

PS Reservoir Delineation Using Spectral Decomposition, Spectral Inversion and Neural Network Analysis for an Oily Reservoir in Offshore Thailand*

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Abstract

The Songkhla Basin in offshore Thailand is an oily Tertiary rift basin, with lacustrine source rocks and reservoir sands. As no gas is present in this basin, traditional seismic attributes are not particularly helpful in identifying the black oil accumulations. Inversion to illuminate the presence of reservoir sands and optimally locate exploration and development drilling locations was very useful as part of a highly successful geophysical effort that resulted in significant reserve additions and new field discoveries. Early fast track and wedge model testing of the work flow resulted in the final stream of spectral decomposition, spectral inversion and neural network analysis, to derive the optimum combination of attributes to predict an accurate and useful target Vclay log 3D volume. The final inversion incorporated the total existing ~ 250 square miles of 3D seismic and was trained within three separate Tertiary reservoir intervals, using existing oil wells and the recent exploration discovery wells. As the inversion results had resolution superior to the input seismic data and are especially important in illuminating the stratigraphic variability and structural details within the three Tertiary intervals evaluated, this volume is now in use in final field development planning and exploration target mapping and evaluation.

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Original proposal

Seismic Reservoir Characterization Feasibility Study, Bua Ban Field, Offshore Thailand, Coastal Energy

The purpose of this project is to determine if seismic methods, including pre-stack analysis, can be used to characterize thin high impedance Oligocene oil sands in the Bua Ban Field, Thailand, and vicinity. The objective is to determine reservoir thickness and porosity or any property that can be inferred from the existing seismic. Well ties and phase calibration will be performed using up to 4 wells that will be used also for pre-stack modeling and sensitivity analysis to reservoir thickness, fluid type, shale content, and porosity. Spectral decomposition attributes and spectral inversion volumes will be calculated over approximately 20 sq km to identify possible patterns useful to discriminate the reservoir presence, quality and thickness far from the well control areas. Multi-attribute inversion and/or neural network analysis will be used to predict sand percentage, thickness, and porosity. Pattern recognition inversion will be used to ascertain if sand can be resolved in the vicinity of the wells.

Project objective

Seismic illumination and characterization of Tertiary oils sands in the Bua Ban and Songkhla fields, offshore Thailand, through Vclay estimation using multi-attribute analysis.

Estimation methodology – Inputs and variables

Input attribute: Input seismic & seismic attributes, spectral decomposition (magnitude and phase), spectral inversion (reflectivity and relative impedance)

