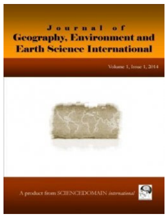

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Computer Processed Interpretation of Geophysical Logs of an Oil Field Niger Delta Sedimentary Basin, Onshore, Nigeria

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The computer processed log interpretation allows analysing and evaluating numerous types of logs with ease and presenting the results as functions of depth in graphical forms for visualisation. Computer processed interpretation of geophysical logs from five deep oil wells has been carried out for Niger Delta Sedimentary Basin. The composite wire line logs consisting of gamma ray, resistivity, density and neutron have been used for the study. The qualitative interpretation of the gamma ray log showed alternation of sandstone and shale lithologies which is an indication that the interval logged is within Agbada Formation of the Niger Delta. Four reservoirs were delineated and correlated across the five oil wells. The density and neutron logs were used for differentiating the hydrocarbon fluid into oil and gas. The delineated reservoirs were labelled as R1, R2, R3 and R4. The R1 is a gas bearing reservoir while R2, R3 and R4 reservoirs are oil bearing. The results of the formation evaluation showed that porosity and water saturation of the reservoirs range from 19.0 to 22.7 percent and 0.19 to 0.286 respectively. The computed permeability ranges from 516 to 1662

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milliDarcy (mD). The Net to Gross ratio for the four reservoirs ranges from 0.844 to 0.947. The computed values of the porosity, water saturation, Net to Gross ratio and permeability show that the four reservoirs have good to excellent quality.

Keywords: Computer processed interpretation; geophysical logs; porosity; water saturation; Niger Delta.

1. INTRODUCTION

Well logs present a concise detail plot of physical and chemical properties of formation versus depth in a borehole. Geophysical logging involves the process of detecting physical properties of insitu rocks such as density, gamma ray, resistivity, interval transits time and the size of boreholes. The measured parameters are used to obtain other petro-physical parameters such as lithology, porosity, water saturation, porous and non-porous rocks, pay zones in the subsurface, hydrocarbon saturation and possibly permeability. The measured petrophysical parameters are affected by the formation fluid, bore hole surface irregularities, shale and adjacent beds.

Geophysical well logs data processing and interpretation are complex processes and they involve mathematical, statistical and numerical techniques. Well log data evaluation and analysis can be carried out by manual and/or by employing a computer [1,2]. The first and most common technique is the manual evaluation, which makes use of charts and cross-plot. Recently, computer methods based processed interpretations are increasingly been used. Computer processed interpretation has been used by many researchers [2-5].

In this study, computer processed interpretation (CPI) of geophysical well logs data was carried out with the aid of Interactive Petrophysics (IP) software V3.5. It gives a continuous reading of lithology, porosity, fluid saturation and other petrophysical properties [6]. The quality of the logs was assessed before the application of the computer processed interpretation to avoid errors in the derived parameters.

Petrophysical evaluation of the reservoir rock is fundamental for all kinds of studies usually planned to be performed on an oil field. The purpose of this step is to define some rock properties such as porosity, permeability and fluid saturation throughout the reservoir. These data are necessary for volumetric calculation, definition of the flow behaviour and the recovery estimation. Petrophysical evaluation of shaly sand reservoirs has long been one of the most difficult problem in the oil and gas industry. Determination of petro-physical properties is crucial in quantitative well log interpretation. Some geoscientists have worked on the formation evaluation of different oil fields using wireline logs in the Niger Delta [7-10].

Well log analysis is the most crucial stage in petro-physical data evaluation. The software package used for this study has a predefined work flow that follows the basic steps of formation evaluation and analysis. The study was executed onInteractive Petrophysics (IP) software.The usual routine used by oil and gas companies for formation evaluation was adopted. “The techniques involve lithology and reservoir identifications, shale volume estimation, porosity and fluid saturation determination. The defaultcomputer processed interpretation format of the Interactive Petrophysics (IP) softwarewas used for generating the results.

The objectives of this research are to delineate and evaluate reservoir and petro-physical properties in five oil wells based on computer log processed interpretation. A deterministic approach was adopted in evaluating the weighted averages of porosity, water saturation, net-to-gross ratio (NTG) and permeability for each of the delineated reservoirs.

1.1 Summary of Geology of the Niger Delta

The location of the studied area in the Niger Delta sedimentary basin is shown in Fig. 1. The Niger Delta is situated in the Gulf of Guinea and it is within the Benue trough system. The Niger Delta formed along a failed arm at the site of rift triple junction which is related to the separation of southern American and African plates and the consequent opening of the southern Atlantic starting in the Late Jurassic to the Cretaceous. The Tertiary Niger Delta development started in the Eocene and about 12 km of deltaic and shallow marine sediments supply by rivers Niger and Benue have been deposited in the basin.

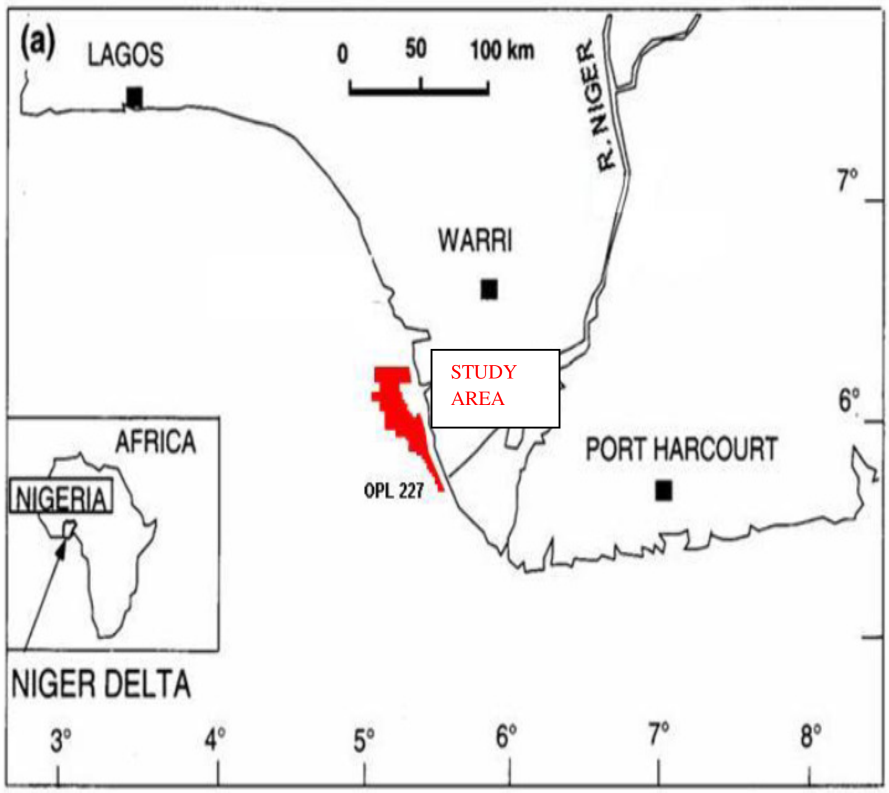


Fig. 1. Map of Niger Delta showing the location of the studied area

From Eocene to date, the Niger Delta sedimentary basin has prograded southwest ward forming depobelts.

Three distinguished geological formations namely Akata, Agbada and Benin are present in the Niger Delta. The Akata Formation is composed of marine shales and it is the main source rock in the basin [11]. The Akata formation is over pressured and it underlies the entire Niger delta. The average thickness of the Akata Formation is about 6 Km. The Akata Formation is overlain by the paralic sand/ shale sequence of the Agbada Formation. The Agbada Formation is the main reservoir rock in the Niger delta. The topmost section is the Benin Formation which is a continental deltaic sand. The basin is characterized with shale diapirs, growth faults and associated rollover anticlines which formed structural trap in the basin [12-15].

2. MATERIALS AND METHODS

Open-hole geophysical well logs from five bore holes distributed in the oil field were used for this study. The composite geophysical logs consist of gamma ray, calliper, resistivity, density, and neutron and sonic. Computer processed interpretation (CPI) was used for the petrophysical properties evaluation. The CPI technique was based on quantitative interpretation methods using Interactive Petrophysics (IP) software V3.5computer software programs.

The software package has a predefined work flows that follow the basic steps of formation evaluation and analysis. The work flows include lithology and reservoir identifications, shale volume estimation, porosity and fluid saturation determination. The defaulted software format was applied for the results generation.

The electronic copies of the logs were obtained fromShell Petroleum Development Company. First, the raw log data were checked for quality control and then edited before qualitative and quantitative interpretations were performed on the data. After that, the logs were edited by removing and correcting anomalies associated with the data. The petrophysical parameters of the formation that were determined for the study are;

2.1 Determination of Shale Volume

Most times, the hydrocarbon reservoir is usually associated with shale content. The gamma-ray log was used for determining the volume of shale in the delineated reservoirs. First, the gamma ray index (IGR) is calculated from the gamma ray log using the following equation [16]:

$$I_{GR} = \frac{GR_{\log} - GR_{\min}}{GR_{\max} - GR_{\min}} \quad (1)$$

Where,

I_{GR} = gamma ray index
GR_{log} = gamma ray reading of formation from log
GR_{min} = minimum gamma ray (clean sand)
GR_{max} = maximum gamma ray (shale)

The volume of shale was then calculated by applying the gamma ray index in the appropriate volume of shale equation for tertiary rocks [17], [18];

$$V_{sh} = 0.083\left(2^{3.7 X I_{GR}} - 1.0\right) \quad (2)$$

Where,

V_{sh} = volumeof shale
I_{GR} = gamma ray index.

2.2 Determination of Porosity from Density Log

Porosity can be determined from the density, neutron and sonic log. However, in this work, porosity was derived from density log. The Wyllie equation for density log derived porosity is given as:

$$\varphi_D = \frac{\ell_{\max} - \ell_b}{\ell_{\max} - \ell_{fl}} \quad (3)$$

Where

ℓ_{max} = density of rock matrix = 2.65 g/cm^3
ℓ_b = bulk density from log
φ_D = total Porosity from the Density log
ℓ_{fluid} = density of fluid occupying pore spaces (0.4 g/ cm^3 for gas, 0.9 g/cm^3 for oil and 1.0 g/ cm^3 for water)

Effective porosity excludes all the bound water associated with clays but involves all the connected pores in the pore system. The effective porosity is determined from the density log as,

$$\varphi_e = \varphi_D * \left(1 - V_{sh}\right) \quad (4)$$

Where

φ_D = Total porosity
φ_E = Effective Porosity
V_{sh} = Volume of shale

2.3 Formation Water Resistivity (R_w)

The resistivity of formation water (Rw) is an important interpretation parameter since it is required for the calculation of hydrocarbon saturations. There are several sources of formation water resistivity [16]. Formation Water Resistivity is estimated in this study from deep resistivity log in a clean water zone. The water resistivity was calculated from deep resistivity log by using Archie equation:

$$R_w = Ø^m * R_t \quad (5)$$

Where:

Ø = Porosity
R_t = Resistivity reading
R_w = formation water resistivity

2.4 Determination of Water Saturation

Water saturation is very crucial in volumetric analysis because it is used for estimating the hydrocarbon saturation. The water saturation is calculated based on the formula:

$$Sw = \sqrt[2]{\frac{Ro}{Rt}} \quad (6)$$

Where

Sw = water saturation
Ro = resistivity of the reservoir 100 percent saturated with saline water.
Rt = resistivity of the reservoir

Both the Rt and Ro were obtained from deep resistivity log. The hydrocarbon saturation is computed from the water saturation with the formula;

$$Sh = 1 - Sw \quad (7)$$

Where

Sw = water saturation
Sh = hydrocarbon saturation

2.5 Permeability Estimation

Several researchers have proposed various empirical relationships with which permeability can be estimated from porosity and irreducible water saturation derived from well logs. In this study, one of such empirical relations was used to estimate the intrinsic (absolute) permeability. The empirical relations used in this work to obtained permeability for gas and oil are;

$$K = (79*\Phi^3/Sw_{irr})^2 \quad \text{for Gas} \quad (8)$$

And

$$K = (250*\Phi^3/Sw_{irr})^2 \quad \text{for Oil} \quad (9)$$

Where

K = permeability,
ϕ = porosity
S_{wirr}= irreducible water saturation

Equations 8 and 9 were used for gas and oil reservoirs respectively.

3. RESULTS AND DISCUSSION

The formation evaluation was executed with the computer processed interpretation techniques of the software programmes. The qualitative interpretation of the geophysical logs from the five boreholes showed that sandstones, shale, and sandy shale are the major lithologies present in the formations encounter in the boreholes. The gamma ray logs show alternation of sandstone and shale which is an indication of Agbada formation in the Niger delta. Four hydrocarbon bearing reservoirs were delineated from the resistivity and gamma ray logs. The four reservoirs were denoted as R1, R2, R3 and R4. The observed reservoirs were correlated across the five wells. The Computer processed interpretation (CPI) plots of delineated lithology, computed porosity, water saturation and volume of shale generated for the reservoirs in the five boreholes are presented below.

