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How to Calculate the Bedding Dip and Strike in Oil and Gas Reservoirs Using Image Logs

M. Alizadeh[*,1,a], *Z. Movahed*[1,b], *R. Junin*[1,c], *R. Mohsin*[1,d], *M. Alizadeh*[2,e] *and M. Alizadeh*[3,f]

[1]Faculty of Petroleum and Renewable Energy Engineering, Universiti Teknologi Malaysia, 81310, Johor, MALAYSIA
[2]Gachsaran Oil and Gas Production Company – GOGPC, 7581873849 Gachsaran, Iran
[3]Mechanical Engineering Department, Tarbiat Modares University, 14155-111 Tehran, Iran
[*,a]*mostafa.alizadeh88@yahoo.com*, [b]*zmovahed@gmail.com*, [c]*radzuan@petroleum.utm.my*,
[d]*rahmat@petroleum.utm.my*, [e]*alizadeh.me@gmail.com*, [f]*ymohsen.alizadeh@yahoo.com*

Abstract – *In this work, the process that the bedding dip and strike can be calculated using image logs will be explained by using a unique case study and a number of valuable image log interpretation examples. This job will 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.* ***Copyright © 2015 Penerbit Akademia Baru - All rights reserved.***

Keywords: Bedding Dip and Strike, Oil and Gas Reservoirs, Image logs

1.0 INTRODUCTION

Gachsaran oil field is in the southwest of Iran (Fig. 1) with an anticline structure, made of anhydrite/salt, 80 km long, 300 m-1500 m thickness, 8-18 km wide.

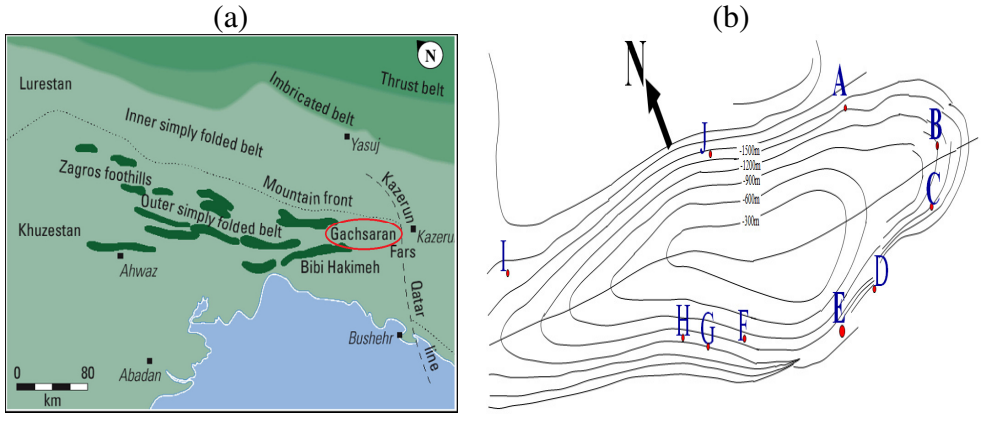

Figure 1: a) Location of the Gachsaran field [2]; b) UGC map of the Gachsaran field and the studied wells

It provides an excellent seal for the Asmari reservoir, the Pabdeh reservoir, the Gurpi reservoir and the other reservoirs (Fig. 2) [1].

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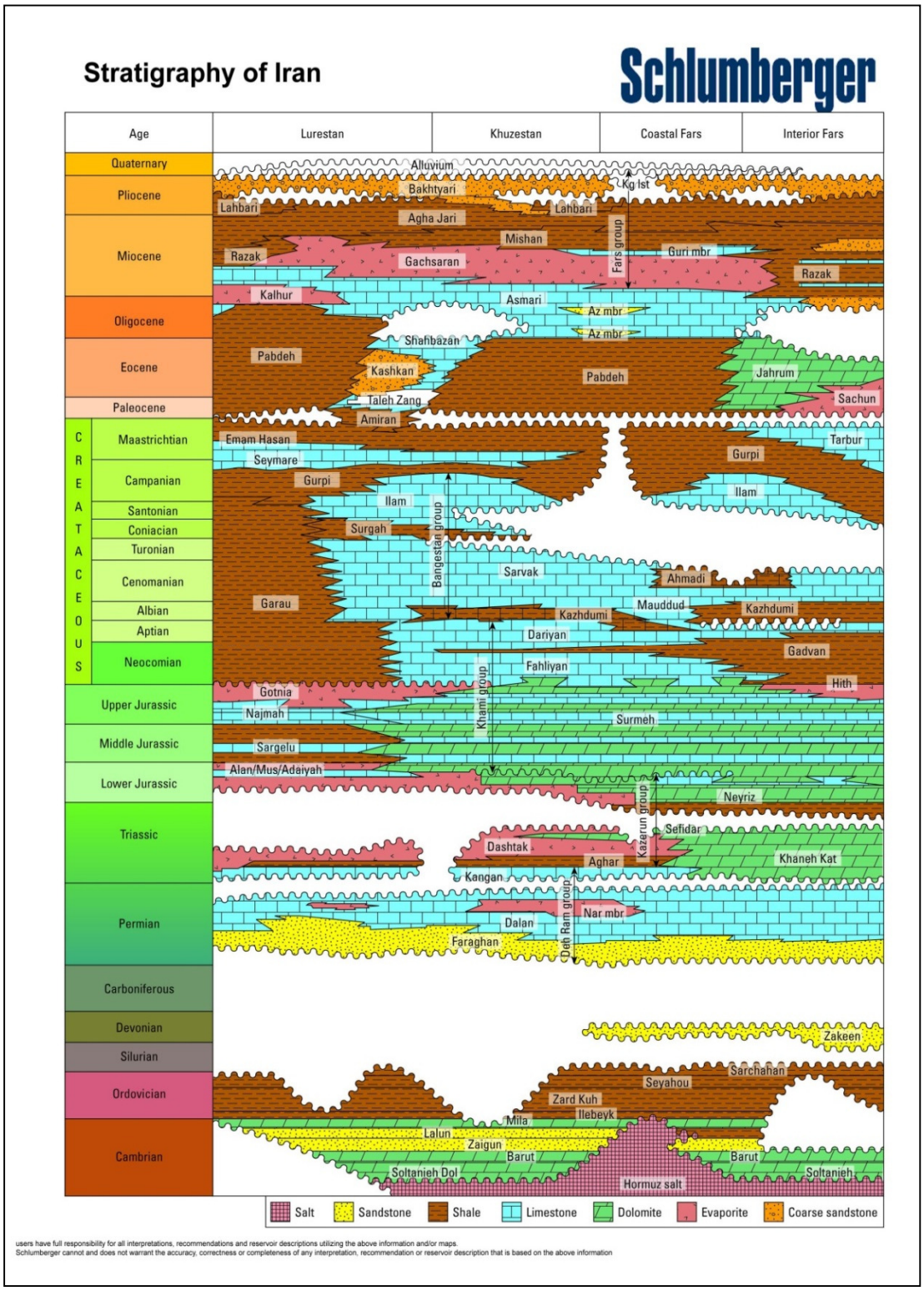

Figure 2: Picture showing the Gachsaran field overlying the Asmari, Pabdeh, Gurpi and other reservoirs, and stratigraphic nomenclature of rock units and age relationships in the Zagros basin [3]

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-

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situ stress analysis [4, 5]. 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, this process will be explained 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. The structural analysis will be done 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.

By interpreting the image logs, the direction of structural bedding for every well can be calculated then by comparing the result, the structural bedding direction for the field can be calculated.

2.0 MATERIALS AND 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 [6]. 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 (Fig. 3). While the dips corresponding to vague and uneven bed / layer surfaces are categorized as low confidence (Fig. 4).

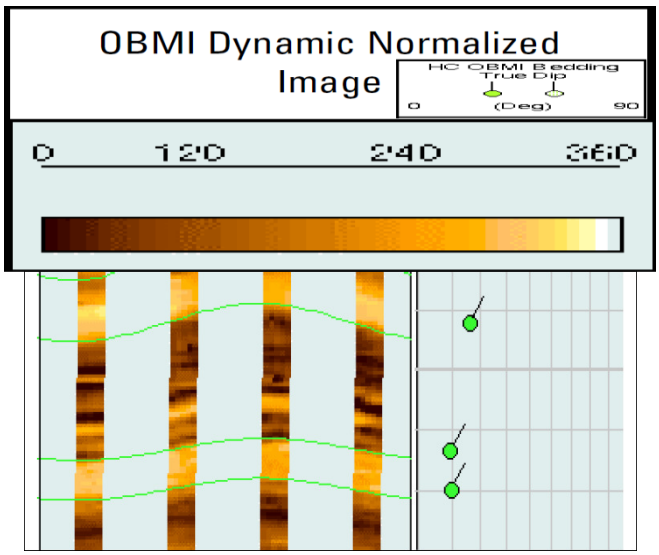

Figure 3: High confidence dips from sharp and planar layer / bed boundaries seen by OBMI

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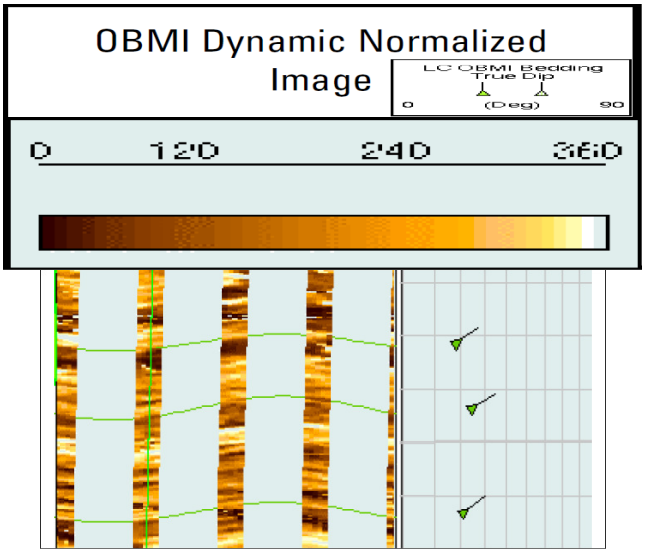

Figure 4: Low confidence dips from less sharp and relatively uneven layer / bed boundaries seen by OBMI

3. RESULTS AND DISCUSSION

3.1 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 (Fig. 5-6).

