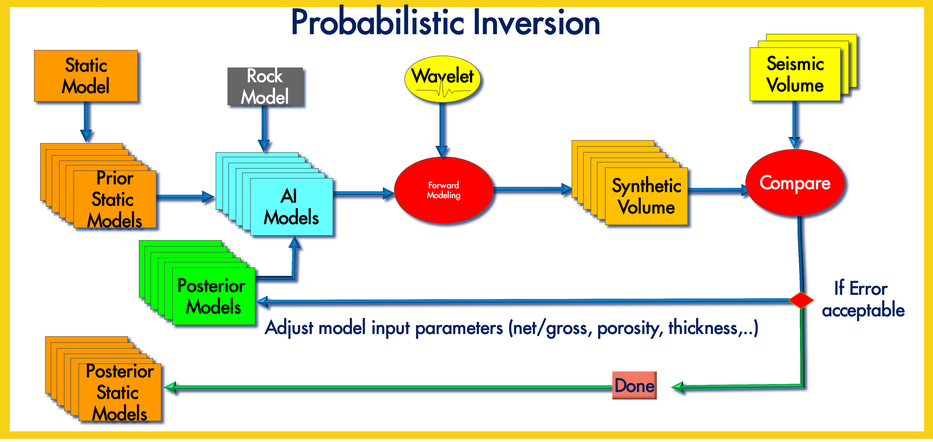
Location



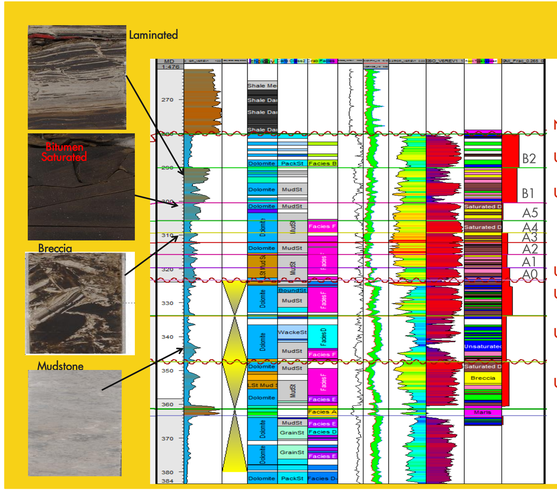
Shell Leases are shown in yellow on the map.

Promise – Layer Based Inversion

To determine the validity of the reservoir model by identifying key inconsistencies between the reservoir model, well logs and seismic, and to provide suggestions for model property and/or structure update that would improve the model-to-seismic match.



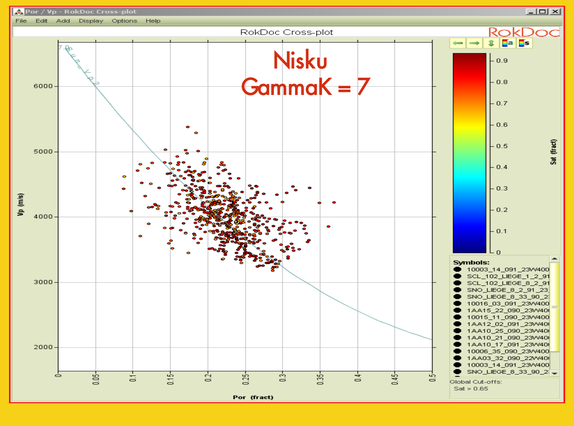
Grosmont Type Log

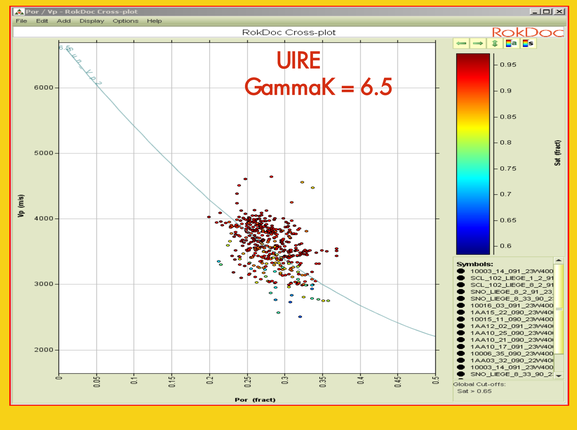


Upper Ireton Reservoir Characteristics

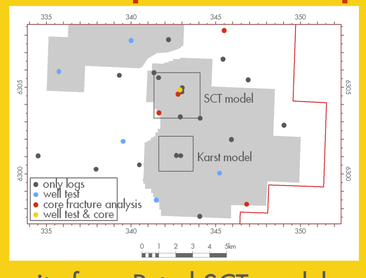
- Dolomite with thin laminations, brecciated zones, corrosion intervals.
- Depth 300 m
- Temperature 11°C @ 320 m
- Pressure 1.4 MPa @ 320 m
- Bitumen saturation 80-90%
- Porosity ~30% (Matrix)
- Horizontal matrix permeability range 20-200 mD; fracture permeability range 2-30 Darcies
- Bitumen viscosity 1,800,000+ cp
- Stratiform relationships across northern half of lease