3.1 Petrophysical Evaluation of Reservoir (R1)

The reservoir R1 is predominantly gas bearing reservoir. The CPI of the various measured petrophysical parameters for R1 reservoir in well 1-5 are shown in Fig. 2. The computer processed log interpretation output shows suite of both the input and the derived logs. The input gamma ray and calliper logs are in column 1, deep resistivity log in track 5, density and neutron in track 6. The derived water saturation is presented in track 8; porosity, bulk water volume and volume of shale in track 9 while permeability is in track 10.

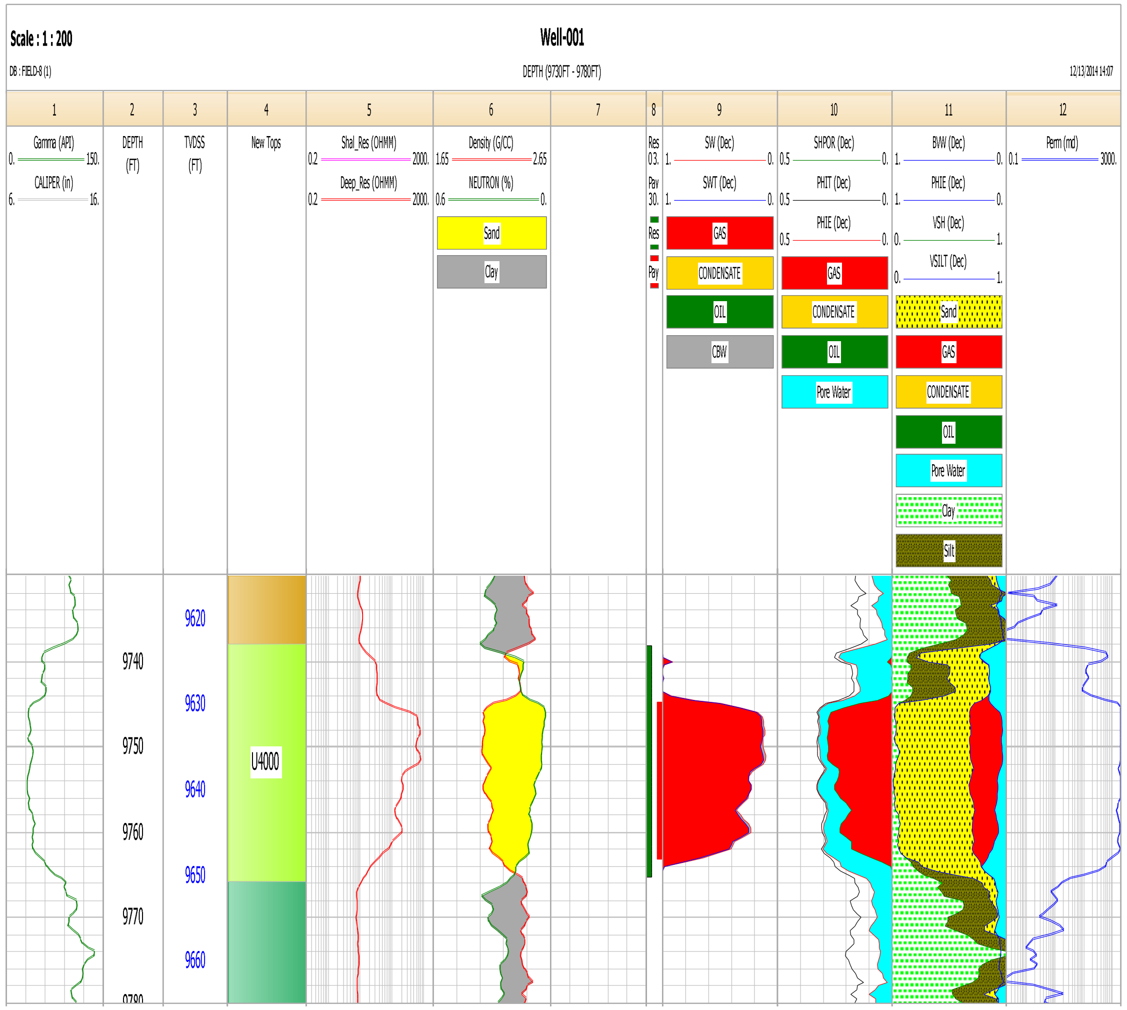
The computed average effective porosity, NTG, Sw, and permeability for reservoir R1 are 0.23, 0.84, 0.29 and 1662 mD respectively. This reservoir has good petrophysical properties and with permeability in the Darcies, range which confirmed the reducibility of this reservoir without any artificial support like GasLift support.

3.2 Petrophysical Evaluation Reservoir R2

Reservoir R2 is an oil bearing reservoir with Original-Oil-Water-Contact (OOWC) logged by Well-1 at 9799 ft. The fluid types and contacts are interpreted using the logs (GR, Resistivity, Density, and Neutron) from the five wells. Fig. 3 is the CPI for the five wells (Well-1 to Well-5). R2 has an average effective porosity of 0.21, NTG of 0.95, Sw of 0.26 and permeability of 812 mD. This reservoir has good petrophysical properties and will be able to flow to the surface without Gaslift support.

3.3 Petrophysical Evaluation Reservoir R3

R3 is an oil bearing reservoir with a clear Original-Oil-Water-Contact (OOWC) logged by Well-3 at 10127 ft. Fig. 4 is the R3(CPI) for the five wells (Well-1 to Well-5). The reservoir has average effective porosity of 0.20, NTG of 0.90, Sw of 0.27 and permeability of 516 mD. This reservoir has good petrophysical properties and will be able to flow to the surface without Gaslift support.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Gamma (API)
CALIPER (in)
DEPTH (FT)
TVDSS (FT)
New Tops
Shal_Res (OHMM)
Deep_Res (OHMM)
Density (G/CC)
NEUTRON (%)
Sand
Clay
SW (Dec)
SWT (Dec)
GAS
CONDENSATE
OIL
CBW
SHPOR (Dec)
PHIT (Dec)
PHIE (Dec)
Pore Water
BVW (Dec)
VSH (Dec)
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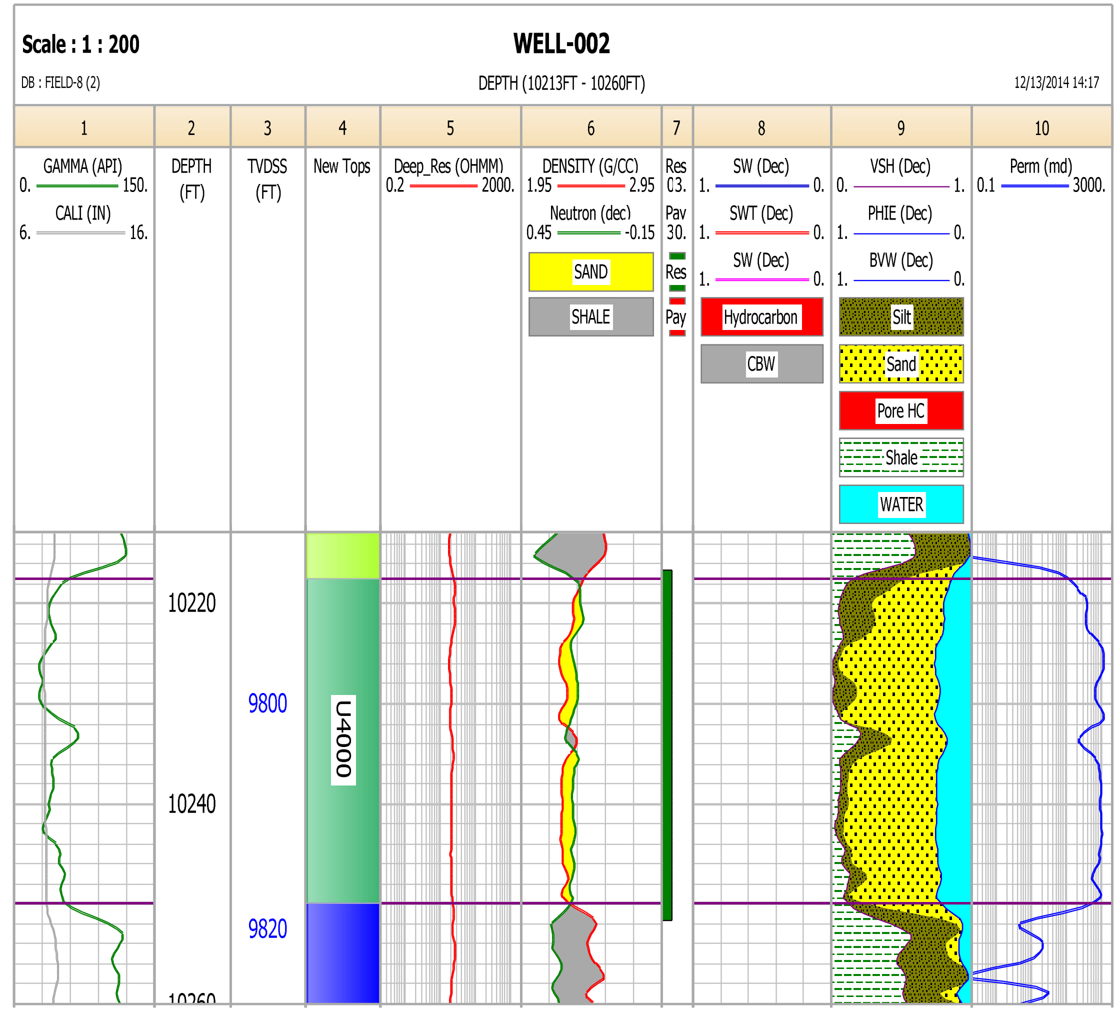
9640
9650
9660
U4000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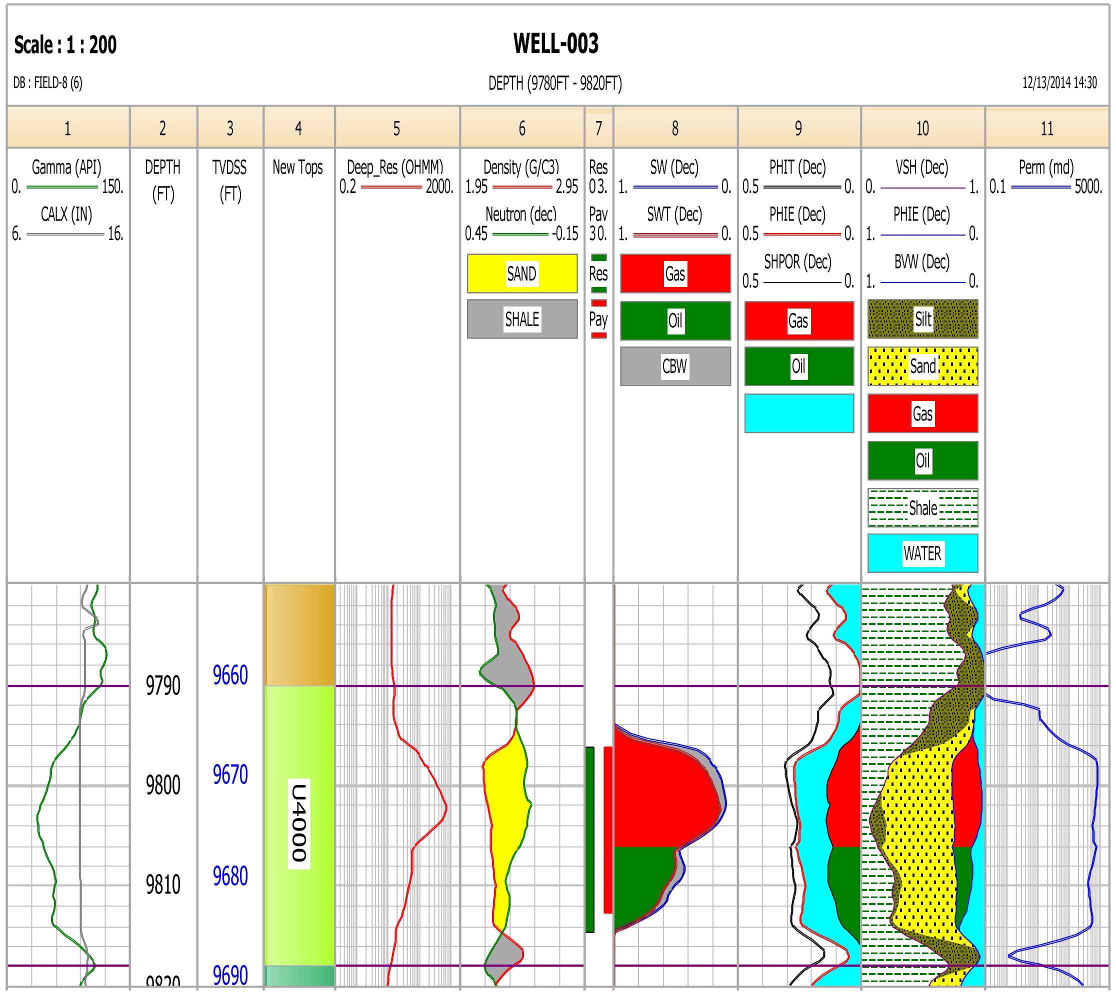
DEPTH (10213FT - 10260FT)
12/13/2014 14:17
1
2
3
4
5
6
7
8
9
10
GAMMA (API)
0. 150.
CALI (IN)
6. 16.
DEPTH (FT)
TVDSS (FT)
New Tops
Deep_Res (OHMM)
0.2 2000.
DENSITY (G/CC)
1.95 2.95
Neutron (dec)
0.45 -0.15
SAND
SHALE
Res
Pay
SW (Dec)
SWT (Dec)
Hydrocarbon
CBW
VSH (Dec)
PHIE (Dec)
BVW (Dec)
Silt
Sand
Pore HC
Shale
WATER
Perm (md)
0.1 3000.
10220
10240
9800
9820
U4000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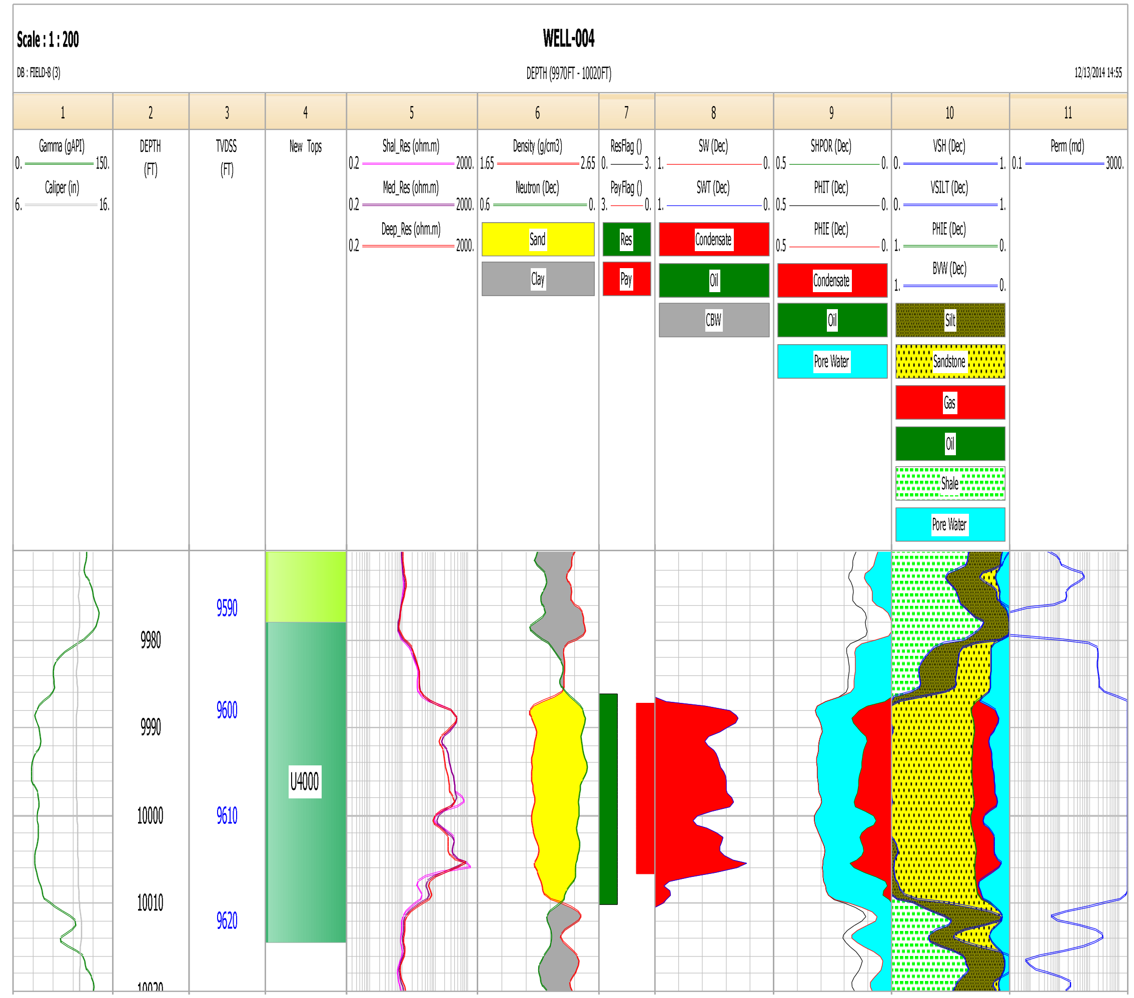
Gamma (API)
0. 150.
CALX (IN)
6. 16.
DEPTH (FT)
TVDSS (FT)
New Tops
Deep_Res (OHMM)
0.2 2000.
Density (G/C3)
1.95 2.95
Neutron (dec)
0.45 -0.15
SAND
SHALE
Res
Pay
SW (Dec)
SWT (Dec)
Gas
Oil
CBW
PHIT (Dec)
PHIE (Dec)
SHPOR (Dec)
VSH (Dec)
BVW (Dec)
Silt
Sand
Shale
WATER
Perm (md)
0.1 5000.
9790
9800
9810
9660
9670
9680
9690
U4000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WELL-004
DEPTH (9970FT - 10020FT)
Gamma (gAPI)
Caliper (in)
DEPTH (FT)
TVDSS (FT)
New Tops
Shal_Res (ohm.m)
Med_Res (ohm.m)
Deep_Res (ohm.m)
Density (g/cm3)
Neutron (Dec)
Sand
Clay
ResFlag ()
PayFlag ()
Res
Pay
SW (Dec)
SWT (Dec)
Condensate
Oil
CBW
SHPOR (Dec)
PHIT (Dec)
PHIE (Dec)
Pore Water
VSH (Dec)
VSILT (Dec)
BVW (Dec)
Silt
Sandstone
Gas
Shale
Perm (md)
9980
9990
10000
10010
9590
9600
9610
9620
U4000

