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Structural analysisusing image logs

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ABSTRACT

Structural analysis is the way to have a better understanding of structural geology in oil and gas fields. By using the image log technology, we can do this analysis very well, but this process is complicated and it is still unknown to many researchers. Therefore, we decided to explain this process by using a unique case study and a number of valuableimage log interpretation examples. This jobwill be done in Gachsaran field, one of the most important Iranian fields, and the main reservoir that will be studied is Asmari reservoir, one of the most important Iranian oil and gas reservoirs. We aim to offer a unique educational paper that will be very useful for the other researchers who are interested in structural geology and image log technology. This job showed that the direction of bedding strike is almost NW-SE direction for theAsmari reservoir in the section of Gachsaran field. © 2015 Trade Science Inc. - INDIA

KEYWORDS

Structural geology;
Structural analysis;
Oil and gas reservoirs;
Image log technology.

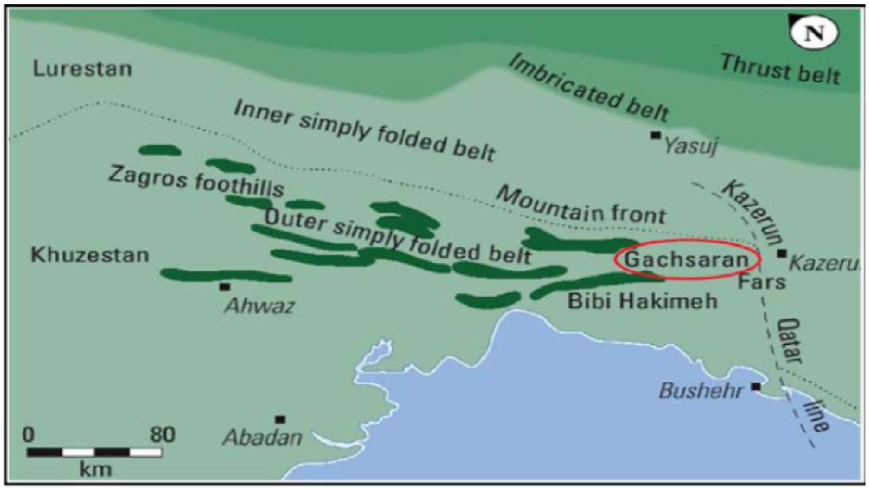
INTRODUCTION

Gachsaran oil field is in the southwest of Iran Figure 1 with an anticline structure, made of anhydrite/salt, 80 km long, 300m-1500m thickness, 8-18 km wide; it provides an excellent seal for the Asmari reservoir, the Pabdeh reservoir, the Gurpi reservoir and the other reservoirs Figure 2[1].

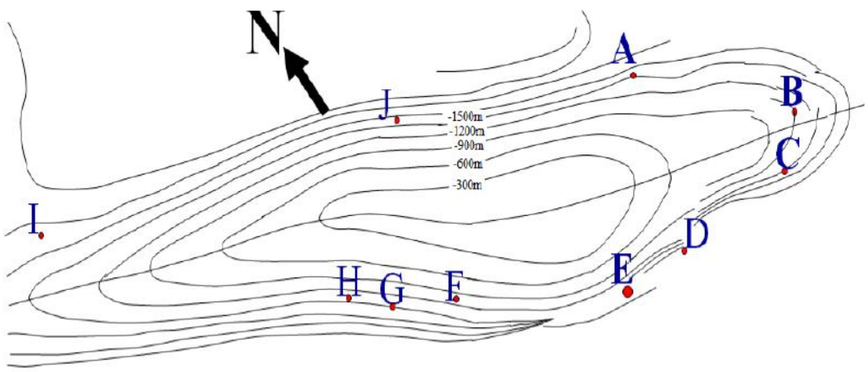
Image log technology is a new technology that can characterize the oil and gas reservoirs in many cases such as structural analysis, fracture characterization, fault interpretation and in-situ stress analysis[3]. These applications are still unknown to some researchers that are interested in learning the way that we can do the structural analysis using image logs, so in this job using a case study and numbers of valuable log interpretation we will explain this process completely.

In this work, 9 wells located in Gachsaran oil field will be selected, and the structural analysis will be done in these wells by using the image logs and the other geological logs interpretation. We will do the structural analysis in order to both having a better understanding of structural geology in this field and also explaining the methodology by showing the selected log interpretation examples from this field.

By using the image log technology, we can do the structural analysis very well; by interpreting the image logs, we will find out the direction of structural bedding for every well, and then we will show them together in order to find out the structural bedding direction for the field. By using the result of



(a)



(b)

Figure 1: (a) Location of the Gachsaran field[2]; (b) UGC map of the Gachsaran field and the studied wells

this work, we will be able to do any operation in this field more correctly.

MATERIALS & METHODS

The main data for this job are the image log data including the Formation Micro Scanner (FMS), Oil-Base-Mud Imaging (OBMI), Formation Micro Imager (FMI) and the Ultrasonic Borehole Imager (UBI). In this work, 9 wells (Wells number GS-A, GS-B, GS-C, GS-D, GS-E, GS-F, GS-G, GS-H, and GS-I), located in Gachsaran oil field, will be studied.

Layer / bed boundaries in carbonate sequences are not always sharp and planar, due to diagnostic processes, to be used for structural dip determination[4]. Therefore, while interpreting images, the dips from such boundaries are computed interactively with a geological workstation and categorized into two types based on their sharpness and planarity. The dips corresponding of sharp and well planar bed / layer boundaries are categorized as high confidence (Figure 3). While the dips corresponding to vague and uneven bed / layer surfaces are categorized as low confidence (Figure 4).

RESULTS AND DISCUSSION

Structural analysis in the well number GS-A

In this well, form the FMS tool only 41 boundaries were identified that their mean dip is 43 degrees with a variation from 35 to 52 degrees. They dip dominantly to the N27E with a spread from N20E to N42E and their dominant strike is N63W-S63E Figures 5 and 6.

Structural analysis in the well number GS-B

Both the electrical (OBMI) and acoustic (UBI amplitude) borehole images clearly indicate layering / bedding at several places throughout the logged

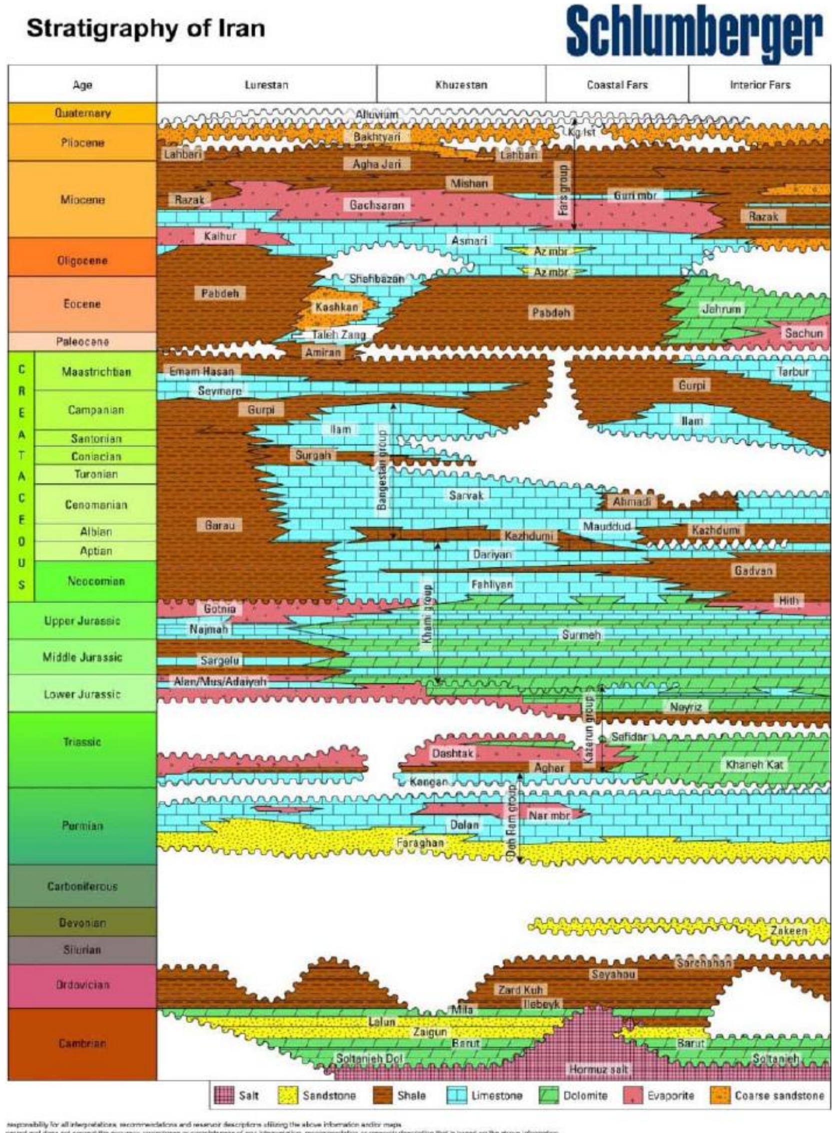


Figure 2 : Picture showing the Gachsaran field overlying the Asmari, Pabdeh, Gurpi and other reservoirs, and stratigraphic nomenclature of rock units and age relationships in the Zagros basin