Rock Physics Parameters

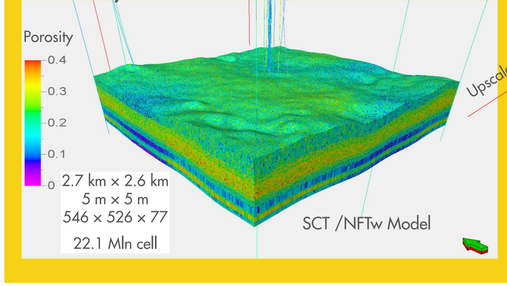




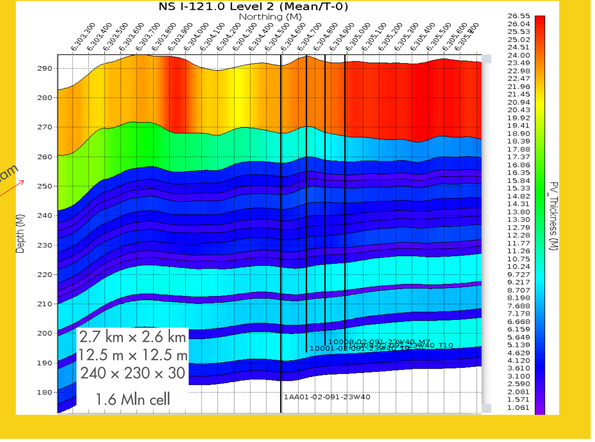
Petrel Depth Model (properties and grid size)



Porosity from Petrel SCT model



Cross-section from XStream after upscaling (seismic scale)



"3D Close-the-Loop" Modeling of the Grosmont Reservoir

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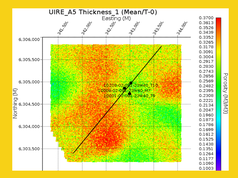
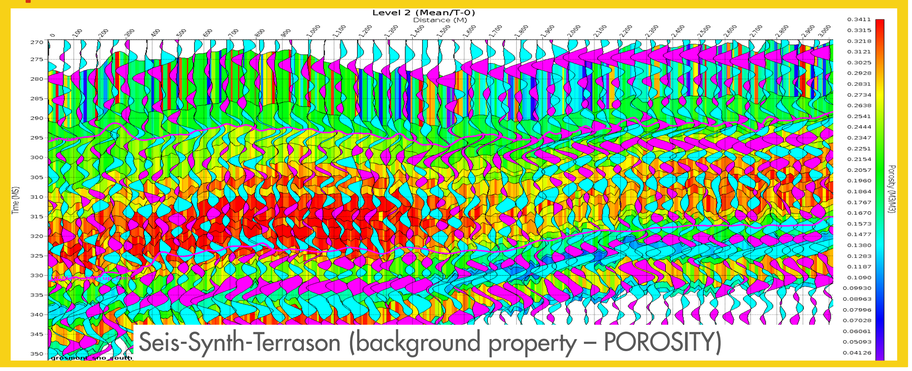
3D Check-the-Loop Results

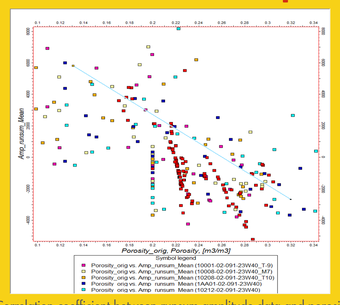


Amplitudes are showing the difference between original seismic data and generated synthetics based input data

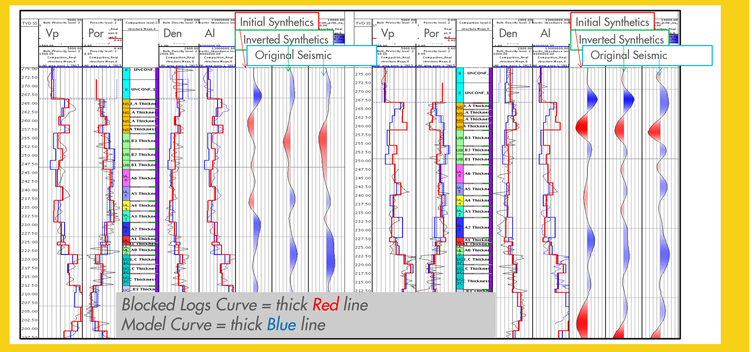


Seis-Synth-Terrason (background property – POROSITY)

