APPENDIX A

Seismic Acquisition Parameters and Processing Workflow

A.1 Seismic Acquisition Parameters

1) Acquisition Contractor

Main Vessel:	M/V GECO SAPPHIRE
Date:	between May to August 1998
Field Coverage:	40
Field Bin Size:	6.25m inline x 25m crossline

2) Source parameters

Source type:	Bolt Airgun array
Number of source Arrays:	2
Source pressure:	140 bar (2000 psi)
Volume:	1354 cu.in each
Source Depth:	4m $\pm$ 0.5m
Source Separation:	50 m
Shot Point Interval:	18.75 m (flip flop)

3) Receiver Parameters

Streamer Type	NAP-4B (Nessie 3)
Streamer Length	3000m
Number of Streamers	6

Streamer Depth	5 m+- 1.0 m (seq1-138)
	6 m+- 1.0 m (seq139-end)
Streamer Separation	100m
Number of Receiver Groups	12
Number of Group per streamer	240
Receiver Group Interval	12.5m

4) Recording Parameters

Recording System	GECO TRIACQ 1.4
Recording Format	SEGD-8015
Record Length	5sec
Sample Interval	2ms
Low Cut Filter	3Hz, 18 dB/Oct
High Cut Filter	180Hz, 70 dB/Oct

5) Geodetic Parameters

Datum	RTSD 181 EVEREST IND
Spheroid	
Semi Major Axis	6377276.345
Inverse Flat	300.8017
Projection	001 UTM NORTHERN HEMISPHERE
Zone	47N
Central Meridian	99.00E
Scale Factor	0.999600
False Easting	500000.00E
False Northing	0.00N

A-2. Seismic Processing Workflow

1) Seismic Reformatting from SEGY into Geovation format
    a. Recording length 5000 ms
    b. Sampling rate 2 ms
2) Geometry update (seismic & navigation merge) and trace header update
3) Geometry QC
4) Gain recovery using T^2 gain function
5) Zero phase conversion using the zero phase operator derived from far field signature (Note: Negative Number of amplitude = Increase in Impedance Downward = Trough)
6) Linear noise attenuation in Tau-P domain:

    A least squares anti-alias filter is applied to optimize the de-noise result.
    a. 1st pass linear noise attenuation is done in positive slope (shot gathers)
    b. 2nd pass linear noise attenuation is done in negative slope (shot gathers)

    Slope range design of linear noise:

Time (ms)	Mute Zone (ms)
0	1300 to 4500
1500	1000 to 4500
3500	1000 to 4500
5100	1000 to 4500

    Frequency range for attenuation 0 - 250 Hz

    Application window is 1200 - 5000 ms with taper
7) Spike editing and Noise Burst attenuation (including swell) in shot domain by using spatial amplitude smoothing (SPASM)
    a. Statistical spike editing on noisy traces
8) Shallow Water Demultiple (SWD)
    a. 3:1 Shot point interpolation to perform 12.5 m shot interval prior to SWD & output only original traces after SWD.
    b. Multiple subtraction is performed using Least Squares adaptive approach
9) 3D Surface Related Multiple Elimination (SRME)
    a. 3:1 Shot point interpolation to perform 12.5 m shot interval prior to SRME and output only original traces after SRME.

b. Multiple subtraction is performed using Least Squares adaptive approach

10) Tau-P predictive deconvolution

Forward and Reverse Tau-P transform

(Minimum offset 100 m, Maximum offset 3,200 m)

Time (ms)	GAP (ms)	Operator Length (ms)
500 - 2500	24	200
3000- 5500	64	200

11) Velocity Analysis

Using average trend of RMS Velocity data from previous processing (2001 seismic vintage) as reference with adjustment

12) 1st Pass high resolution Radon demultiple

a. 3:1 Shot point interpolation to perform 12.5 m shot interval prior to demultiple and output only original traces after demultiple
b. Parabolic model limit:
c. Min slope = -8000 ms, Max Slope = 8000 ms, based on 3,200 m offset,
d. Parabolic model scan is made based on 20 ms interval
e. Time variant demultiple is made following water bottom reference with time variant cut off

Time (ms)	Kept Zone (ms)
0	-1000 to 400
2000	-600 to 200
5000	-300 to 100

Reference offset = 3,200 m

f. Application window:

Start time: 200 ms, end time: 5100 ms with taper

g. Maximum frequency for computation: 120 Hz

13) Amplitude de-striping scalar estimation in sail line domain

This is to compensate amplitude variation due to acquisition seismic equipment:

Shot, Smoothing Operator = 41shots

Channel, Smoothing Operator = 41 channels

CABLE, Smoothing Operator =3 cables

14) Trace regularization and interpolation

3D trace regularization and interpolation were performed to obtain:

Offset groups for every 50m

Re-gridding the seismic to 12.5m x 12.5m bin dimension

Nominal offset: 40

15) SEGY Output of Non-migrated CDP gathers after all pre-migration processing and after regularization (without NMO and without mute)