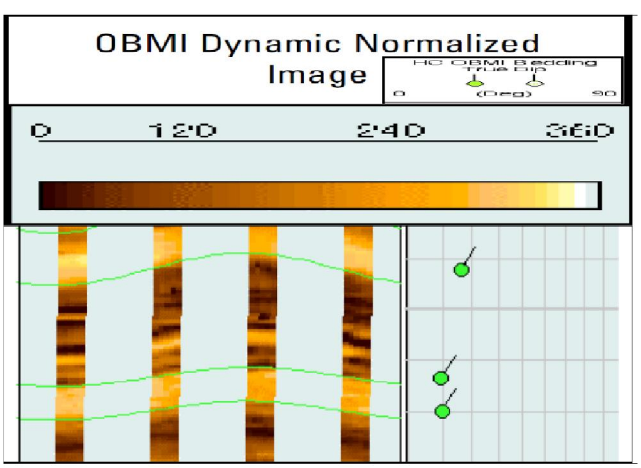


Figure 3 : High confidence dips from sharp and planar layer / bed boundaries seen by OBMI

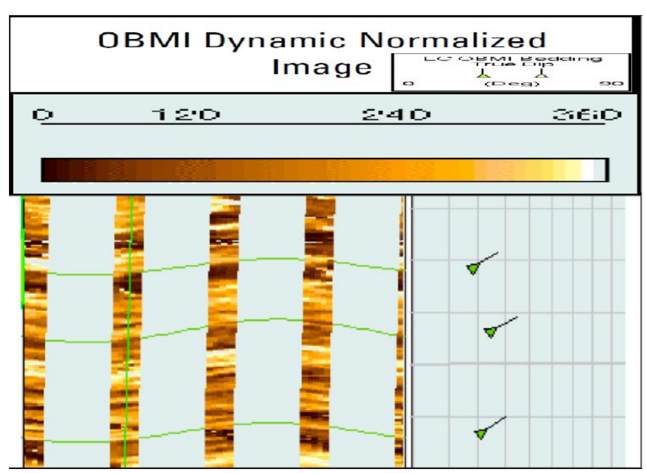


Figure 4 : Low confidence dips from less sharp and relatively uneven layer / bed boundaries seen by OBMI

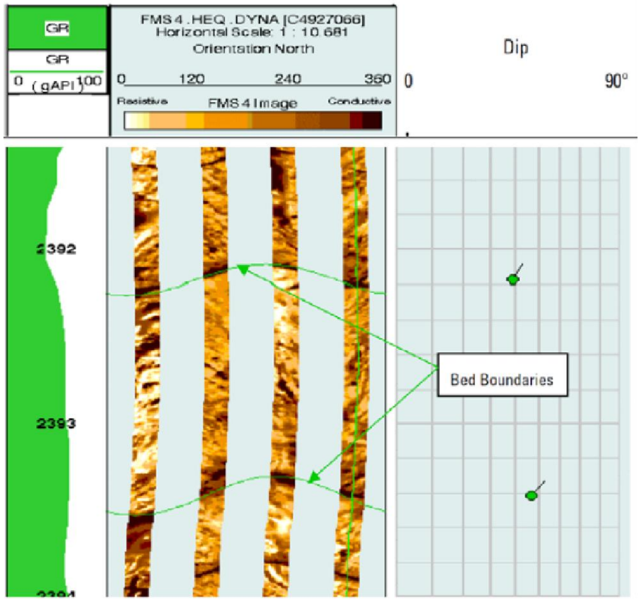


Figure 5 : Bed boundaries in Asmari formation for well GS-A

& 8.

Structural analysis in the well number GS-C

Both classes of bedding dips from UBI and OBMI show a dominant dip azimuth of S20W and strike N70W-S70E Figures 9 to 11.

Structural analysis in the well number GS-D

In this well, the UBI and OBMI images show that the structural dip varies from an average of 45 degrees to 63 degrees with the same S18W azimuth Figures 12 to 14.

Structural analysis in the well number GS-E

In this well, the FMI images show that the structural dip in the entire interval (520m) gradually increases from approximately 65 degrees towards S30W at the top (2450 m) to 90 degrees striking N70W at the bottom (2970 m). A number of over

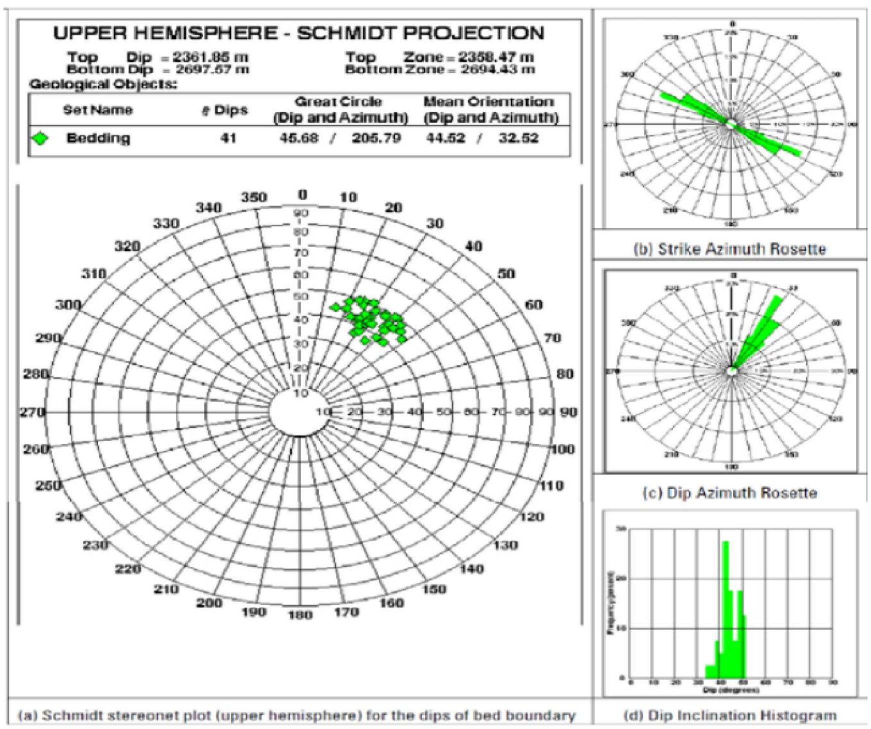


Figure 6 : Statistical plots in well GS-A for the dips of bed boundaries in the Asmari formation; a) Schmidt stereonet plot (upper hemisphere) for the dips of bed boundary; b) strike azimuth rosette; c) dip azimuth rosette; d) dip inclination histogram

interval. Some layer / bed contacts appear sharp and planar, while some have vague and uneven contacts. Both classes of bedding dips from both tools, UBI and OBMI, give more or less similar dominant dip magnitude and dip azimuth. They show a dominant dip azimuth of N88E and strike N2W-S2E Figures 7

turned low confidence bed boundaries are present at the bottom (2970 m). The orientation of bed boundaries, except a small number of them, is consistent throughout the interval Figure 15 to 19.

Structural analysis in the well number GS-F

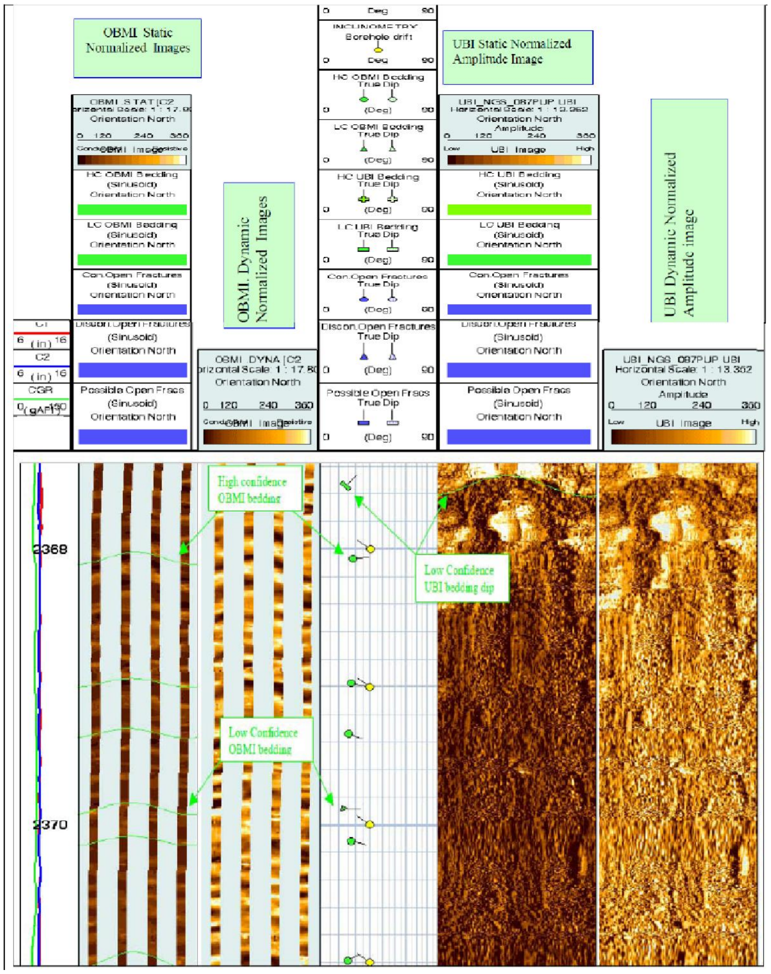


Figure 7 : OBMI and UBI images showing layering within lower Asmari. The dips corresponding to layer / bed boundaries are shown as low and high confidence based on their sharpness and planarity for computation of structural dip