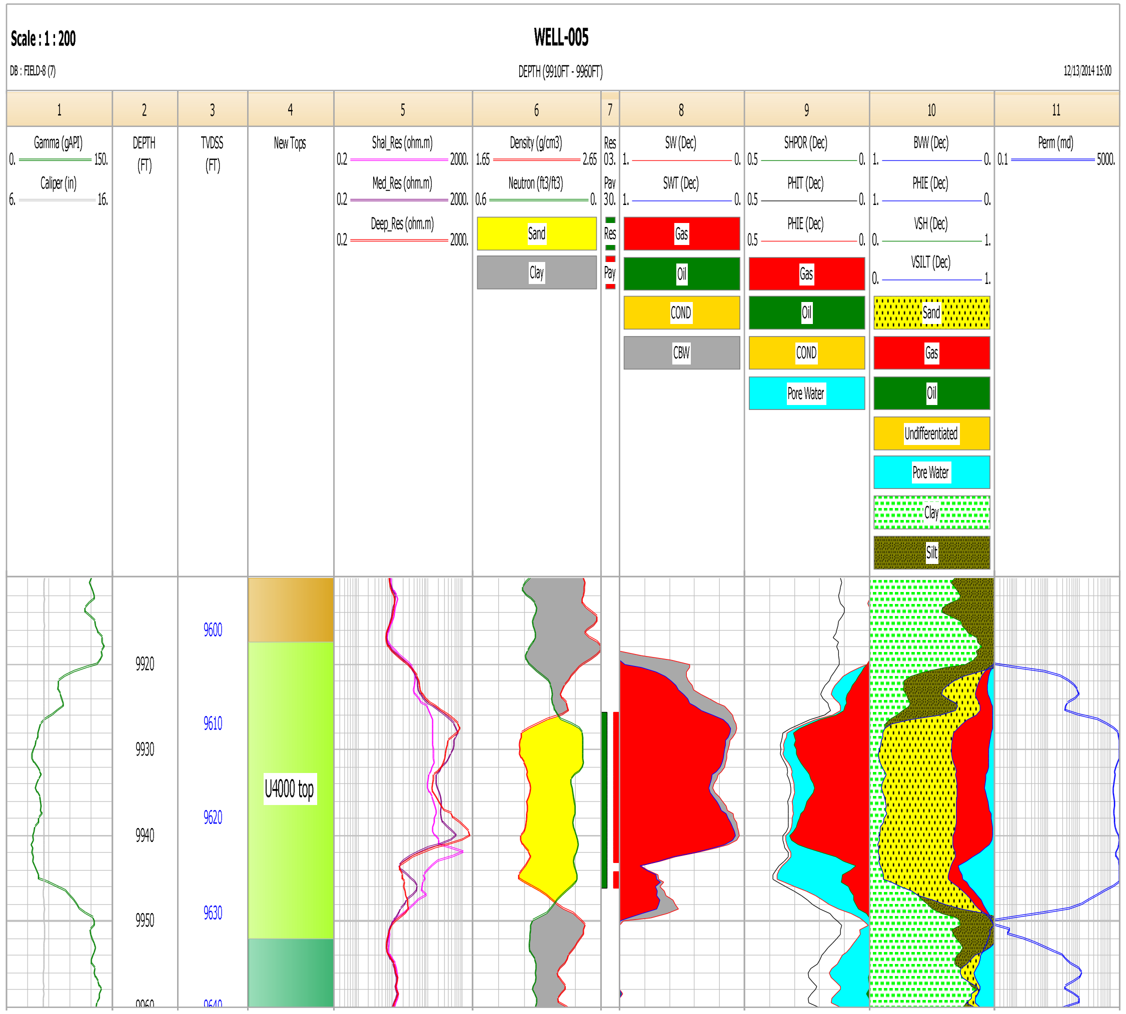
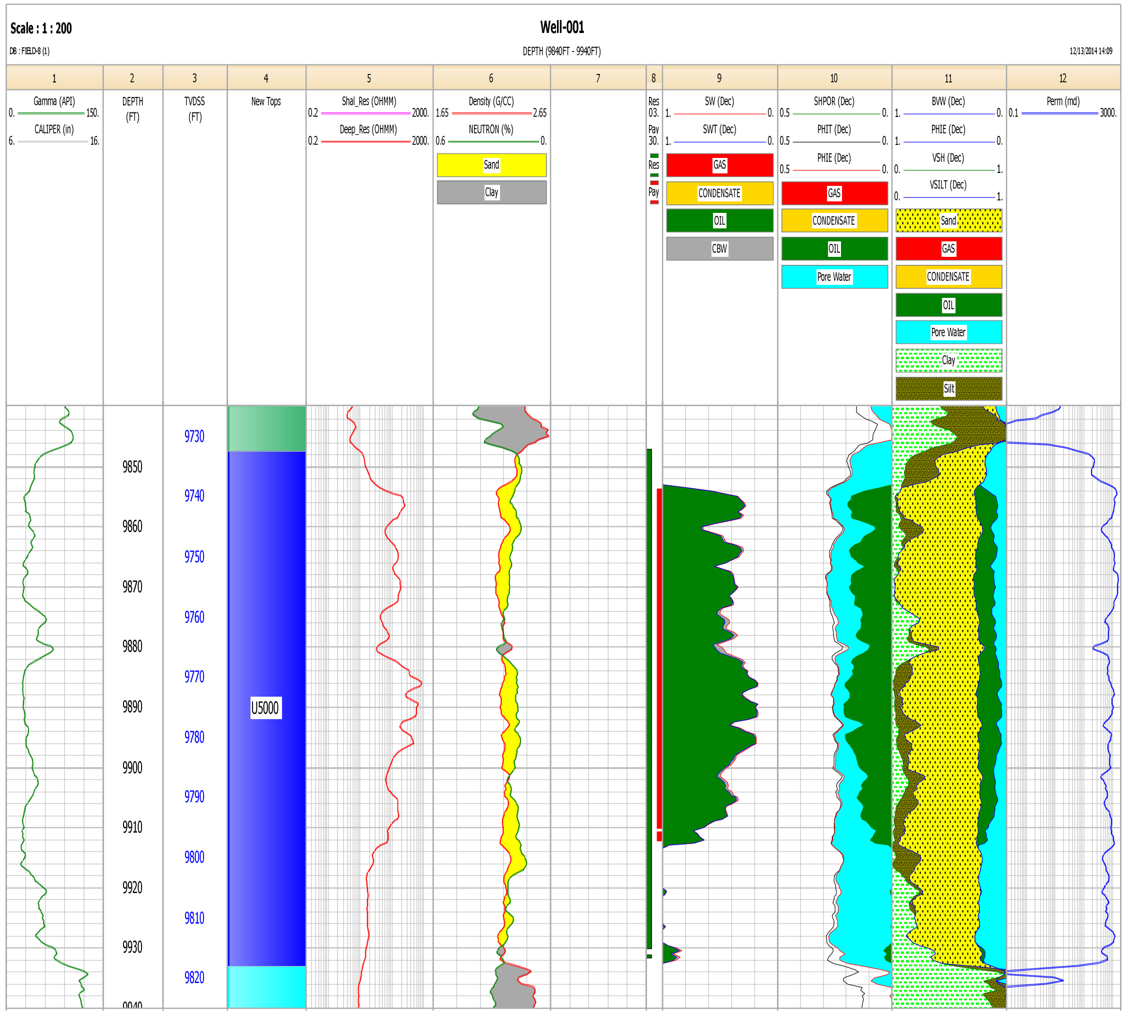


