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Image Logs Application for Locating Faults in Oil and Gas Reservoirs

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Abstract–*Image log technology is an advanced technology that helps us in finding the location, dip, azimuth, strike and type of faults in any science related to geology. Finding out this information from image logs is not so easy, and many geologists are looking for an industrial source with real examples of log interpretation to have a better understanding of this technology. Therefore, in this study, a unique case study and a number of valuable log interpretation examples were used, and the process was explained completely. This job was done in Gachsaran field, one of the most important Iranian fields, and the main reservoir is Asmari reservoir, one of the most important Iranian oil and gas reservoirs. A unique educational paper is produced from this study, which can be useful for other geologists who are interested in fault interpretation and image log technology.*

Keywords: Faults, Image logs, Oil and gas reservoirs

1.0 INTRODUCTION

Gachsaran oil field is located in the southwest of Iran (Figure 1), with an anticline structure. The thick sequence consists of anhydrite/salt, 80 km long, 300-1500 m thickness, 8-18 km wide, which provides an excellent seal and overlying Asmari reservoir, Pabdeh reservoir, Gurpi reservoir and other reservoirs [1] (Figure 2).

Asmari, Pabdeh, Gurpi and other reservoirs that are covered by Gachsaran oil field are naturally fractured reservoirs and in some wells, there is evidence of existing faults. Finding out the location and details of faults is an important task that will assist in having a better understanding of the field, and this task can be done correctly by using image logs. Interpreting the faults from image logs is very difficult. The task needs a good knowledge of both geology and image log technology. Therefore, in this paper, we explained an approach that can be used to find out the fault details from image logs by using appropriate log interpretation examples.

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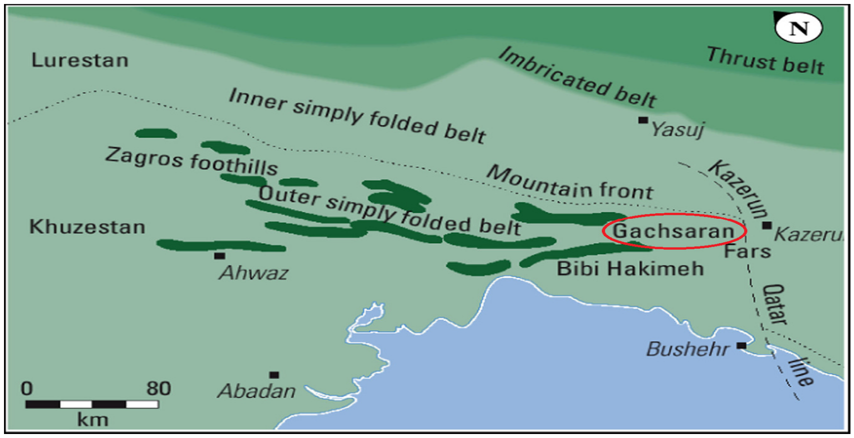

Figure 1: Location of Gachsaran oil field [2]

Seismic data and geological logs have been used to locate faults in the oil and gas industry, but the advanced technology that can provide us better understanding of the faults attributes is image log technology. Image log tools provide images from the borehole, in which interpreting these images will provide more detailed information of the faults [4, 5].

The best approach is to use image logs and also other geological logs in order to obtain the most reliable data. Hence, in this work, the Formation Micro Imager (FMI) tool was used in parallel with the Corrected Gamma Ray (CGR) tool.

2.0 METHODS

Borehole imaging delivers micro resistivity and acoustic images of the formation in both water-based and nonconductive mud. Borehole imaging is the preferred approach for determining net pay in the laminated sediments of fluvial and turbidite depositional environments.

The FMI has a four-arm eight-pad array (i.e., four pads and four flaps as shown in Figure 3). Each pad and flap contain 24 buttons, which makes a total of 192 buttons for all four pads and four flaps. The tool includes a general purpose inclinometer cartridge, which provides accelerometer and magnetometer data. The triaxial accelerometer gives speed determination and allows re-computation of the exact position of the tool. The magnetometers determine tool orientation. During logging, each microelectrode emits a passive, focused current into the formation. The current intensity measurements, which reflect micro resistivity variations, are converted to variable-intensity gray or color images. The observation and analysis of the images provide information related to changes in rock composition, texture, structure or fluid content.