Target log: Vclay

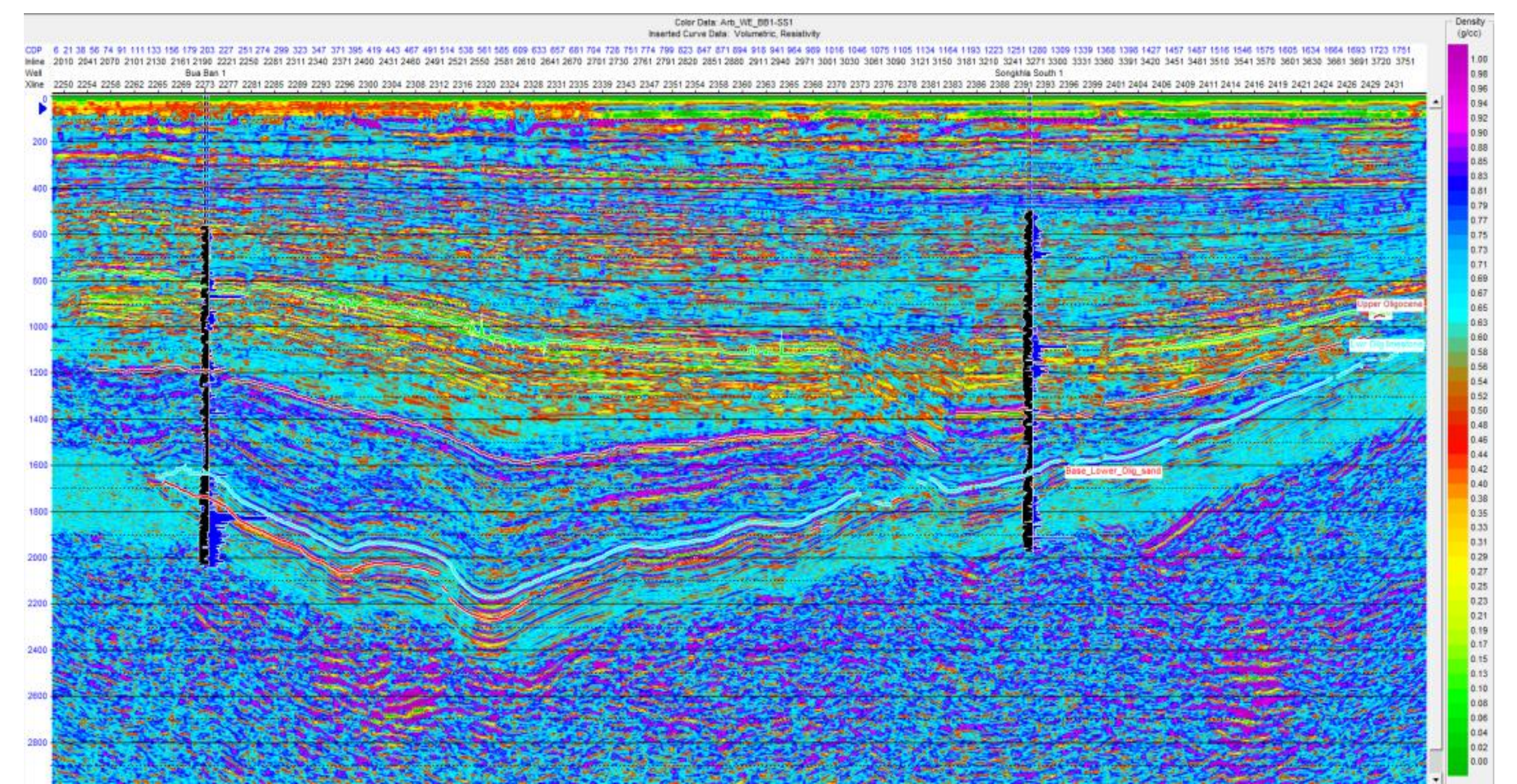
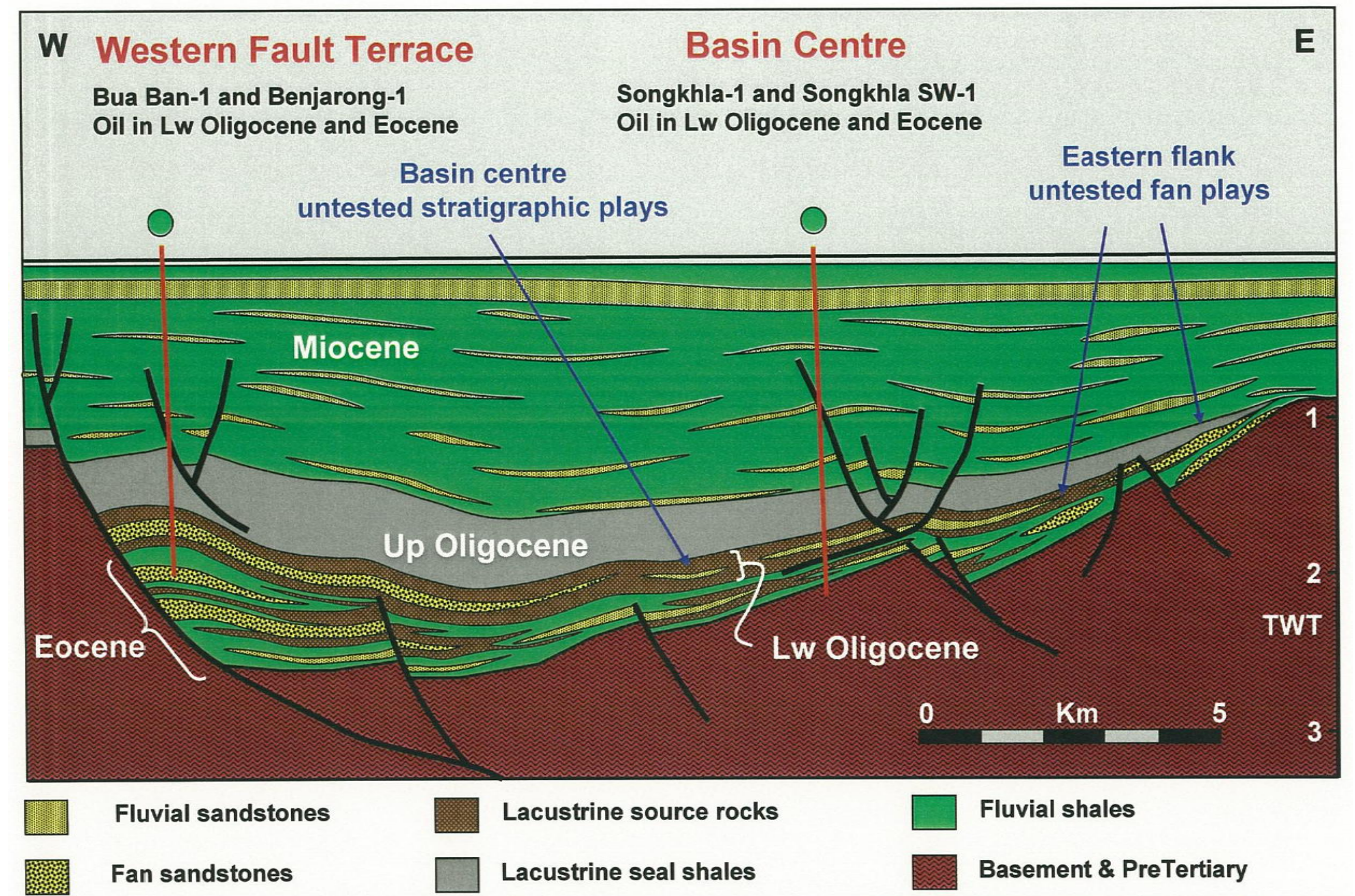
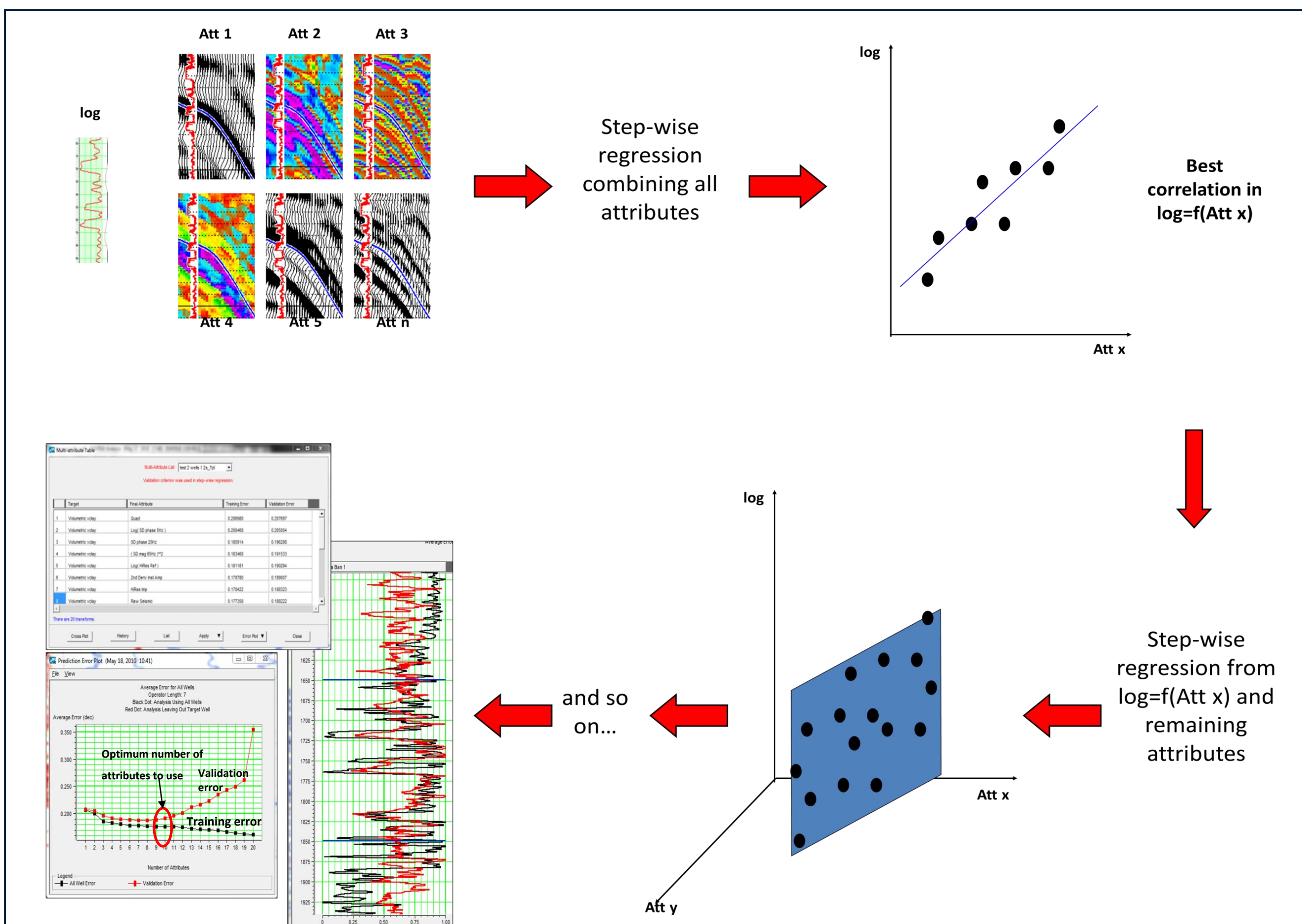
Methodology: Test different operator lengths, Test different combination of wells, Test different combination of attributes

Estimation methodology – Step-wise regression

Step-wise regression performed automatically in all wells, leaving one well out at a time

