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RESEARCH ARTICLE

APPLICATION OF CONDITIONING, CURVE SYNTHESIZING AND QUALITY CONTROL OF WELL LOG DATA'S.

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Abstract

During exploration and development stage Petrophysical evaluation of well log data has always been crucial step for identification and assessment of hydrocarbon bearing zones. In this paper, petrophysical evaluation of well log data from cluster of five wells in the selected study area is carried out in National Petroleum Reserve Alaska (NPRA). Petrophysical evaluation has provided the estimation of reservoir location, the fluid type and its amount. Log conditioning and quality control of log data's play a significant role in the interpretation process. In this work we had done quality control of log data's for the selected wells and conditioned those data's which are poor in quality using MLR (Multi Linear Re-gression) method and the bad data points are identified by cross plotting the curve with respect to others, which is carried out in the petrophysical software, IPv4.2 and TECHLOG^{2015}.

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Introduction:-

Well logging, as a terminology, is originated from France in 1927. Its primary meaning is electrical cor-ing, which is a continuous record of characteristics of rock formations traversed by a measurement device in the well bore. Well logging is the process of continuous recording various physical, chemical, electrical, or other properties of the rock or fluid mixtures penetrated by drilling a well into the earth's mantle. The most appropriate name of this continuous depth-related record is a wire-line geophysical well log, conveniently shortened to well log or log. It has often been called an "electrical log" because historically the first logs were electrical measurements of electrical properties. However, the measurements are no longer simply electrical, and modern methods of data transmission do not necessarily need a wire-line so the name above is recommended.

To perform a logging operation, the measuring instrument, often called a probe or sonde, is lowered into the borehole on the end of an insulated electrical cable. The cable provides power to the downhole equipment. Additional wires in the cable carry the recorded measurement back to the surface. The cable itself is used as the depth measuring device, so that properties measured by the tools can be related to particular depths in the borehole. A logging tool is made up of a sonde and a cartridge. The sonde is the portion of the tool which gives off energy, receives energy, or both. The cartridge contains the electrical circuitry or computer components needed to control the downhole equipment, and to transmit data to and from the surface. Combination logging tools consist of more than one sonde and cartridge, so that more than one log can be recorded on a single trip into the wellbore. Surface equipment is mounted in a logging truck, van, or skid unit from which all logging operations are controlled. The

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logging unit contains hoisting equipment for lowering and raising the tools in the hole, and electronic or computer equipment for controlling and recording the downhole measurements. Measurements are recorded in two forms, analog and digital. The analog data may be recorded on photographic film, electronic plotter, or chart recorder. The same data are captured in digital form on magnetic tape or disc for later use in computer aided analysis. Many in-strument control and calibration functions are now han-dled by the same computer used to record the digitaldata, with some human control. The result is a log, (as shown in fig 1).

After that log interpretation is done by loading the log data's available, which is in *.las* format, into the TECHLOG software. After loading and checking of log data, it was found that most of the wells are aligned in depth and does not require any depth shift. However, on analyzing all the raw well data, it was observed that most of the wells have high differential caliper reading which may affect the quality of the logs. Especially the padded tools may suffer from poor pad contact and hence may give poor quality data. One way to understand the effect of this borehole caving is to cross plot the recorded data taking differential caliper (DFCAL) in the third axis. Moreover, the effects of tool current fluctuation, irregular tool tension, cycle skipping have been understood by careful observation of log plots and crossplots.

Log conditioning is the final stage in preparation of log data for petrophysical evaluation, in which poor quality data are identified and are replaced by synthesized data. The measured curve is replaced by the synthesized curve, the later is determined to be more representative of the in situ rock density. The conditioning is an important process as the derived porosity and volume of clay as well as the rock physics analysis is strongly dependent on the density log.

Study area and location map

The study area chosen is the National Petroleum Reserve in Alaska (NPRA), northwest of Canada. From the area we had chosen five wells namely

1. well A: South Barrow 16 (2400 ft)
2. well B: South Barrow 17 (2382 ft)
3. well C: South Barrow 18 (2125 ft)
4. well D: South Barrow 19 (2300 ft)
5. well E: South Barrow 20 (2356 ft)

A thick mantle of Mississippian to Cenozoic sedimentary rocks overlies the pre-Mississippian basement rocks in the Colville basin north of the Brooks Range in north-ern Alaska. These rocks are divided into three primary sequences based on provenance: 1) the lower Cretaceous to recent Brookian sequence with its source to the south, 2) the Jurassic to lower Cretaceous Beaufortian sequence with sources dominantly from the north, and 3) the Mississippian to Triassic Ellesmerian sequence with sources to the north.