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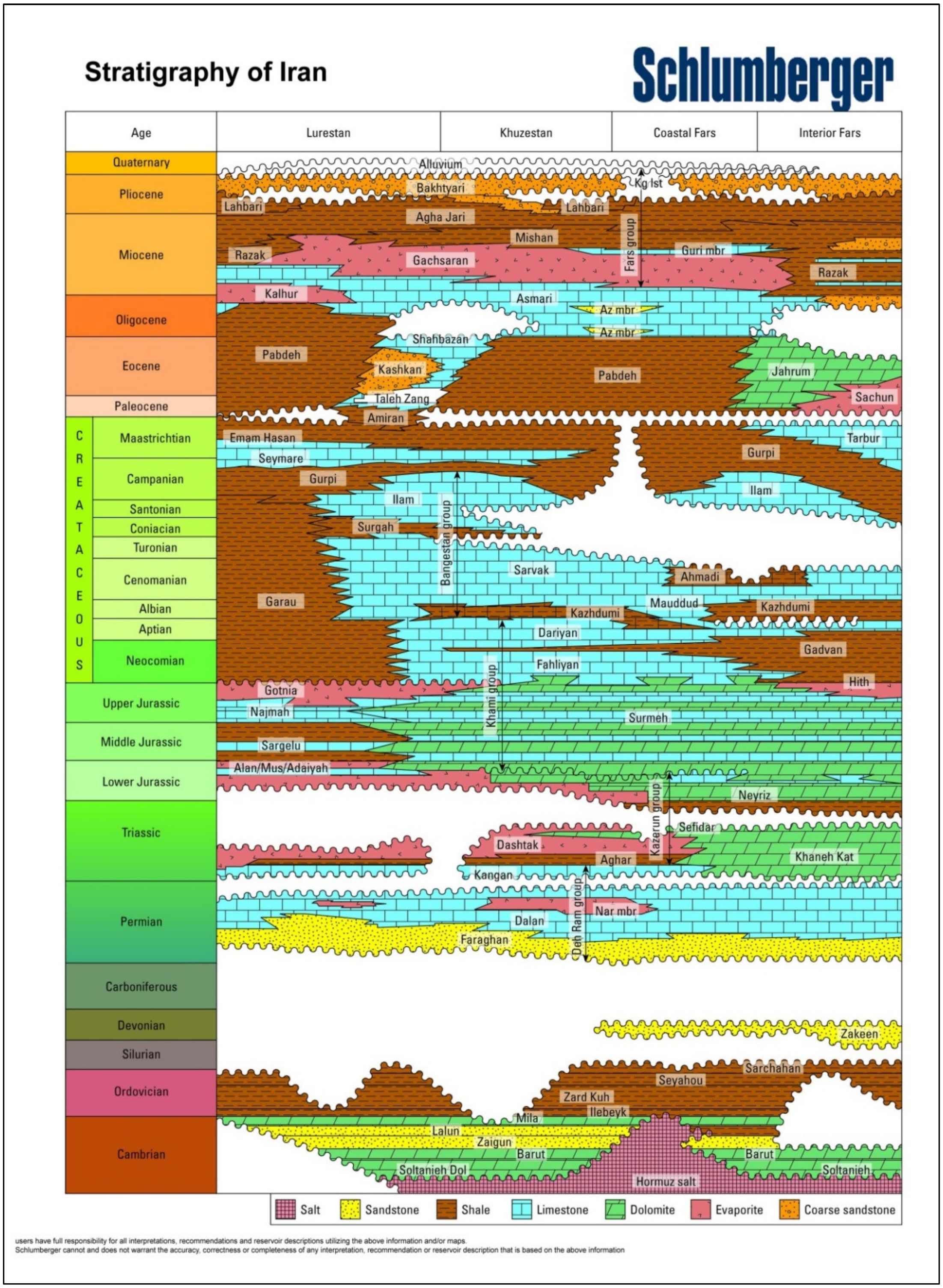

Figure 2: The location of Gachsaran oil field overlying the Asmari, Pabdeh, Gurpi and other reservoirs, and stratigraphic nomenclature of rock units and age relationships in the Zagros basin [3]

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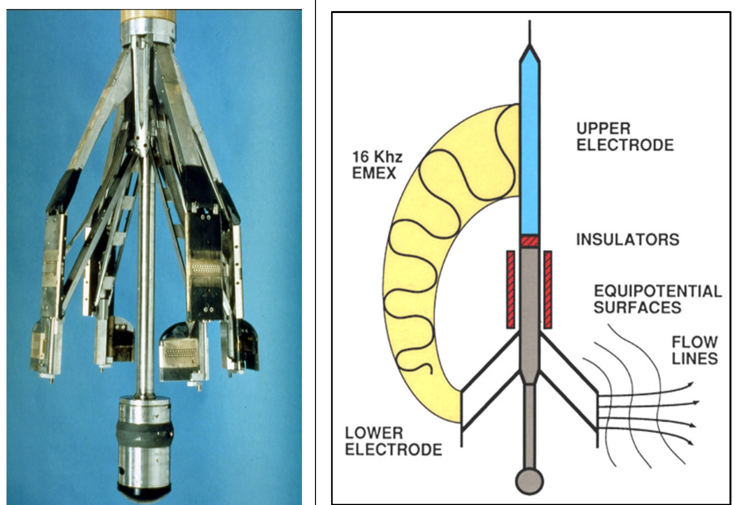