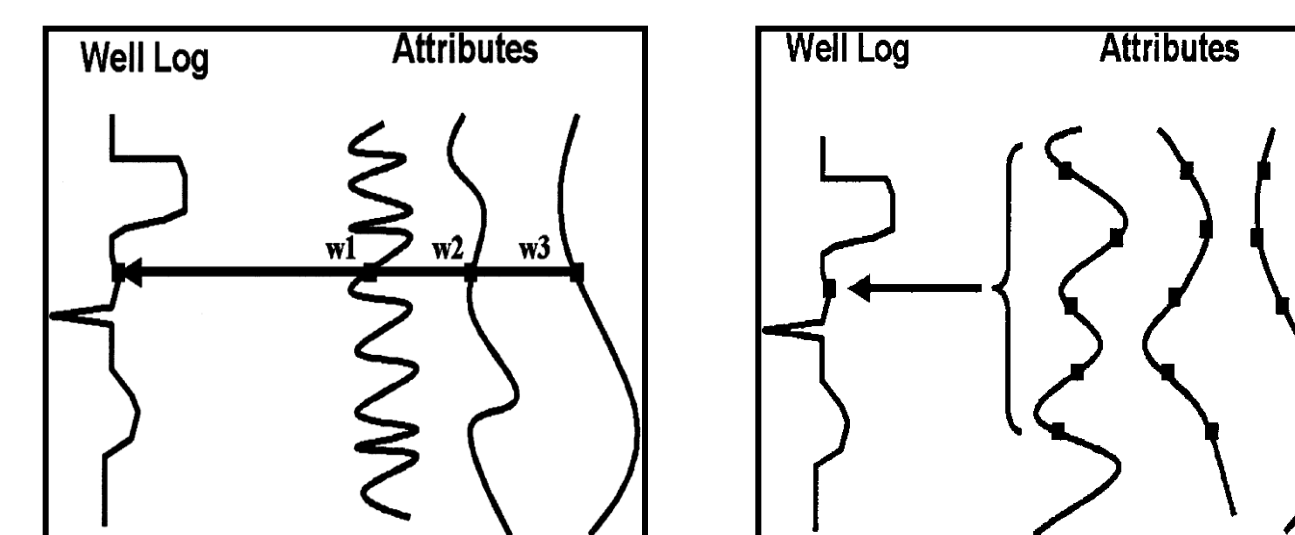
Validation error is the error of prediction using a blind test

Minimum validation error represents “best” result based on the data available



By use of step-wise regression, Vclay logs are estimated from seismic attributes (seismic amplitude, seismic derived attributes, spectral decomposition, spectral inversion (RC and Impedance)). Long operator lengths help account for differences in resolution between well data and seismic data. Resulting operator works as a sort of “deconvolution operator” to convert the seismic response into Vclay response.

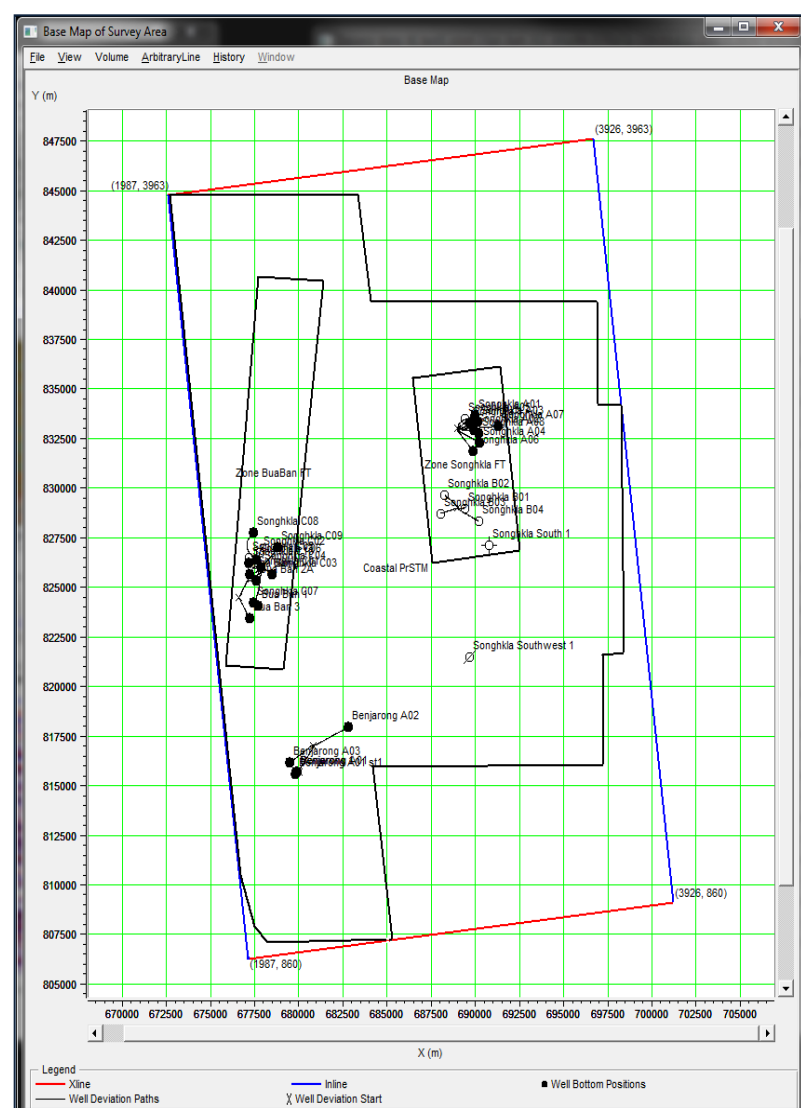
Estimation methodology – Operator length



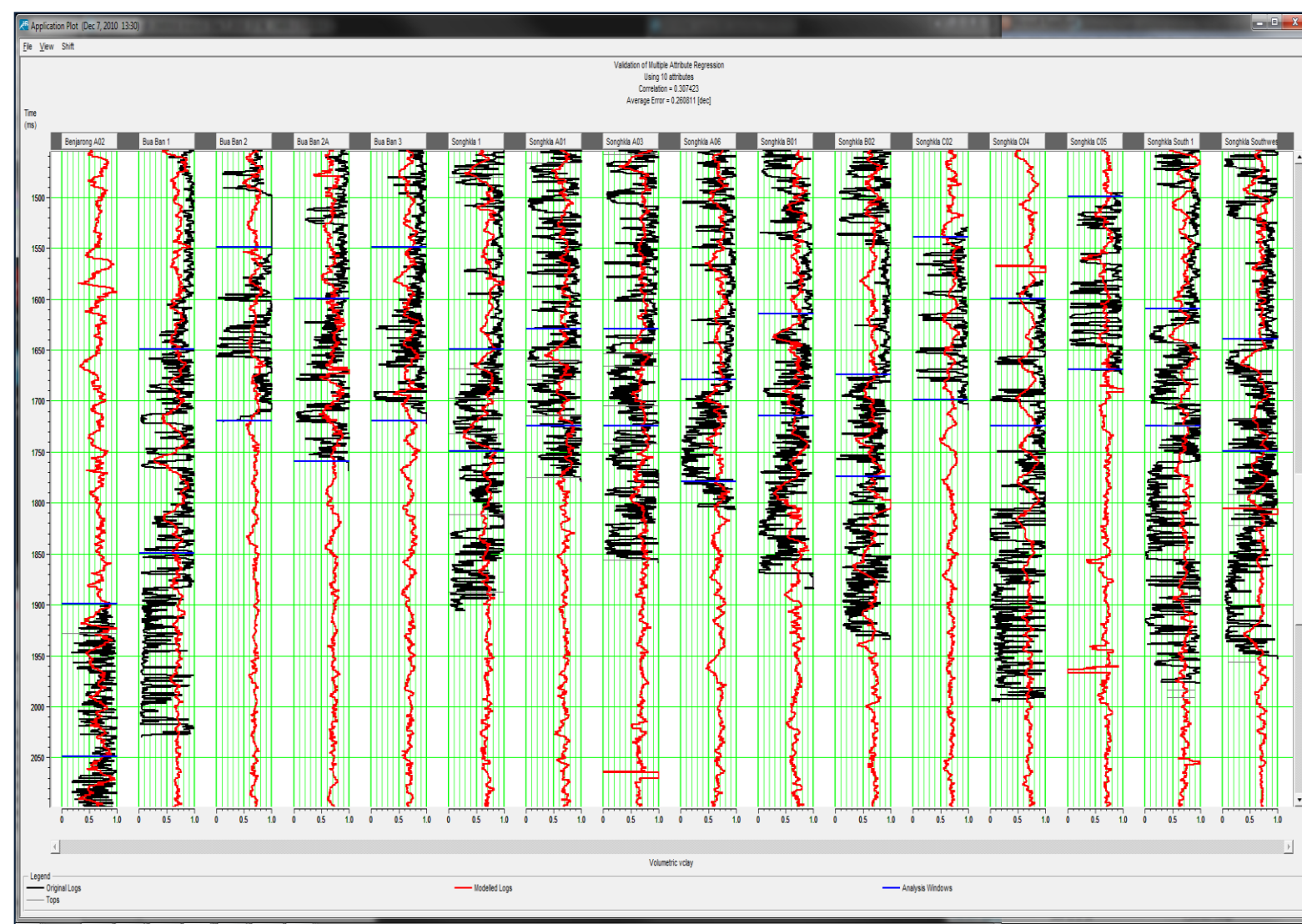
Oligocene Vcl estimation

Currently existing Oligocene Vcl volume is the combination Bua Ban area (phase 1), Songkhla A-B area (phase 2), Complete survey (phase 3). Verifications of all phases were integrated in phase 3 for consistency in results. Vcl estimation for Oligocene sands was calculated only at Oligocene level.