Fig. 2. Computer processed interpretation of composite geophysical logs for reservoir R1 in wells 1, 2, 3, 4 and 5. Water saturation, porosity, permeability are tracks 8, 9 and 10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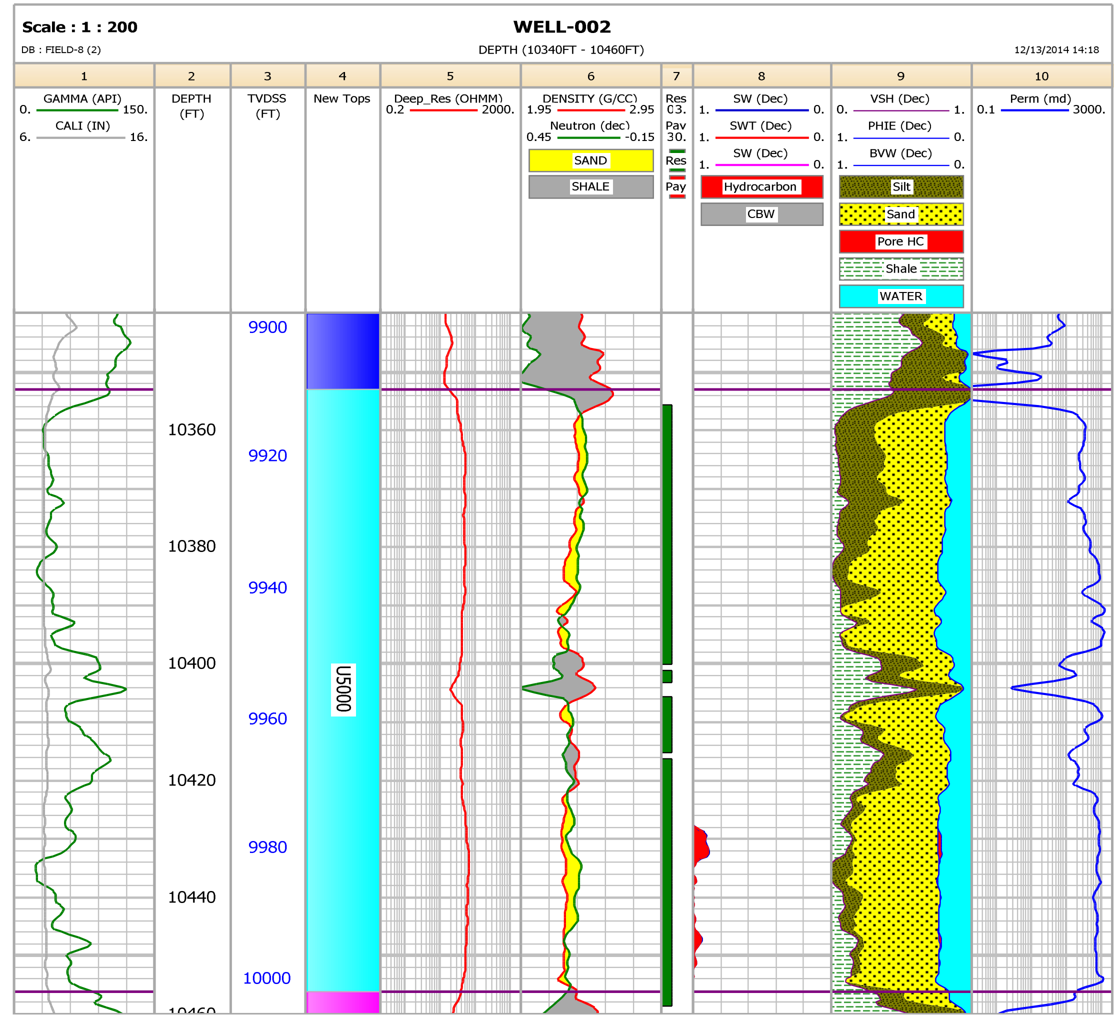
Well-001
DEPTH (9840FT - 9940FT)
Gamma (API)
CALIPER (in)
DEPTH (FT)
TVDSS (FT)
New Tops
Shal_Res (OHMM)
Deep_Res (OHMM)
Density (G/CC)
NEUTRON (%)
Sand
Clay
SW (Dec)
SWT (Dec)
GAS
CONDENSATE
OIL
CBW
SHPOR (Dec)
PHIT (Dec)
PHIE (Dec)
Pore Water
BVW (Dec)
VSH (Dec)
VSILT (Dec)
Silt
Perm (md)
U5000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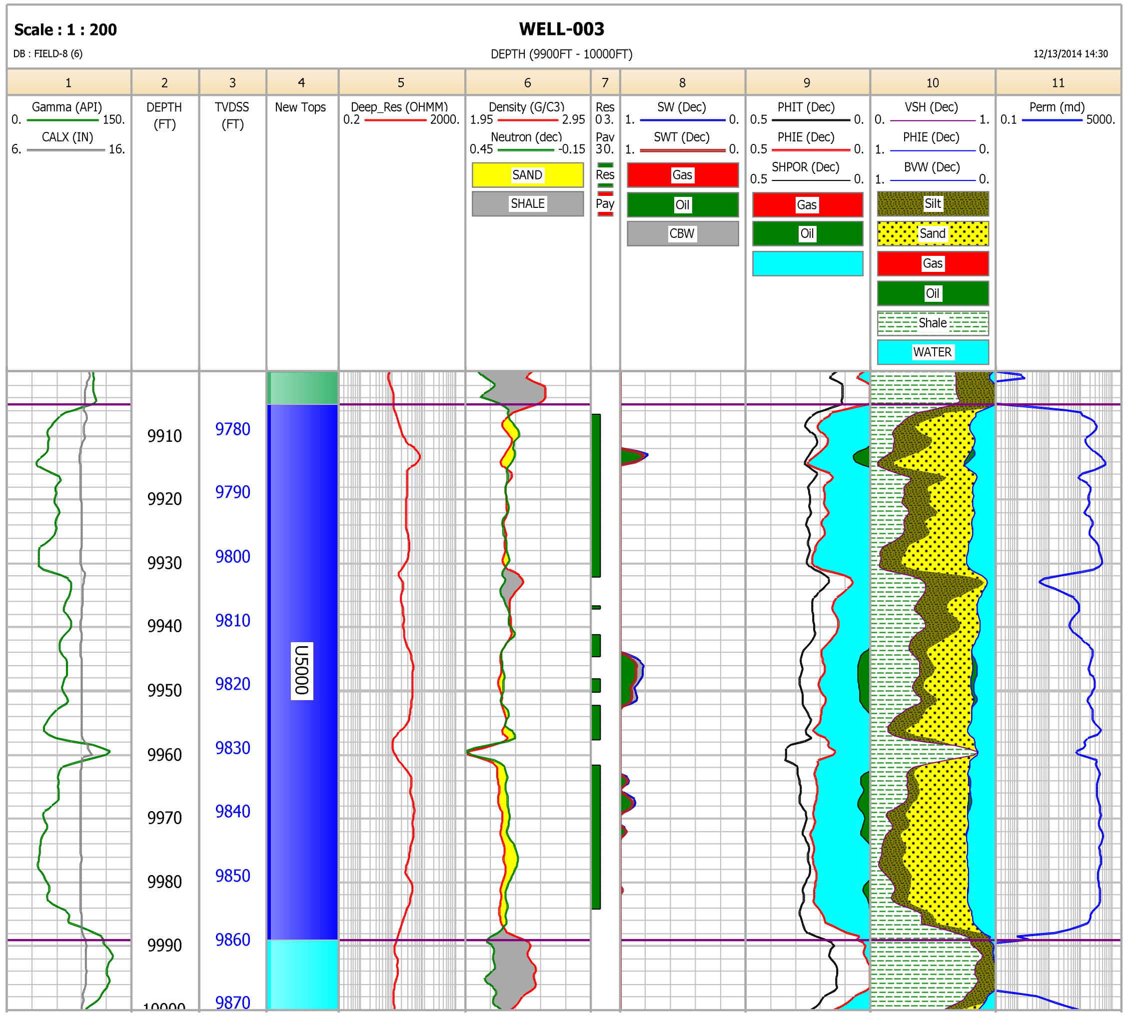
GAMMA (API)
CALI (IN)
DEPTH (FT)
TVDSS (FT)
New Tops
Deep_Res (OHMM)
DENSITY (G/CC)
Neutron (dec)
SAND
SHALE
Res
Pay
SW (Dec)
SWT (Dec)
Hydrocarbon
CBW
VSH (Dec)
PHIE (Dec)
BVW (Dec)
Silt
Sand
Pore HC
Shale
WATER
Perm (md)
U5000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WELL-003
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DEPTH (9900FT - 10000FT)
12/13/2014 14:30
1
2
3
4
5
6
7
8
9
10
11
Gamma (API)
0. 150.
CALX (IN)
6. 16.
DEPTH (FT)
TVDSS (FT)
New Tops
Deep_Res (OHMM)
0.2 2000.
Density (G/C3)
1.95 2.95
Neutron (dec)
0.45 -0.15
SAND
SHALE
Res
0 3.
Pay
30.
Res
Pay
SW (Dec)
1. 0.
SWT (Dec)
1. 0.
Gas
Oil
CBW
PHIT (Dec)
0.5 0.
PHIE (Dec)
0.5 0.
SHPOR (Dec)
0.5 0.
Gas
Oil
VSH (Dec)
0. 1.
PHIE (Dec)
1. 0.
BVW (Dec)
1. 0.
Silt
Sand
Gas
Oil
Shale
WATER
Perm (md)
0.1 5000.
9910
9920
9930
9940
9950
9960
9970
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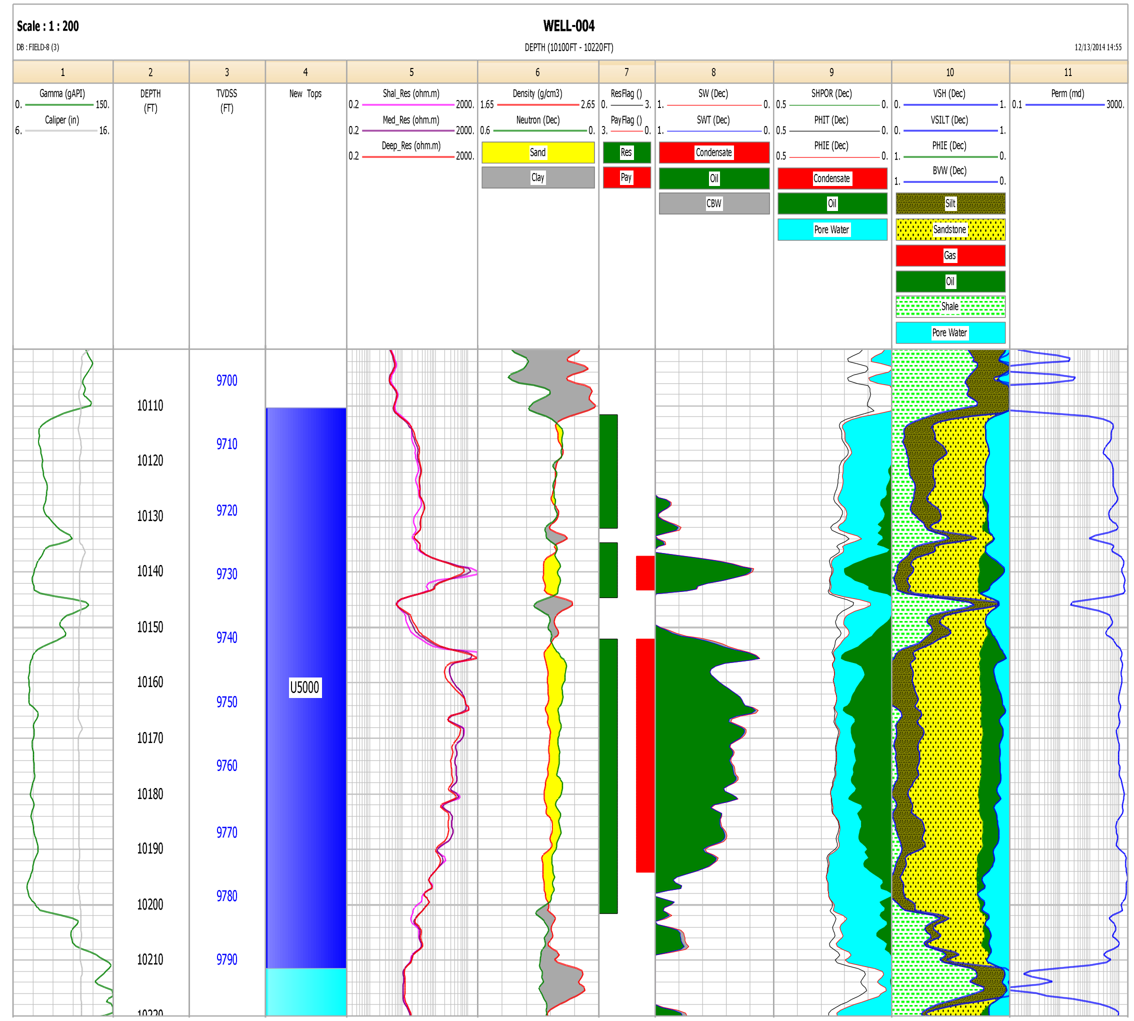
9850
9860
9870
U5000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WELL-004
DEPTH (10100FT - 10220FT)
1
2
3
4
5
6
7
8
9
10
11
Gamma (gAPI)
Caliper (in)
DEPTH (FT)
TVDSS (FT)
New Tops
Shal_Res (ohm.m)
Med_Res (ohm.m)
Deep_Res (ohm.m)
Density (g/cm3)
Neutron (Dec)
Sand
Clay
ResFlag ()
PayFlag ()
Res
Pay
SW (Dec)
SWT (Dec)
Condensate
Oil
CBW
SHPOR (Dec)
PHIT (Dec)
PHIE (Dec)
Condensate
Oil
Pore Water
VSH (Dec)
VSILT (Dec)
PHIE (Dec)
BVW (Dec)
Silt
Sandstone
Gas
Oil
Shale
Pore Water
Perm (md)
10110
10120
10130
10140
10150
10160
10170
10180
10190
10200
10210
9700
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9750
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9770
9780
9790
U5000