Basement Lithology

At least 30 wells penetrate basement rocks in NPRA, but most of these are along the Barrow Arch in the northernmost study area. These wells have encountered three lithologic assemblages previously considered to be part of the NPRA basement:

1. Ordovician and Silurian argillite with local silt-stone, sandstone, and chert is present along the Barrow Arch and in the Peard 1 well along the Chukchi Sea coast
2. Probable Devonian conglomerate, sandstone, and some carbonaceous claystone and coal are present in two wells south of the Barrow Arch. The Topagoruk basement is paleontologically dated as definite Devonian. The South Meade basement is undated, but lithologic similarities with Topagoruk basement suggest a similar age.
3. Probable Devonian granite is present in the East Teshekpuk 1 well on the Barrow Arch in northeast NPRA.

Log Data Analysis

Log interpretation is done by loading the log data's available, which is in *.las* format, into the TECHLOG software. After loading and checking of log data, it was found that most of the wells are aligned in depth and does not require any depth shift. However, on analyzing all the raw well data, it was observed that most of the wells have high differential caliper reading which may affect the quality of the logs. Especially the padded tools may suffer from poor pad contact and hence may give poor quality data. One way to understand the effect of this borehole caving is to cross plot the recorded data taking differential caliper (DFCAL) in the third axis. Moreover, the effects of tool current fluctuation, irreg-ular tool tension, cycle skipping have been understood by careful observation of log plots and crossplots. For log data quality check (QC) and to identify the potential bad data points for the density curve, we need to cross-plot:

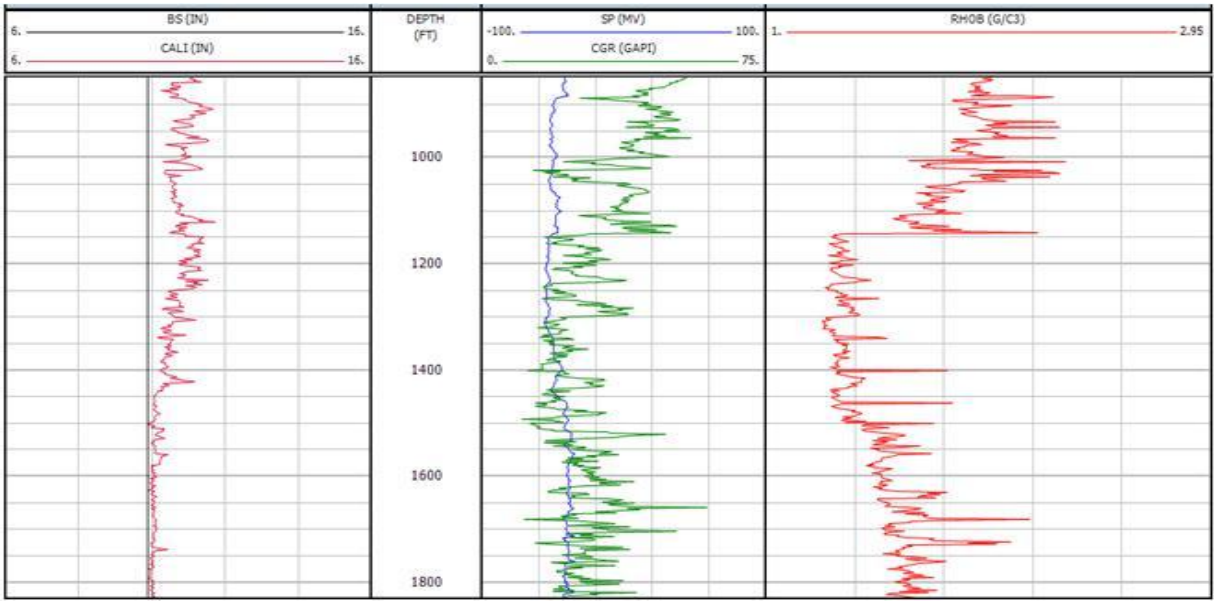

Figure 1:-Example of Record of Well Log data

1. RHOB versus NPHI colored by differential caliper
2. RHOB versus transit travel time (DT) colored by differential caliper

The cross-plot for well A (fig 3 and fig 4) is shown below with the bad data points marked. From the cross-plots, it is noticed that there are effects of bad borehole in the logs. There are some data points which fall outside the main trend and have high differential caliper (DFCAL).