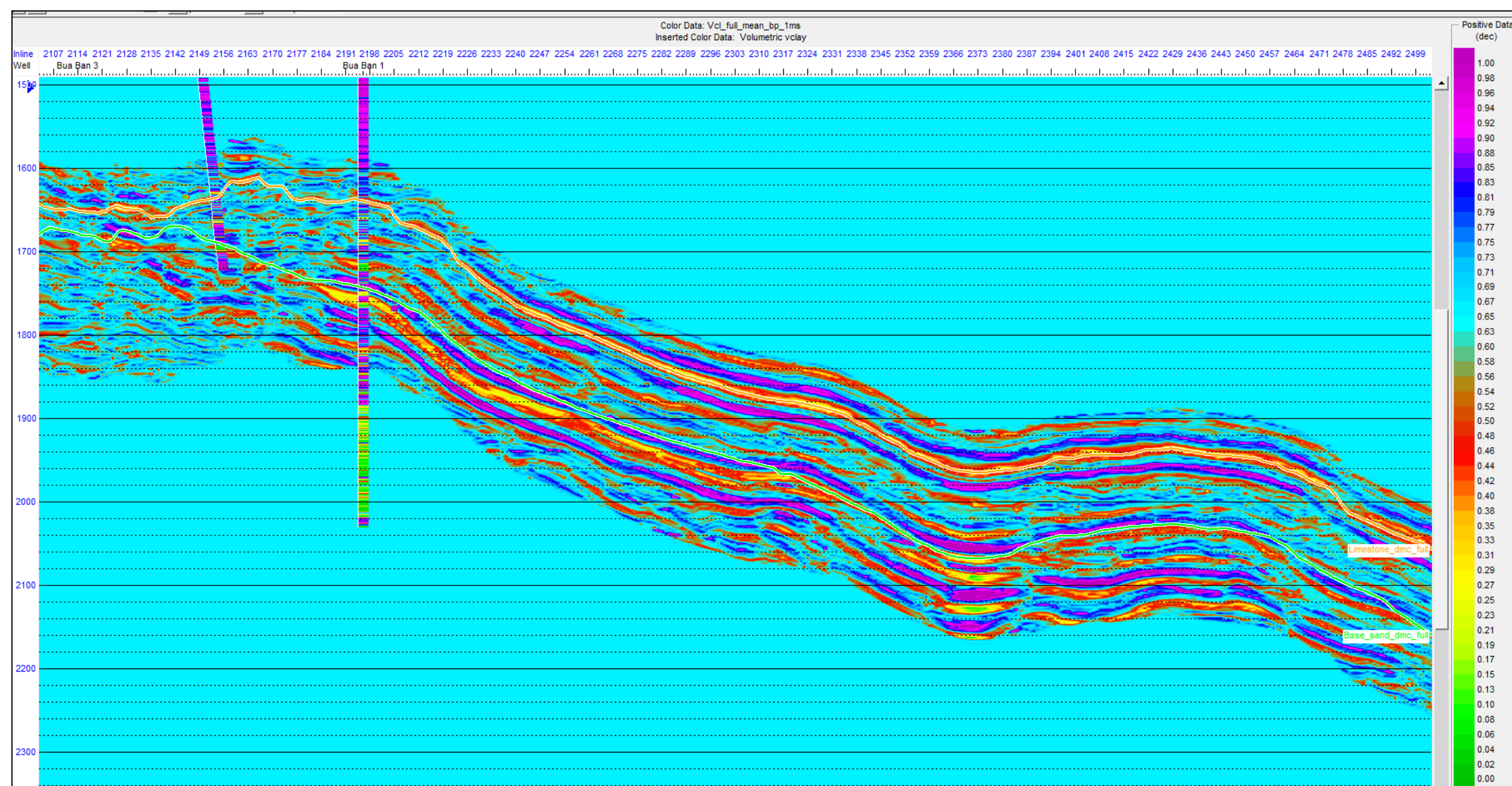
Base Map



Oligocene Vcl estimation – Validation results

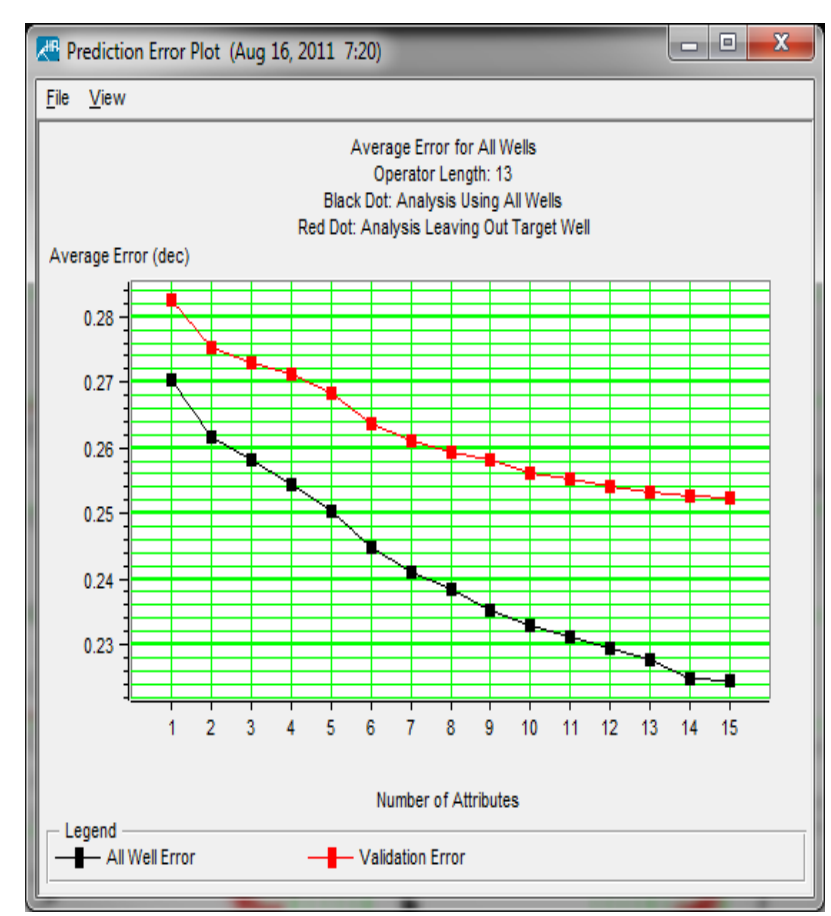