Well Correlation plots



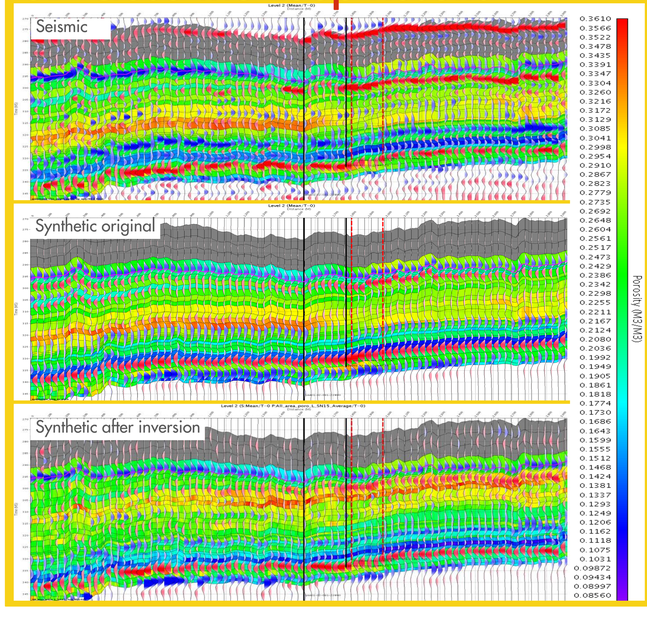
- Correlation coefficient between runsum amplitude data and porosity is 0.68
- The data are scattered
- Amplitude based porosity will be stochastically distributed during inversion



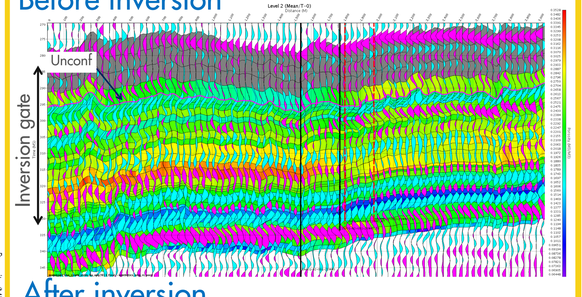
Blocked Logs Curve = thick Red line
Model Curve = thick Blue line

Based on details of existing Petrel model generation one major limitation was noticed. Porosity property was created using only one seismic attribute map available for entire Upper Ireton interval. This seismic amplitude attribute was generated within old seismic dataset at that moment and used as an additional parameter for better control of spatial distribution. Based on these investigations the new methodology/technique to create porosity property was used. The main idea of it is creature artificial "seismic porosity" property driven by seismic amplitudes (using re-processed volume) which won't be biased by spatial distribution from old map based on seismic before re-processing. The technique consists of the following: generation runsum data, extraction seismic amplitudes, cross-correlation amplitudes data with porosity logs at well location and populating new seismic porosity property using co-kriging method for the entire model.