Log Conditioning

Log conditioning is the final stage in preparation of log data for petrophysical evaluation, in which poor qual-ity data are identified and are replaced by synthesized data. In particular, the key logs for petrophysical evaluation are conditioned. Here we illustrates how poor quality data in density log are synthesized using other logs. The solution is achieved by synthesizing a density log through multiple linear regressions from other log curves. The regression formula is obtained by running regression analysis for all wells in zones where the density log is considered to be of good quality.

The synthetic density curve is then compared with the measured density log. The measured curve is replaced by the synthesized curve where the later is determined to be more representative of the in situ rock density. The conditioning is an important process as the derived porosity and volume of clay as well as the rock physics analysis is strongly dependent on the density log. Several iterations are required to produce a log that is consistent with rock physics model and sonic log data. The process of density conditioning is illustrated below:

The objective of curve synthesis and reconstruction is to condition the logging data at washout intervals, missing sections or where the data are obviously incorrect. In example, the density curve was conditioned at badhole interval by curve synthesis and reconstruction using data from the closest interval with good borehole conditions for the well A.

In Fig. 5, track-3, the red curve is the measured density data in which some poor quality data are observed against the washout section. The synthetic density curves are generated for this interval using the multi-linear regression equation established using deep resistivity (LLD) and DT data in the interval 2190-2220 m. The log plot in Fig. 5 shows varying values of the caliper reading in the interval 2160-2190 m also in the cross-plot of NPHI vs. RHOB shows that the data points at this interval fall outside the main trend and have high differential caliper (DFCAL). The measured data in this interval may be affected by the bad hole. However, hole is good in the interval 2190-2220

m. Hence, measured data in this interval is suitable to establish regression relation of density with other available curves and thereby in construction of a synthetic density curve. In this case, deep resistivity and P-sonic showed a good correlation with the measured density and have been used to syn-thesize the density curve.