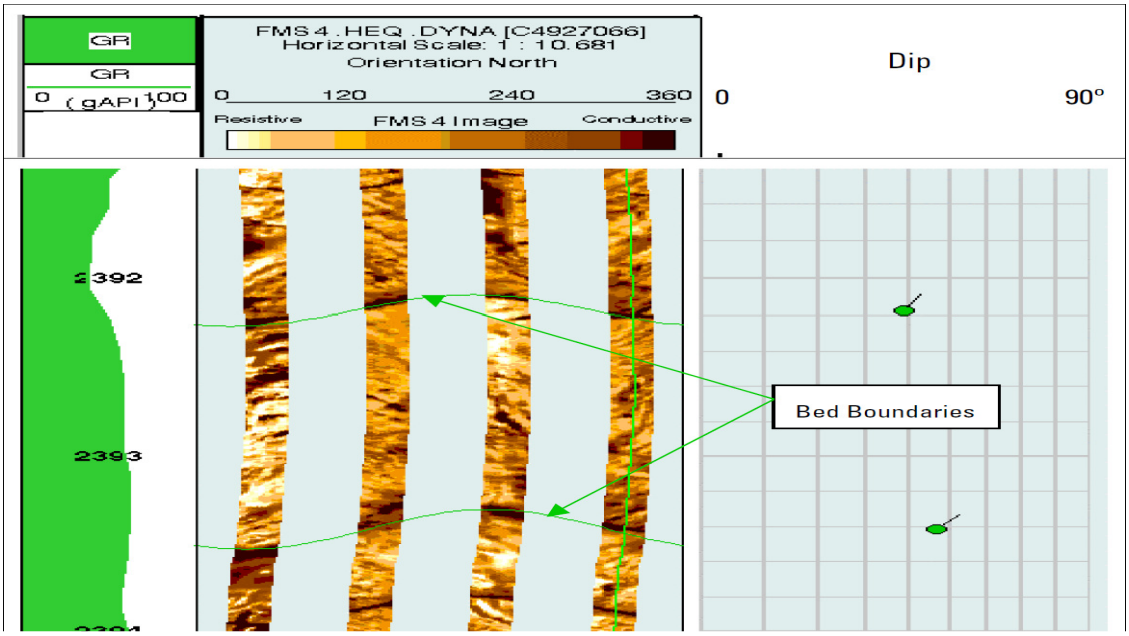

Figure 5: Bed boundaries in Asmari formation for well GS-A

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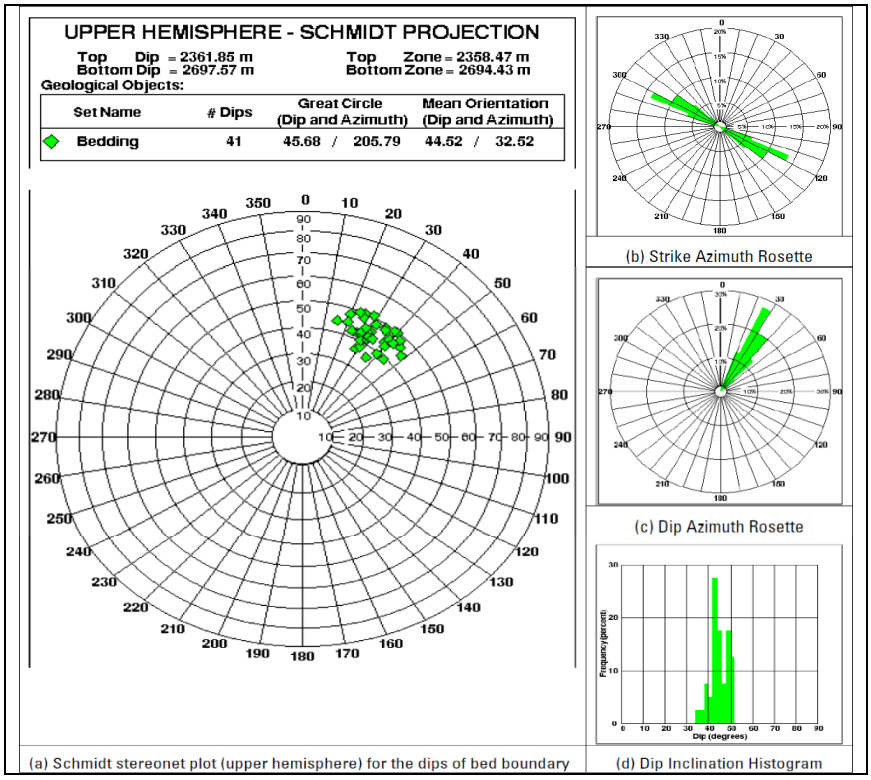

Figure 6: Statistical plots in well GS-A for the dips of bed boundaries in the Asmari formation; a) Schmidt stereonet plot (upper hemisphere) for the dips of bed boundary; b) strike azimuth rosette; c) dip azimuth rosette; d) dip inclination histogram

3.2 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 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 (Fig. 7-8).

3.3 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 (Fig. 9-11).

3.4. 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 (Fig. 12-14).

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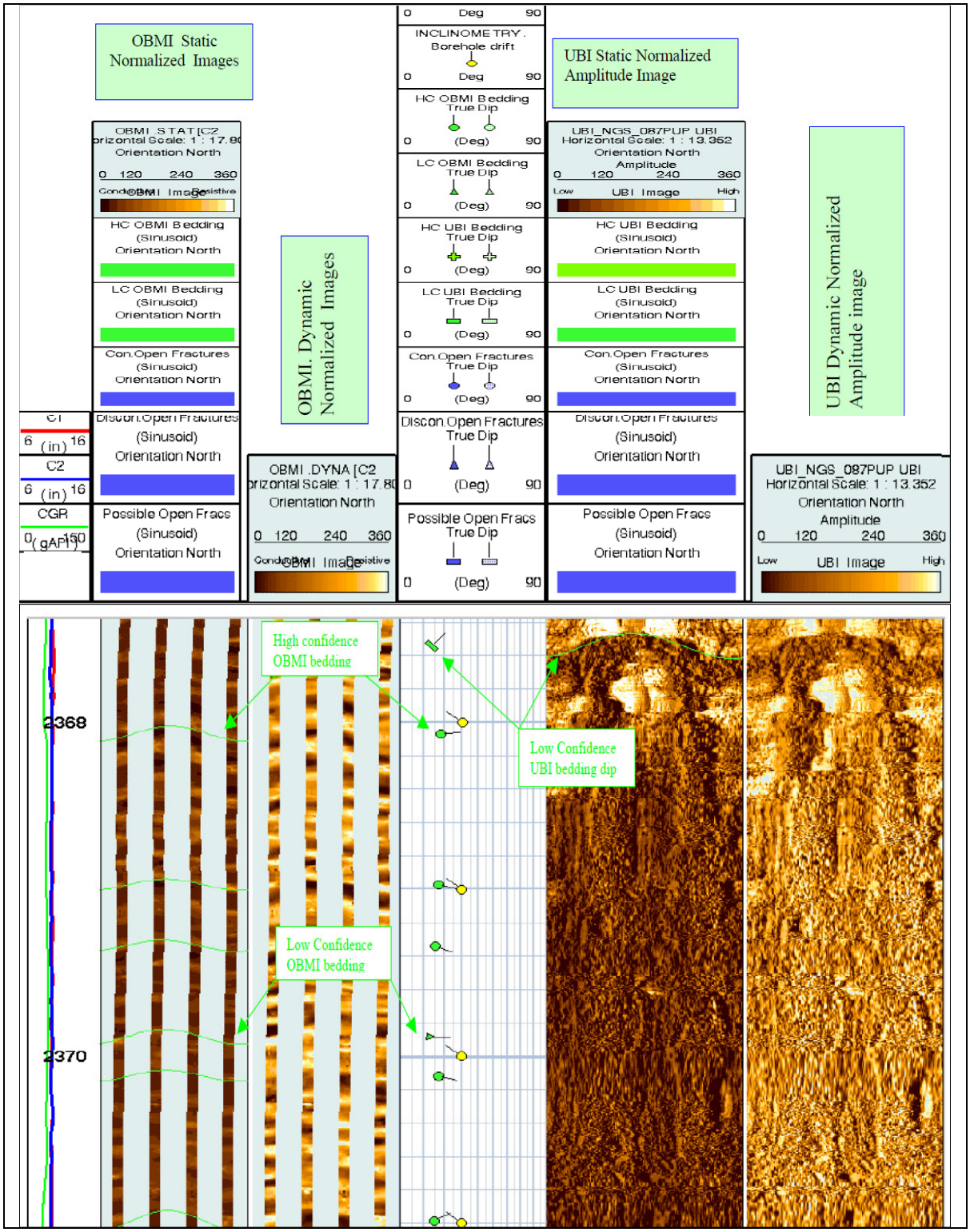

Figure 7: OBMI and UBI images showing layering within lower Asmari. The dips corresponding to layer / bed boundaries are shown as low and high confidence based on their sharpness and planarity for computation of structural dip

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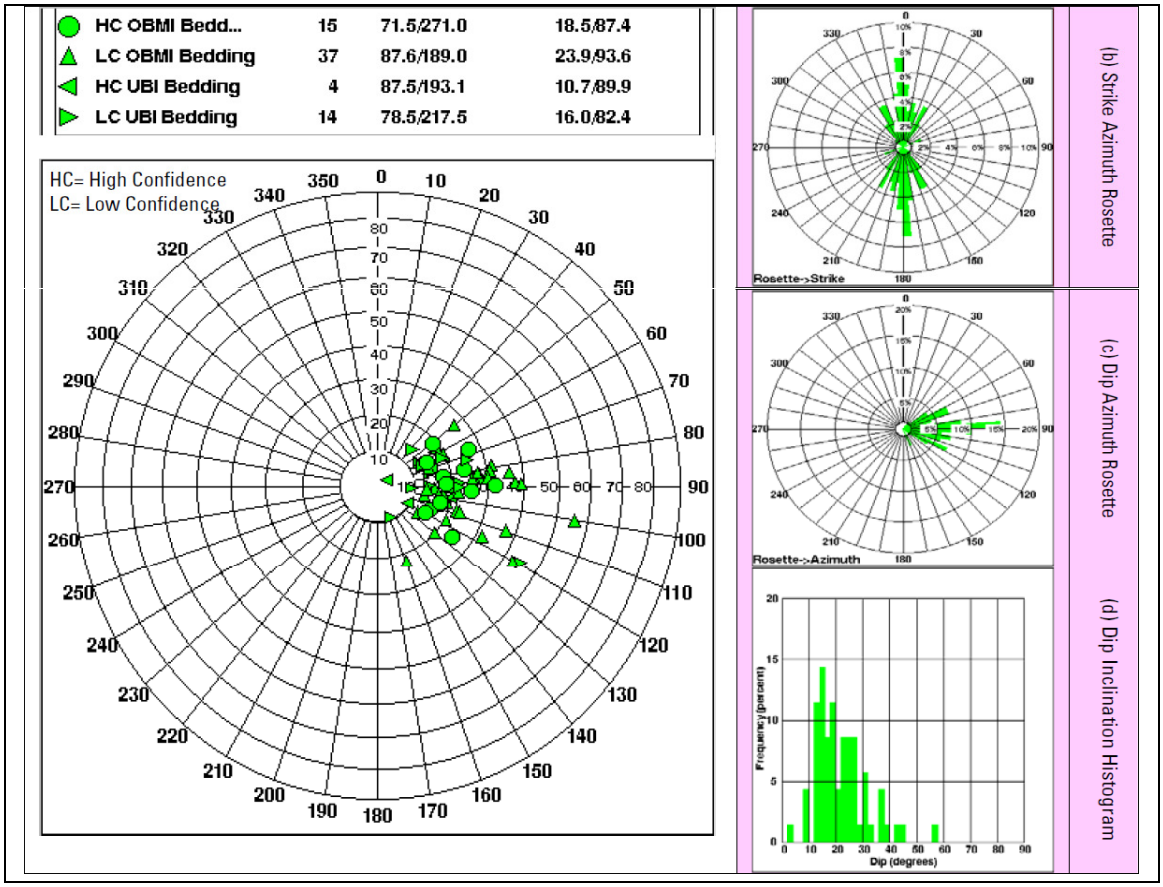

Figure 8: Statistical plots in well GS-B for the dips of bed boundaries in the Asmari formation; a) Schmidt stereonet plot (upper hemisphere) for the high confident (HC) OBMI bedding, low confident OBMI bedding (LC), high confident (HC) UBI bedding and low confident (LC) UBI bedding; b) strike azimuth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

3.5. Structural Analysis in the Well Number GS-E

In this well, the FMI images show that the structural dip in the entire interval (520 m) 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 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 (Fig. 15-19).