16) Velocity Analysis for 300 m x 300 m by manual velocity picking

17) Migration velocity analysis using high density velocity picking for 100 m x 100 m grid with anisotropic Eta field analysis at every 8 CDP interval

a. Semblance window interval: 20 ms

b. Time Variant High Density Picking Range for RMS Velocity:

Time (ms)	Velocity Tolerance from Central Function (%)
0	1
500	5
1000	10
2000	10
3000	10
4000	15
5000	5

c. Time Variant High Density Picking Range for Anisotropic parameter:

Time (ms)	SH from Central Function (Min, Max)
0	(-5, 50)
500	(-10,100)
1000	(-20,150)
2000	(-20,250)
3000	(-20,250)
4000	(-20,100)
5000	(-20,100)

d. Smoothing operator for outliers: 300 m x 300 m x100 ms

18) 3D Anisotropic Kirchhoff Pre-Stack Time Migration

Aperture length:	4000 meters (half aperture)
Dip limit:	75^{o}

Maximum frequency: 250 Hz

Using smoothed Vrms and Eta field from High Density Picking No.16

Geometrical spreading compensation: Applied

Input/ Output bin size: 12.5 m x 12.5 m

19) SEGY Output of Raw Kirchhoff APSTM CDP gathers (with NMO and without mute)

20) Residual move out analysis using high density velocity picking for 25 m x 25 m grid with Eta field analysis at every 2 CDP interval

   a. Semblance window interval: 20 ms

   b. Time Variant High Density Picking Range for RMS Velocity:

Time (ms)	Velocity tolerance from Central Function (%)
0	1
500	5
1000	10
2000	10
3000	10
4000	15
5000	15

   c. Time Variant High Density Picking Range for Anisotropic parameter:

Time (ms)	SH from Central Function (Min, Max)
0	(-5, 50)
500	(-10,100)
1000	(-20,150)
2000	(-20,250)
3000	(-20,250)
4000	(-20,100)
5000	(-20,100)

   d. Smoothing operator 100 m x 100 m x 100 ms

21) Residual high resolution radon demultiple on migrated CDP gathers

Parabolic model limit:

MIN Slope = -5000 ms, MAX Slope = 5000 ms,

Parabolic model interval is made for every 20 ms

Time variant multiple cut off following water bottom:

Time (ms)	Kept Zone (ms)
0	-1000 to 300
1000	-400 to 150
1000	-200 to 100
5000	-150 to 60

Reference offset = 3,200 m

Application window: start time 200 ms, end time 5,100 ms

Frequency limit = 240 Hz

22) CDP gathers flattening

23) Random noise attenuation in CDP domain

Spatial model: 20 traces

High frequency part:

Computation window = 1,800 ms – 4,800 ms

Temporal model: 1,000 ms

Threshold:

Freq. range (Hz)	Impulse noise freq. (Hz)	Threshold	Operator length (ms)
0-5	0-5	2.0	7
80-90	80-90	3.0	3
90-130	90-130	2.0	7

Low frequency part:

Computation Window: 200 ms – 4,400 ms

Temporal model: 1,000 ms

Threshold:

Freq. range (Hz)	Impulse noise freq. (Hz)	Threshold	Filter length (ms)
0-5	0-5	2.0	10
5-8	5-8	4.0	7
8-15	8-15	2.0	7

24) Time variant amplitude scaling in CDP domain

Time (ms)	Amplitude gain (dB)
0	0
500	0

5000	20

25) Inverse Q compensation (amplitude only)

Amplitude only Q compensation using Q = 135 with amplitude gain limit 5 dB (frequency = 80 Hz)

26) SEGY Output of Final Kirchhoff APSTM CDP gathers (after all post-migration processing and without mute)

27) Mute and stacking

Final mute is calculated using bending ray with 255m minimum offset preserved;

Stack mode	Angle range (degrees)
Full stack	0-12
Near angle stack	8-20
Mid angle stack	16-28
Far angle stack	24-36

28) SEGY output of Kirchhoff PSTM raw full stack (without any post-stack processing)

29) Acquisition footprint attenuation in the 3D F-Kx-Ky domain

Inline model:	300 traces
Crossline model:	300 traces
Time model:	400 ms
Frequency range:	0-100 Hz

30) Spectral whitening with two passes of frequency boosting

a. 1st pass: 25-60 Hz at 120% boost and smoothing bandwidth 15%
b. 2nd pass: 15-45 Hz at 100% boost and smoothing bandwidth 20%

31) 3D Random noise attenuation in F-X-Y domain

Inline model:	40 traces
Crossline model:	40 traces
Time model:	1000 ms
Computational window:	0 - 4900 ms
Frequency Range:	3 – 70 Hz

32) Nosie attenuation in decomposed frequency slice and reconstructed using Eigenvalues

Inline model:	13 traces
Crossline model:	13 traces
Time model:	250 ms

33) Post-stack residual Q-compensation in crossline and inline direction

Crossline direction

Background computational:

Temporal gate = 1200 ms, Spatial gate = 400 traces

Local computational:

Temporal gate = 400 ms, Spatial gate = 100 traces

Inline direction

Background computational:

Temporal gate = 1200 ms, Spatial gate = 400 traces

Local computational:

Temporal gate = 400 ms, Spatial gate = 100 traces

34) Time-variant frequency filter using Bandpass filter

Window (ms)	Bandpass filter (ORMSBY)
0-1200	06-10-120-150 Hz
1500-2700	05-08-100-120 Hz
3000-5000	03-05-60-80 Hz

Operator Length 300 ms

35) Time Variant Amplitude Gain

Time (ms)	Amplitude Scalar (dB)
0	0
500	-2.5
1000	4
2000	10
2500	12
3000	13
4000	13
4500	13
5000	10

36) SEGY output of Intermediate full Kirchhoff PSTM Stack (with time-variant filter and amplitude scaling)

37) Automatic Gain Control (AGC)

1st pass:

Averaged amplitude level 5000

Operator Length 1000 ms

Sliding operator movement by half operator length

2nd pass:

Time variant AGC as following details;

Time window (ms)	Average amplitude level
0-400	5500
600-1200	5000
1400-2200	5000
2400-3400	4500
3400-3900	3500
3900-5000	2000

38) SEGY output of Final full Kirchhoff PSTM Stack (with filter & AGC)

APPENDIX B

Geostatistical Inversion Results

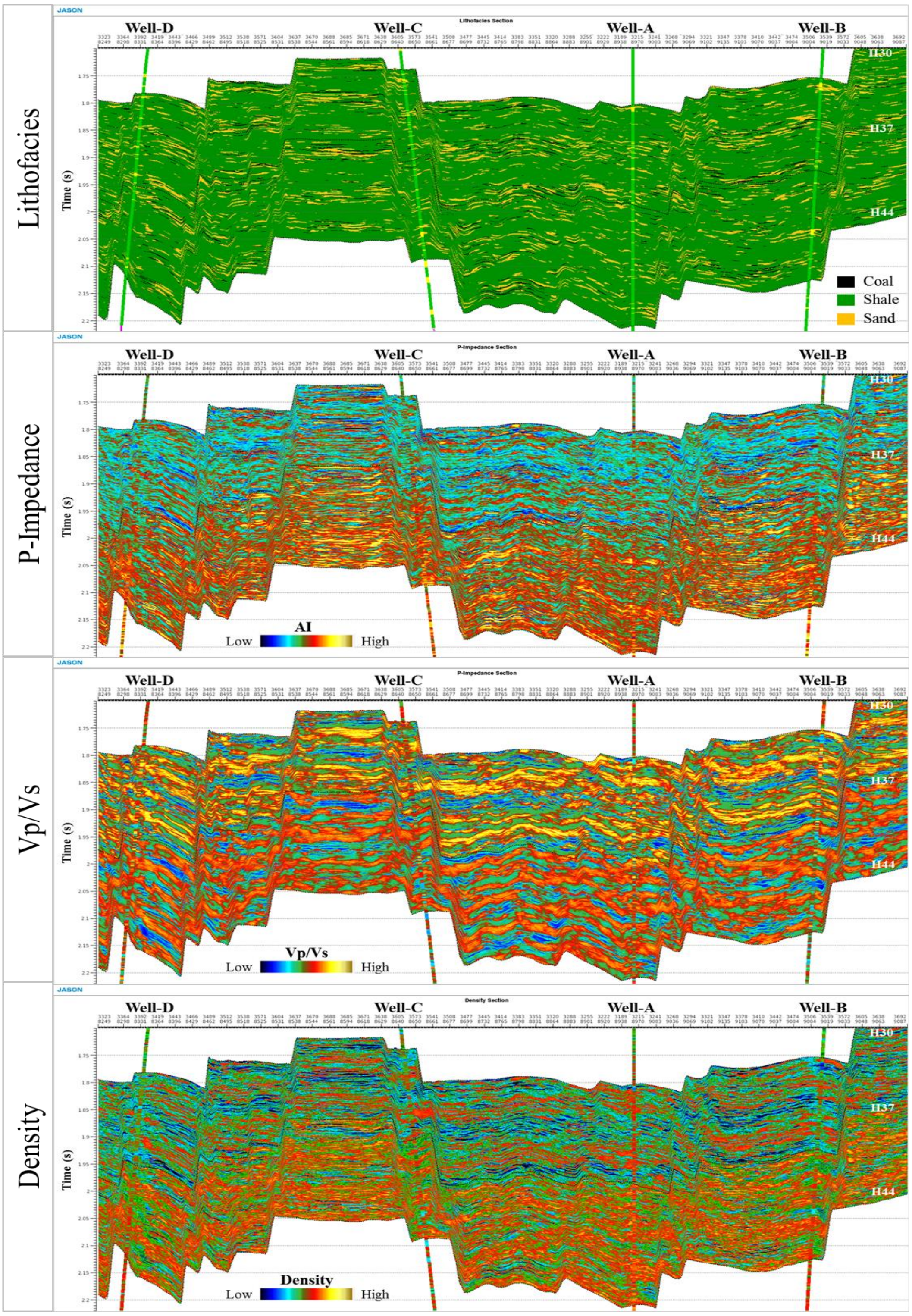

Figure B.1 Geostatistical inversion results, including lithofacies, P-Impedance, Vp/Vs and density generated from inversion realization 1.