(a) (b)

Figure 3: (a) Picture of an FMI tool and (b) explanation of the principle of measurement. EMEX current flows into the formation from the FBCC (upper electrodes) housing to the pad section (which is the FMI sonde section carrying 192 imaging microelectrodes), known as lower electrode.

The factors taken into account for locating faults on the FMI images are as follows [6, 7]:

- Grade 1: Sudden change of the dip trend.
- Grade 2: Abrupt change of borehole drift.
- Grade 3: High angle resistive or conductive events developed across the wellbore.
- Grade 4: Enlarged hole at the fault/ borehole intersection.
- Grade 5: Shift in the trend of in-situ stress.
- Grade 6: Abrupt termination of layers on the fault plane.
- Grade 7: Changing thickness of the fault bounded layer across the wellbore.
- Grade 8: Occurrence of fractures.
- Grade 9: Sudden change at the other geological log responses.
- Grade 10: Sudden change of the formation's pressure (sealed fault).

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3.0 RESULTS & DISCUSSION

3.1 Fault Evidence

Based on the fault identification criteria, three faults were identified in the well. The observations based on each fault that was identified are given in Table 1:

Table 1: Faults explanation attributes

Fault Number	Depth (m)	Dip of the Contact Between Different Facies / Lithologies / Zones	Nature of the Plane (conductive / Resistive)	Change in Logs	Drag Present	Fracture Association	Change in Borehole Azimuth	Change in Borehole Drift
Fault-1	2188.7	63 deg.-SW	Conductive	Abrupt change in Resistivity logs & pressure points	No	Yes	Not clear	Not clear
Fault-2	2251.6	65 deg. - NE	Resistive	No	No	Not clear	Not clear	Not clear
Fault-3	2233.4	62 deg. - NNE	Resistive	No	No	Not clear	Not clear	Not clear

Each fault is discussed in more detail below:

(a) Fault 1 (possible)

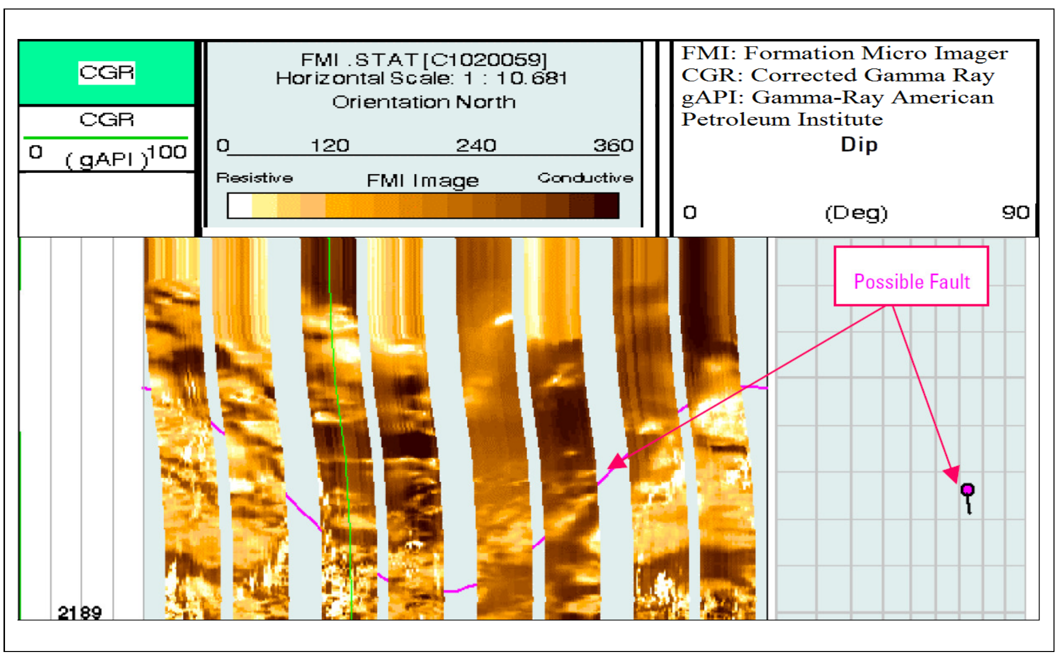

Figure 4: Close-up view of the possible fault

The reason that this fault is interpreted as possible fault is because of a high angle contact between porous and dense layers around 2188.7 m, and the dip of the faulted contact is very

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different from the SW dipping beds/ layers of average inclination of 30-40 degrees. It dips at 63 degrees to the South with E-W strike, and there is an abrupt change in resistivity log response across the faulted contact.