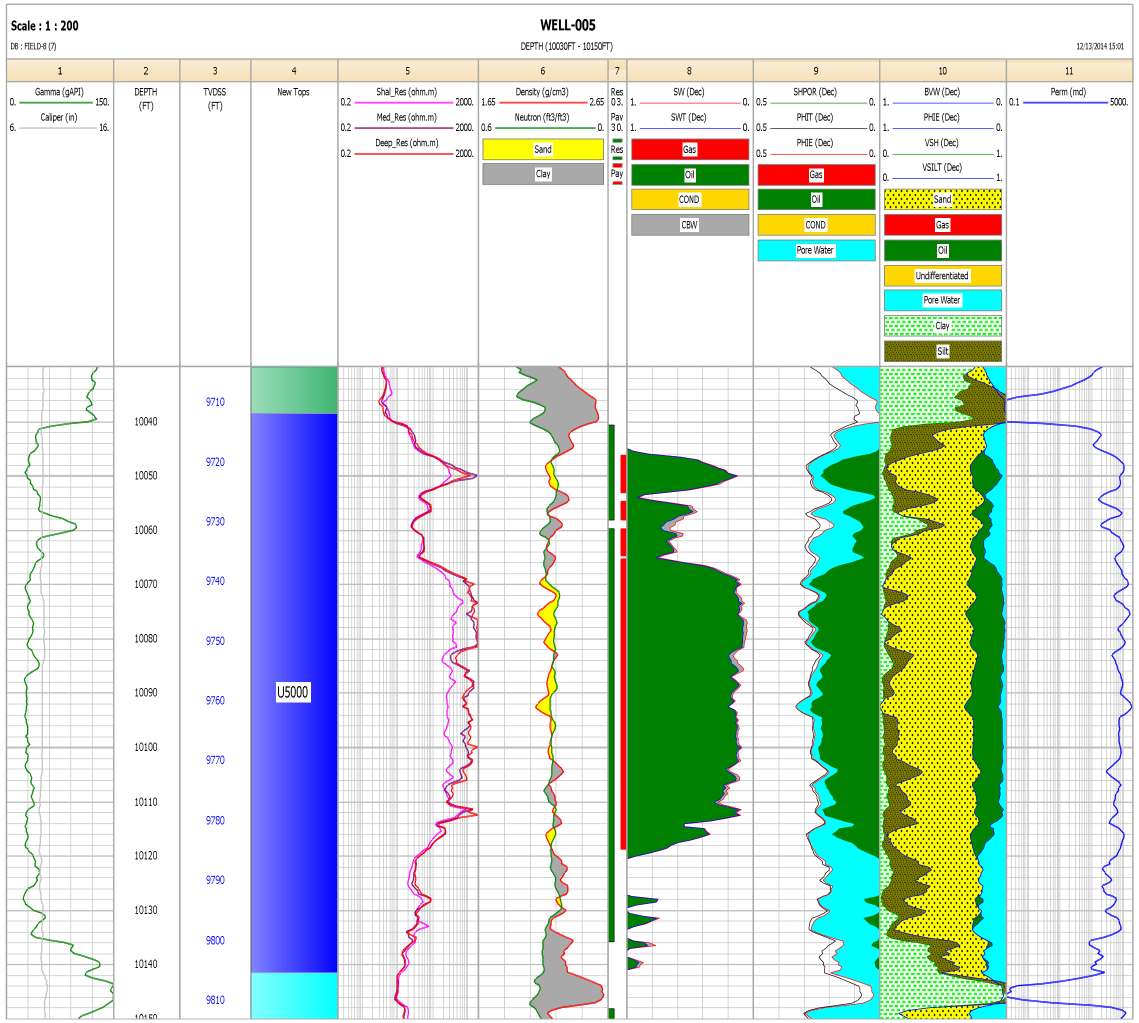
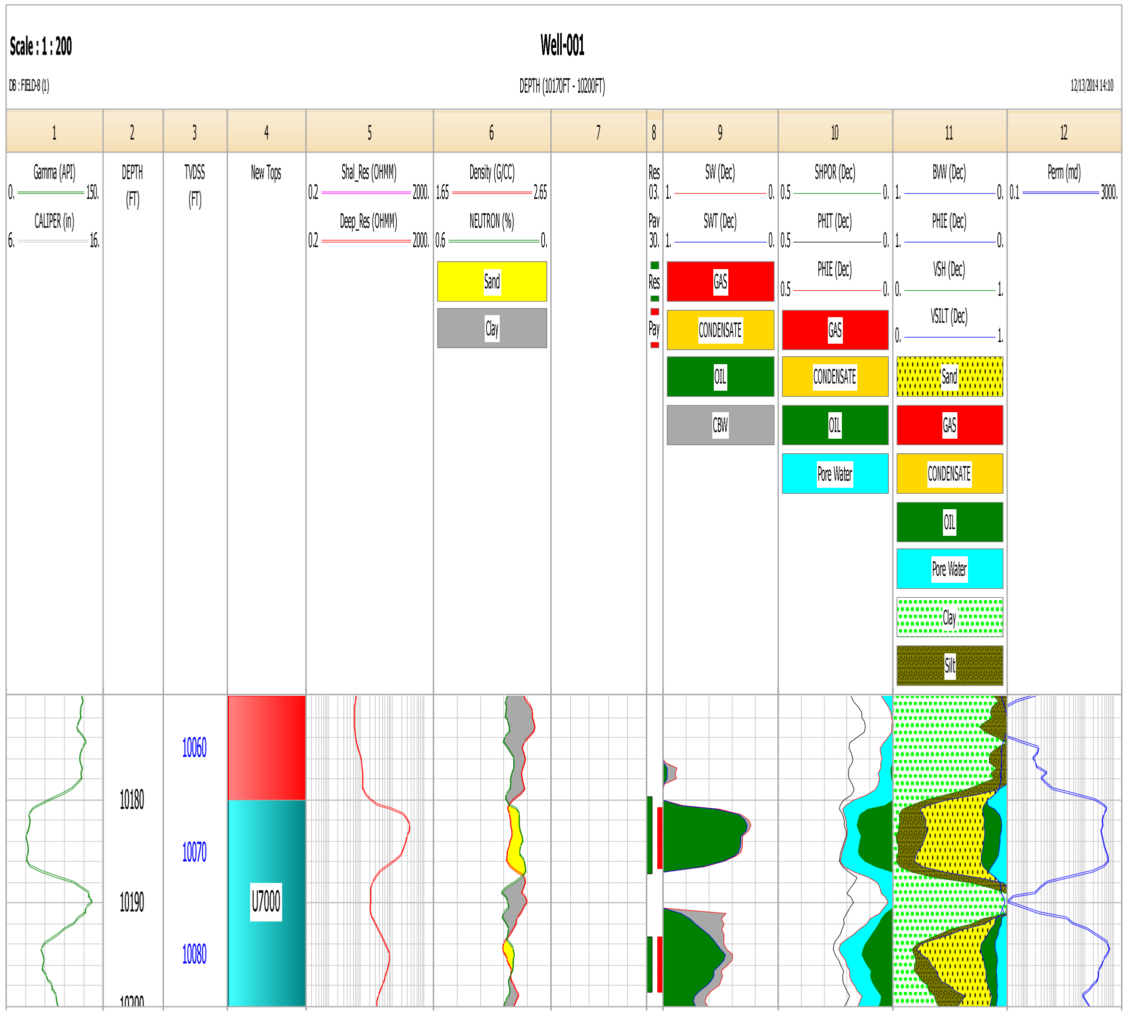