3.6. Structural Analysis in the Well Number GS-F

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) (Fig. 20-23).

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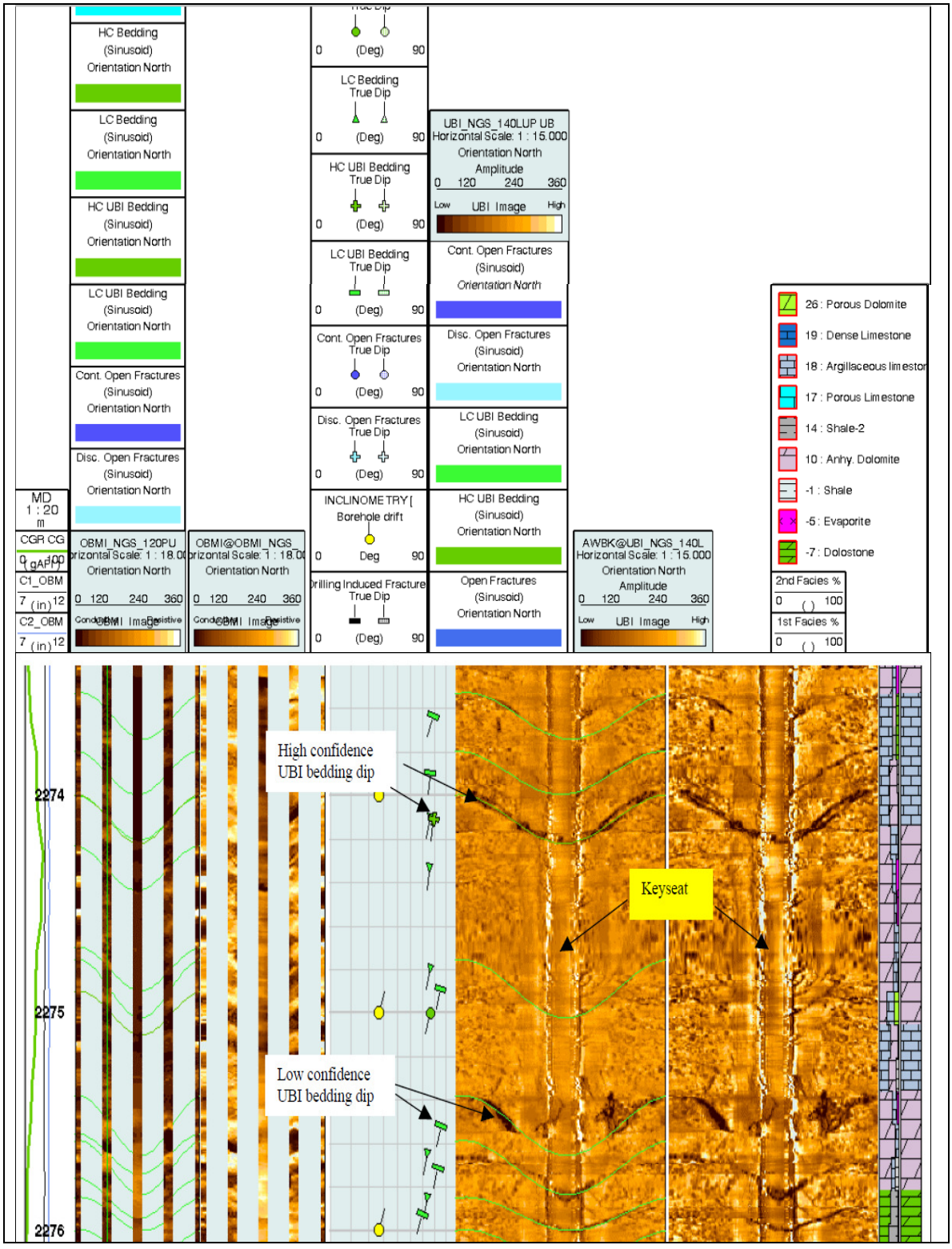

Figure 9: OBMI and UBI images showing layering within Cap Rock. The dips corresponding to layer / bed boundaries are shown as low and high confidence based on their sharpness and planarity for computation of structural dip.

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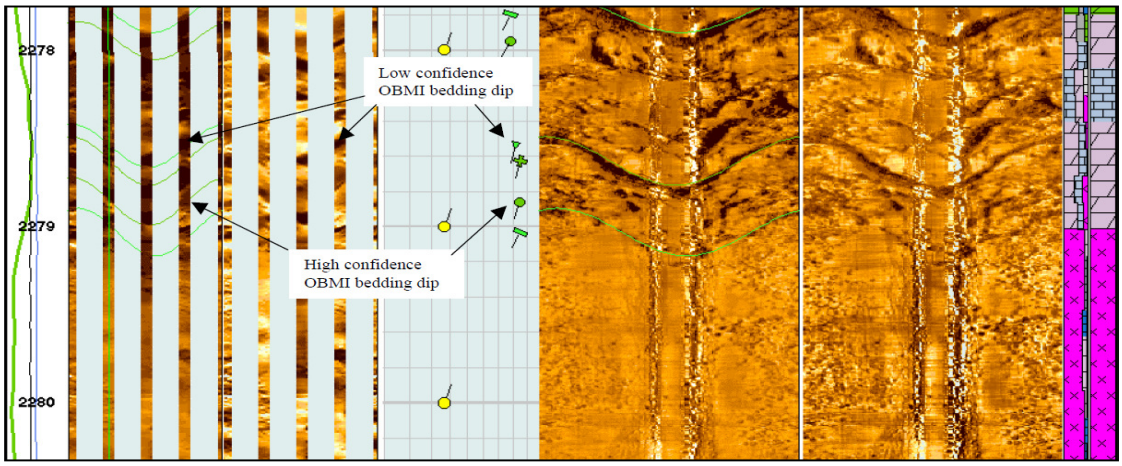

Figure 10: OBMI and UBI images showing layering within Cap Rock. The dips corresponding to layer / bed boundaries are shown as low and high confidence based on their sharpness and planarity for computation of structural dip. Header details is given in Fig. 9.

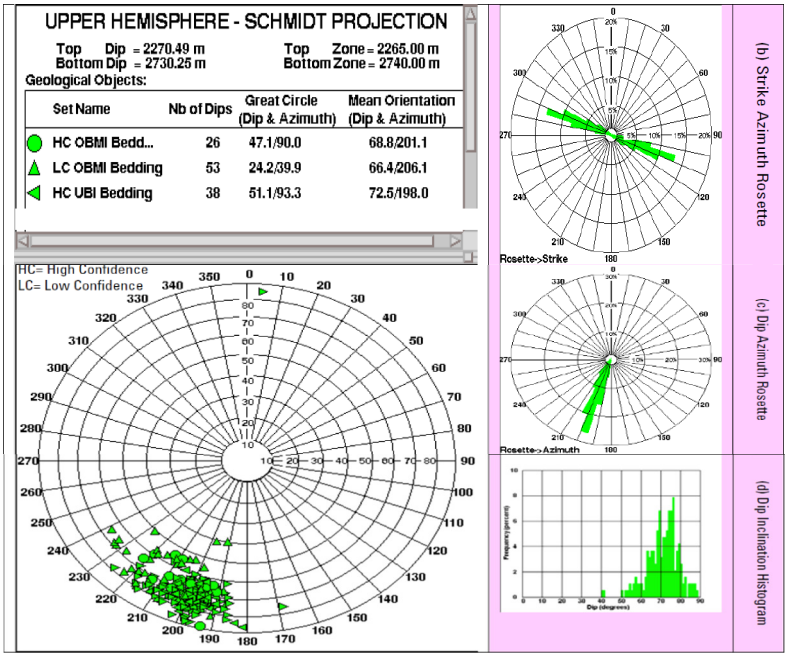

Figure 11: For the well GS-C, statistical plots of bedding dips indicating a structural dip of 62-80 degrees S20W and strike N70W-S70E; a) Schmidt stereonet plot (upper hemisphere) for the high confident (HC) OBMI bedding, low confident OBMI bedding (LC), high confident (HC) UBI bedding and low confident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

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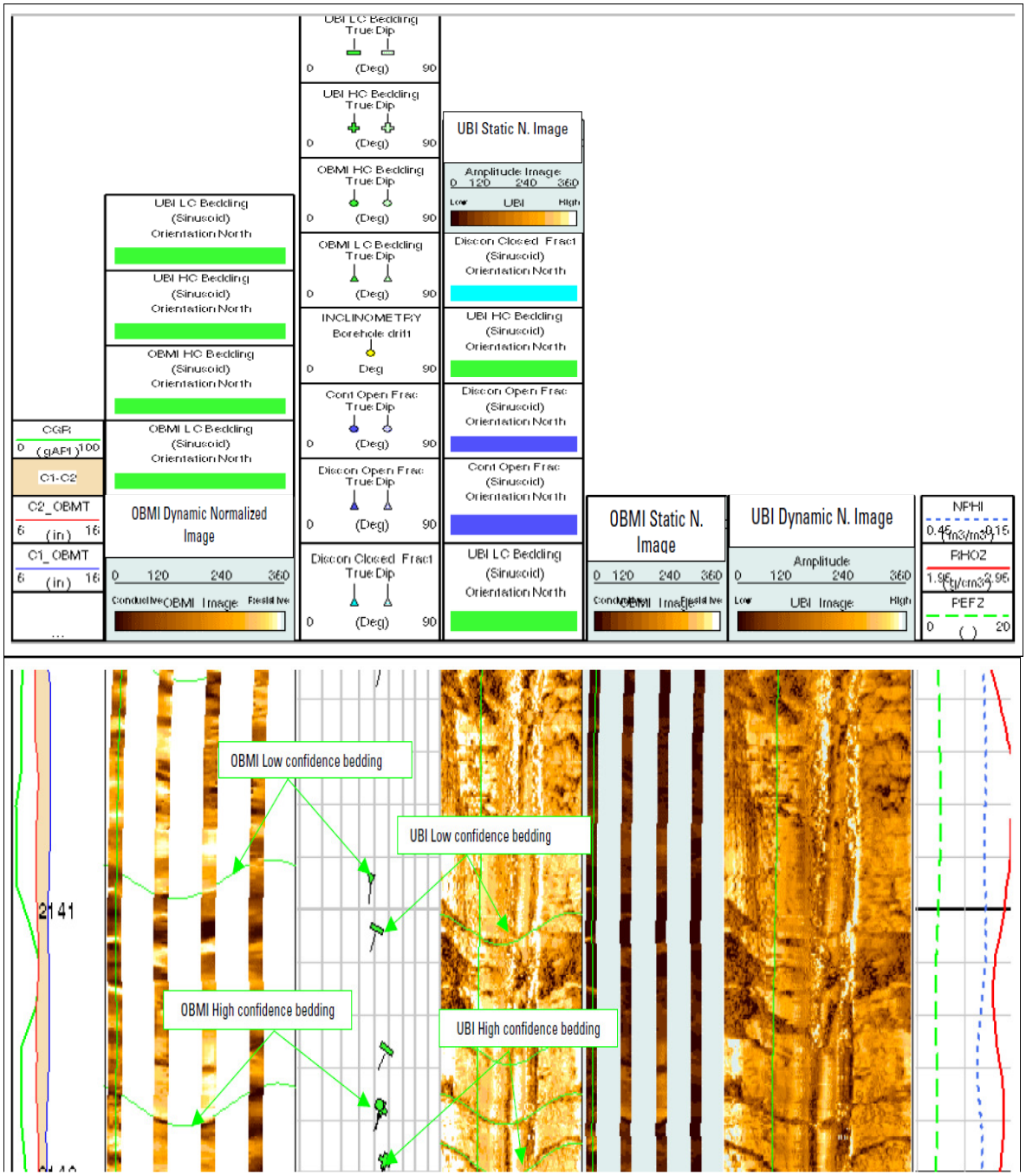