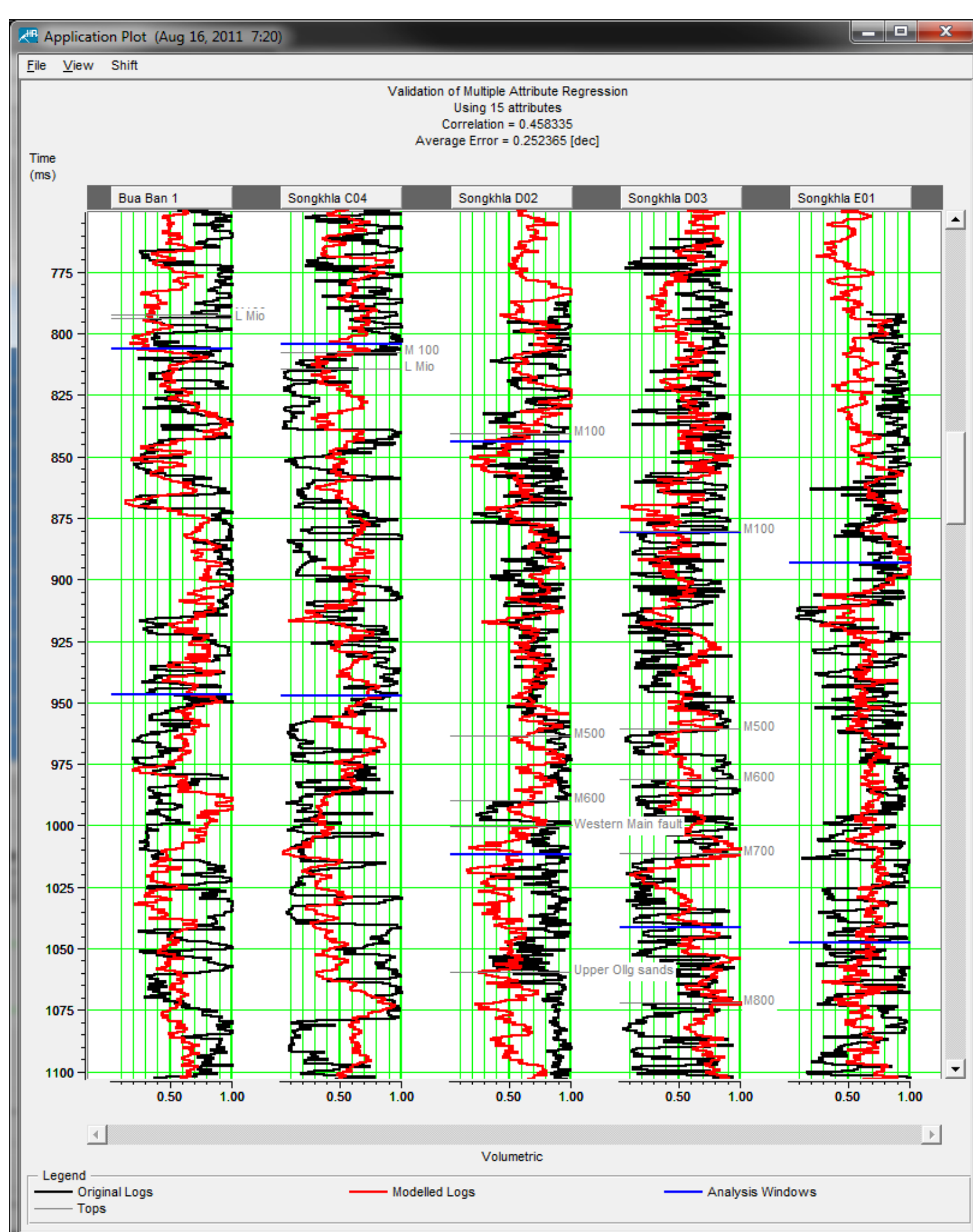


Oligocene Vcl estimation – XL 2270

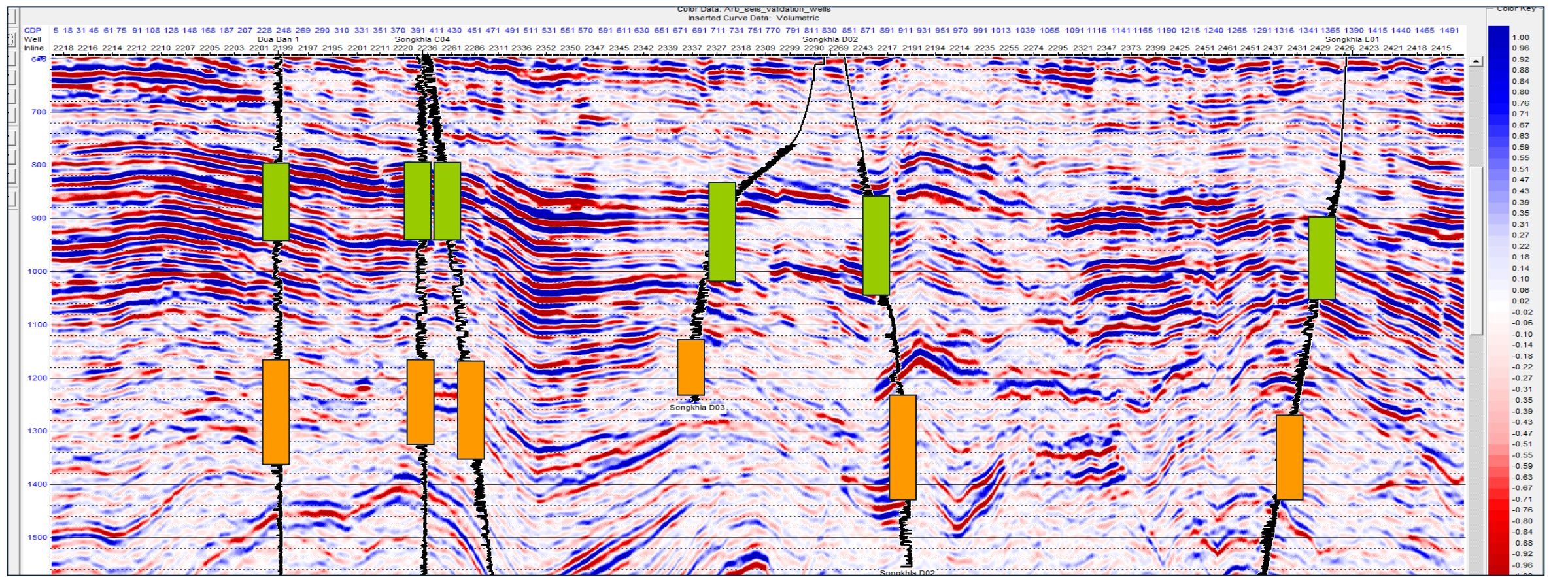


Miococene Vcl estimation – Test 1 (validation)