Fig. 3. Computer processed interpretation of composite geophysical logs for reservoir R2 in wells 1, 2, 3, 4 and 5: Water saturation, porosity, permeability are tracks 8, 9 and 10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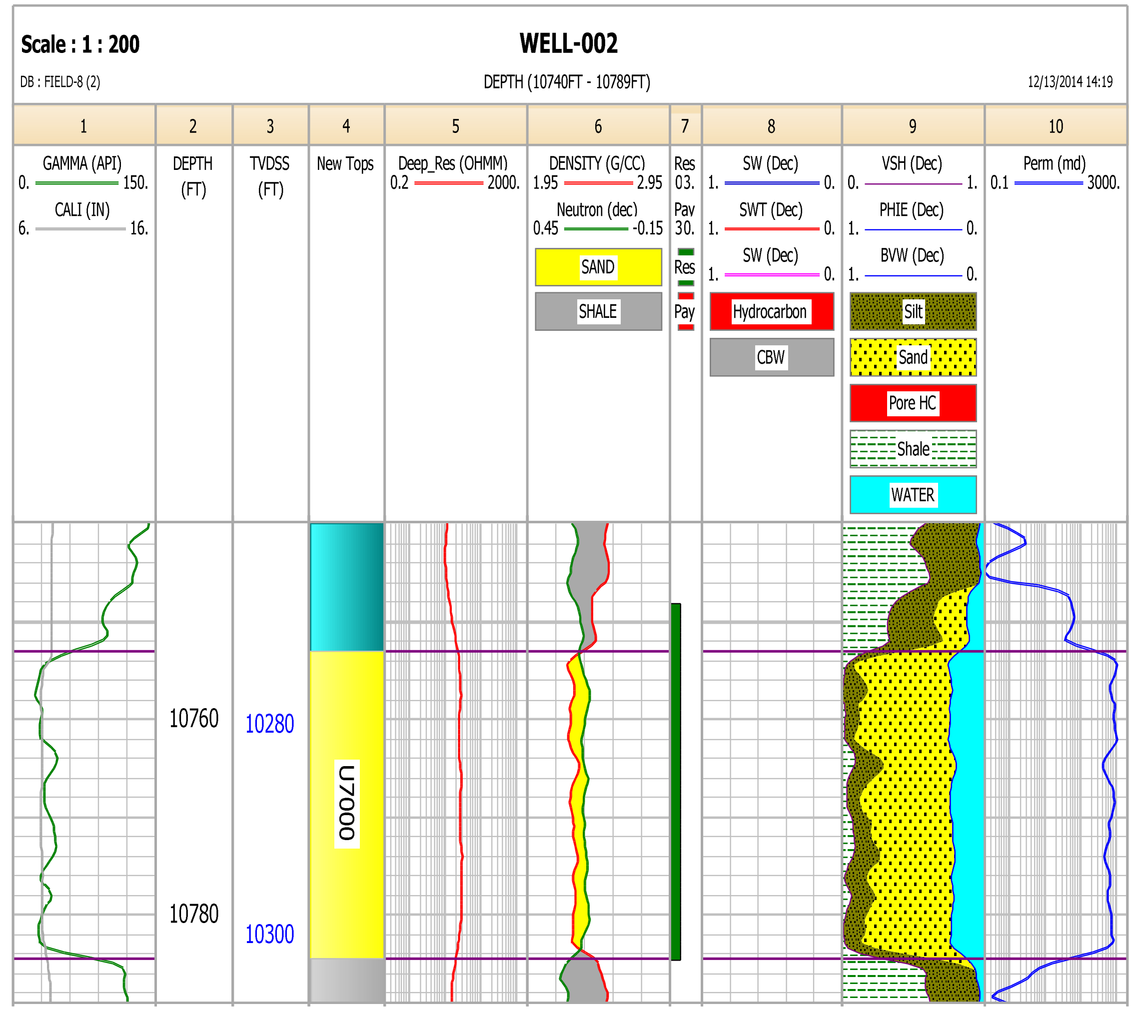
12/13/2014 14:10
1
2
3
4
5
6
7
8
9
10
11
12
Gamma (API)
CALIPER (in)
DEPTH (FT)
TVDSS (FT)
New Tops
Shal_Res (OHMM)
Deep_Res (OHMM)
Density (G/CC)
NEUTRON (%)
Sand
Clay
Res
Pay
SW (Dec)
SWT (Dec)
GAS
CONDENSATE
OIL
CBW
SHPOR (Dec)
PHIT (Dec)
PHIE (Dec)
Pore Water
BVW (Dec)
VSH (Dec)
VSILT (Dec)
Silt
Perm (md)
10180
10190
10060
10070
10080
U7000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12/13/2014 14:19
1
2
3
4
5
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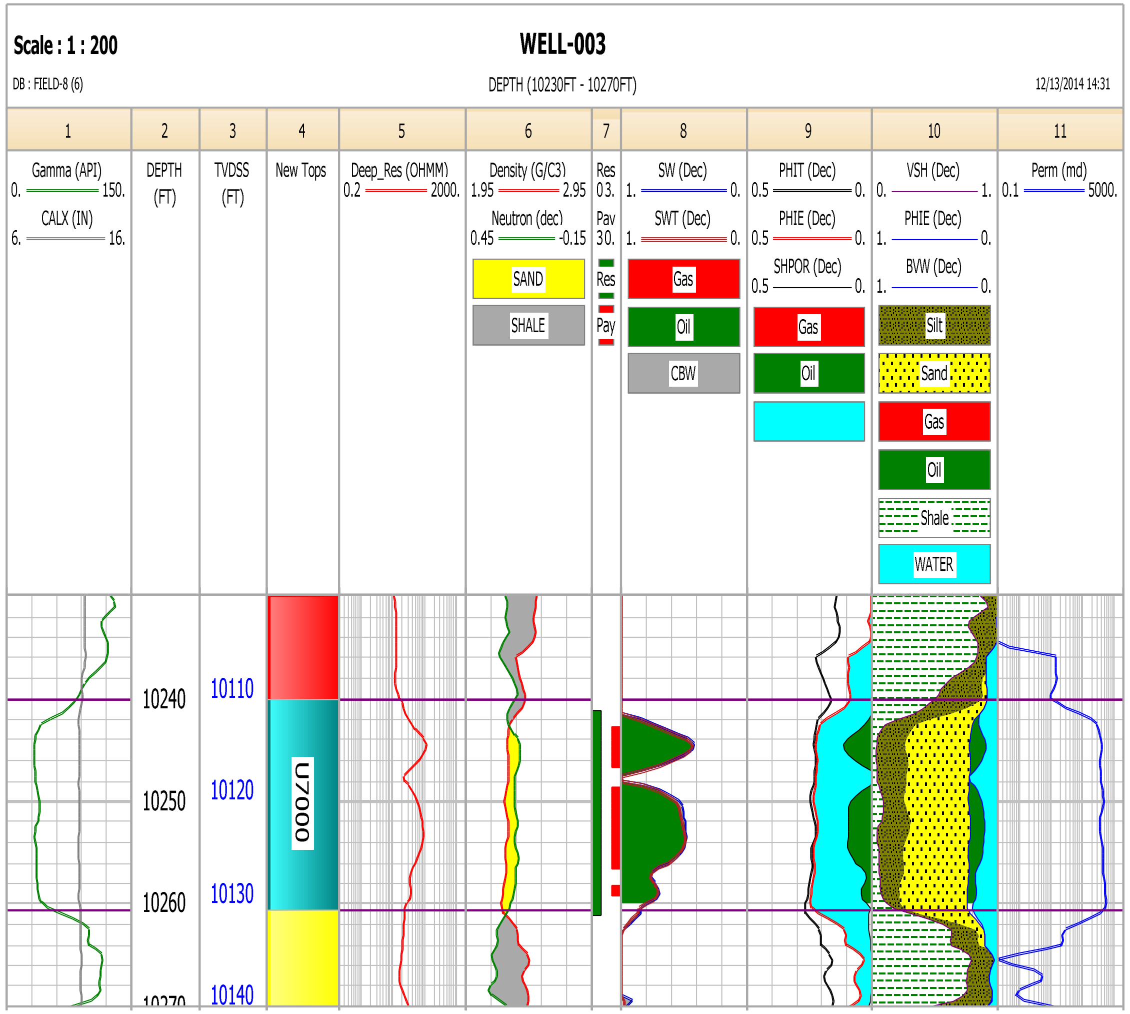
7
8
9
10
GAMMA (API)
0. 150.
CALI (IN)
6. 16.
DEPTH (FT)
TVDSS (FT)
New Tops
Deep_Res (OHMM)
0.2 2000.
DENSITY (G/CC)
1.95 2.95
Neutron (dec)
0.45 -0.15
SAND
SHALE
Res
03.
Pay
30.
SW (Dec)
1. 0.
SWT (Dec)
1. 0.
SW (Dec)
1. 0.
Hydrocarbon
CBW
VSH (Dec)
0. 1.
PHIE (Dec)
1. 0.
BVW (Dec)
1. 0.
Silt
Sand
Pore HC
Shale
WATER
Perm (md)
0.1 3000.
10760
10780
10280
10300
U7000



Scale : 1 : 200
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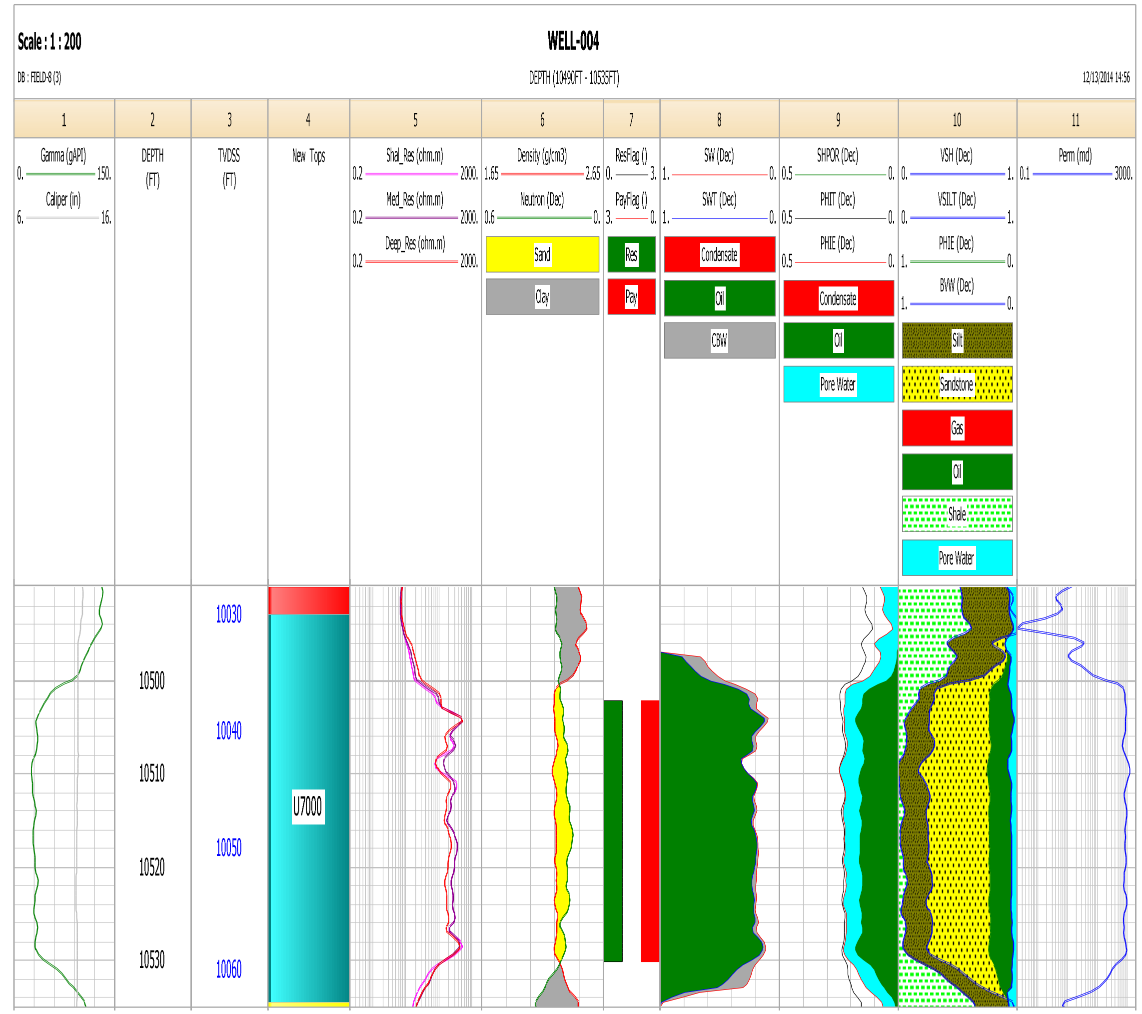
DEPTH (10230FT - 10270FT)
12/13/2014 14:31
1
2
3
4
5
6
7
8
9
10
11
Gamma (API)
0. 150.
CALX (IN)
6. 16.
DEPTH (FT)
TVDSS (FT)
New Tops
Deep_Res (OHMM)
0.2 2000.
Density (G/C3)
1.95 2.95
Neutron (dec)
0.45 -0.15
SAND
SHALE
Res
03.
Pav
30.
Res
Pay
SW (Dec)
1. 0.
SWT (Dec)
1. 0.
Gas
Oil
CBW
PHIT (Dec)
0.5 0.
PHIE (Dec)
0.5 0.
SHPOR (Dec)
0.5 0.
Gas
Oil
VSH (Dec)
0. 1.
PHIE (Dec)
1. 0.
BVW (Dec)
1. 0.
Silt
Sand
Gas
Oil
Shale
WATER
Perm (md)
0.1 5000.
10240
10250
10260
10110
10120
10130
10140
U7000



Scale : 1 : 200
WELL-004
DB : FIELD-8 (3)
1
2
3
4
5
6
7
8
9
10
11
Gamma (gAPI)
0. 150.
Caliper (in)
6. 16.
DEPTH (FT)
TVDSS (FT)
New Tops
Shal_Res (ohm.m)
0.2 2000.
Med_Res (ohm.m)
0.2 2000.
Deep_Res (ohm.m)
0.2 2000.
Density (g/cm3)
1.65 2.65
Neutron (Dec)
0.6 0.
Sand
Clay
ResFlag ()
PayFlag ()
Res
Pay
SW (Dec)
1. 0.
SWT (Dec)
1. 0.
Condensate
Oil
CBW
SHPOR (Dec)
0.5 0.
PHIT (Dec)
0.5 0.
PHIE (Dec)
0.5 0.
Condensate
Oil
Pore Water
VSH (Dec)
0. 1.
VSILT (Dec)
0. 1.
PHIE (Dec)
1. 0.
BVW (Dec)
1. 0.
Silt
Sandstone
Gas
Oil
Shale
Pore Water
Perm (md)
0.1 3000.
10500
10510
10520
10530
10030
10040
10050
10060
U7000