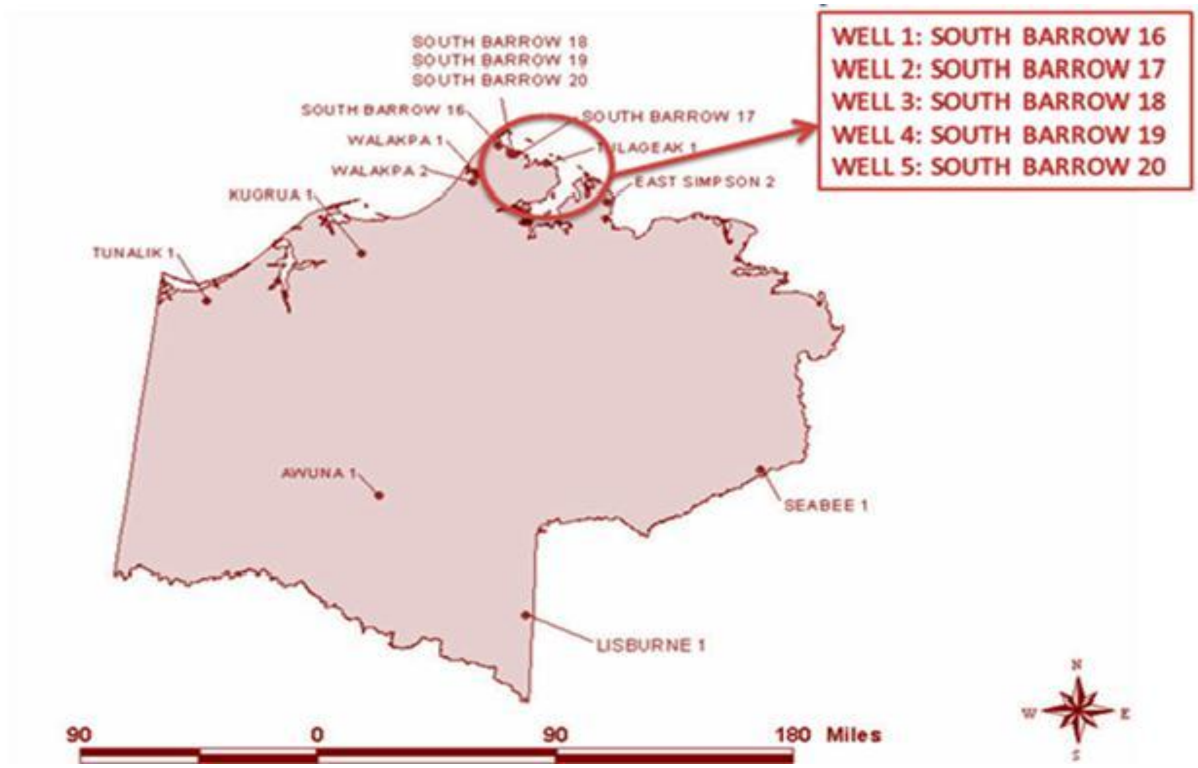

Figure 2:-Location map of the selected wild cat wells in the National Petroleum Reserve in Alaska

The log plot in Fig 6 confirms that the synthesized density log is reliable. It shows a good match with the measured data over the good-hole section and hence can be used to replace density data against the bad-hole section where the measured data is bad. Thus, the measured density was replaced by the synthesized density data in the 2160-2190 m. The same technique is applied to con-dition measured density, P-sonic and neutron porosity curves for all the wells can be used where the data quality was poor or there were data gaps.

Quality Control (QC)

Since we have conditioned the poor quality curve us-ing synthesized curve, now we need to quality check the conditioned curve for its reliability. The corrected and conditioned data must be confirmed through quality control methods in order to guarantee the reliability of the correction and conditioning. In order to do that, cross-plots have been used to carry out the quality control of the conditioned data. Figures 7 and 8 depict neutron versus density cross-plot and density versus sonic cross-plot of the raw (colored in blue) and conditioned (colored in green) data for well A (South Barrow 16).

From these figures, it is clear that the conditioning has helped to bring the scattered data outside the main trend back into the main trend. However, there are some suspicious data trends still remaining in density versus neutron plot which are supposed to be coming from coal zone. To synthesize these data, there should be some good quality data available from a similar coal zone in and around the bad data zone. In this case there is no such zone available and hence for this zone curve syn-thesis was not possible.

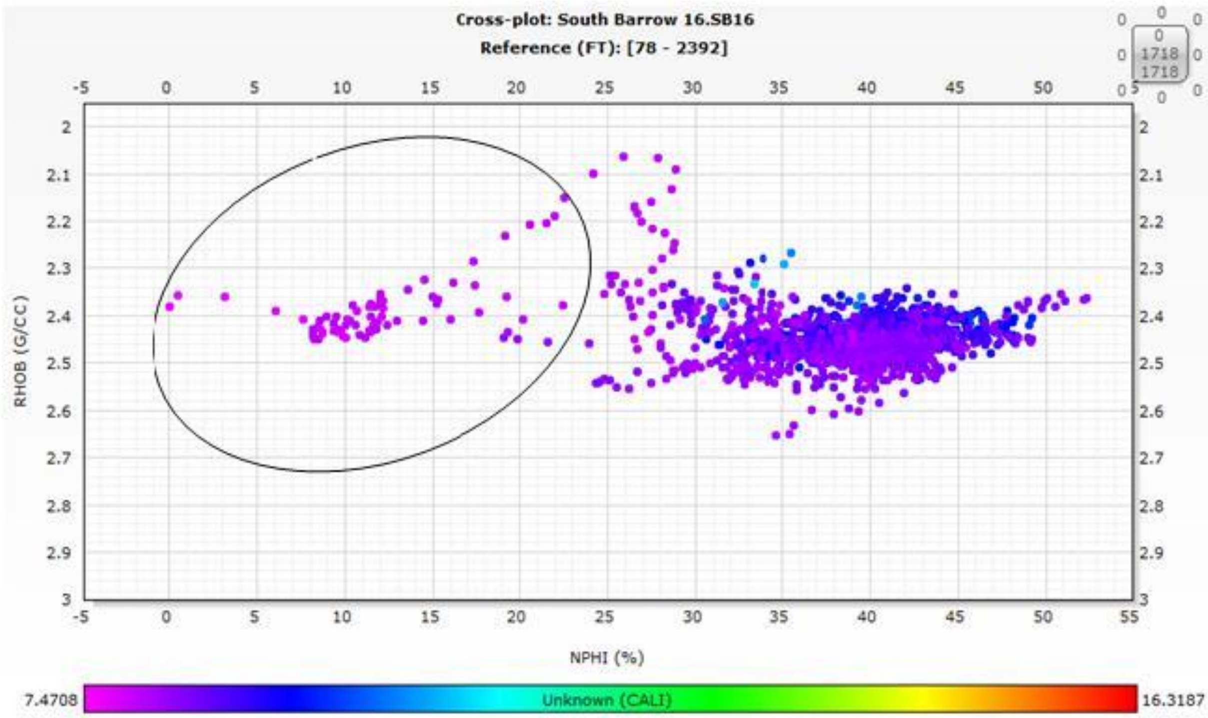

Figure 3:-RHOB versus NPHI cross-plot colored by differential caliper (data falling within the marked circle represent bad data)