Figure12: OBMI and UBI images showing layering in a section of Asmari. The dips corresponding to layer/bed boundaries are shown as high or low confidence based on their high or low degree of sharpness and planarity, respectively, for computation of structural dip

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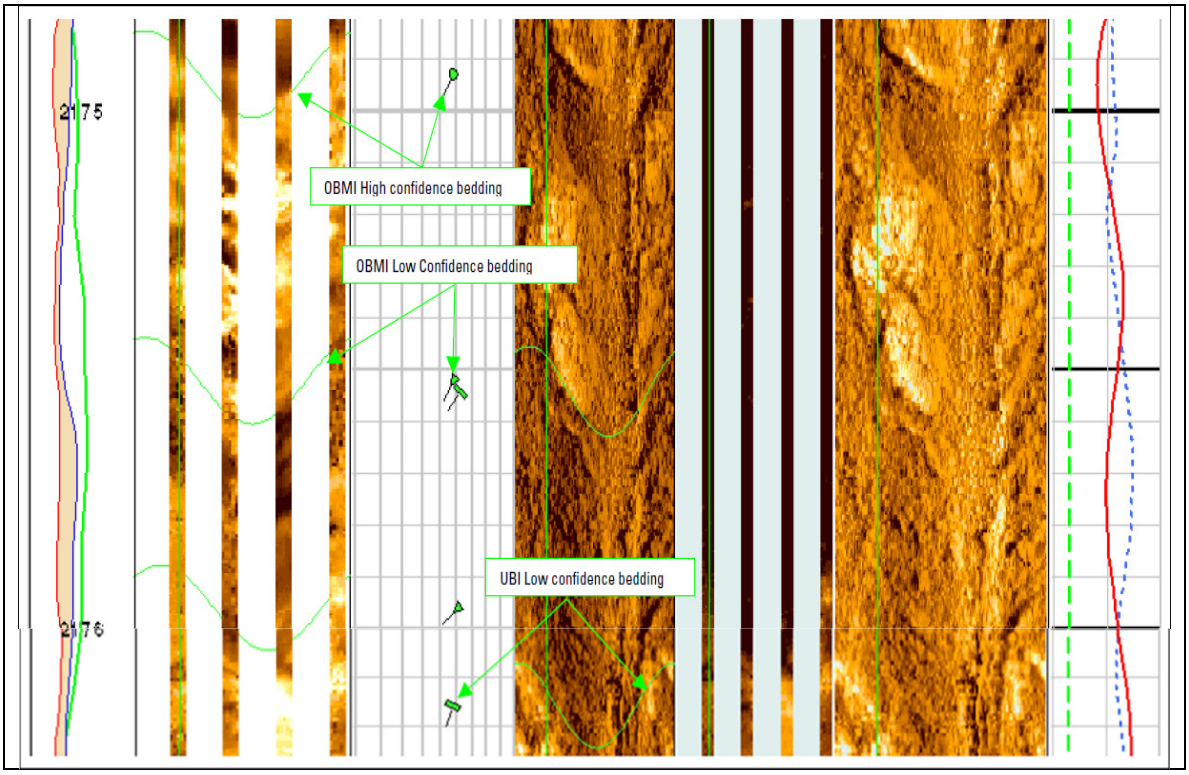

Figure 13: OBMI and UBI images showing layering in a section of Asmari. The dips corresponding to layer/bed boundaries are shown as high or low confidence based on their high or low degree of sharpness and planarity, respectively, for computation of structural dip. Header is given in Fig. 12

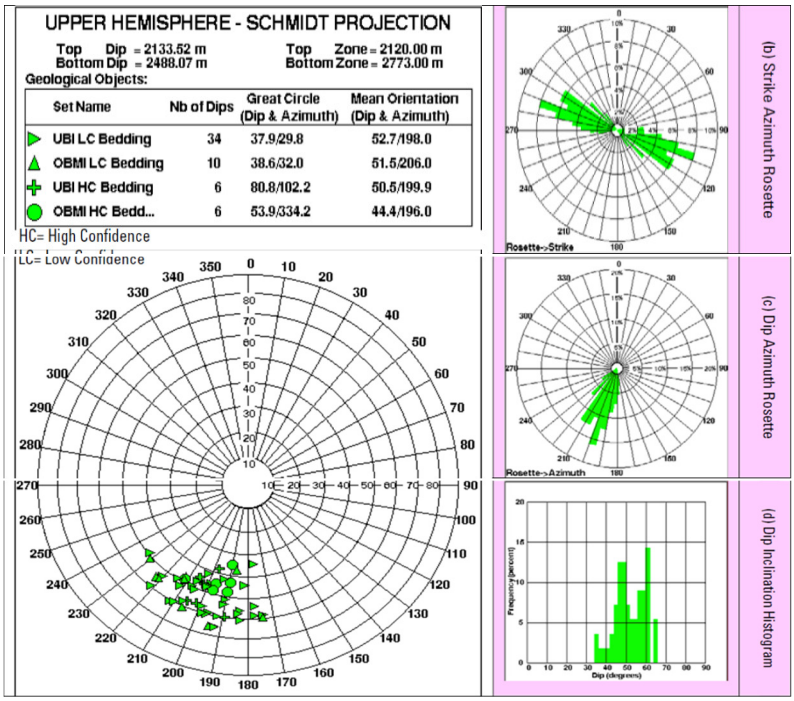

Figure 14: Statistical plots of bedding dips indicating bedding dip varying from 34 to 64 degrees S18W and strike N72W-S72E

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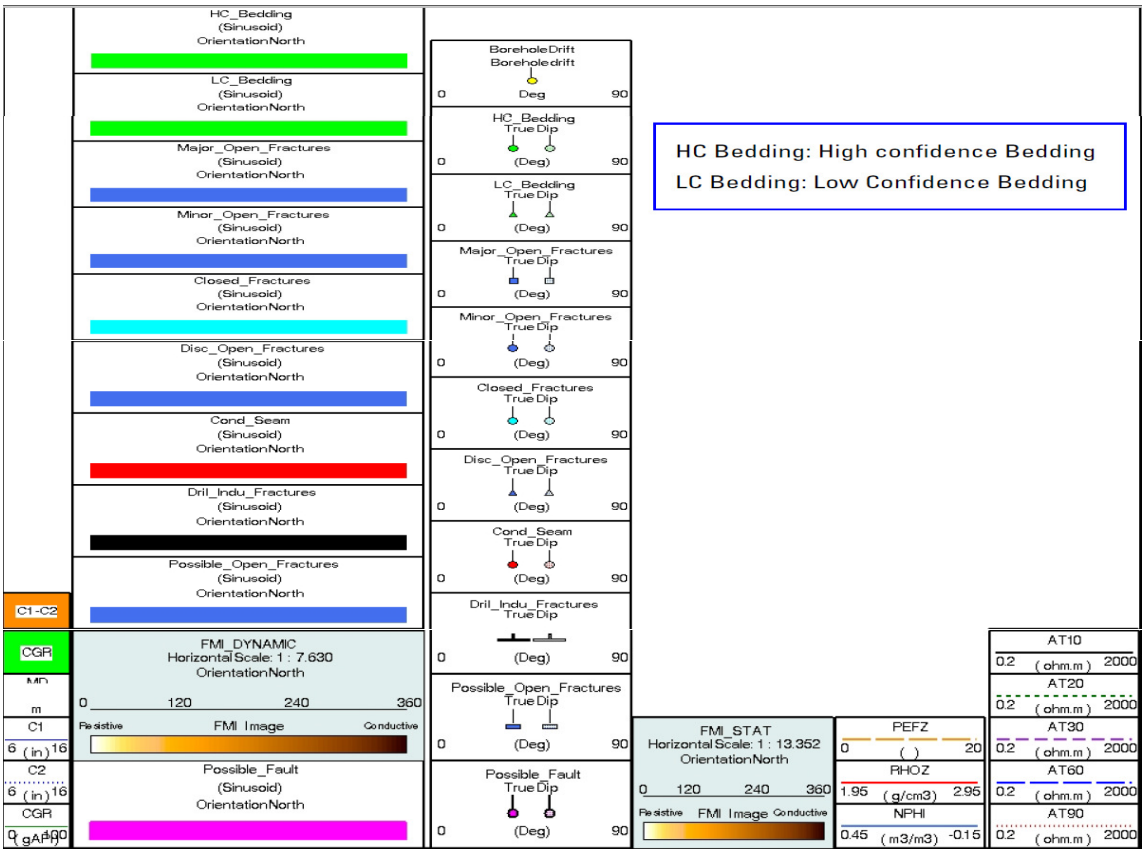

Figure 15: Header of Fig. 16-17

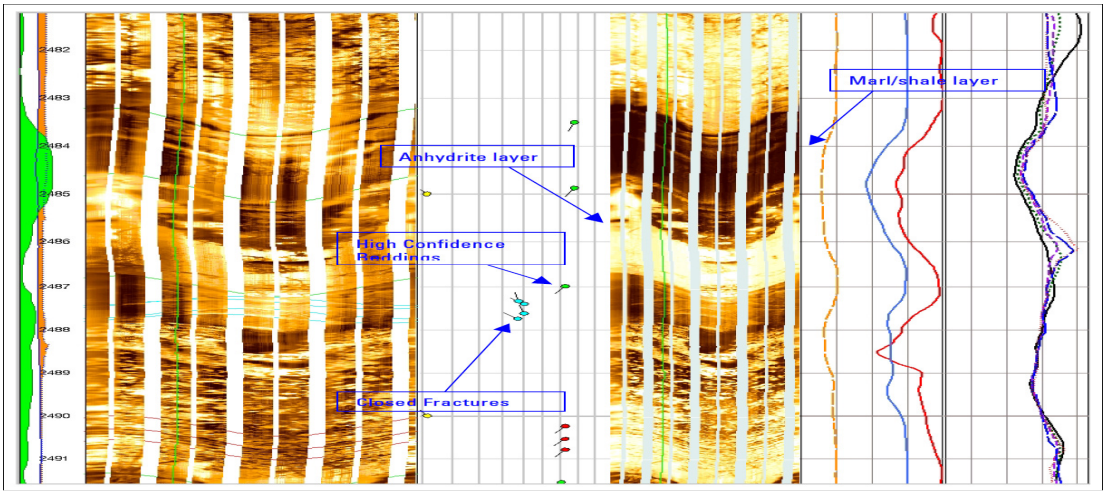

Figure 16: Image in the Caprock indicating high confidence bedding and closed fracture, the anhydrite portions are clear by the high resistivity. Header is given in Fig. 15