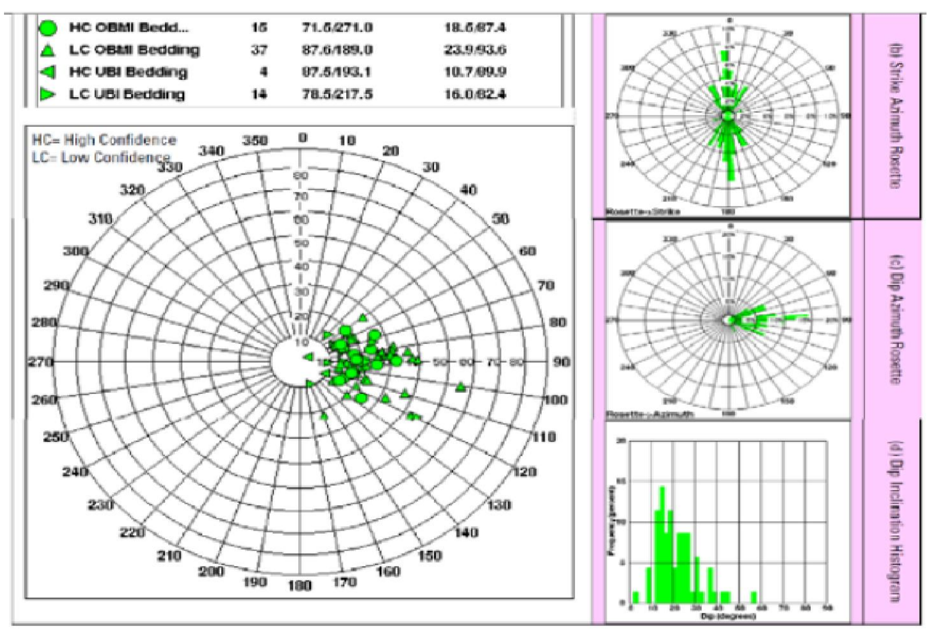


Figure 8 : Statistical plots in well GS-B for the dips of bed boundaries in the Asmari formation; a) Schmidt stereonet plot (upper hemisphere) for the high confident (HC) OBMI bedding, low confident OBMI bedding (LC), high confident (HC) UBI bedding and low confident (LC) UBI bedding; b) strike azimuth osette; c) dip azimuth rosette; d) dip inclination histogram

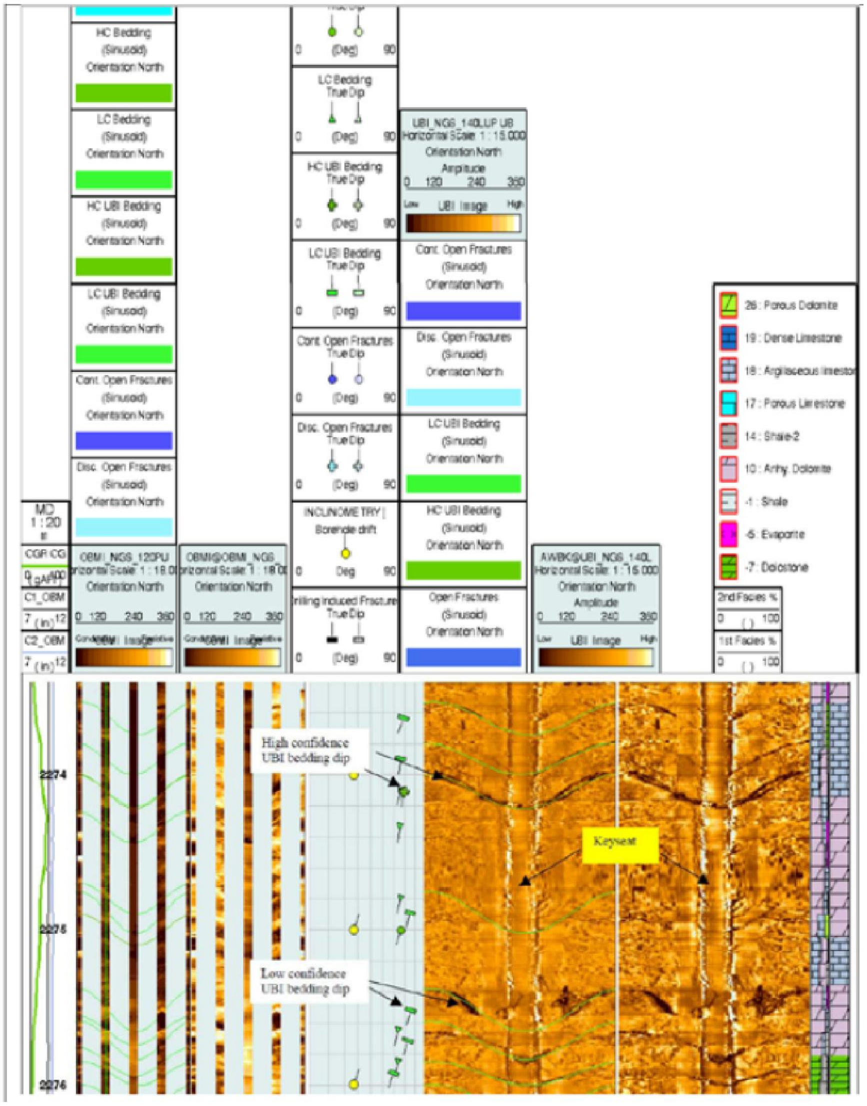


Figure 9 : OBMI and UBI images showing layering within Cap Rock. The dips corresponding to layer / bed boundaries are shown as low and high confidence based on their sharpness and planarity for computation of structural dip

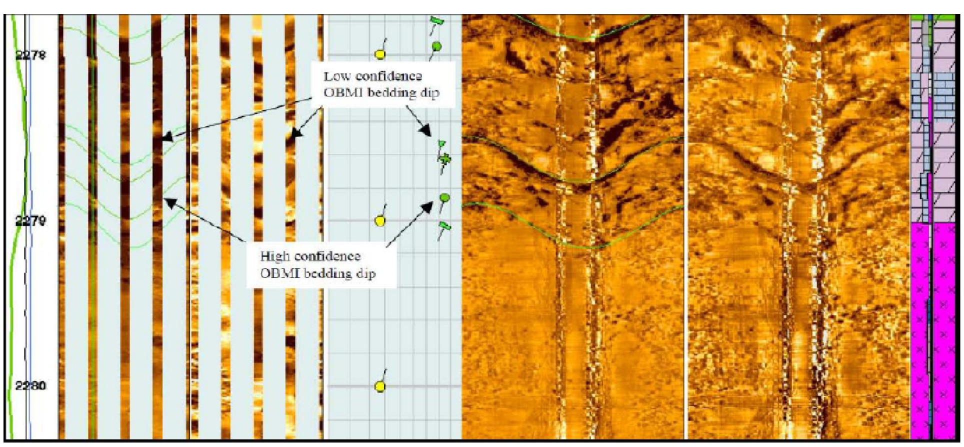


Figure 10 : OBMI and UBI images showing layering within Cap Rock. The dips corresponding to layer / bed boundaries are shown as low and high confidence based on their sharpness and planarity for computation of structural dip. Header details is given in Figure 9

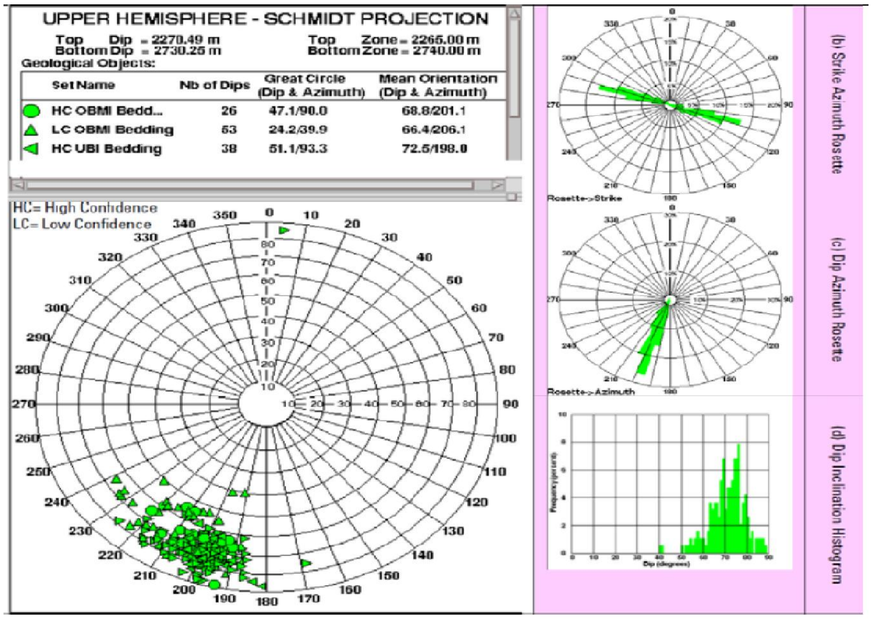


Figure 11 : For the well GS-C, statistical plots of bedding dips indicating a structural dip of 62-80 degrees S20W and strike N70W-S70E; a) Schmidt stereonet plot (upper hemisphere) for the high confident (HC) OBMI bedding, low confident OBMI bedding (LC), high confident (HC) UBI bedding and low confident (LC) UBI bedding; b) strike azimuth rosette; c) dip azimuth rosette; d) dip inclination histogram