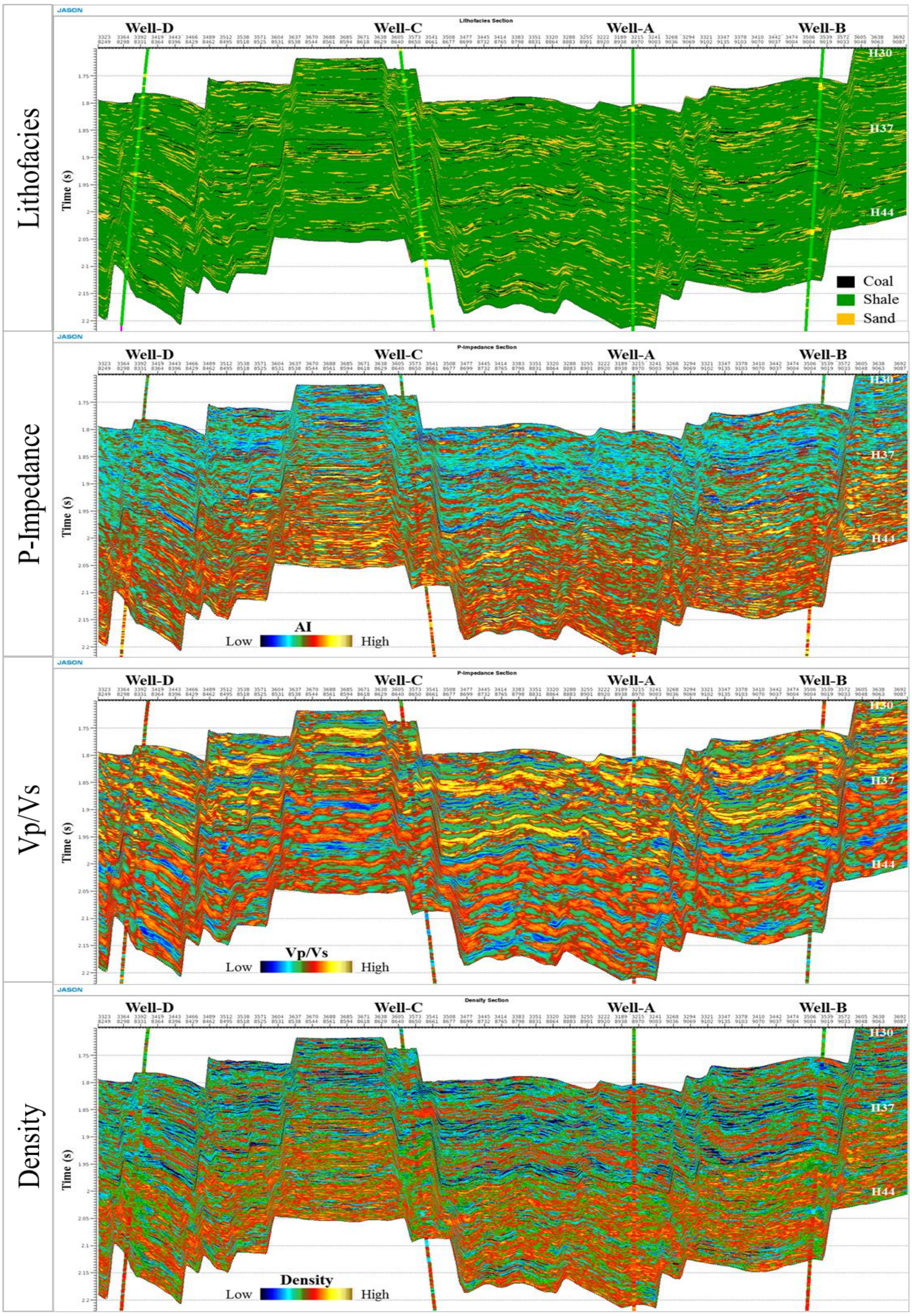

Figure B.2 Geostatistical inversion results, including lithofacies, P-Impedance, Vp/Vs and density generated from inversion realization 2.