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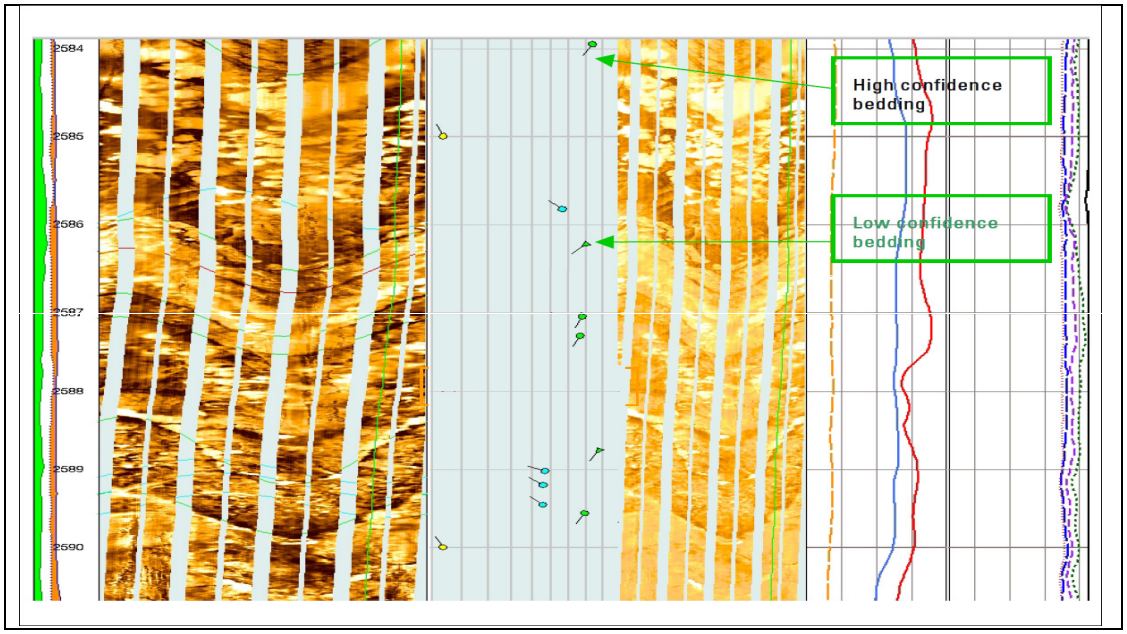

Figure 17: High and low confidence bedding in the Asmari formation. Header is given in Fig. 15.

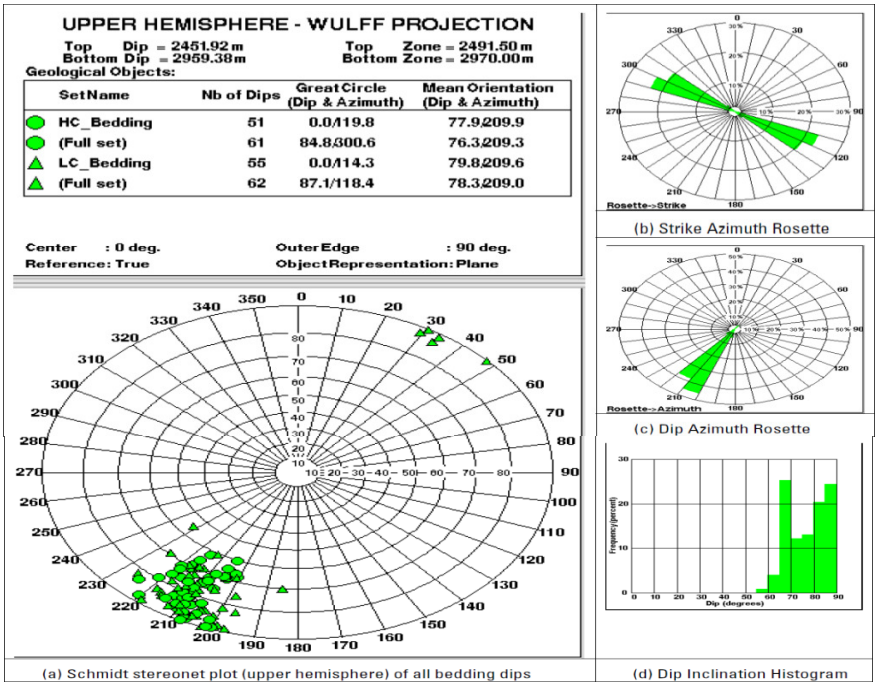

Figure 18: Statistical plot of all bedding in the Asmari formation; HC: High Confidence; LC: Low Confidence; Full set: total number of feature in entire interval

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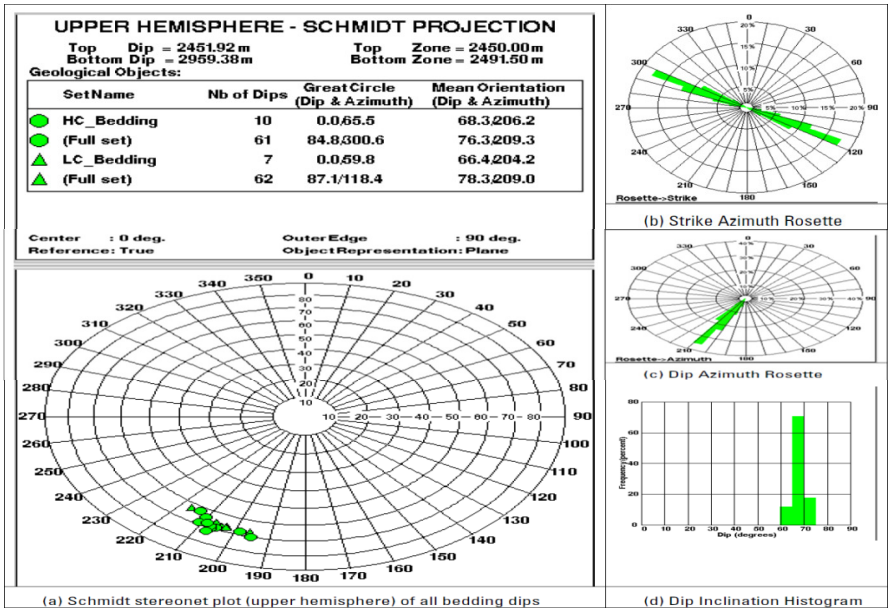

Figure 19: Statistical plots of dips of all bedding in the Cap rock from 2315 to 2337 m; HC: High Confidence, LC: Low Confidence; Full set: total number of feature in entire interval

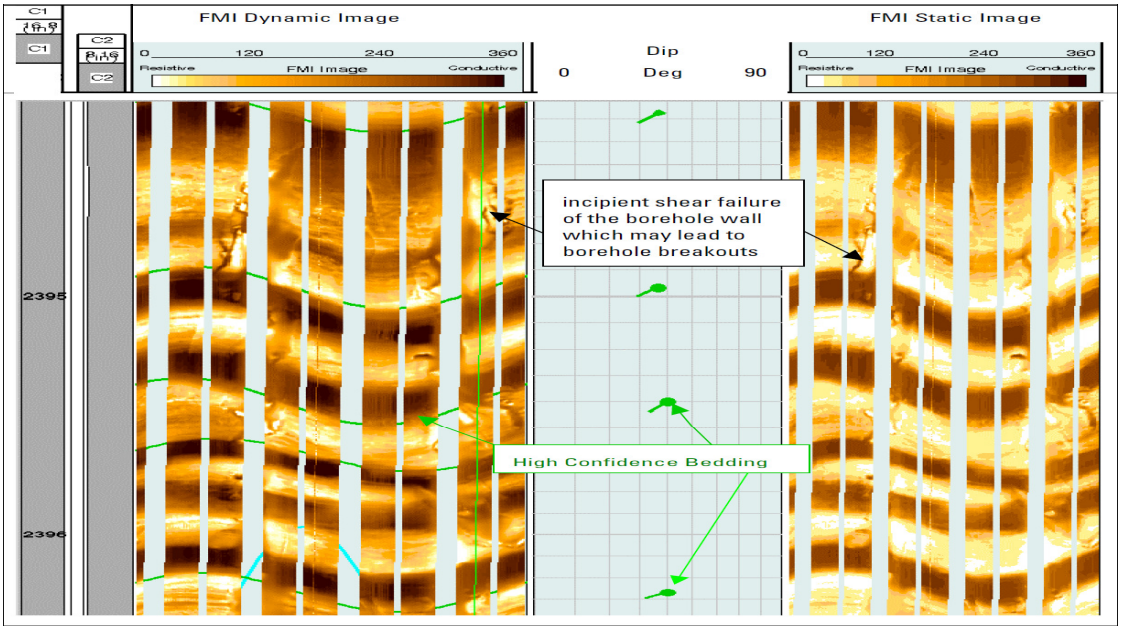

Figure 20: Rather sharp and planar bed boundaries in Asmari giving high confidence bedding / layering dips. Incipient (i.e., early stage) shear failures of the borehole wall are also indicated. Such features would lead to borehole breakouts by excessive trips in and out of the borehole

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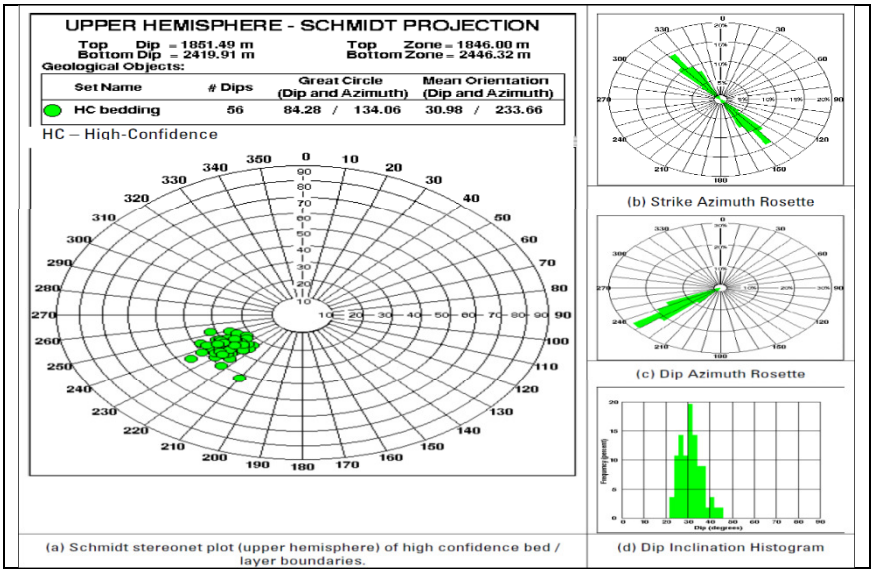

Figure 21: Statistical plots of dips of all high confidence beds / layers boundaries found in Asmari formation