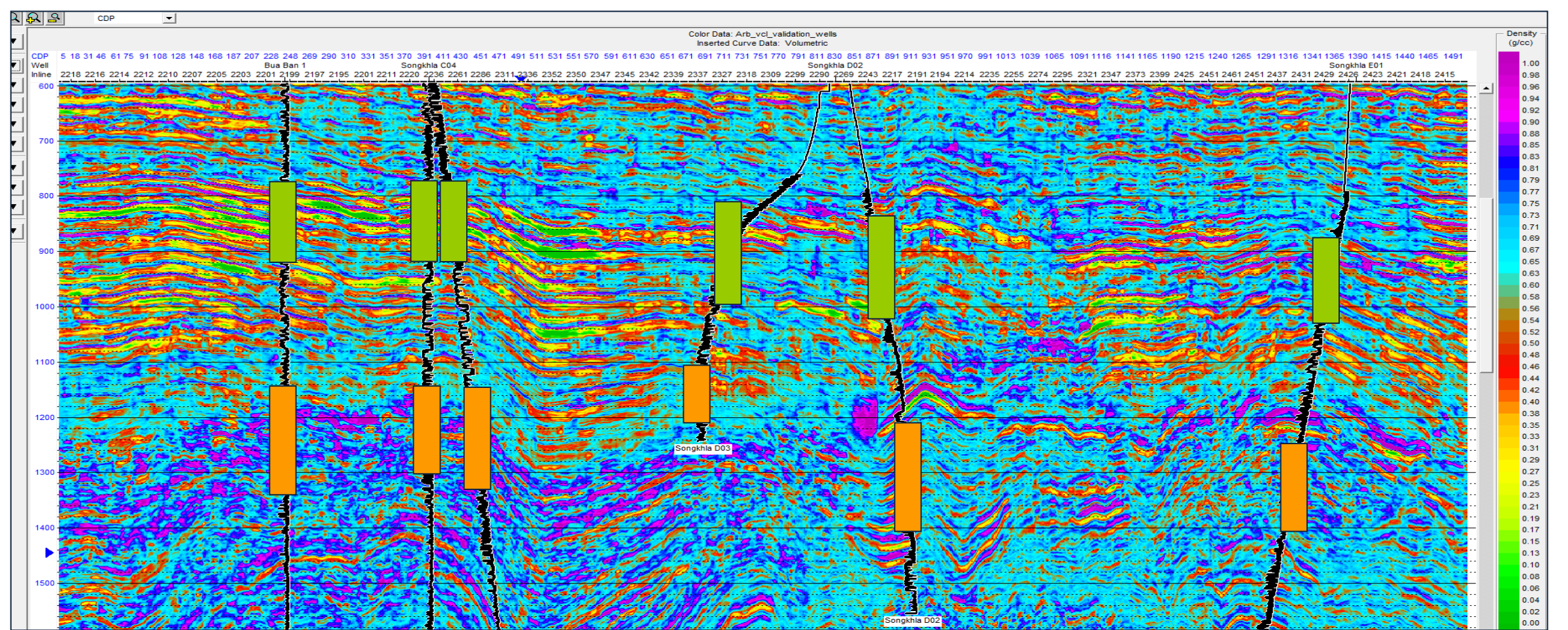
Target	Predictor	Training Error	Validation Error
1	Vcl_m100	0.2503	0.2604
2	Vcl_m100	0.2676	0.2704
3	Vcl_m100	0.2849	0.2804
4	Vcl_m100	0.3022	0.2904
5	Vcl_m100	0.3195	0.3004
6	Vcl_m100	0.3368	0.3104
7	Vcl_m100	0.3541	0.3204
8	Vcl_m100	0.3714	0.3304
9	Vcl_m100	0.3887	0.3404
10	Vcl_m100	0.4060	0.3504
11	Vcl_m100	0.4233	0.3604
12	Vcl_m100	0.4406	0.3704
13	Vcl_m100	0.4579	0.3804
14	Vcl_m100	0.4752	0.3904
15	Vcl_m100	0.4925	0.4004



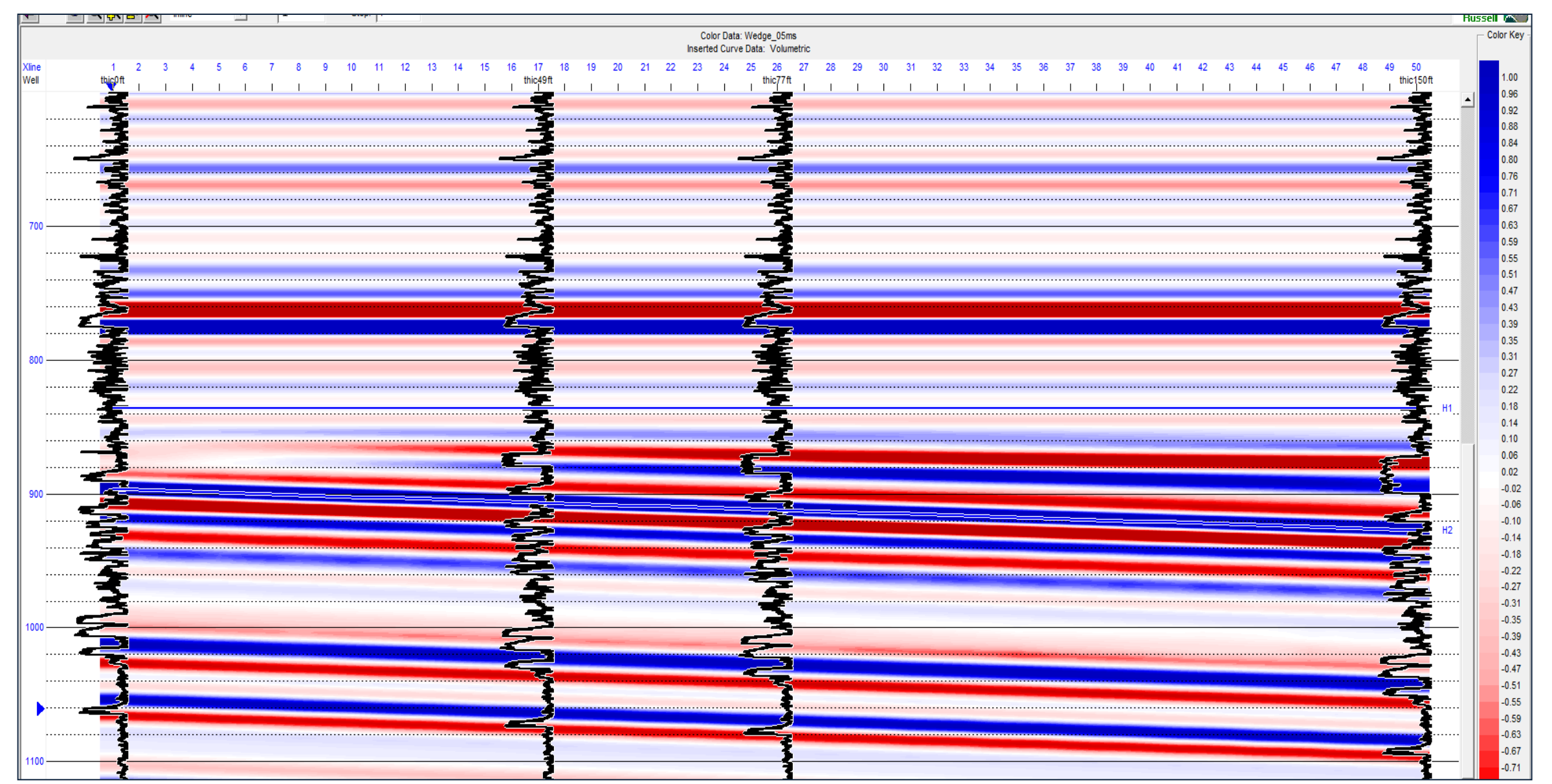
Seismic volume – Arb line with training windows