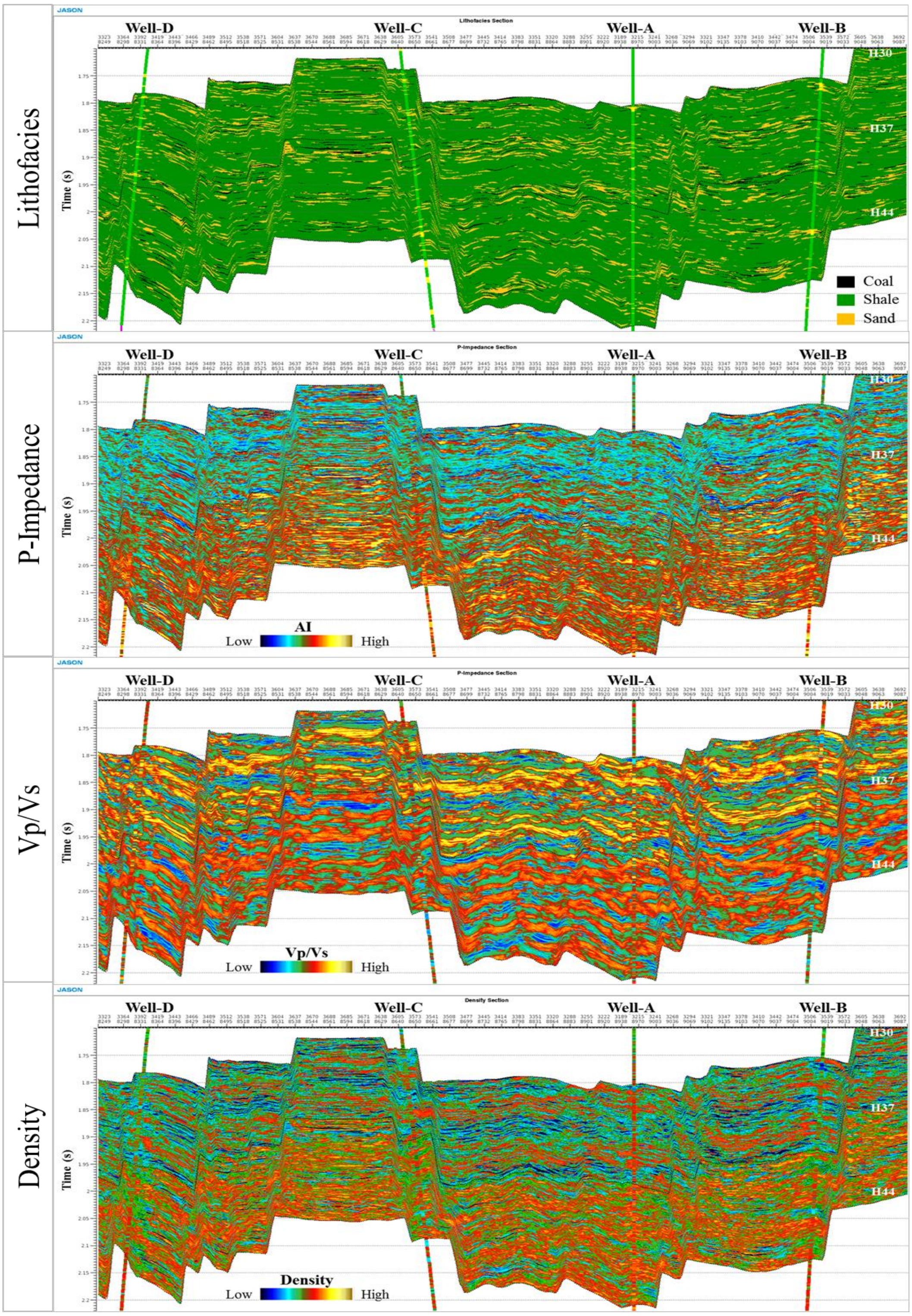

Figure B.3 Geostatistical inversion results, including lithofacies, P-Impedance, Vp/Vs and density generated from inversion realization 4.