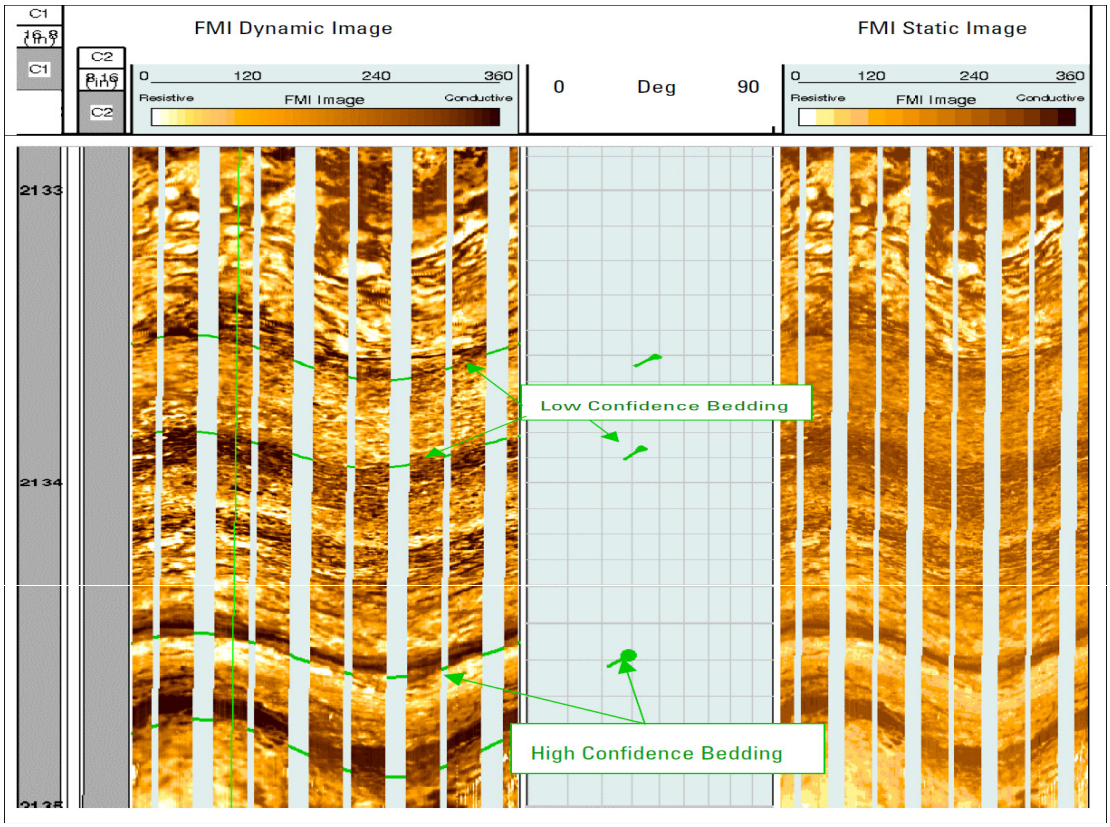

Figure 22: Less sharp and relatively uneven layer / bed boundaries in Asmari giving low confidence bedding / layering dips. One high confidence bedding / layering dip is also indicated

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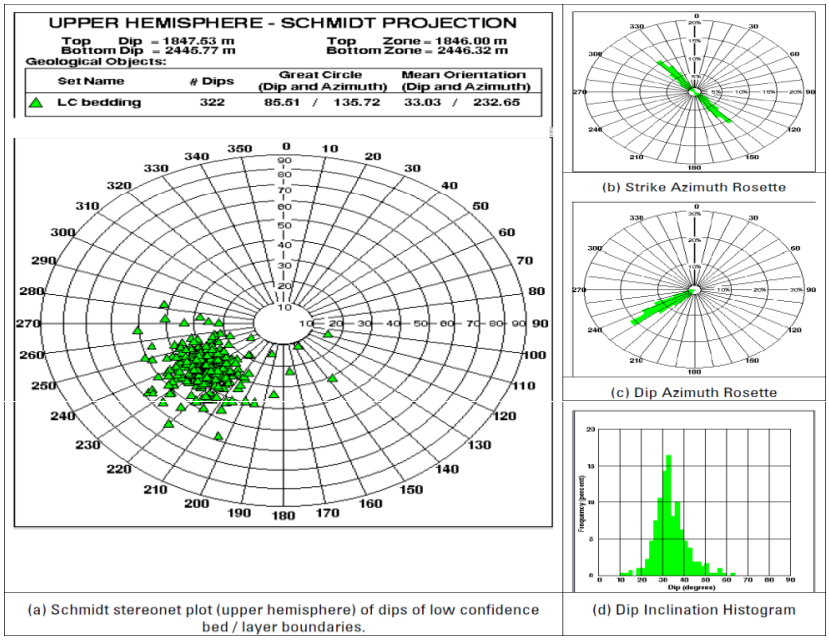

Figure 23: Statistical plots of dips of all low confidence bed / layer boundaries found in Asmari formation

3.7. 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 (Fig. 24-27).

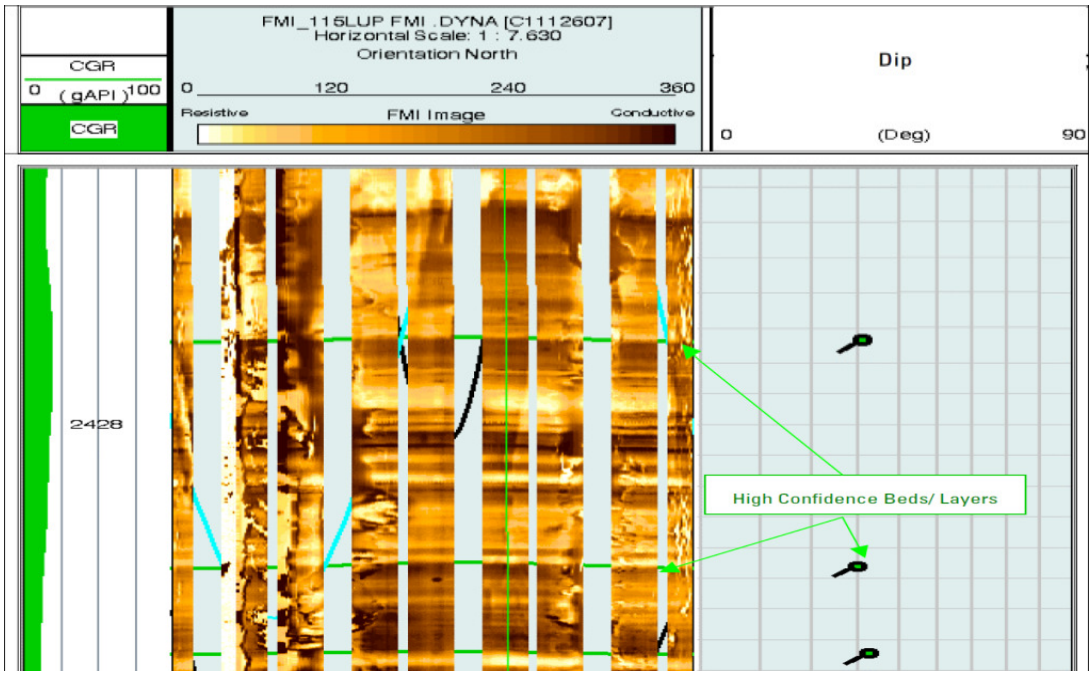

Figure 24: Rather sharp and planar bed boundaries in Pabdeh giving high confidence for dips bed/layer

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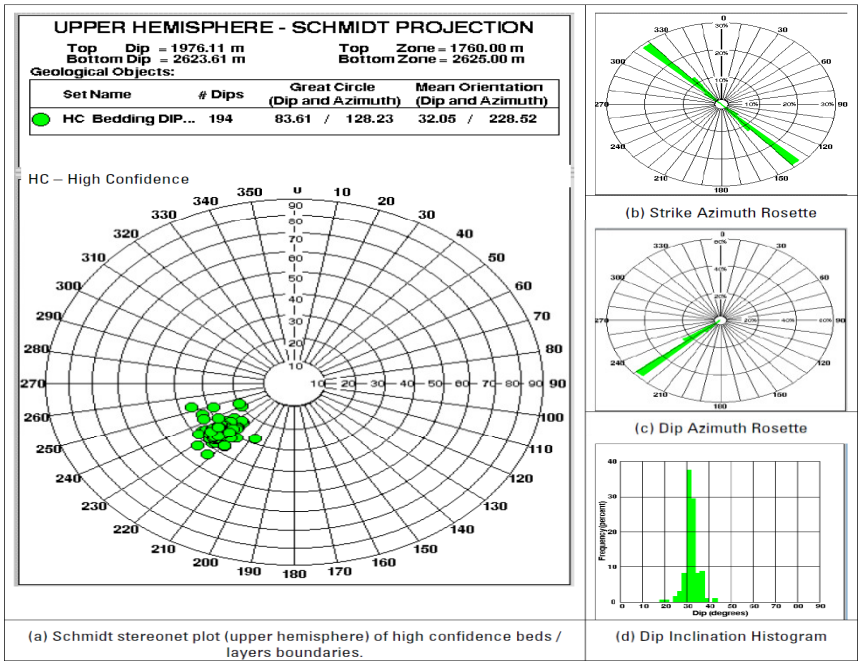

Figure 25: Statistical plots of dips of all high confidence beds / layers boundaries found in Gurpi, Pabdeh, and Asmari formations

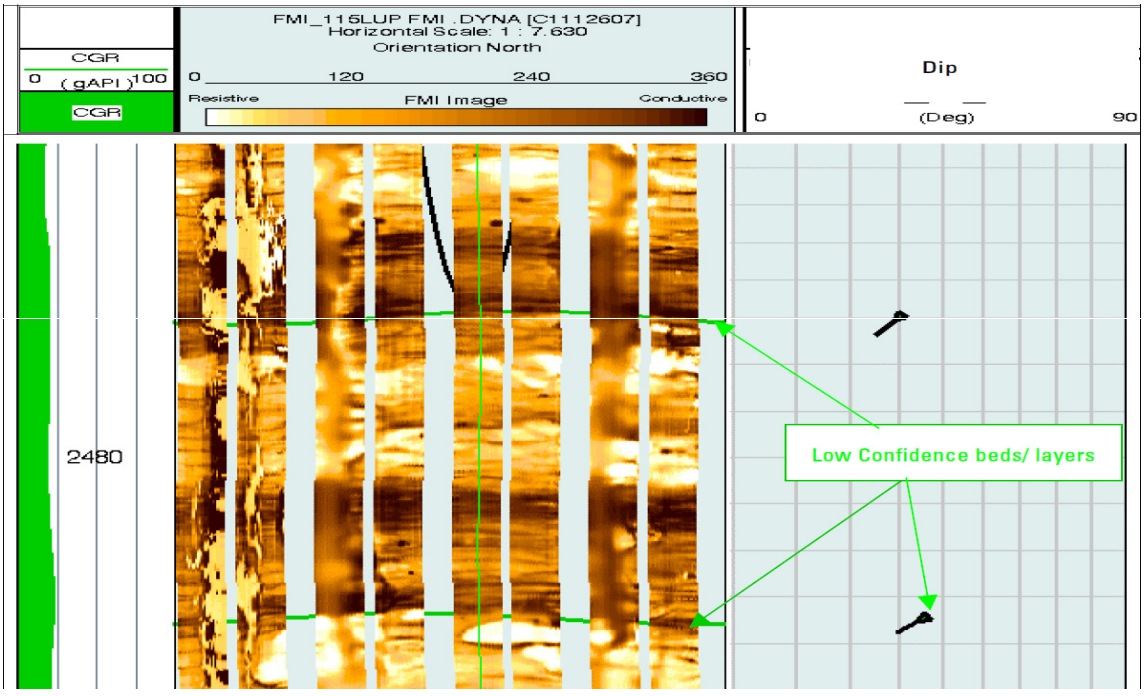

Figure 26: Less sharp and relatively uneven boundaries in Pabdeh giving low confidence dips for beds/layers

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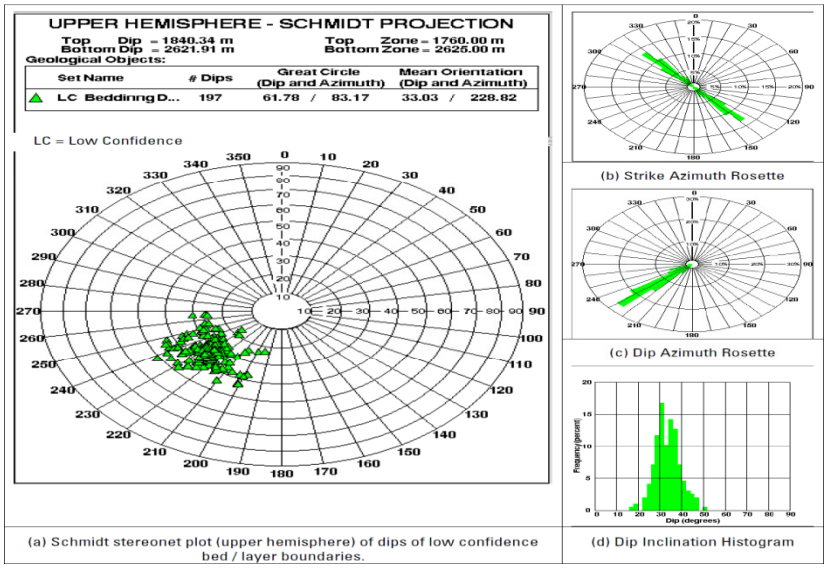

Figure 27: Statistical plots of dips of all low confidence beds / layers found in Gurpi, Pabdeh, and Asmari formations

3.8. 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 (Fig. 28-31).