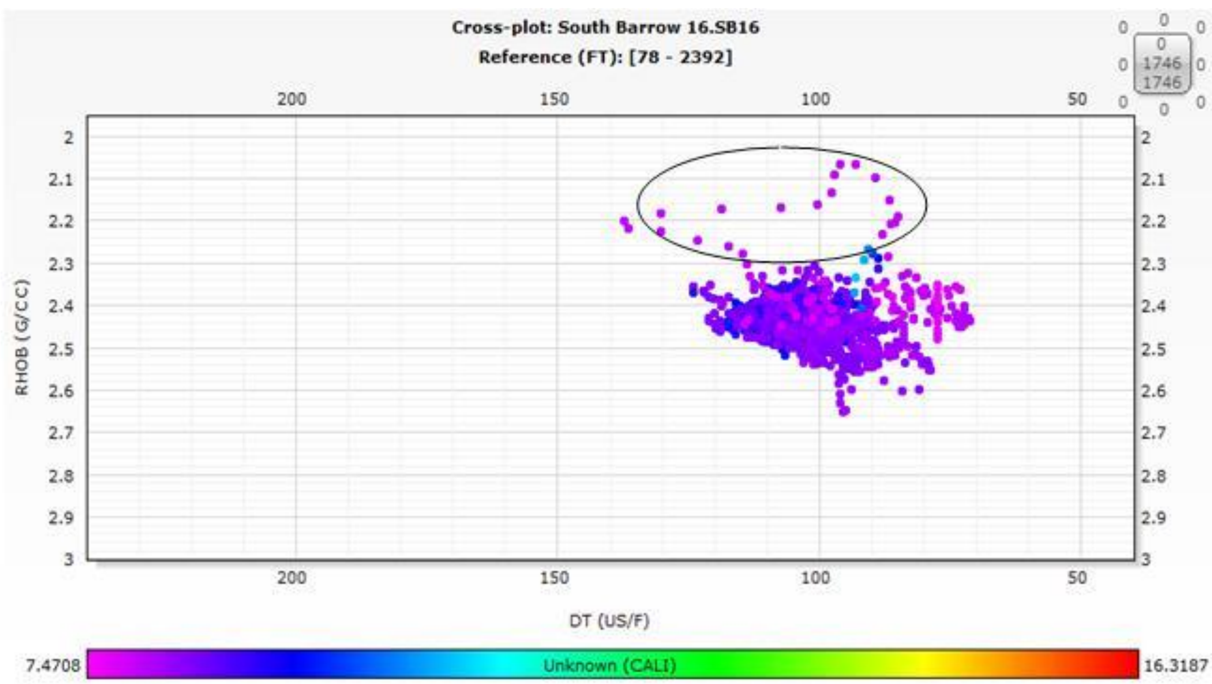

Figure 4:-Cross-plot between RHOB and DT colored by differential caliper (data falling within the marked circle represent erroneousdata)