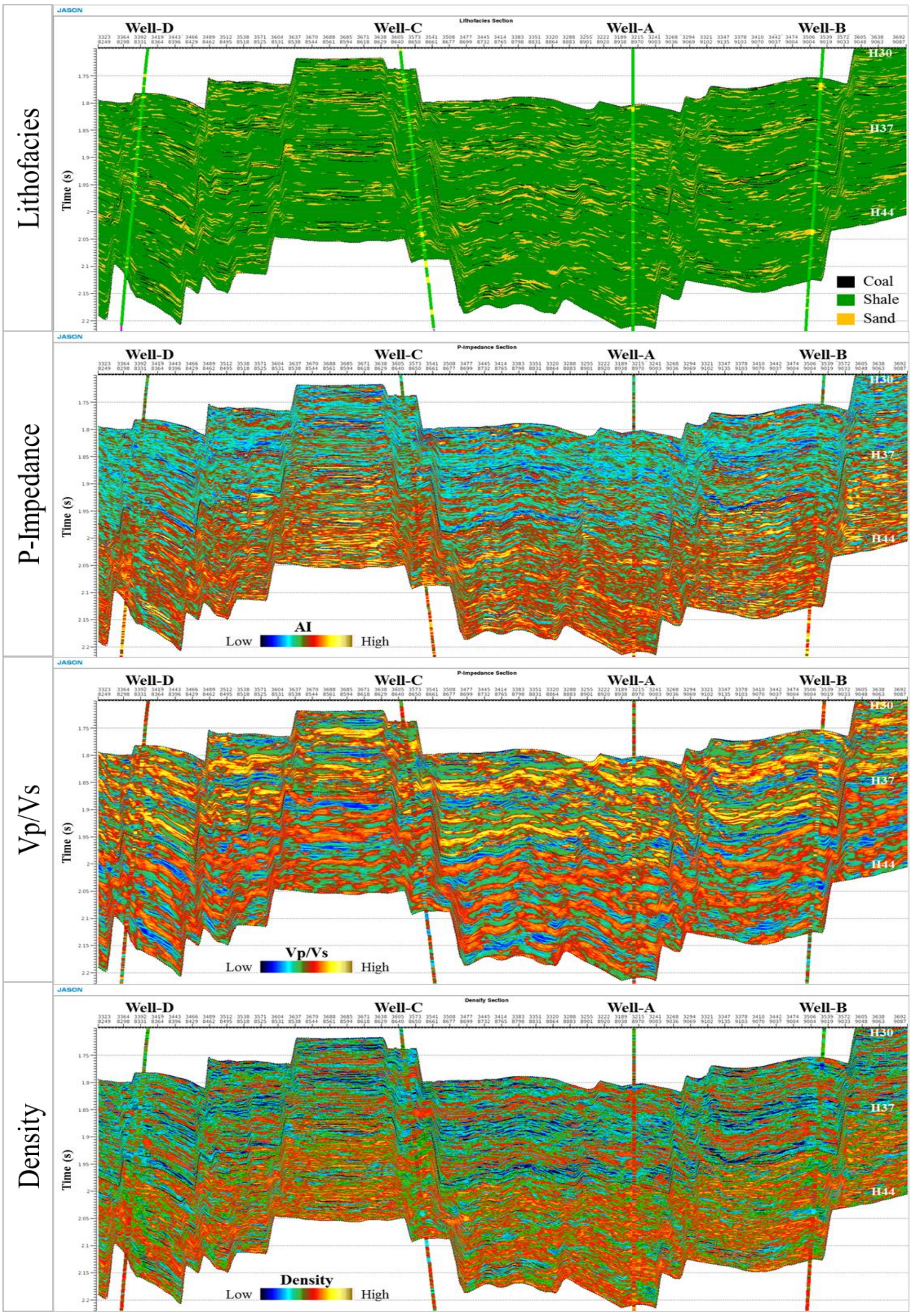

Figure B.4 Geostatistical inversion results, including lithofacies, P-Impedance, Vp/Vs and density generated from inversion realization 5.