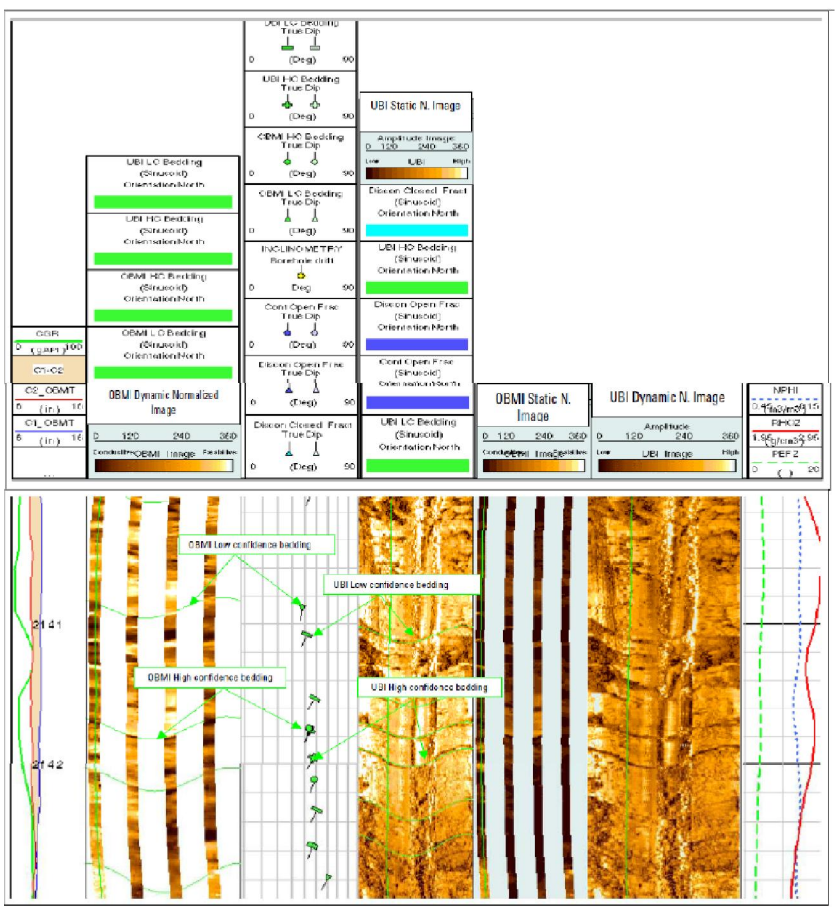


Figure12 : OBMI and UBI images showing layering in a section of Asmari. The dips corresponding to layer/bed boundaries are shown as high or low confidence based on their high or low degree of sharpness and planarity, respectively, for computation of structural dip

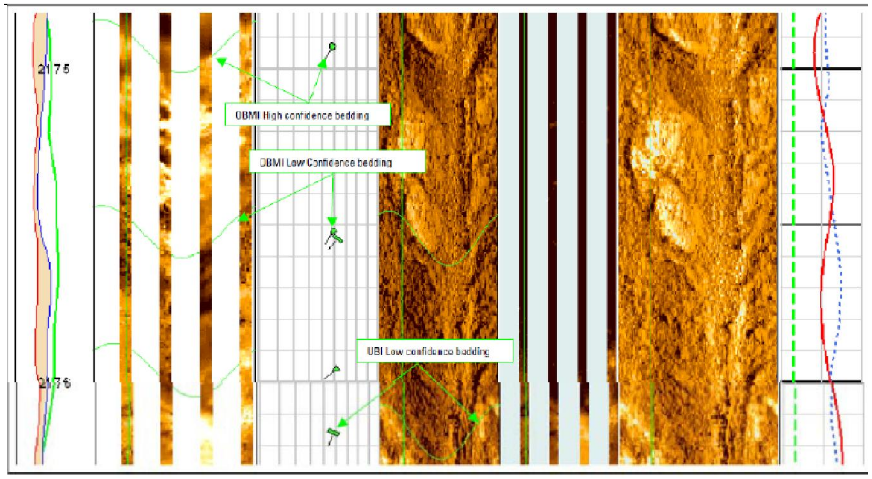


Figure 13 : OBMI and UBI images showing layering in a section of Asmari. The dips corresponding to layer/bed boundaries are shown as high or low confidence based on their high or low degree of sharpness and planarity, respectively, for computation of structural dip. Header is given in Figure 12

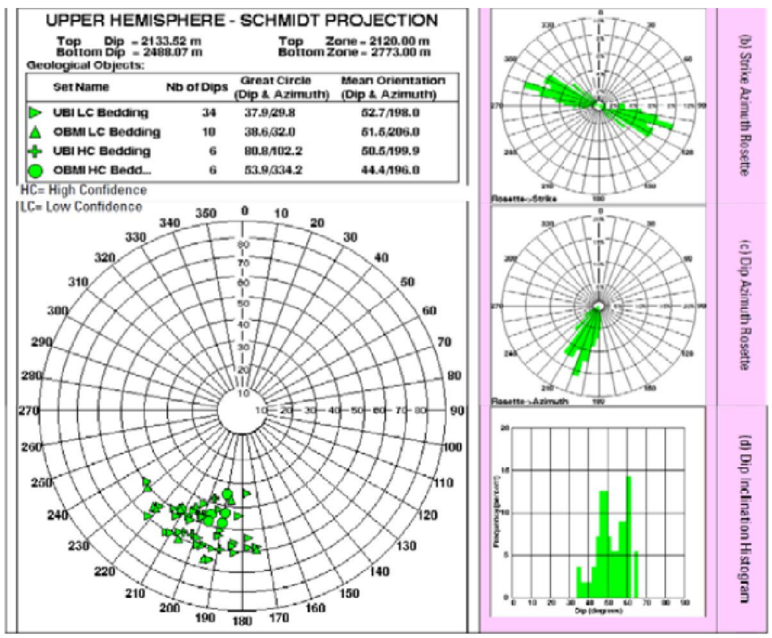


Figure 14 : Statistical plots of bedding dips indicating bedding dip varying from 34 to 64 degrees S18W and strike N72W-S72E

In this well, FMI images show that there is downward increase in structural dip which varies from 26 degrees in the upper zone to 33 degrees in the lower zone of Asmari formation with no major change in the dominant dip azimuth (S52W) and strike (N38W-S38E) Figures 20 to 23.

Structural analysis in the well number GS-G

In this well, the FMI images show that the structural dip varies from 31 degrees in Pabdeh and Asmari formations to 33 degrees in Gurpi formation, with no major change in the dominant S47W dip azimuth. Similarly the general strike does not change much from N43W-S43E Figures 24 to 27.

Structural analysis in the well number GS-H

In this well, the FMI images show that the structural dip varies from 31 degrees in the upper zone of Asmari to 36 degrees in Gurpi, with no major change in the dominant S47W dip azimuth, and similarly the general strike does not change much from N42W-S42E Figures 28 to 31.