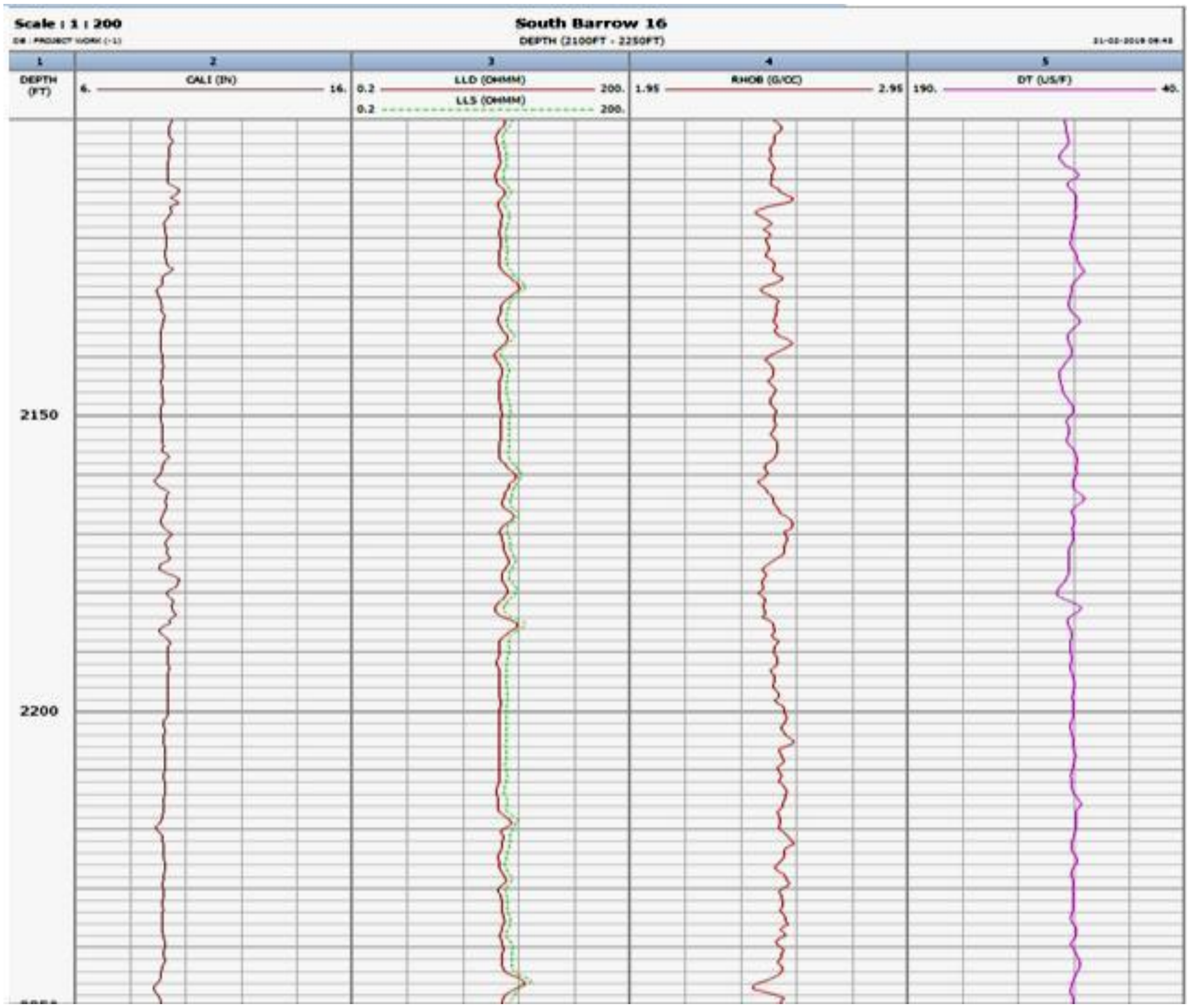

Figure 5:-Measured density curve on track-3 (red) for well A requires conditioning

Discussion and Conclusions:-

We had used the software IPv4.2 and TECHLOG^{2015} for plotting the log, interpretation, and other quality checking process of the available log database. Initially we had imported the data into the above software's and start our interpretation process.

The first and most important process is the quality checking of collected log data. The data should have good quality points since the precision in the calcula-tion of reservoir parameters (porosity, resistivity of water, water saturation and effective porosity) is important in predicting the producible zone. In the quality checking of data we had identified the poor data points using the cross-plotting method. From the cross plot we had identified the bad points and replaced this with good data points from the adjacent depth. Thus we have done the QC of available log datas.

This report presents a most imporatant step in the petro-physical analysis, for reservoir characterization of selected wild cat wells in the National Petroleum Reserve in Alaska, using a suite of well log data from five wells in the field. Log conditioning and Quality checking of the collected data are done. The first four wells have some bad quality data points which are conditioned using the Multi- Linear Regression method which is available in the petrophysical software. The conditioning of log data is the most important part during the interpreta-tion of well log data's, since the identification of recoverable hydrocarbon reservoir needs to be in high precision otherwise there will be high economic loss for the company if there is no resource in the identified location.