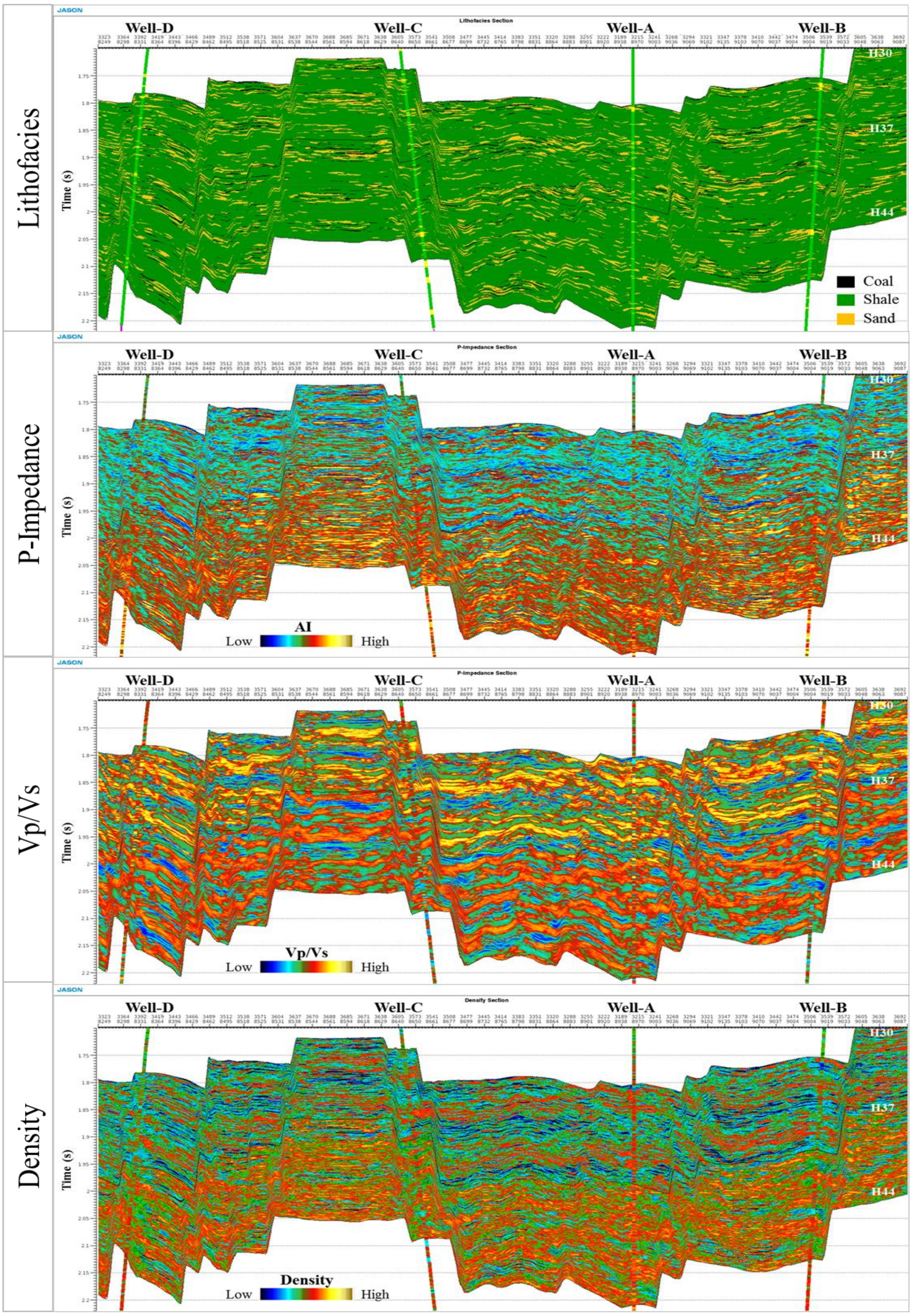

Figure B.5 Geostatistical inversion results, including lithofacies, P-Impedance, Vp/Vs and density generated from inversion realization 7.

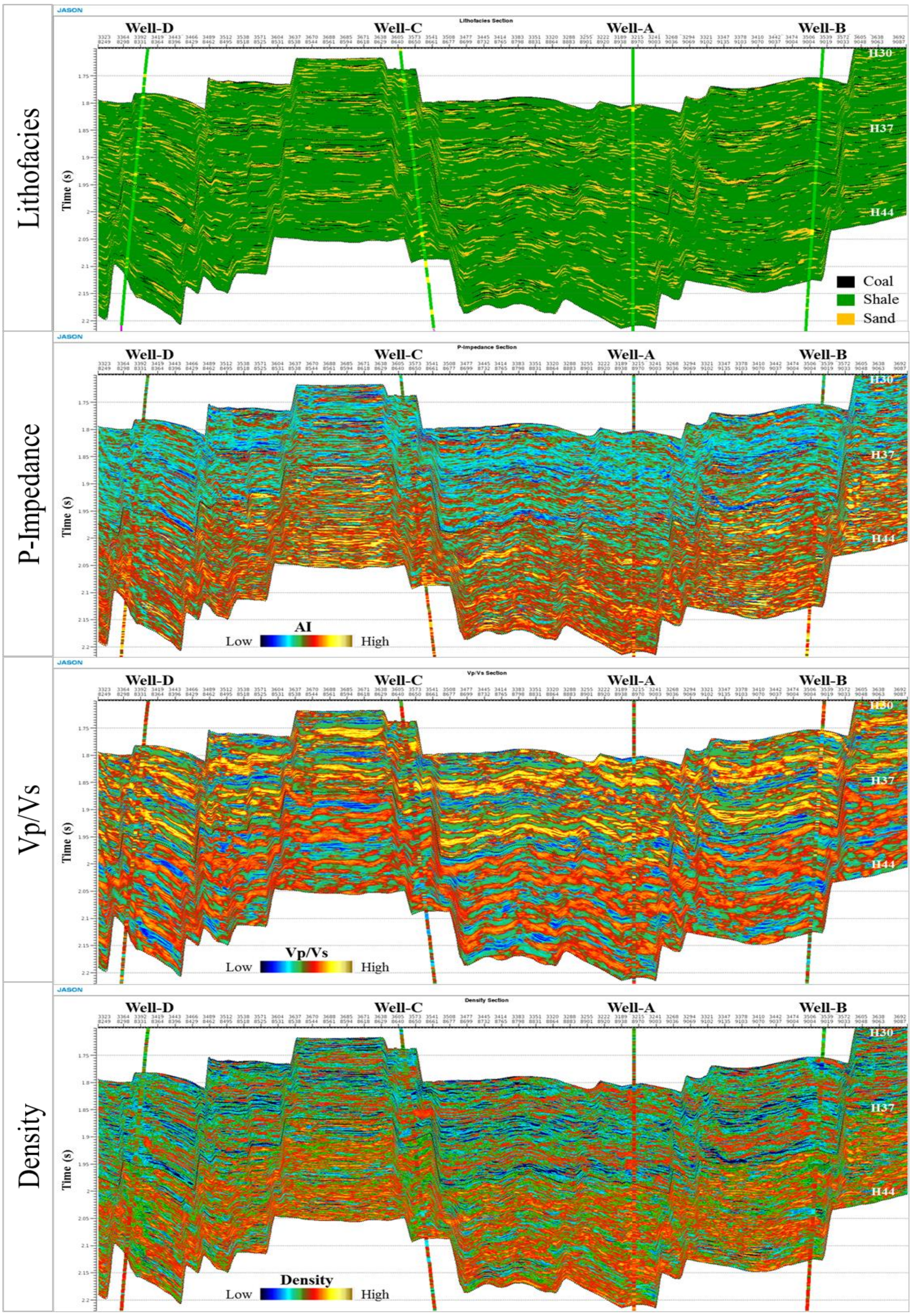

Figure B.6 Geostatistical inversion results, including lithofacies, P-Impedance, Vp/Vs and density generated from inversion realization 8.