Structural analysis in the well number GS-I

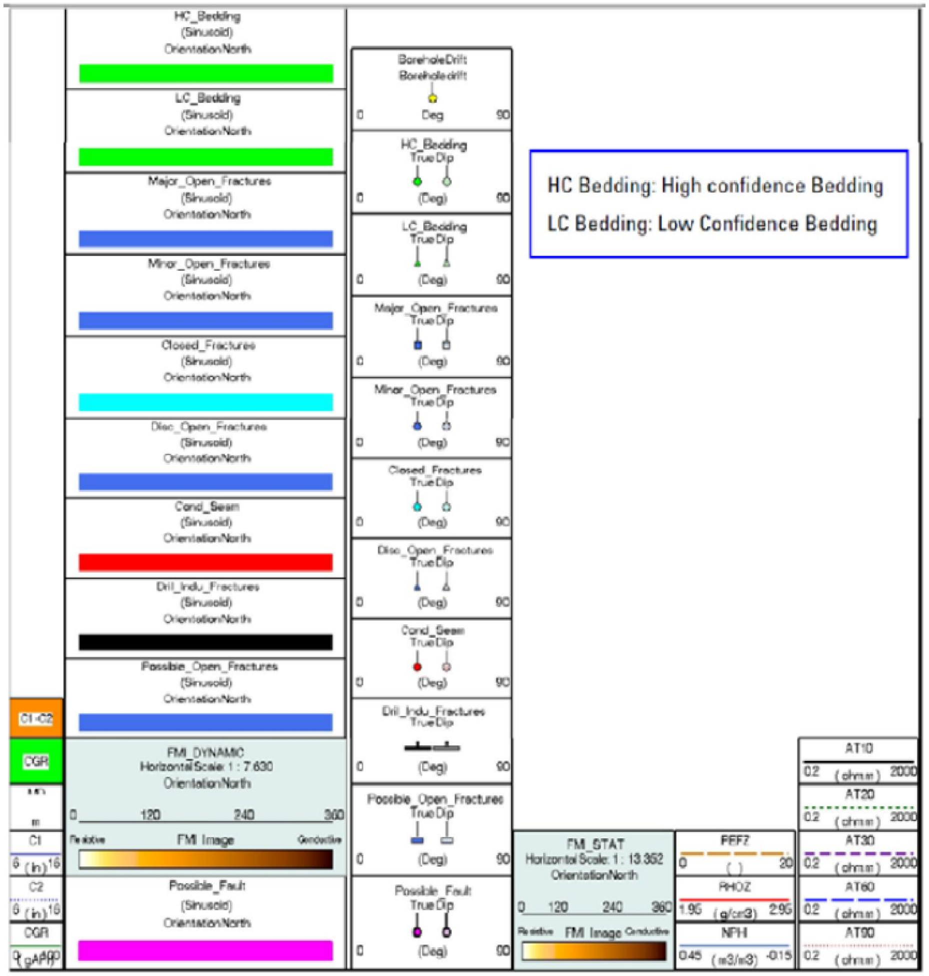


Figure 15 : Header of Figurers 16& 17

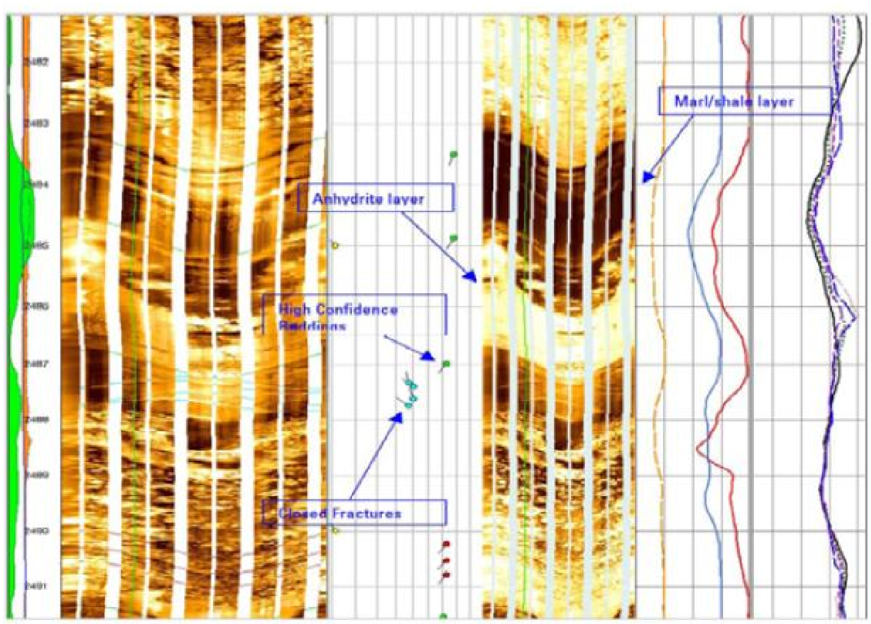


Figure 16 : Image in the Caprock indicating high confidence bedding and closed fracture, the anhydrite portions are clear by the high resistivity. Header is given in Figure 15

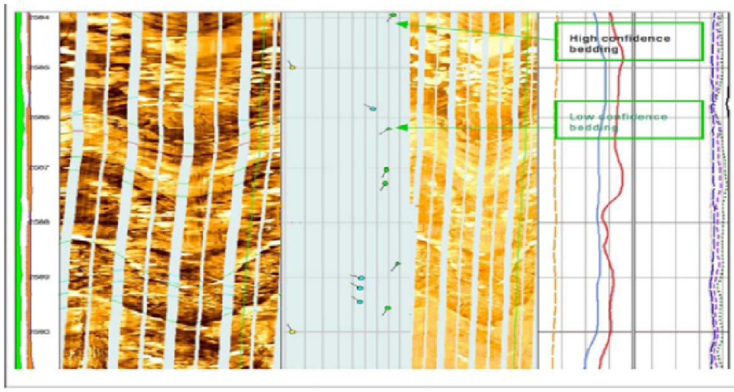


Figure 17 : High and low confidence bedding in the Asmari formation. Header is given in Figure 15

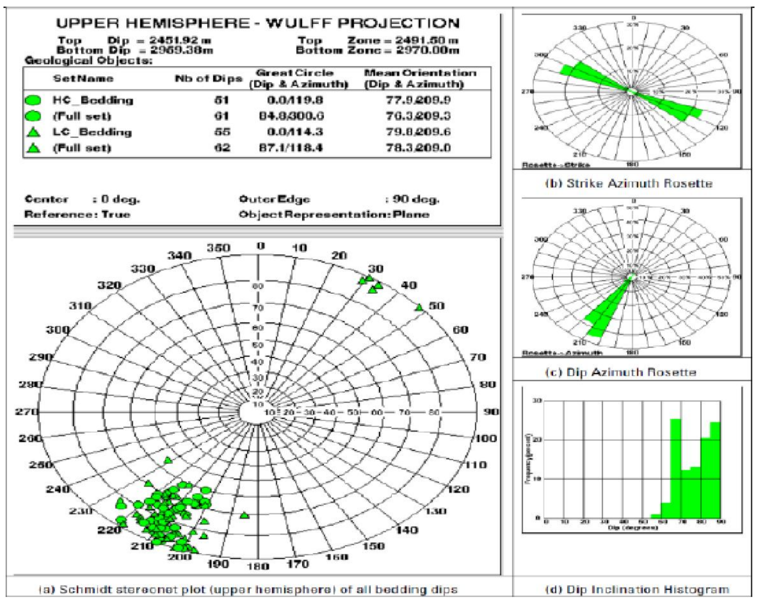


Figure 18 : Statistical plot of all bedding in the Asmari formation; HC: High Confidence; LC: Low Confidence; Full set: total number of feature in entire interval

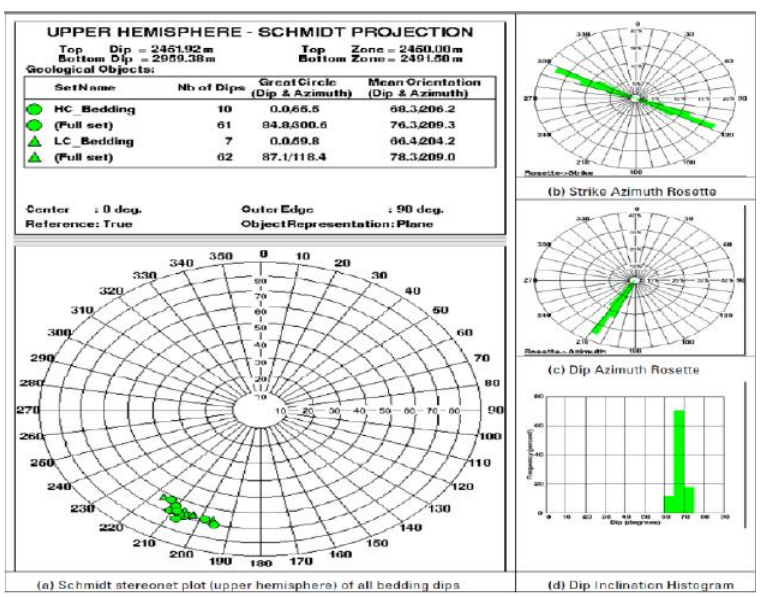


Figure 19 : Statistical plots of dips of all bedding in the Cap rock from 2315 to 2337 m; HC: High Confidence, LC: Low Confidence; Full set: total number of feature in entire interval

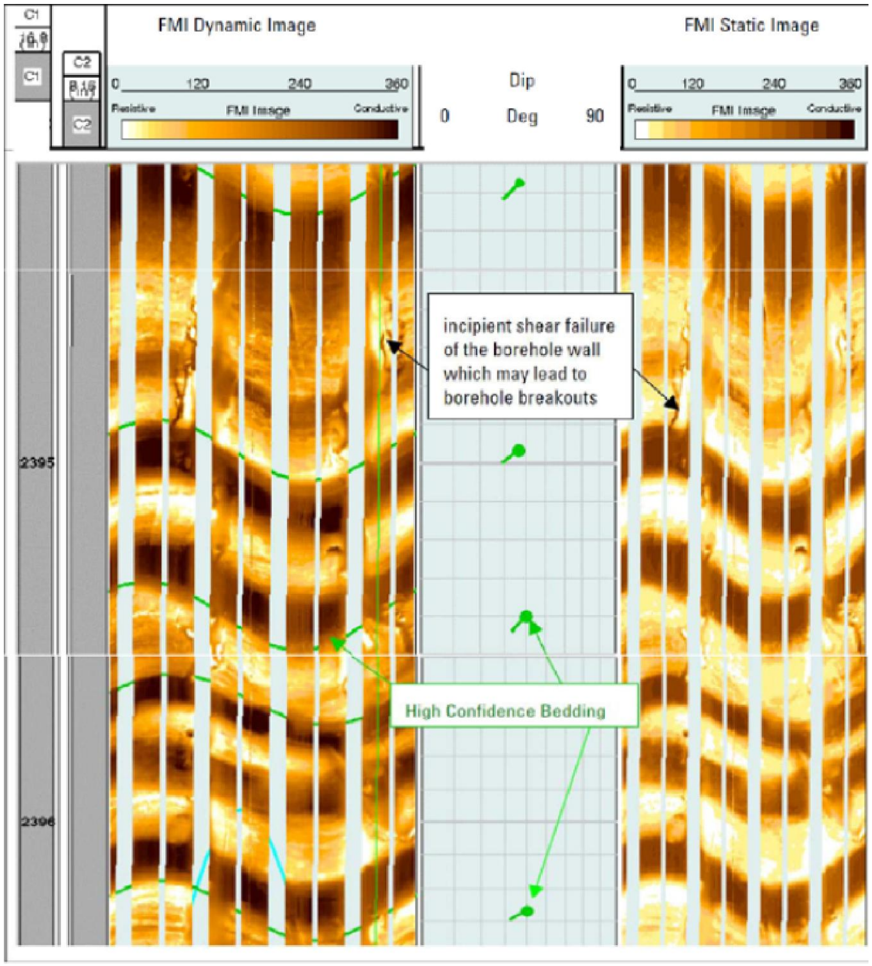


Figure 20 : Rather sharp and planar bed boundaries in Asmari giving high confidence bedding / layering dips. Incipient (i.e., early stage) shear failures of the borehole wall are also indicated. Such features would lead to borehole breakouts by excessive trips in and out of the borehole