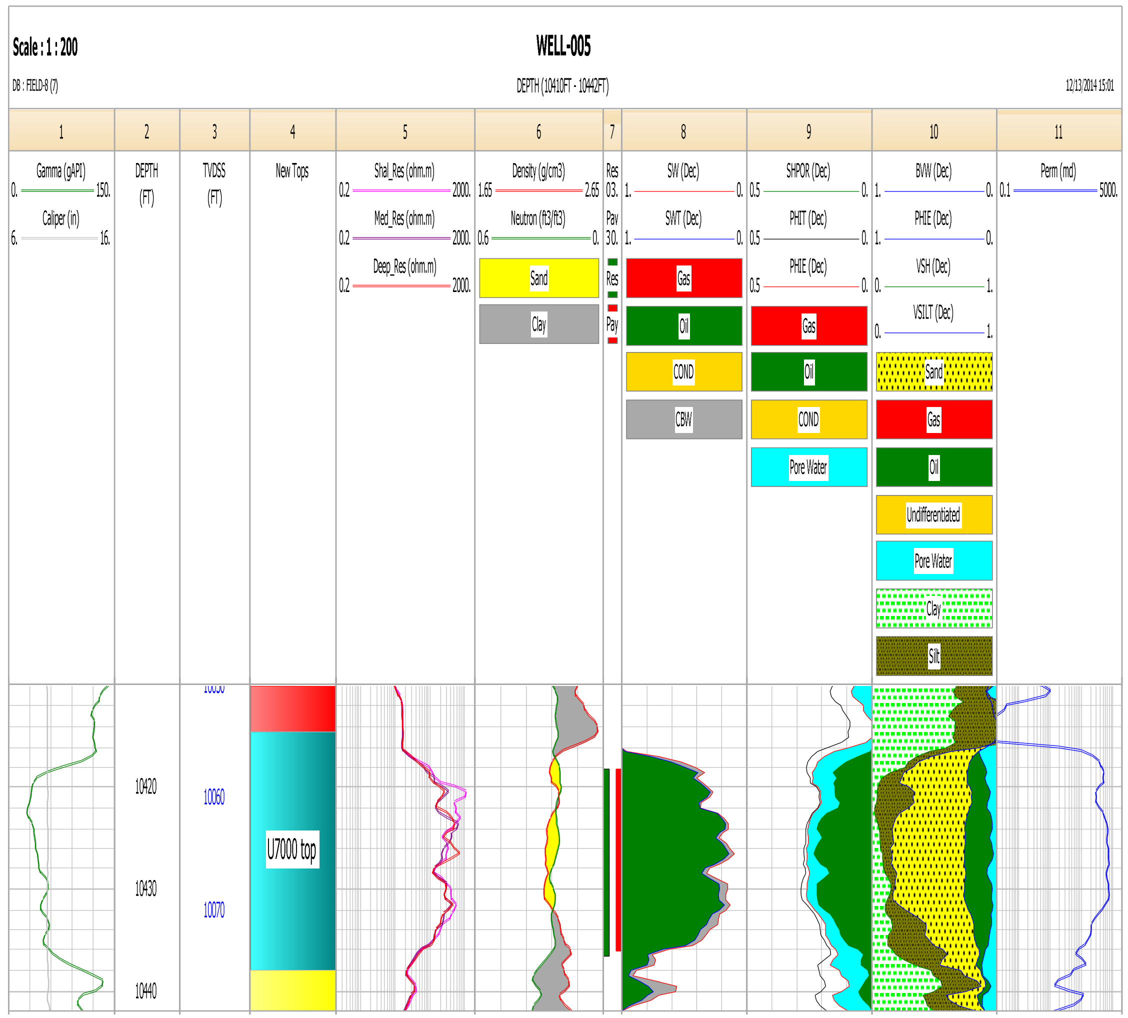
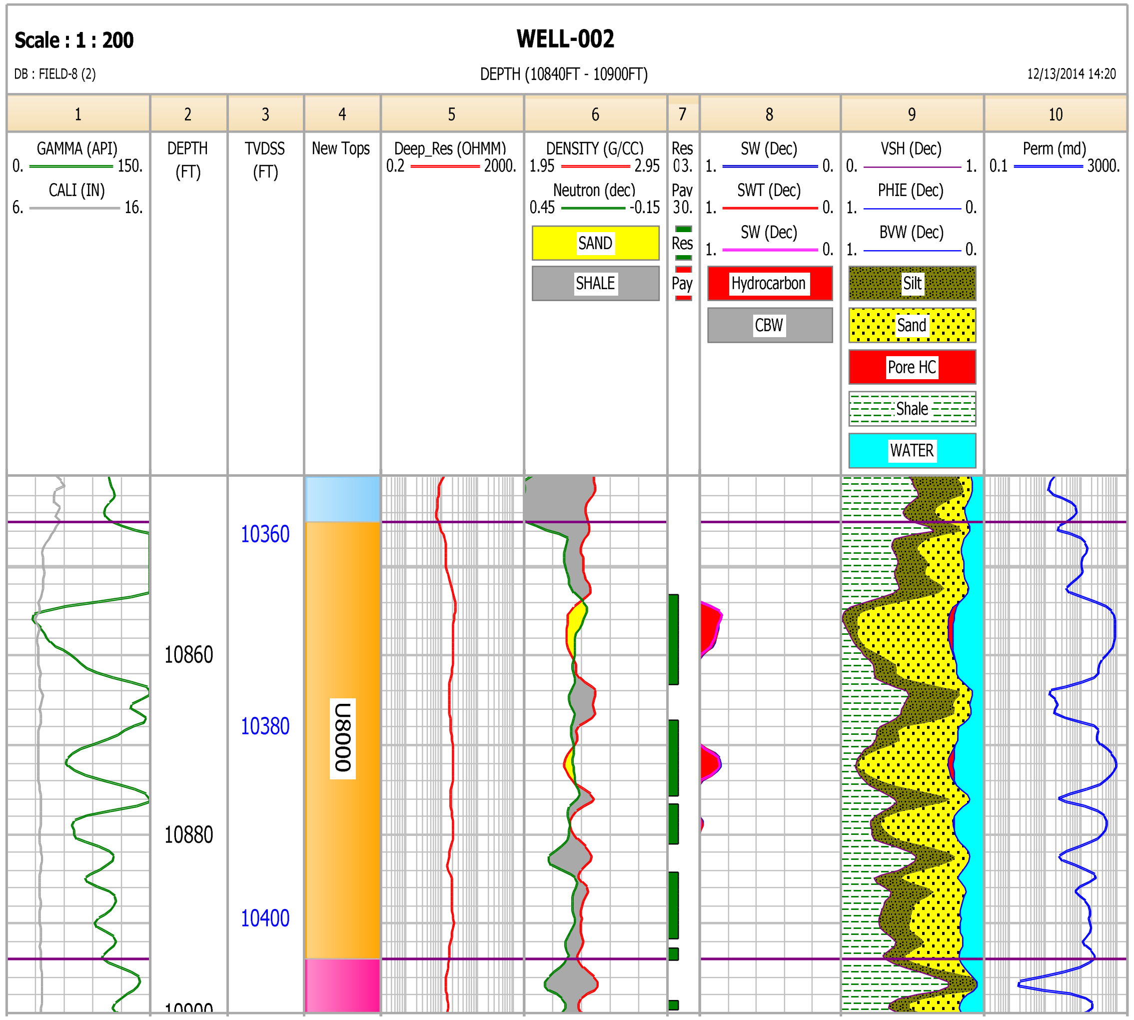
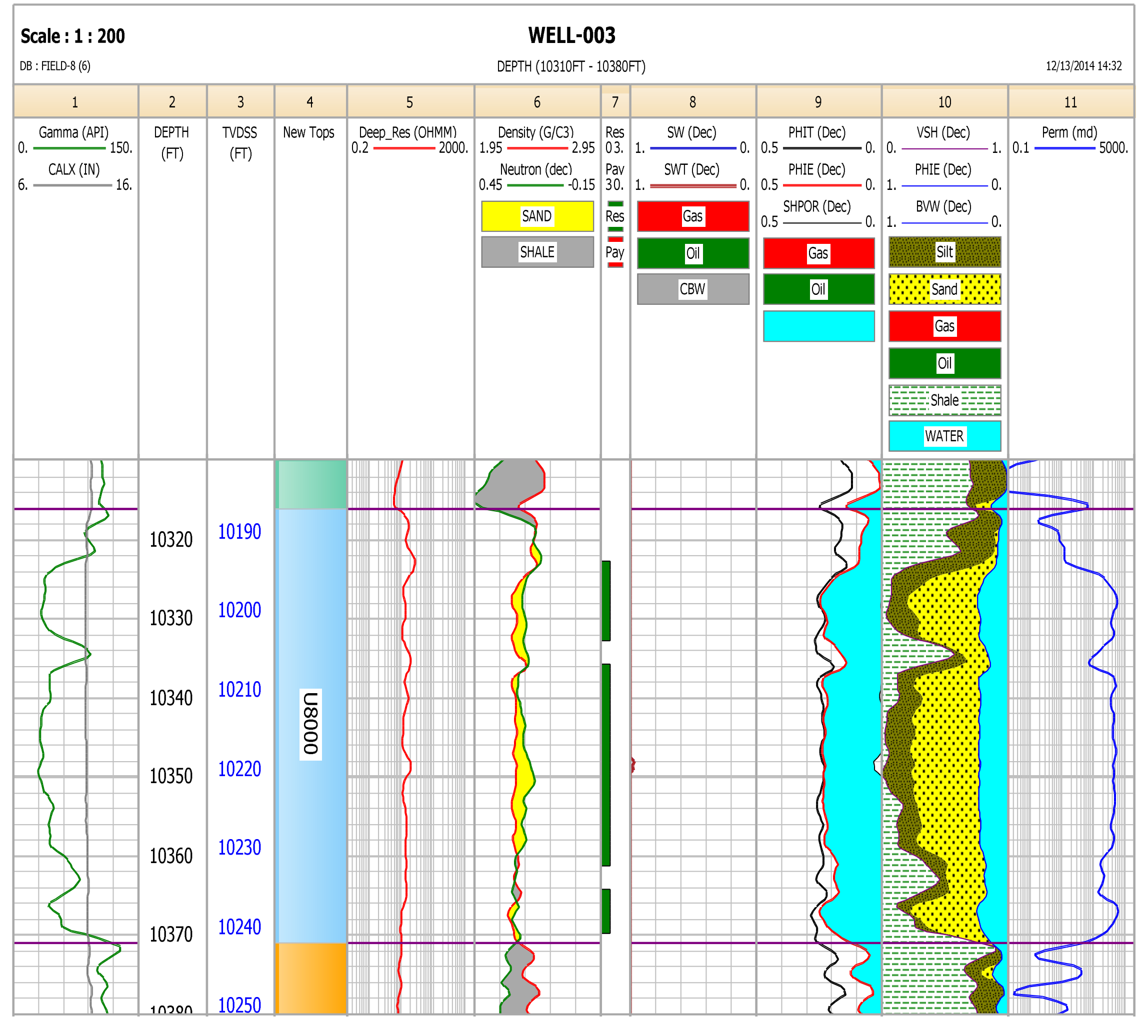
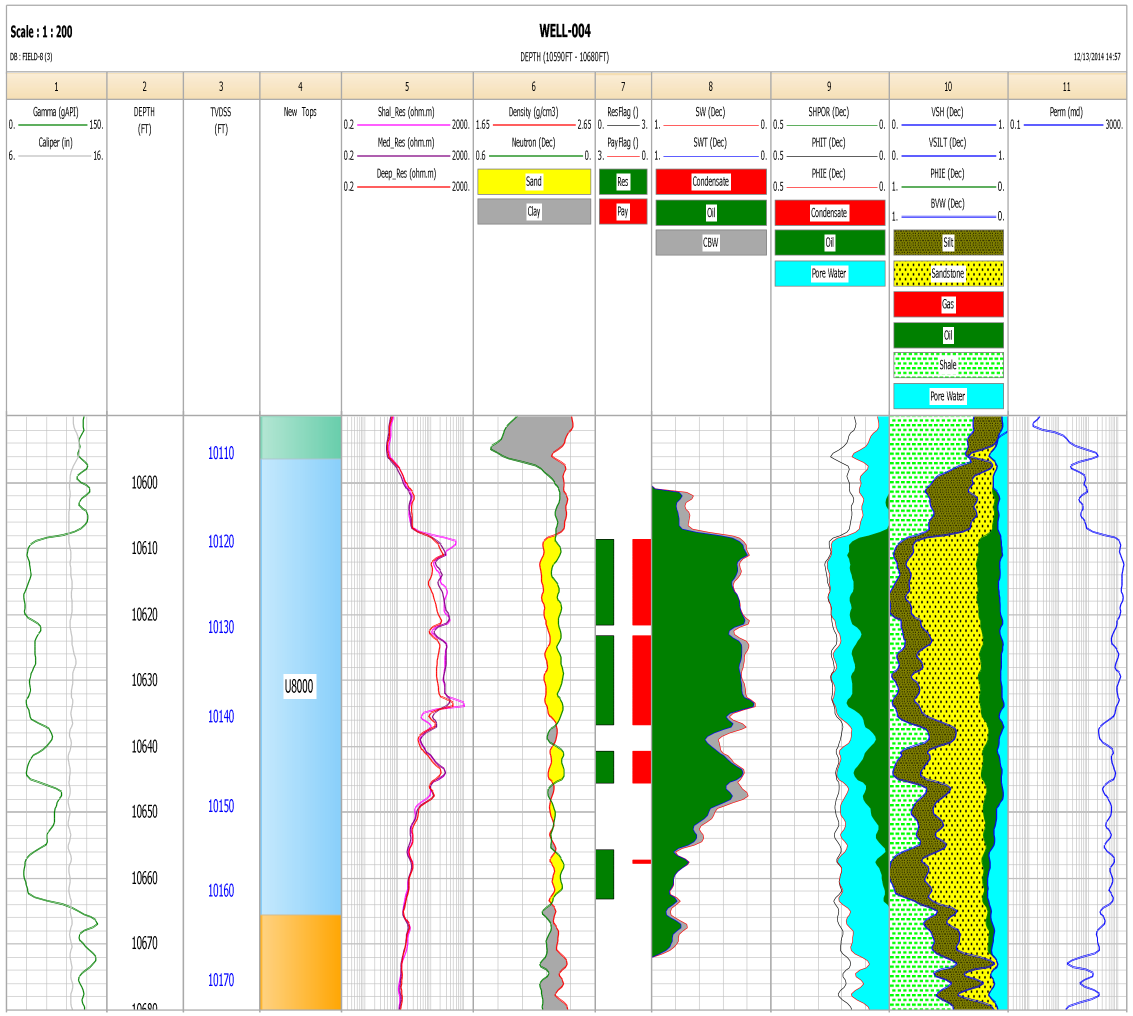
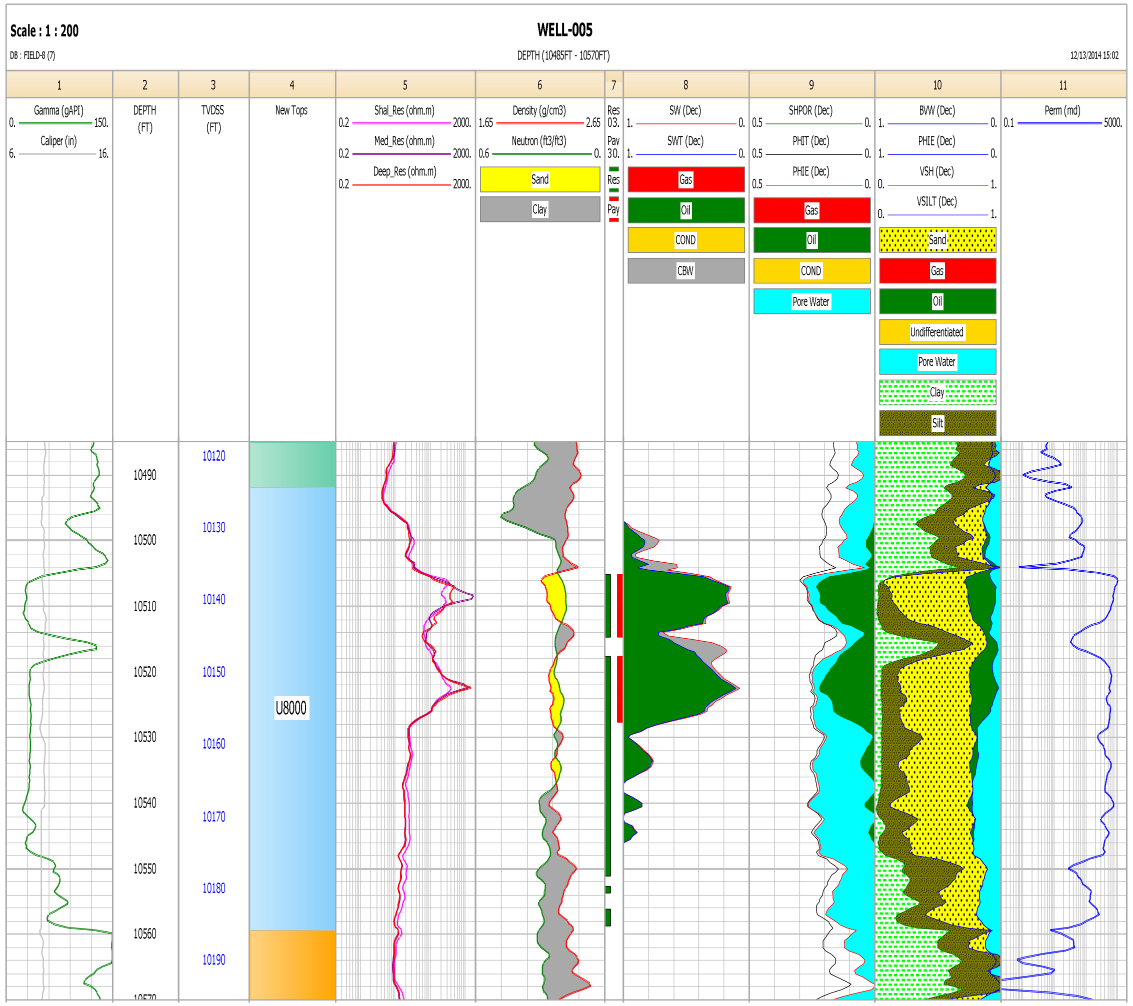