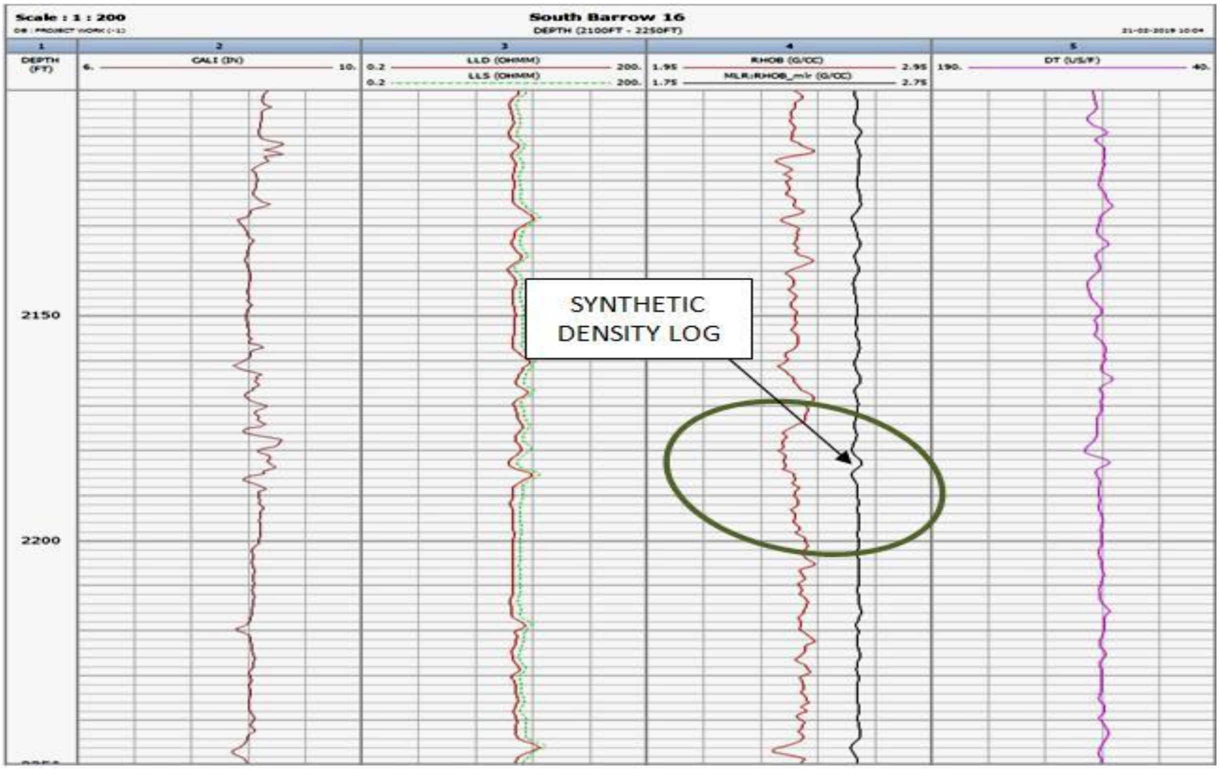

Figure 6:-Well A-synthesized density curve (black) on top of measured density curve (red)