(b) Faults 2 & 3 (Minor)

The reason that these faults are interpreted as minor faults is that the dips of the faults are very different from the SW dipping beds / layers of average inclination of 26-33 degrees, and they dipped at 62 degrees to the North East and NW-SE strike. The other reason is that the layers adjacent to the fault plane seem to be displaced by a few centimeters (because after the displacement, they can be found within the same borehole).

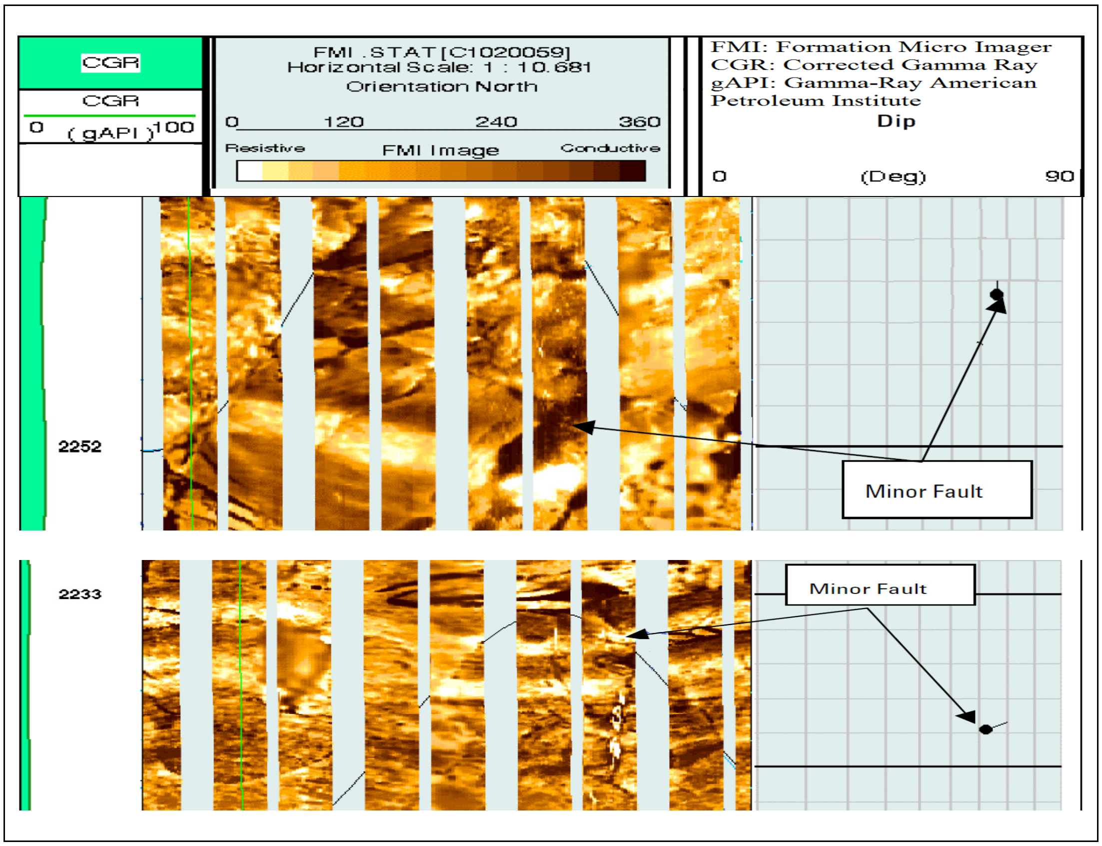

Figure 5: Close-up view of the two minor faults

3.2 Fault Attributes

Table 2: Faults attributes

Fault	Depth (m)	Dip	Dip Azimuth	Strike	Approx. Throw	Apparent Type	Sealing / Non-Sealing	Explanation
Fault-1	2188.7	63 deg.	S7E	E-W	<1m	Not clear	Not clear	There is an abrupt change in resistivity log response and MDT points across the faulted contact
Fault-2	2251.6	65	N1E	E-W	<0.5m	Not clear	Not clear	
Fault-3	2233.4	62	N64E	N26W-S26E	<0.5m	Not clear	Not clear	

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Table 2 gives the detailed information of the faults attributes. The final step of the fault interpretation is drawing the fault attributes using Schmidt projection (Figure 6). Three faults were found in this well. Figure 7 shows the dip inclination degree, dip azimuth, strike azimuth and dip inclination histogram of the previously discussed faults.