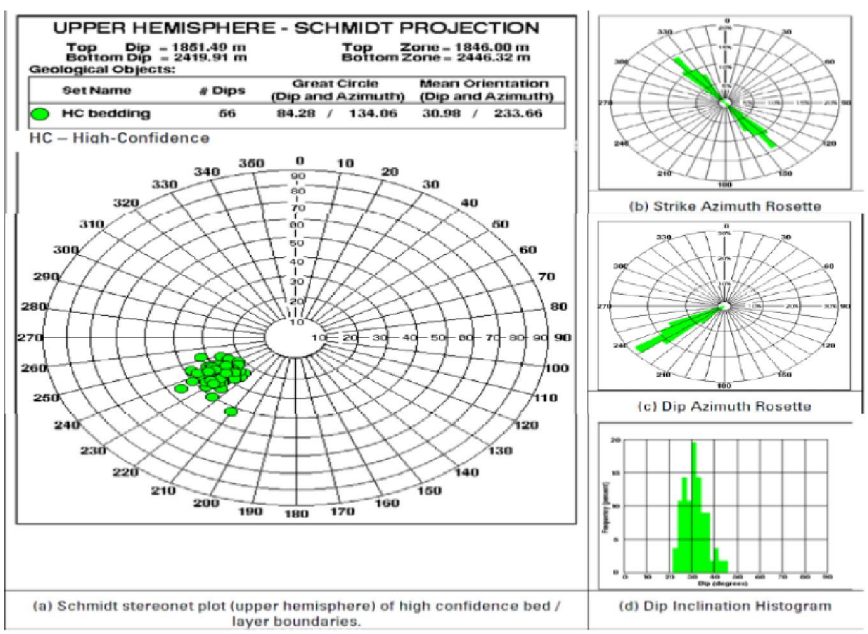


Figure 21 : Statistical plots of dips of all high confidence beds / layers boundaries found in Asmari formation

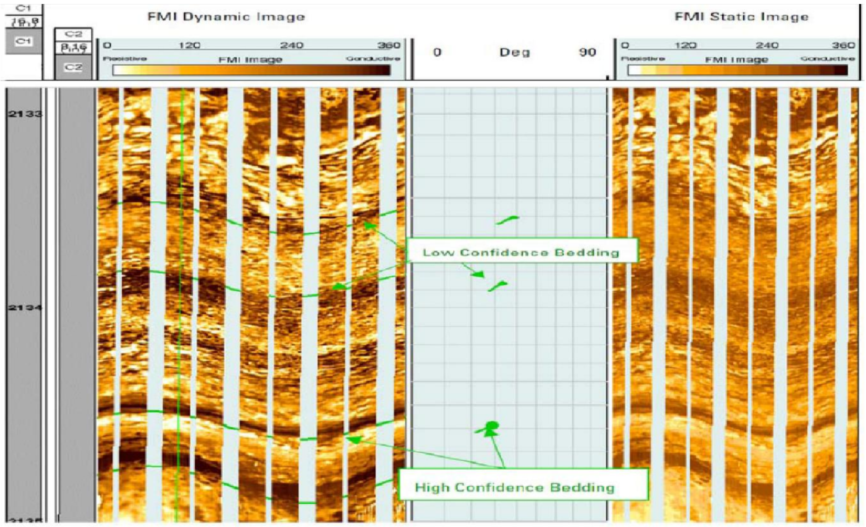


Figure 22 : Less sharp and relatively uneven layer / bed boundaries in Asmari giving low confidence bedding / layering dips. One high confidence bedding / layering dip is also indicated

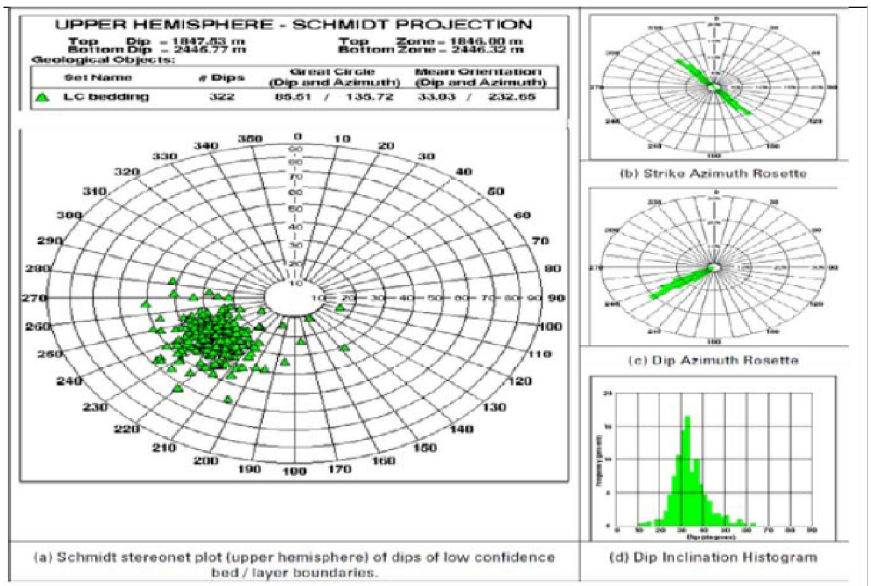


Figure 23 : Statistical plots of dips of all low confidence bed / layer boundaries found in Asmari formation

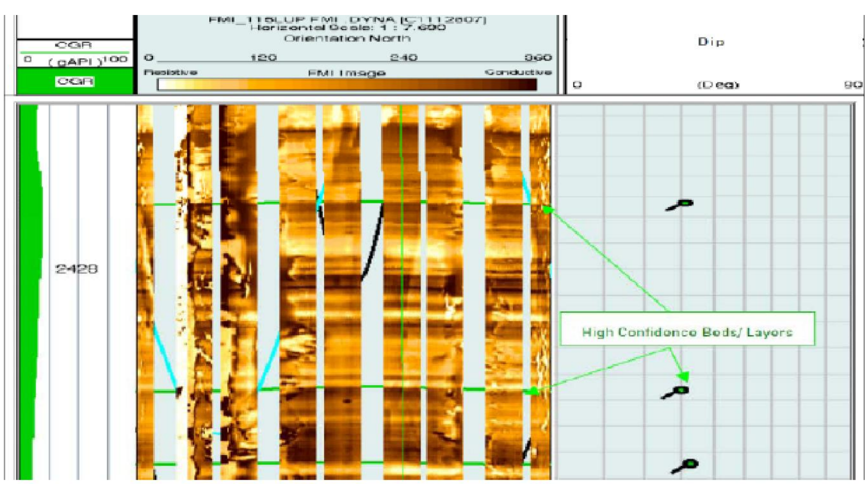


Figure 24 : Rather sharp and planar bed boundaries in Pabdeh giving high confidence for dips bed/layer

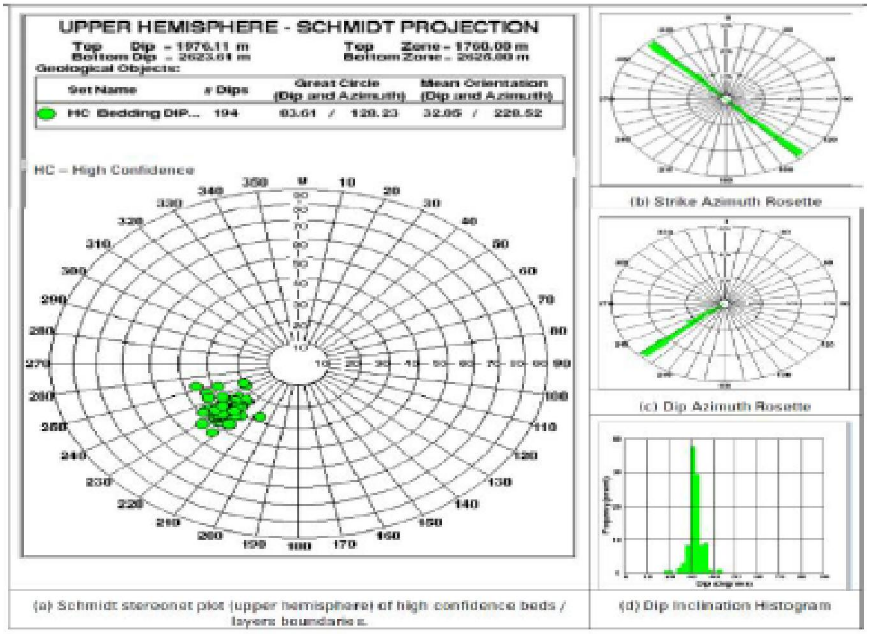


Figure 25 : Statistical plots of dips of all high confidence beds / layers boundaries found in Gurpi, Pabdeh, and Asmari formations

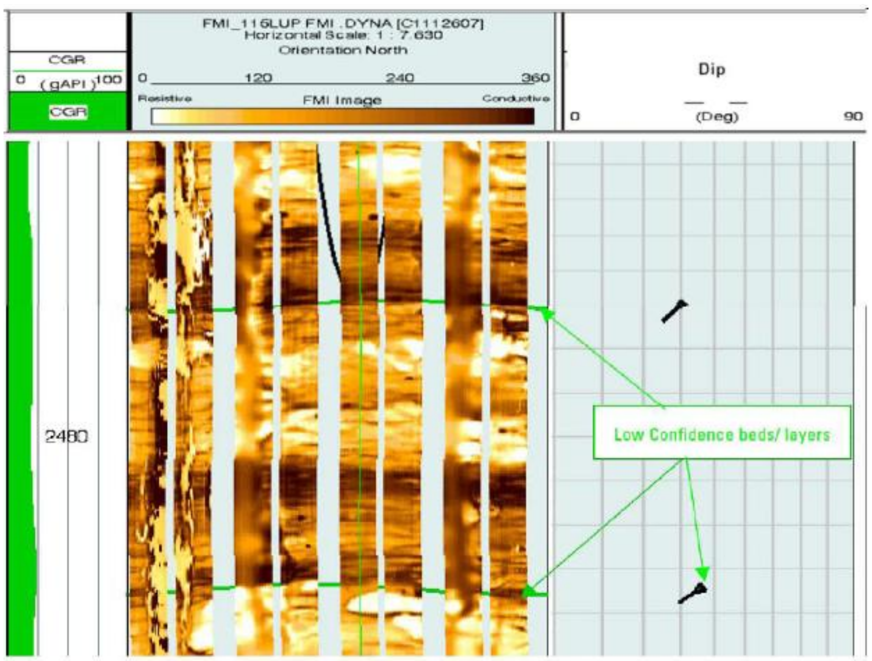


Figure 26 : Less sharp and relatively uneven boundaries in Pabdeh giving low confidence dips for beds/layers

Both classes of bedding dips from both tools, UBI and OBMI, give more or less similar dominant dip magnitude and dip azimuth. They show a dominant dip azimuth of N48E and strike N42W-S42E. However, the spread of dip magnitude varies. The continuous dip plot of all bedding dips grouped into one indicates that 25-27 degrees dip is the most appropriate structural for the from 2649m to 2897.5 m. However, local variations in the dip magnitude are also clear; for example the average dip is 35 degrees at 2680-2720 m Figures 32 to 35.