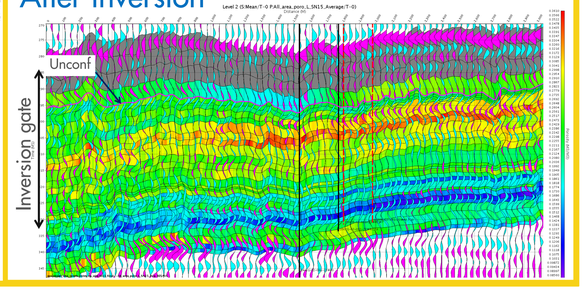
3D Close-the-Loop Results



Before inversion

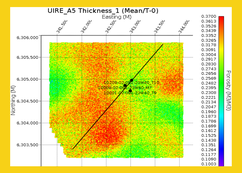


After inversion

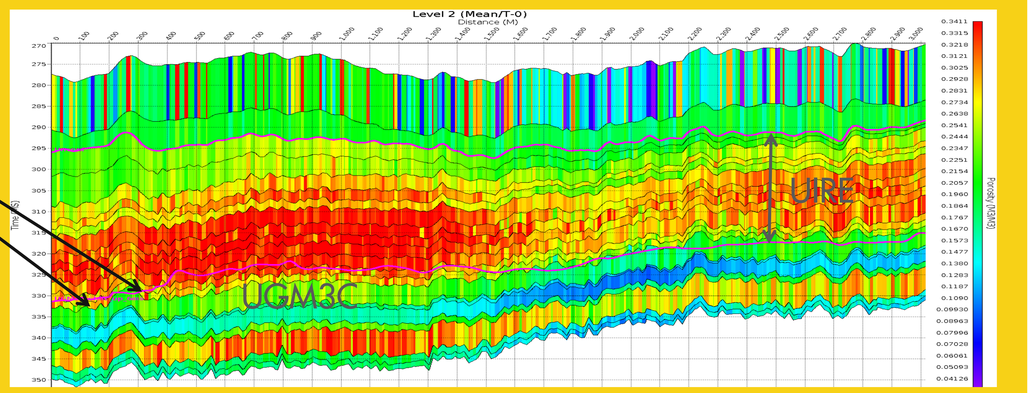


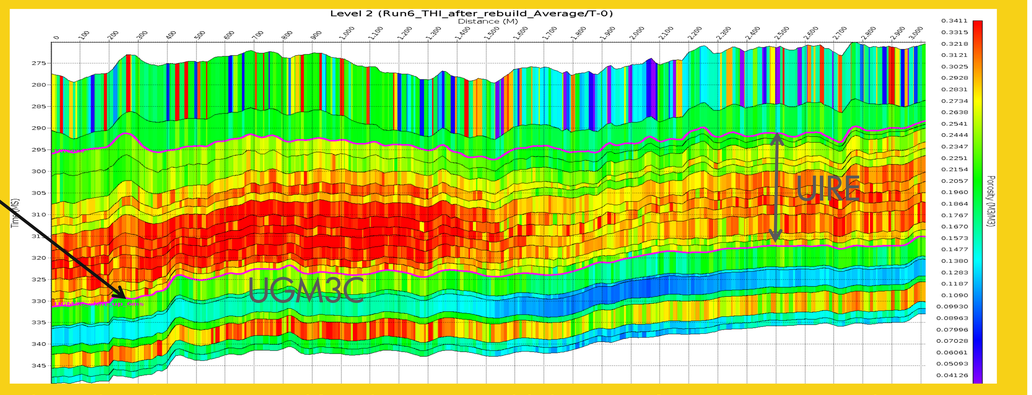
Time Horizon Inversion Results

Time difference (1-5ms) between interpreted horizon and modeled horizon after depth time conversion



The time horizon match was achieved

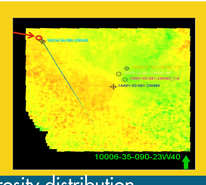


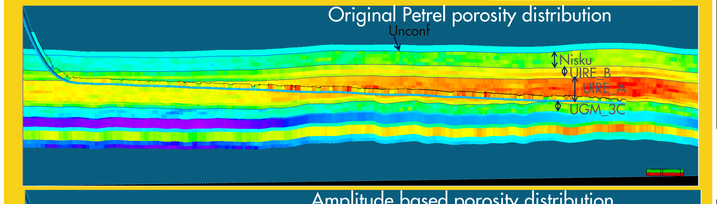


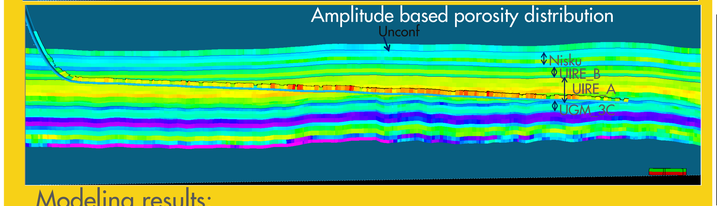
In order to match 3D seismic data with synthetics (generated from the existing model) the output of THI inversion was used as an input for 3D full inversion

QC and Conclusions

Long horizontal well





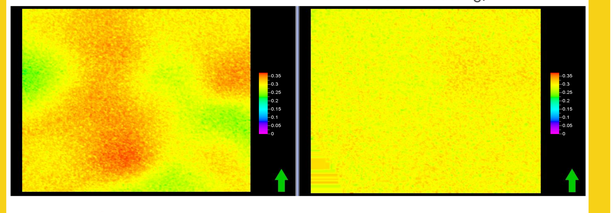


Modeling results:
- Matching Rock Physics model
- Successful 3D Close The Loop (PSI inversion) after multiple iterations including THI inversion
- Validation through several wells showed a reasonable match for the vertical wells and lateral heterogeneity in horizontal well
- Produced XStream porosity volume can be used for porosity distribution Petrel model update instead of old seismic single trend map
- XStream modeling process can be run in future using new NFTw seismic data

Porosity of UIRE A5

With old trend map

With new trend maps (from XStream modeling)



Porosity of UIRE A3

With old trend map

With new trend maps (from XStream modeling)