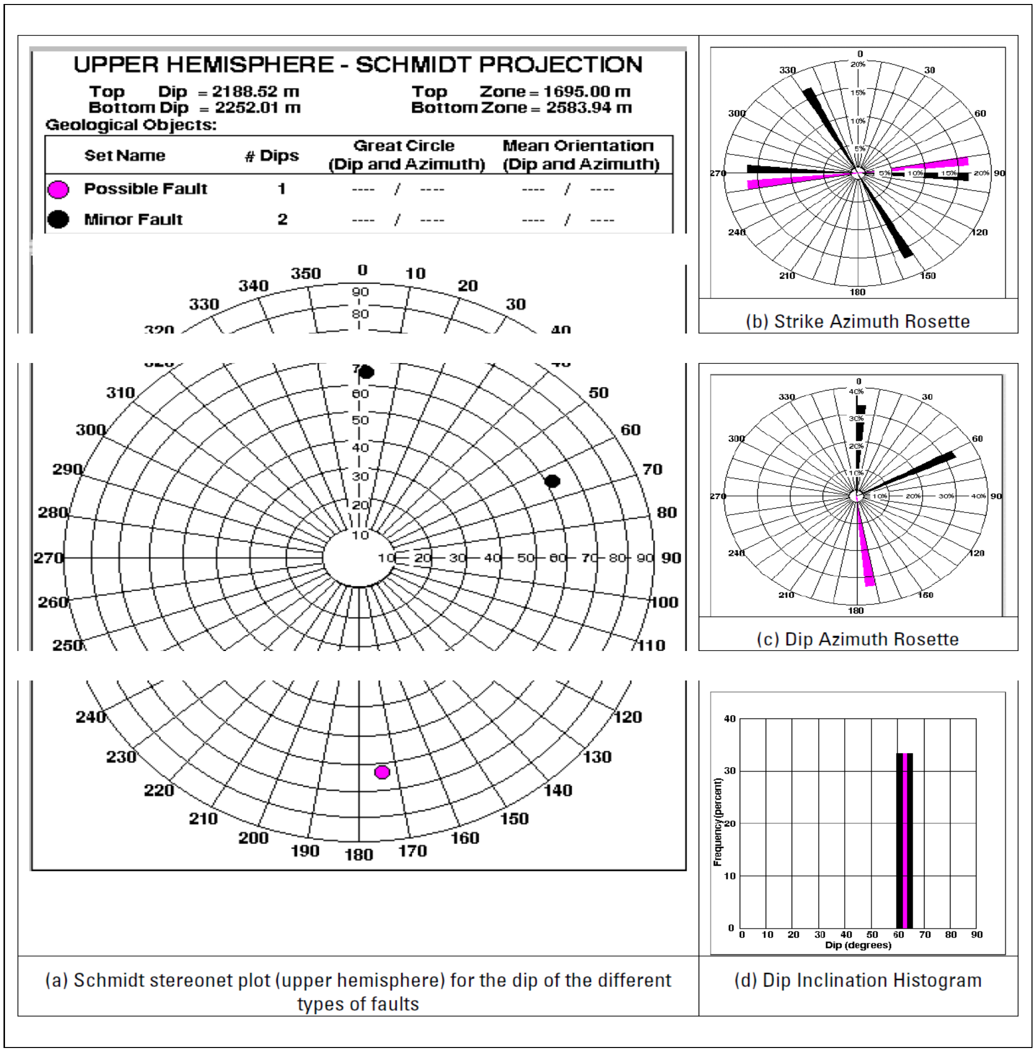

Figure 6: Statistical plots for the attributes of the possible fault and minor faults in Asmari and Pabdeh formations

4.0 CONCLUSIONS

In this paper, by using both image logs and geological logs, detailed information about one possible fault and two minor faults was given. The benefit of this new method compared with previous methods is that in conventional fault interpretation methods, only geological logs are used. However, in this work, both image logs and geological logs are used, which gives more detailed information about the faults. This work is an example that shows the benefit of using both image logs and geological logs in order to find more detailed information about faults in oil and gas reservoirs.

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