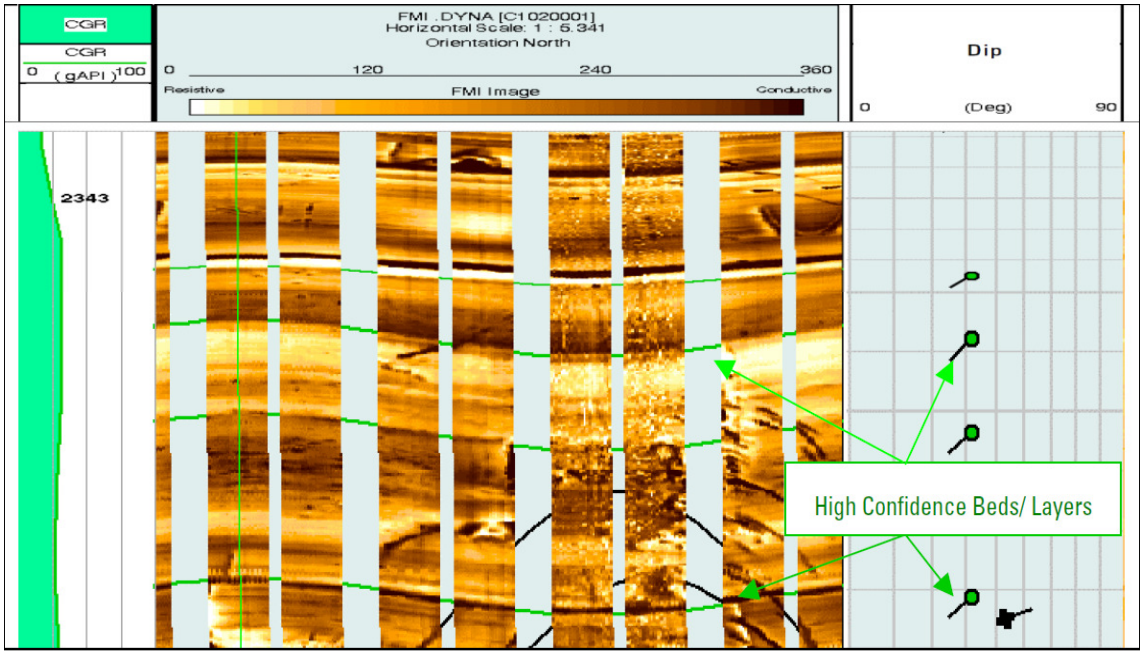

Figure 28: Image showing rather sharp and planar bed boundaries in Pabdeh giving high confidence bedding / layering dips

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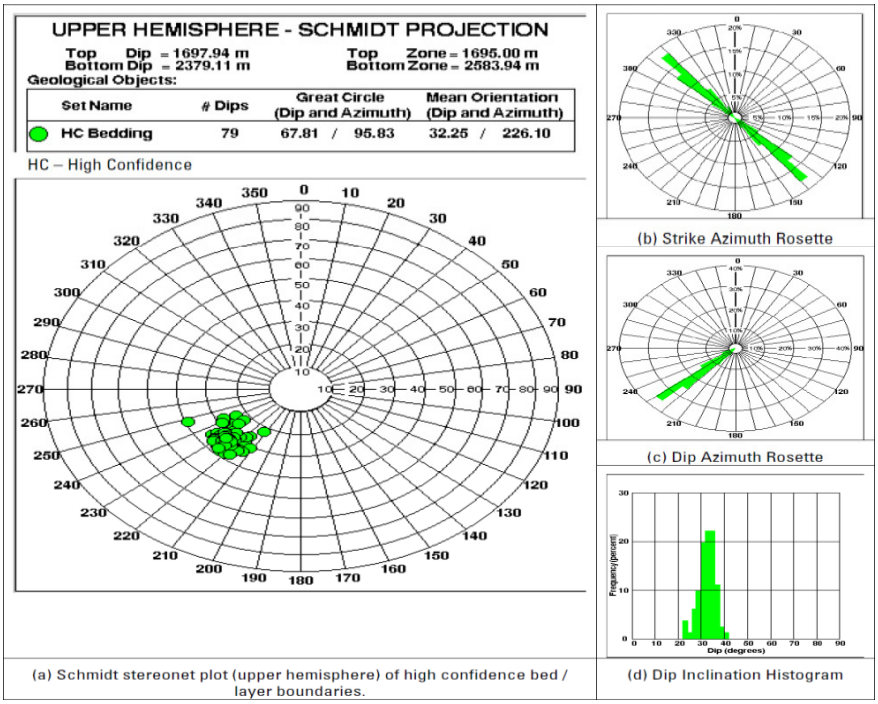

Figure 29: Statistical plots of dips of all high confidence beds / layers boundaries found in Asmari, Pabdeh, and Gurpi formations

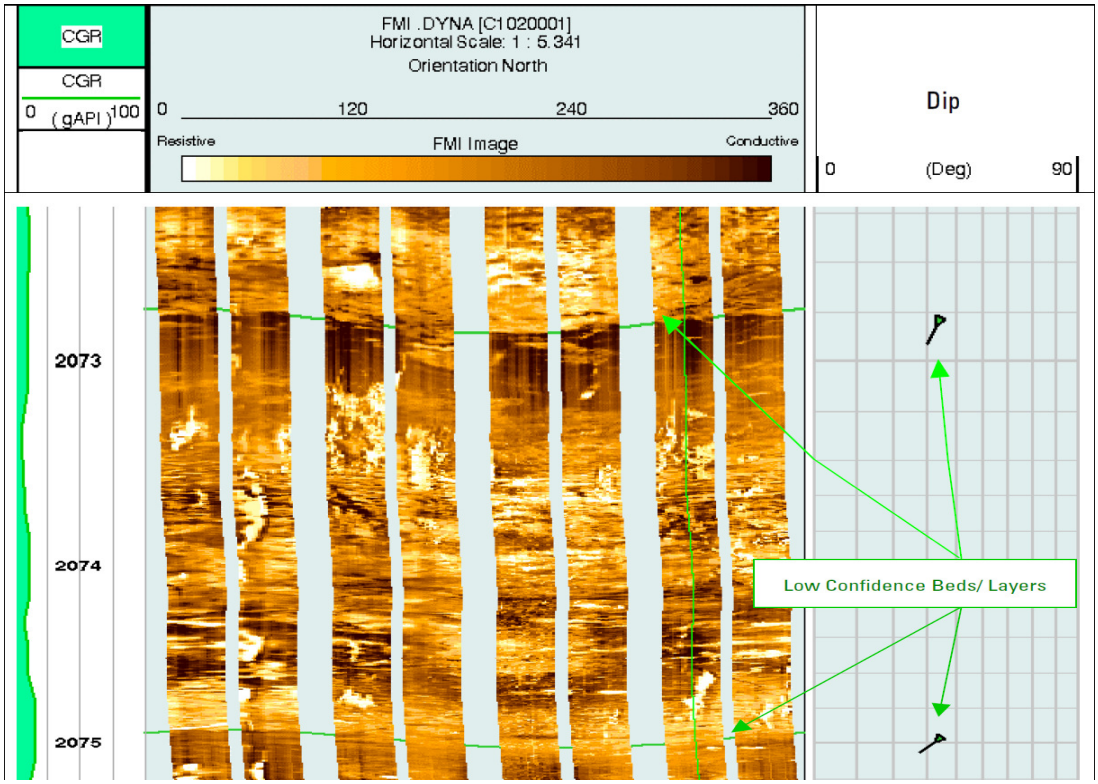

Figure 30: Less sharp and relatively uneven layer / bed boundaries in Asmari giving low confidence bedding / layering dips

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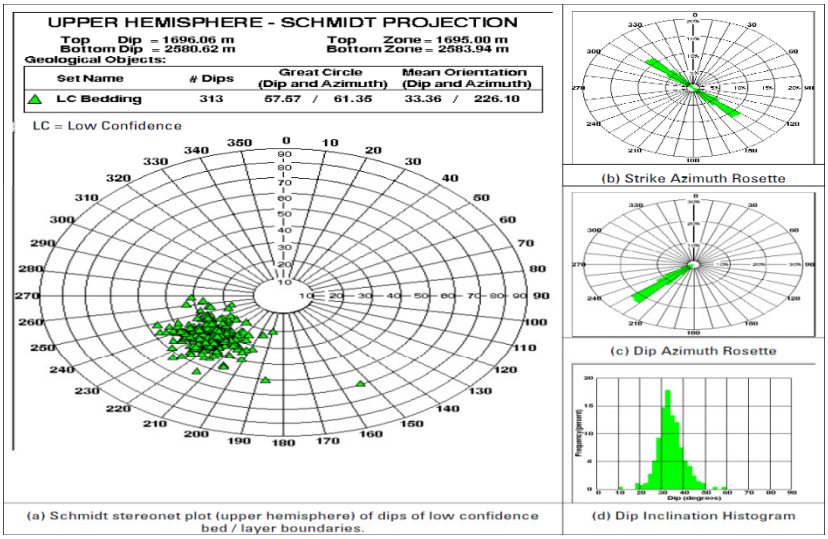

Figure 31: Statistical plots of dips of all low confidence bed / layer boundaries found in Asmari, Pabdeh, and Gurpi formations

3.9. Structural Analysis in the Well Number GS-I:

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 2649 m 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 (Fig. 32-35).