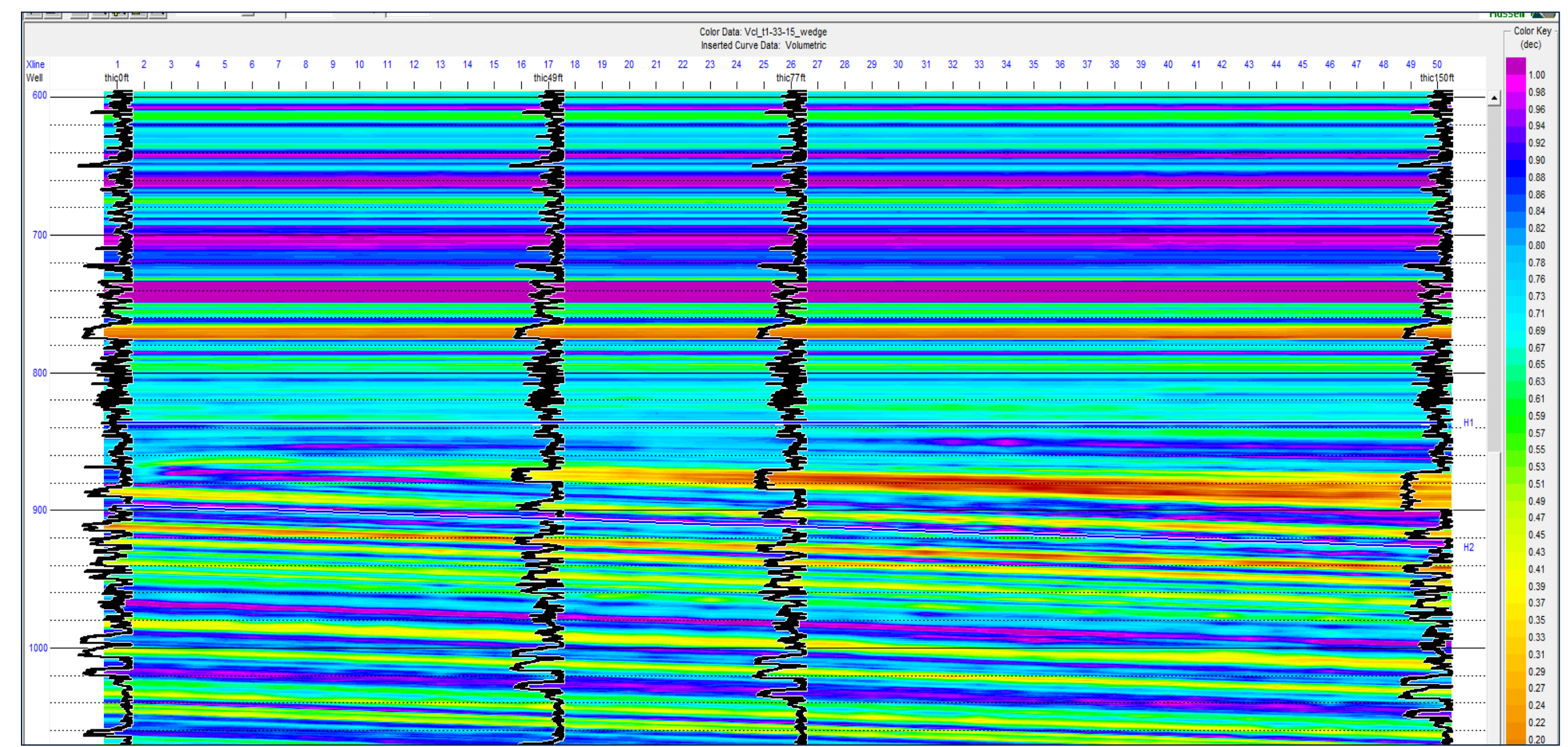
Vcl volume – Arb line with training windows



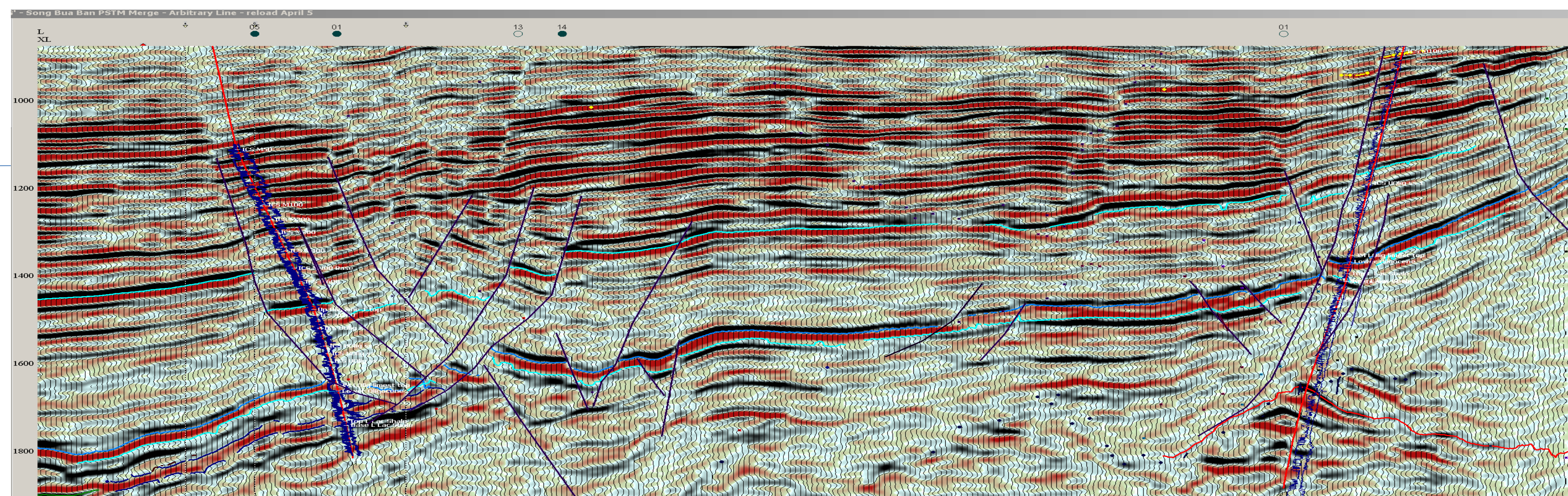
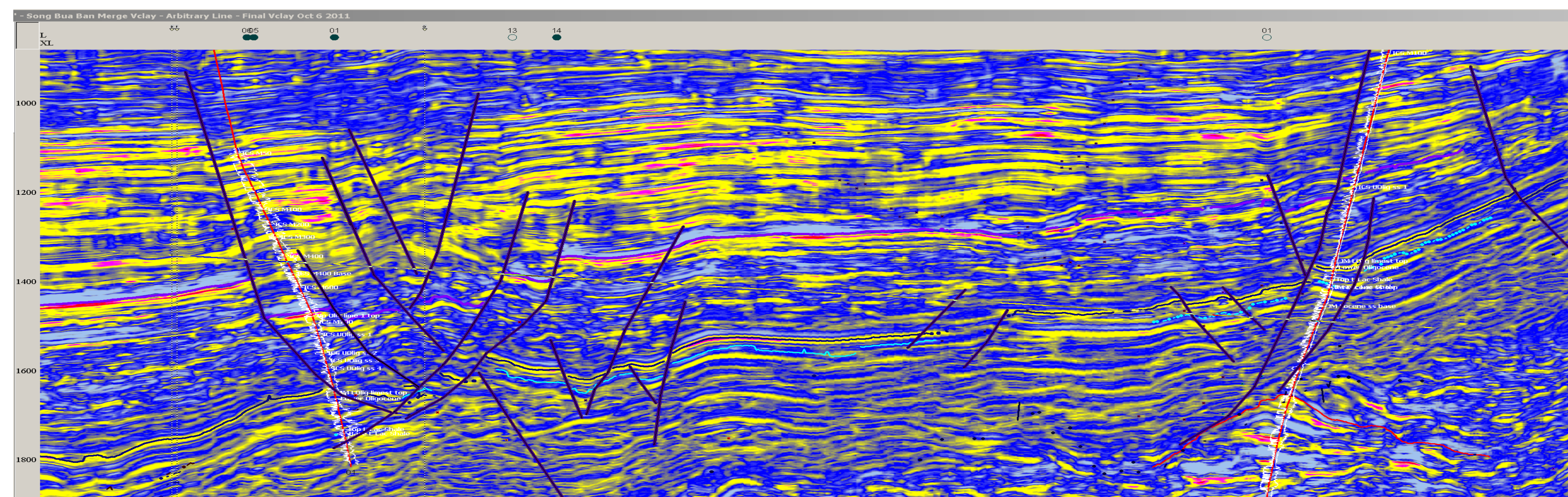
Synthetic wedge model was built of the M100 sand using the Songkhla D06 well, resulting in 50 “synthetic wells”. The wedge model wiggle trace .sgy and only 4 “synthetic wells” .las files were sent to Lumina, where this data was processed (spectral decomposition, etc) with same work flow/processing stream as the Songkhla 3D merge dataset used in the Vclay inversions. Then the wedge was inverted for Vclay after calibration to the 4 wells.