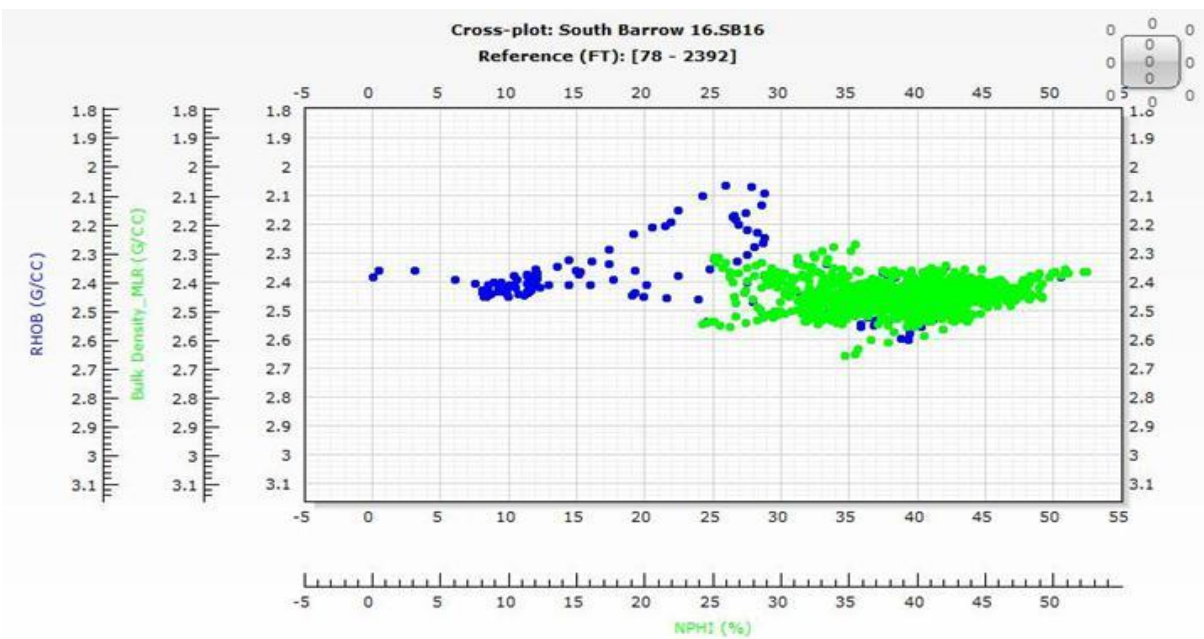

Figure 7:-ConditionedRHOB and NPHI (green) on top of measured RHOB-NPHI (blue) for the well A.

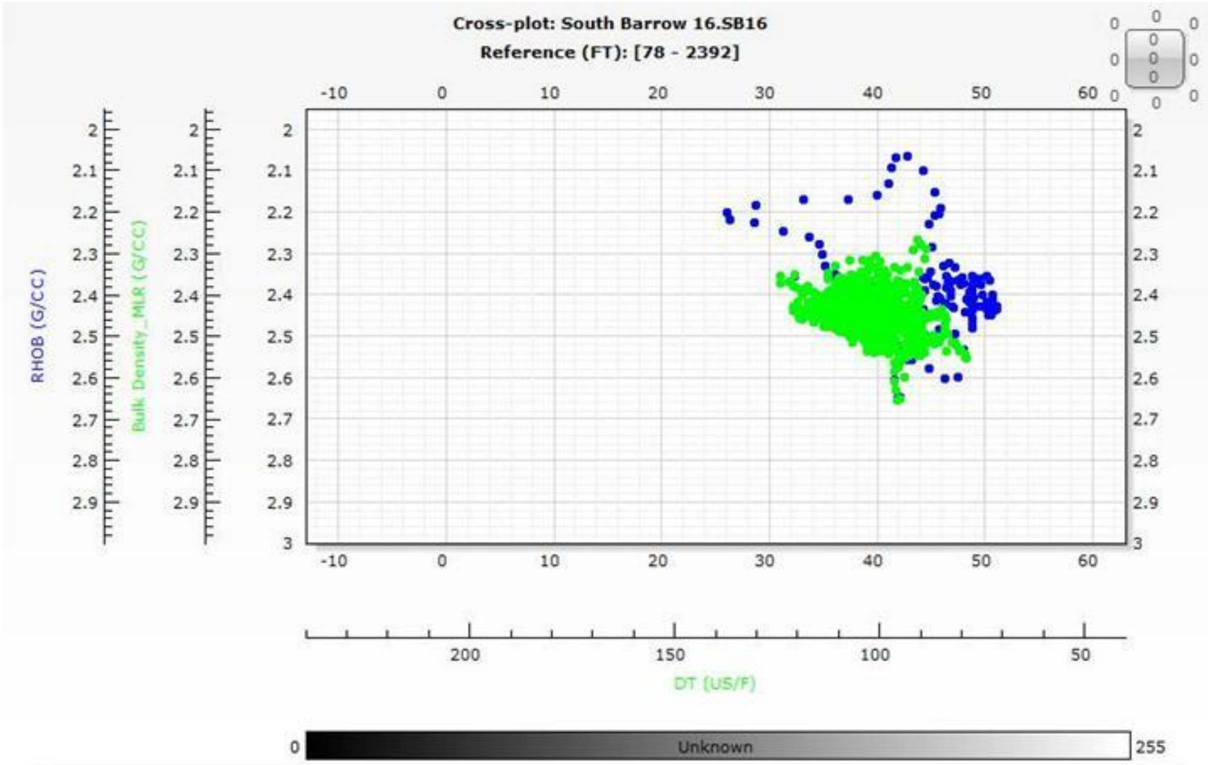

Figure 8:-ConditionedRHOB and DT (green) on top of measured RHOB-DT (blue) for the well A

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