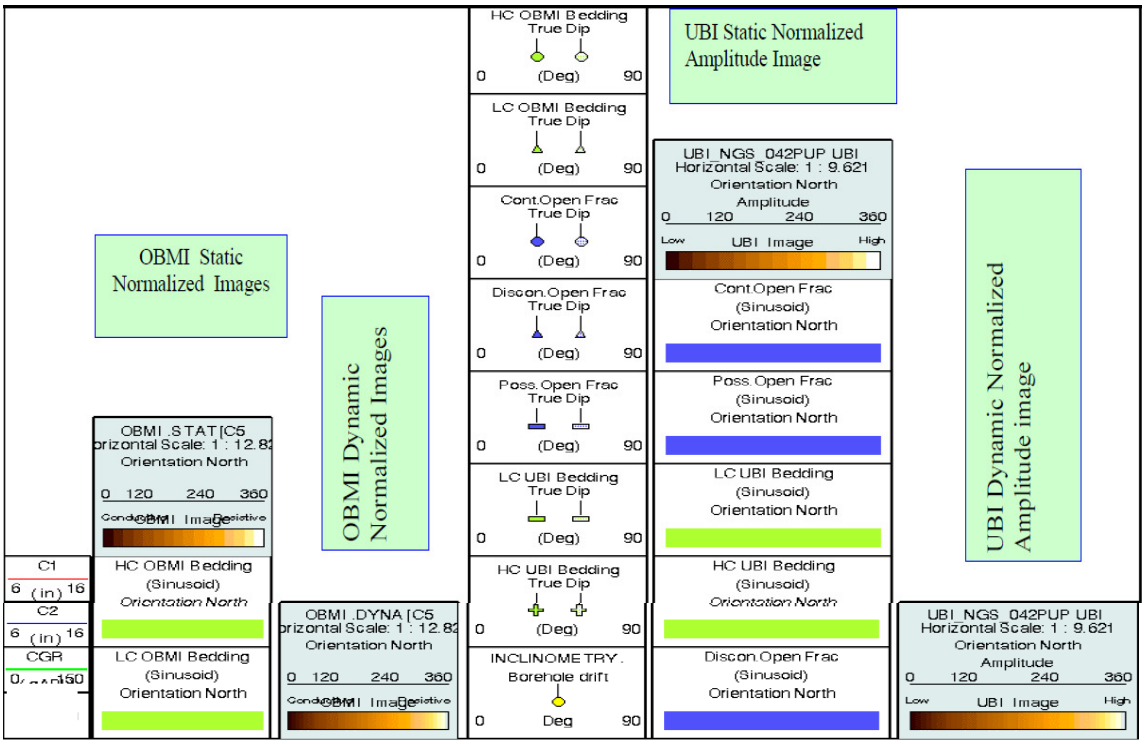

Figure 32: Header detail for Fig. 33-34

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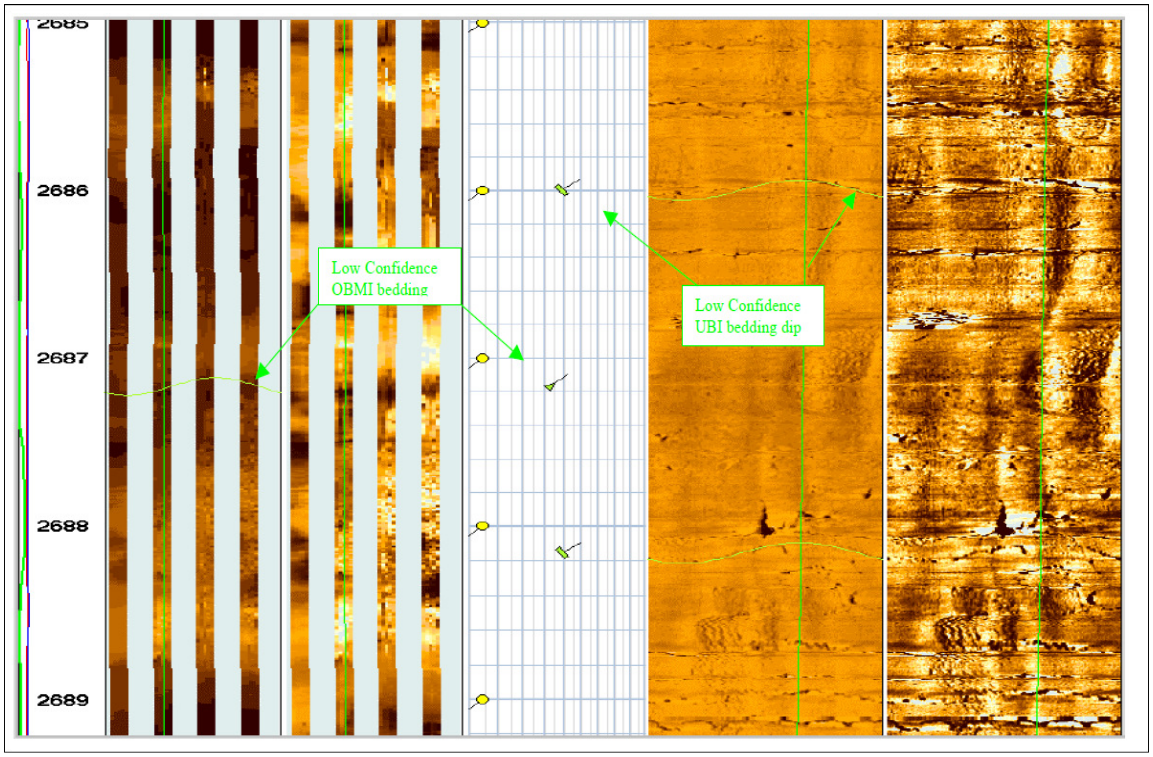

Figure 33: OBMI and UBI images showing layering within lower Asmari. The dips corresponding to layer / bed boundaries are shown as low confidence based on their sharpness and planarity for computation of structural dip. Header is given in Fig. 32

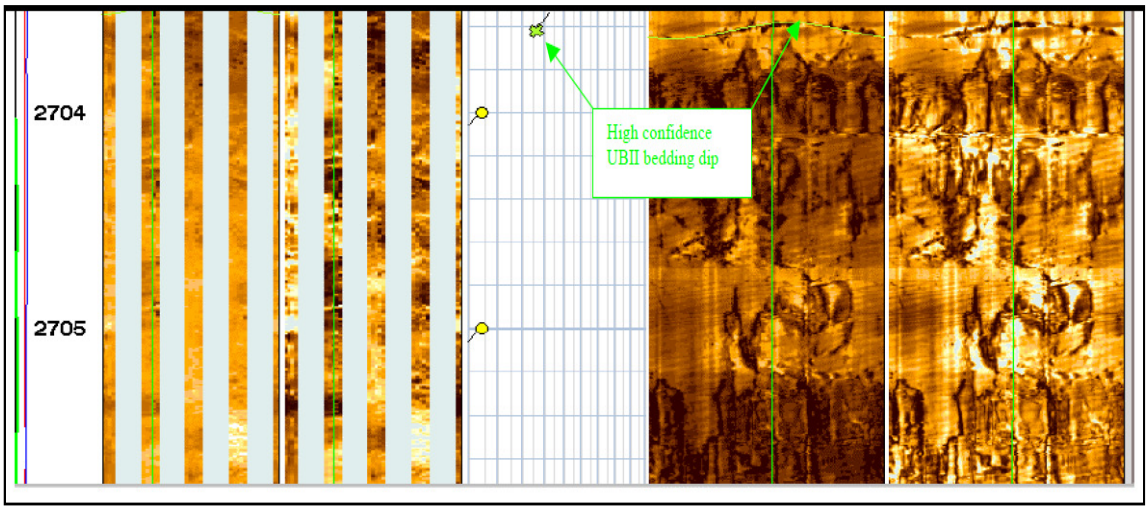

Figure 34: OBMI and UBI images showing a thin layer in the lower part of Asmari. Header is given in Fig. 32

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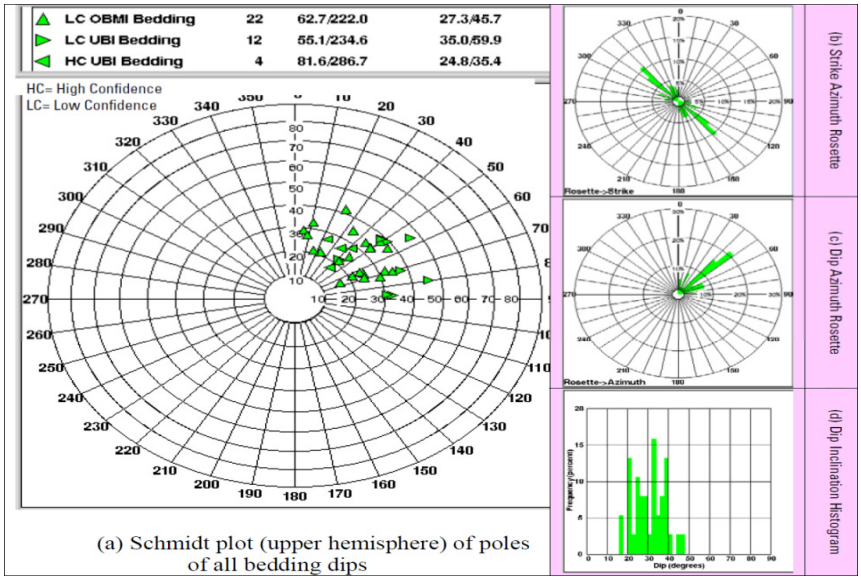

Figure 35: Statistical plots of bedding dips indicating a structural dip of 20-35 degrees N48E and strike N42W-S42E. Structural dip inclination of 25 degrees is the most representative of the whole interval

3.10. Structural Analysis for All the Studied Wells

Finally, the structural strike bedding direction for all the studied wells will be shown together in order to find out this direction for the field. This job showed that the dominant bedding strike direction of the Asmari reservoir in the section of Gachsaran field is NE-SW direction.

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, diapirisms and/or the other reasons that affect the bedding strike direction in these wells that further study is necessary to find out the exact reason.

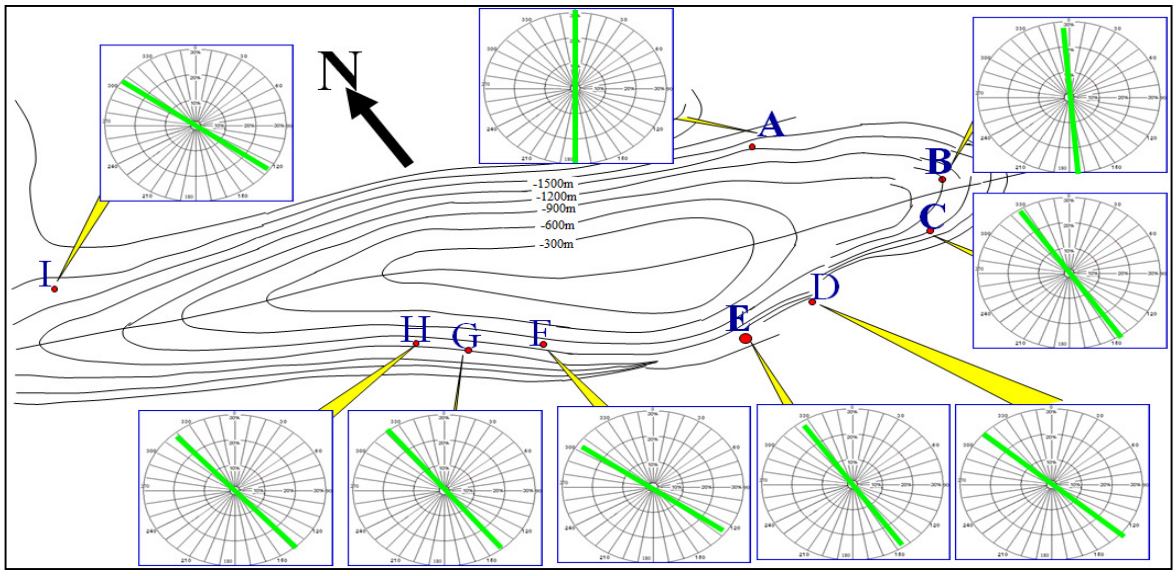

Figure 36: Bedding strike map of Asmari reservoir in Gachsaran field

5. 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 was done in Gachsaran field, located in South of Iran. In this paper, a method was explained to calculate the detailed information about the bedding in oil and gas reservoirs was. In this work, 9 wells, located in this field were studied; 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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