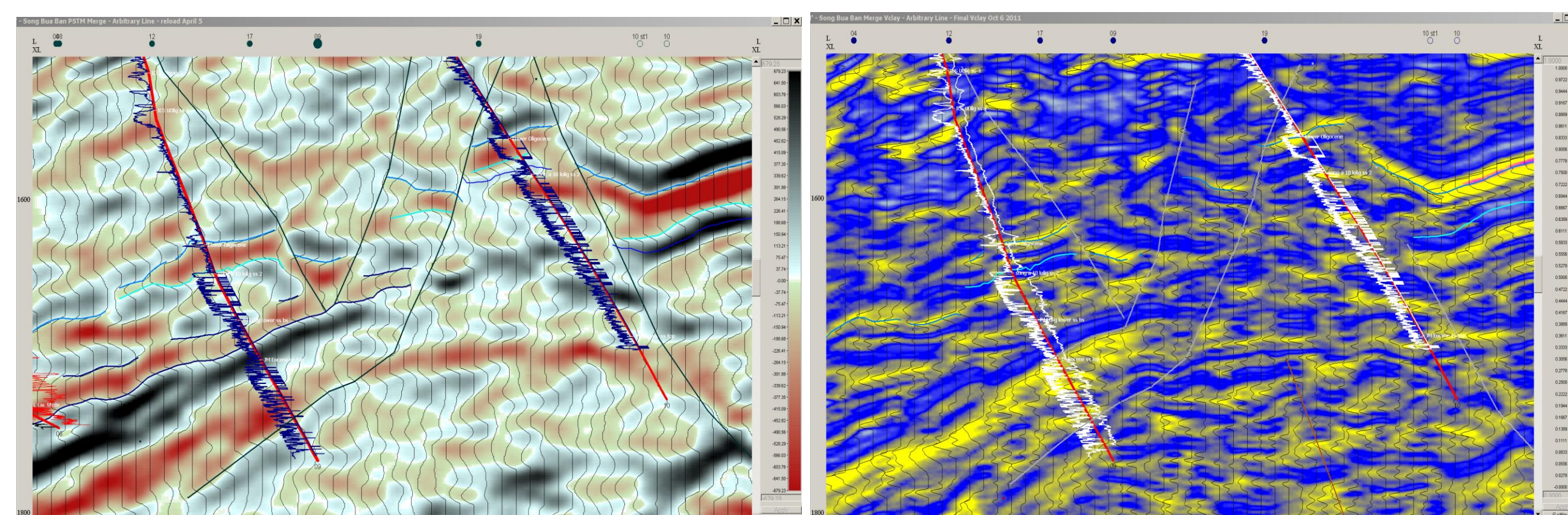
Vclay inversion of the stacked wiggle trace model results are shown here. Model was built using the 4 synthetic wells from the Songkhla D 06 M100 interval. The resulting Vclay model very nicely matches the well data.



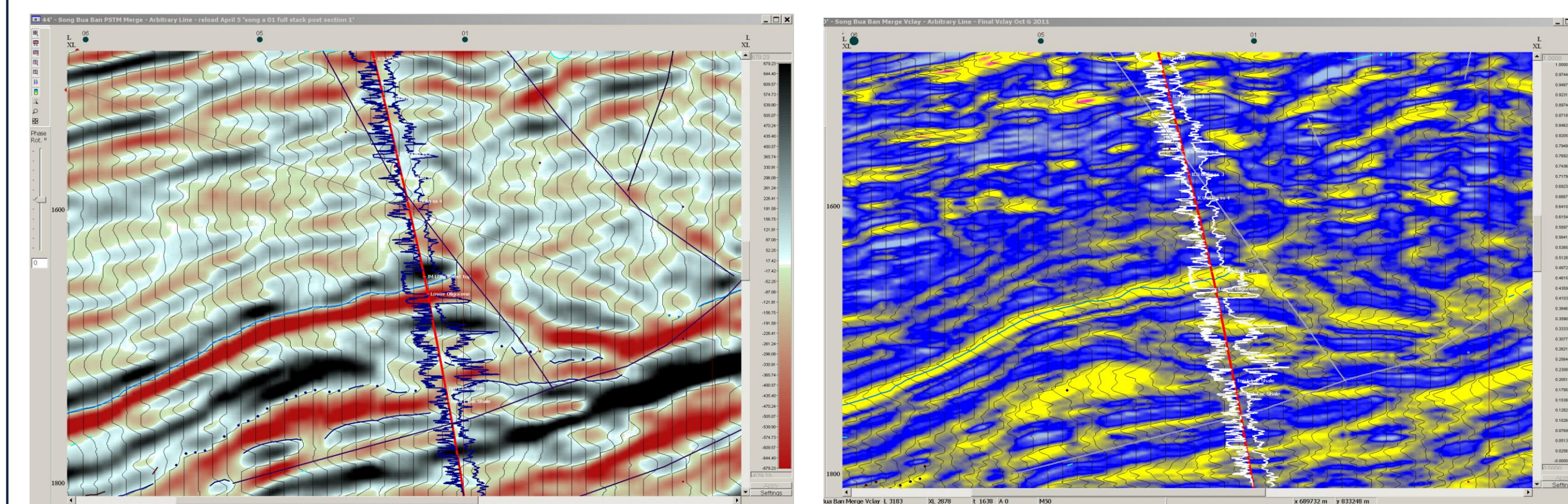
Regional



Local



Intra-well



Summary and Preliminary Conclusions:

Validation tests show a good correlation between Vclay prediction and Vclay logs. Testing showed that the inversion is best when confined to discrete geologic intervals and should not be attempted within thicker intervals that include major geologic boundaries, unconformities, etc. Different calibration windows had to be used in order to get a better resolution from the technique.

Miocene Vclay volume was validated by drilling results and showed similar Vclay predictions vs actual later drilling results. Very few wells were used in the Miocene training and inversion. However, the results suggest that if the neural net inversion was confined to individual Miocene sand reservoirs, the results would have improved over inverting the entire Miocene section, as this geologic interval showed the most complexity in reservoir rock properties, thickness and stratigraphy.

Some of the mismatches observed in the Vclay correlations (volume vs logs) could be associated to small errors and quality of well ties.

There were several steps applied to the final PSTM gathers, the final input into the full stack processing, that were felt to be detrimental to the inversion. These included an over-application of radon for multiple removal and an fxy deconvolution (local smoothing operator). Neither of these steps could be removed from the final stack. The result was a local mixing of data that resulted in a loss of definition of minor structural features and minor stratigraphic details.

This combination of seismic processing, including spectral decomposition, spectral and neural net inversion methodologies seems to be holding as a potential tool for mapping sand occurrence across this complex Tertiary lacustrine basin. Obviously, the more uniform the reservoir rock properties and the better the initial definition of the reservoir in the full stack input volumes, the better the results for inverting to Vclay or other rock properties.

For further inquiries into this presentation:

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