Struactural analysis for all the studied wells

Finally, we will show the structural strike bedding direction for all the studied wells together in order to find out this direction for the field. This job

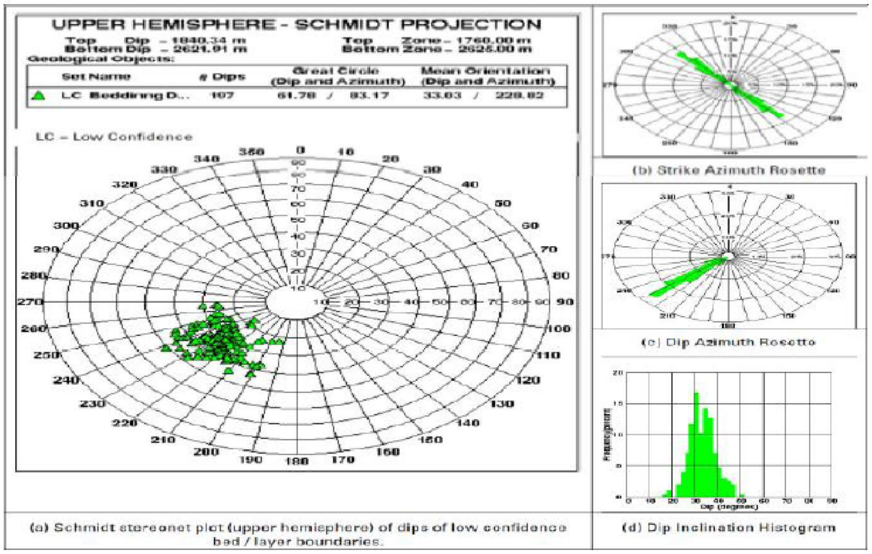


Figure 27 : Statistical plots of dips of all low confidence beds / layers found in Gurpi, Pabdeh, and Asmari formations

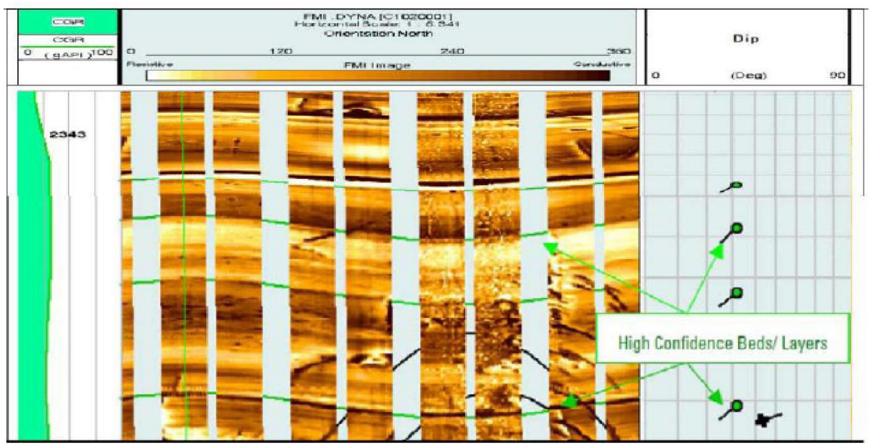


Figure 28 : Image showing rather sharp and planar bed boundaries in Pabdeh giving high confidence bedding / layering dips

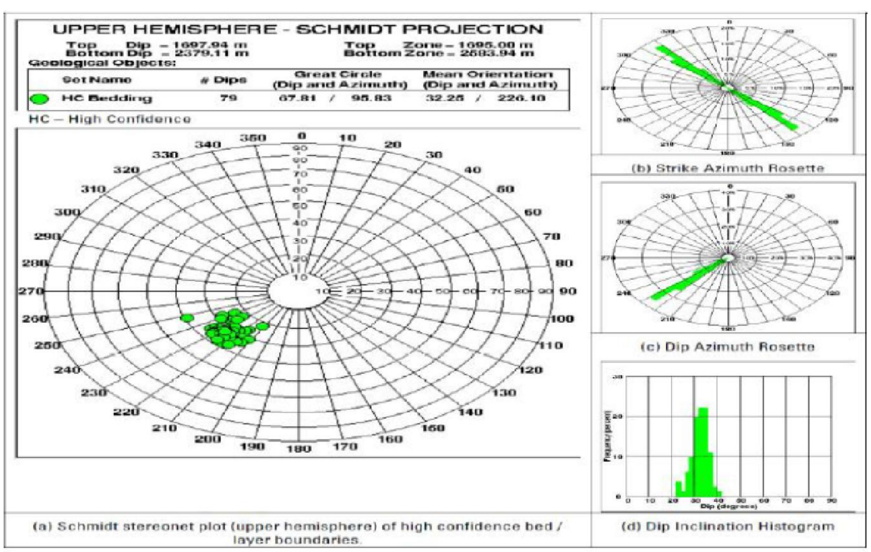


Figure 29 : Statistical plots of dips of all high confidence beds / layers boundaries found in Asmari, Pabdeh, and Gurpiformations

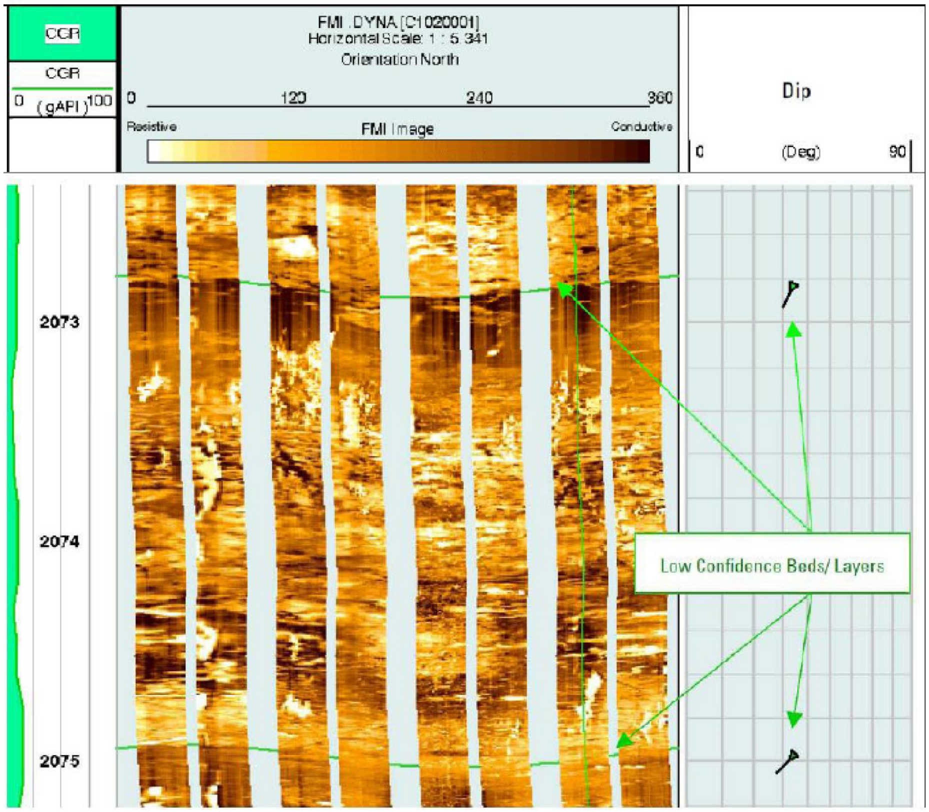


Figure 30 : Less sharp and relatively uneven layer / bed boundaries in Asmari giving low confidence bedding / layering dips