Fig. 4. Computer processed interpretation of composite geophysical logs for reservoir R3 in wells 1, 2, 3, 4 and 5: Water saturation, porosity, permeability are tracks 8, 9 and 10


Scale : 1 : 200
WELL-002
DB : FIELD-8 (2)
DEPTH (10840FT - 10900FT)
12/13/2014 14:20
1 2 3 4 5 6 7 8 9 10
GAMMA (API) 0. 150.
CALI (IN) 6. 16.
DEPTH (FT)
TVDSS (FT)
New Tops
Deep_Res (OHMM) 0.2 2000.
DENSITY (G/CC) 1.95 2.95
Neutron (dec) 0.45 -0.15
SAND
SHALE
Res 03.
Pav 30.
Res
Pay
SW (Dec) 1. 0.
SWT (Dec) 1. 0.
SW (Dec) 1. 0.
Hydrocarbon
CBW
VSH (Dec) 0. 1.
PHIE (Dec) 1. 0.
BVW (Dec) 1. 0.
Silt
Sand
Pore HC
Shale
WATER
Perm (md) 0.1 3000.
10860
10880
10360
10380
10400
U8000


Scale : 1 : 200
WELL-003
DB : FIELD-8 (6)
DEPTH (10310FT - 10380FT)
12/13/2014 14:32
1 2 3 4 5 6 7 8 9 10 11
Gamma (API) 0. 150.
CALX (IN) 6. 16.
DEPTH (FT)
TVDSS (FT)
New Tops
Deep_Res (OHMM) 0.2 2000.
Density (G/C3) 1.95 2.95
Neutron (dec) 0.45 -0.15
SAND
SHALE
Res 03.
Pav 30.
Res
Pay
SW (Dec) 1. 0.
SWT (Dec) 1. 0.
Gas
Oil
CBW
PHIT (Dec) 0.5 0.
PHIE (Dec) 0.5 0.
SHPOR (Dec) 0.5 0.
Gas
Oil
VSH (Dec) 0. 1.
PHIE (Dec) 1. 0.
BVW (Dec) 1. 0.
Silt
Sand
Gas
Oil
Shale
WATER
Perm (md) 0.1 5000.
10320
10330
10340
10350
10360
10370
10190
10200
10210
10220
10230
10240
10250
U8000


Scale : 1 : 200
WELL-004
DEPTH (10590FT - 10680FT)
Gamma (gAPI)
Caliper (in)
DEPTH (FT)
TVDSS (FT)
New Tops
Shal_Res (ohm.m)
Med_Res (ohm.m)
Deep_Res (ohm.m)
Density (g/cm3)
Neutron (Dec)
Sand
Clay
ResFlag ()
PayFlag ()
Res
Pay
SW (Dec)
SWT (Dec)
Condensate
Oil
CBW
SHPOR (Dec)
PHIT (Dec)
PHIE (Dec)
Pore Water
VSH (Dec)
VSILT (Dec)
BVW (Dec)
Silt
Sandstone
Gas
Shale
Perm (md)
U8000


Scale : 1 : 200
WELL-005
DEPTH (10485FT - 10570FT)
Gamma (gAPI)
Caliper (in)
DEPTH (FT)
TVDSS (FT)
New Tops
Shal_Res (ohm.m)
Med_Res (ohm.m)
Deep_Res (ohm.m)
Density (g/cm3)
Neutron (ft3/ft3)
Sand
Clay
SW (Dec)
SWT (Dec)
Gas
Oil
COND
CBW
SHPOR (Dec)
PHIT (Dec)
PHIE (Dec)
Pore Water
BVW (Dec)
VSH (Dec)
VSILT (Dec)
Undifferentiated
Silt
Perm (md)
U8000

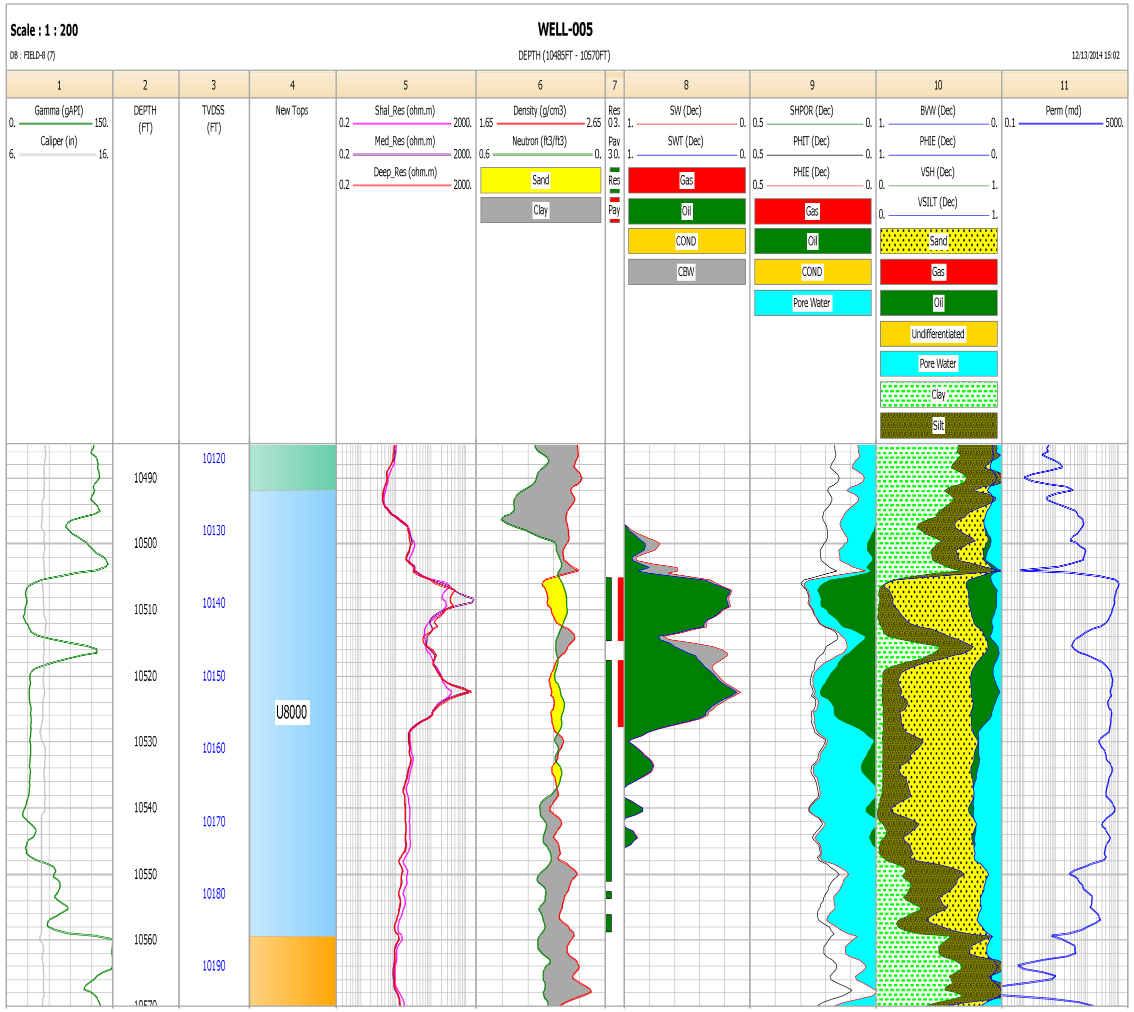


Fig. 5. Computer processed interpretation of composite geophysical logs for reservoir R4 in wells 1, 2, 3, 4 and 5: Water saturation, porosity, permeability are tracks 8, 9 and 10

3.4 Petrophysical Evaluation Reservoir R4

Reservoir R4 is an oil bearing reservoir with a clear Original-Oil-Water-Contact (OOWC) logged by Well-1 at 10170 ftss. A total of about 51 fttvd column of oil was logged in this reservoir. Fig. 5 is the (CPI) for the five wells (Well-1 to Well-5). R4 reservoir has an average effective porosity of 0.19, NTG of 0.85, Sw of 0.27 and permeability of 536 mD. This reservoir has good petrophysical properties and will be able to flow to the surface without Gaslift support.

4. CONCLUSION

The formation evaluation of geophysical logs from an onshore field in Niger delta was carried out to determine the reservoir parameters such as volume of shale, water saturation, porosity, net to gross ratio and permeability. Four reservoir R1, R2, R3 and R4 were delineated in the boreholes. R1 is gas bearing while R2, R3 and R4 reservoirs are oil bearing. The computed porosity and water saturation ranges from 19.0 to 22.7 percent and 0.19 to 0.286 respectively. The computed permeability ranges from 516 to 1662 mD while Net to Gross ratio for the four reservoirs ranges from 0.844 to 0.947. Generally**,** the reservoirs have good petrophysical properties. The computer processed log interpretation gives a quick view of the vertical variation of the petrophysical properties with depth.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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