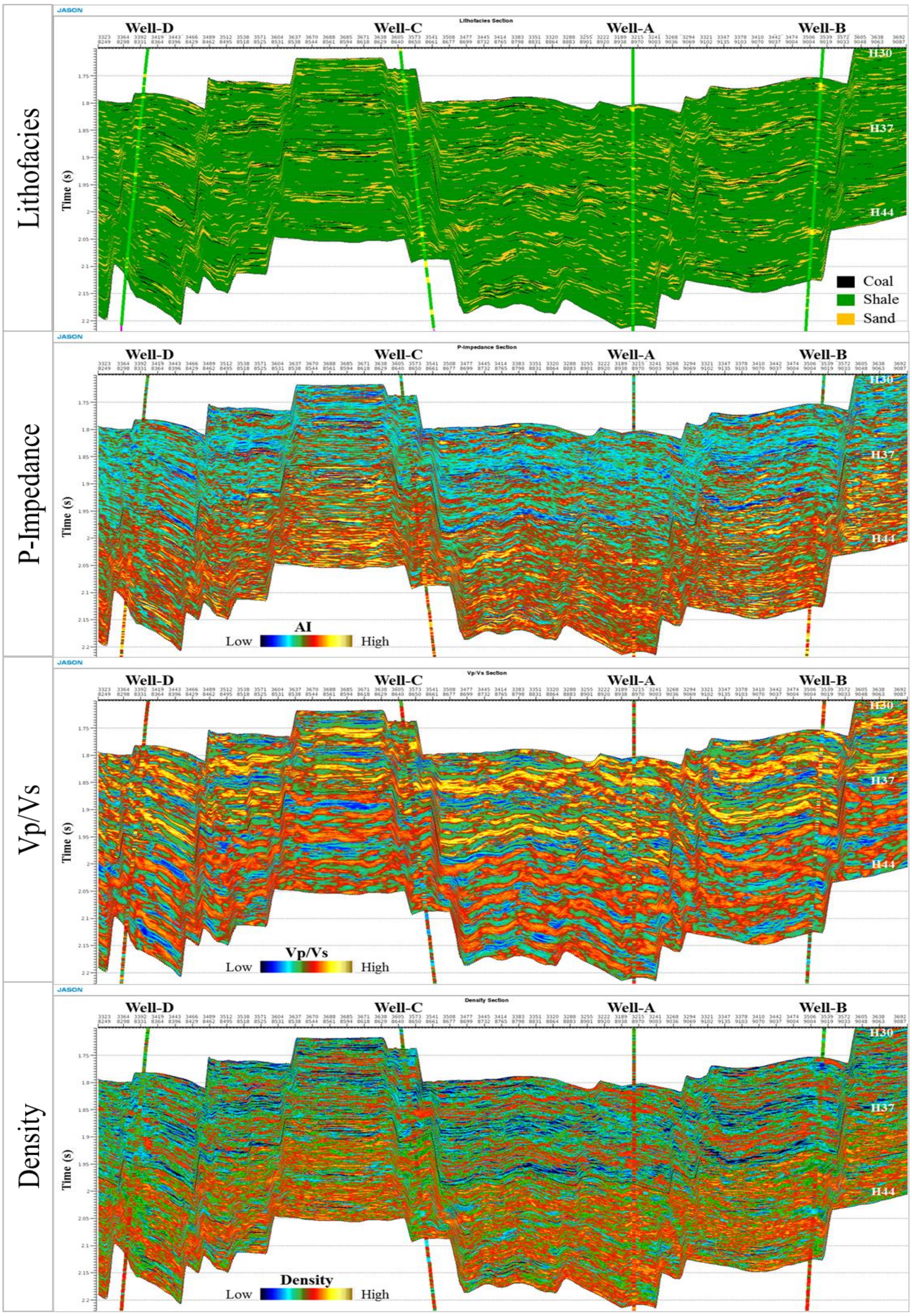

Figure B.7 Geostatistical inversion results, including lithofacies, P-Impedance, Vp/Vs and density generated from inversion realization 10.

CURRICULUM VITAE

Author’s Name	Miss Ratchadaporn Uttareun
Date of Birth	August 29th, 1985
Place of Birth	Chiang Mai Province, Thailand
Education	2004-2008, Bachelor degree of Science in Physics, Department of Physics and Materials Science, Faculty of Science, Chiang Mai University.
Scholarship	August 2016 – December 2017, sponsor by PTT Exploration and Production Public Company Limited, Thailand for study at international program of Petroleum Geophysics, Chiang Mai University.
Experience	2008 – present, Geophysicist for PTT Exploration and Production Public Company Limited.