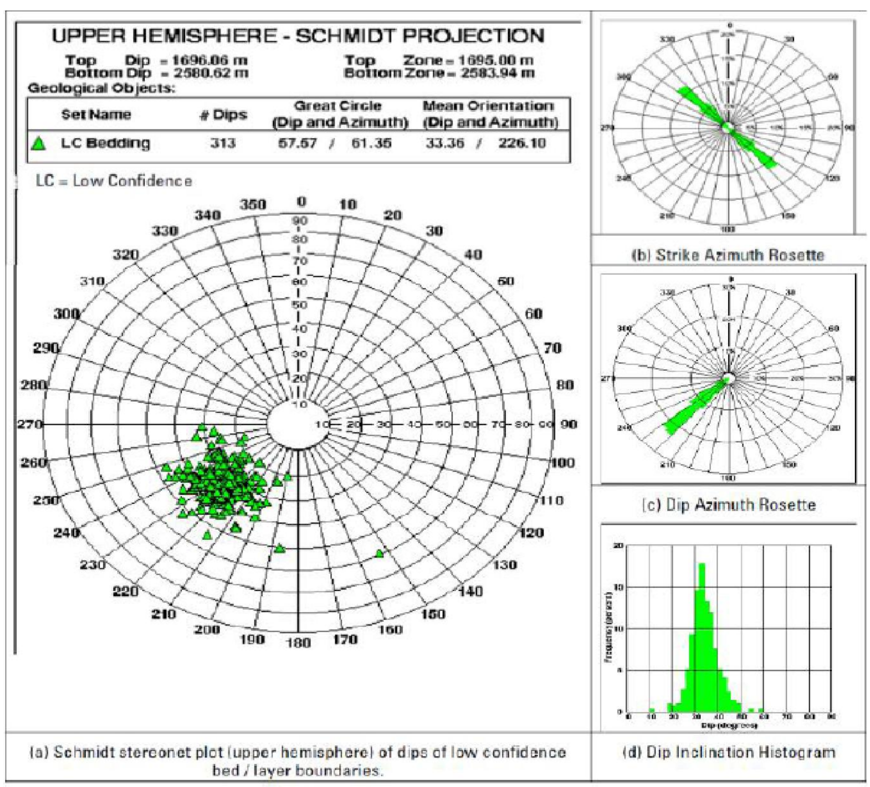


Figure 31 : Statistical plots of dips of all low confidence bed / layer boundaries found in Asmari, Pabdeh, and Gurpi formations

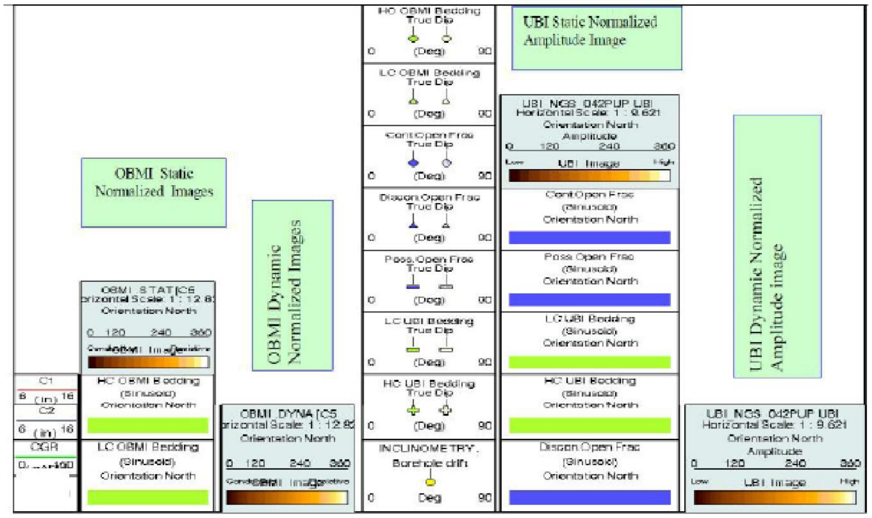


Figure 32 : Header detail for Figures 33 & 34

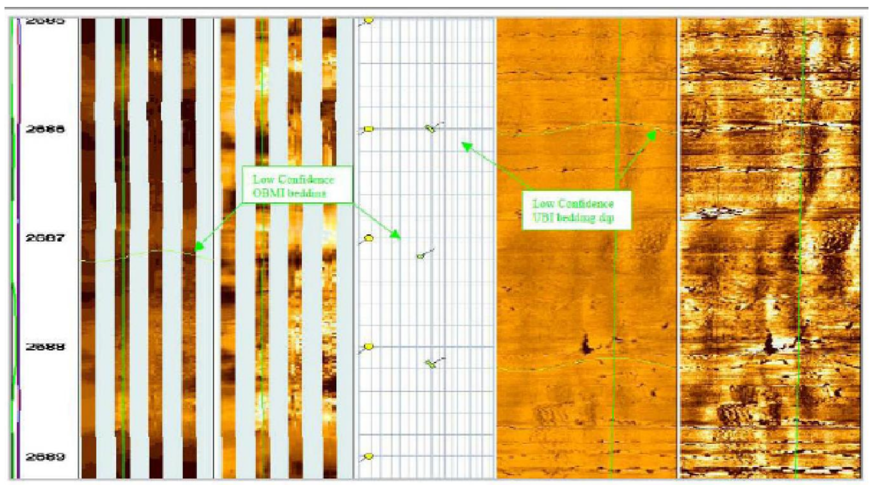


Figure 33 : OBMI and UBI images showing layering within lower Asmari. The dips corresponding to layer / bed boundaries are shown as low confidence based on their sharpness and planarity for computation of structural dip. Header is given in Figure 32

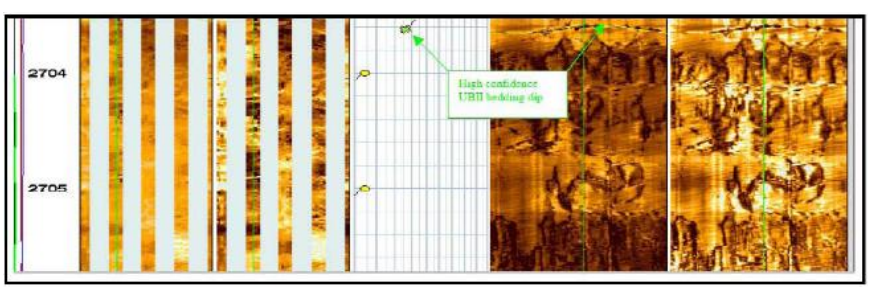


Figure 34: OBMI and UBI images showing a thin layer in the lower part of Asmari. Header is given in Figure 32

showed that the dominant bedding strike direction of theAsmari reservoir in the section of Gachsaran fieldis NE-SW direction; now that we have this direction, we can do any operation in this field more accurate.

This job also showed that the bedding direction for the wells number GS-A and GS-B is a bit different from the dominant bedding direction of the field, and it might be because of the faults, folds, diapirismsand/or the other reasons that affect the bedding strike direction in these wells that further study is necessary to find out the exact reason.

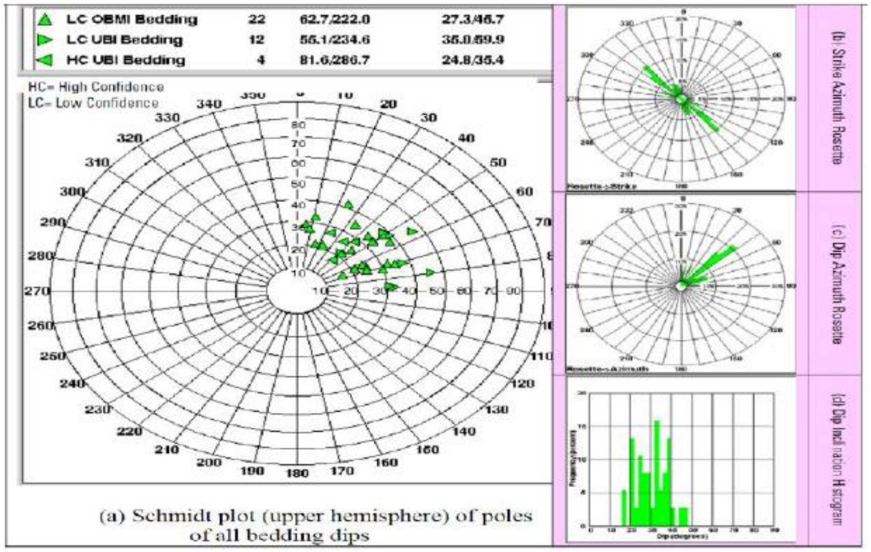


Figure 35: Statistical plots of bedding dips indicating a structural dip of 20-35 degrees N48E and strike N42W-S42E. Structural dip inclination of 25 degrees is the most representative of the whole interval

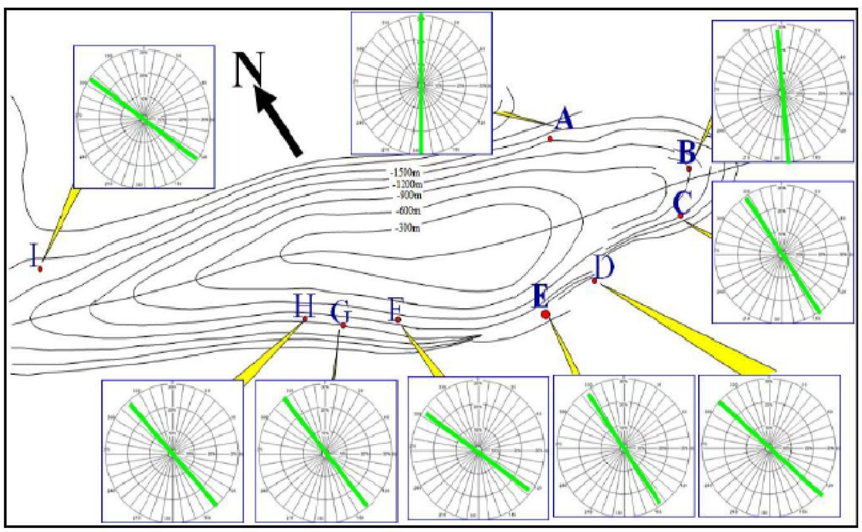


Figure 36: Bedding strike map of Asmari reservoir in Gachsaran field

CONCLUSION

This work shows how image log technology can be used to do the structural analysis in oil and gas reservoirs. It is an example of structural analysis that we did in Gachsaran field, located in South of Iran. In this paper, we describe the method in which we can find out detailed information about the bedding in oil and gas reservoirs. We studied 9 wells, located in this field; the direction of bedding strike is almost NW-SE direction for these wells and it shows the bedding strike direction of the Asmari reservoir in the section of Gachsaran field.

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