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Determination of Horizontal Stress Orientations from Borehole Breakouts in Zubair Oilfield, Southern Iraq

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Abstract: *Breakouts are dependable indicators of the orientations of current minimum and maximum horizontal stresses and can be used to constrain stress magnitudes. The orientation of the regional stress field in the Zubair oilfield was determined from borehole breakouts caused by stress accumulation at the borehole wall. The analysis is based on oriented caliper log data recorded in ten wells within Zubair oilfield. The azimuths of the breakouts are consistent with depth and indicate a stress direction (Maximum horizontal stress direction is about about 40^o to 60^o from the North) which is in good agreement with the regional maximum horizontal stress (S_{hmax}) direction due to Arabian plate subduction with Eurasian plate in the same direction.*

1. INTRODUCTION

The orientation of minimum horizontal stress (S_{hmin}) is an essential element to understand the present stress field and essential aspect in wellbore failure analysis. Borehole breakouts and enlargement are one of the crucial issues during drilling, it can reduce the drill bit life, stuck pipe, logging problems, bad cementing and often the need to sidetrack (Last, 2001). Failure of the borehole walls creates intervals with noncircular cross sections, which has long axes at the same orientation. When reliable in-situ stress measurements are available, the mean breakout axes can be shown to be parallel to S_{hmin} and therefore perpendicular to S_{Hmax}. Therefore, breakouts are used to indicate the orientations of the principal horizontal stresses affecting the borehole.

2. STUDY AREA

Zubair is a supergiant oilfield discovered in 1949, it is located 20Km to the west of Basrah city in southern Iraq, and encompasses an area of 900 Km^2. It forms an 60Km north-south anticline, The field is close to the border of Kuwait in the northeastern part of the Arabian Peninsula as presented in figure (1); it is made up of four domes (Safwan, Rafidiyah, Shuaiba and Hammar).

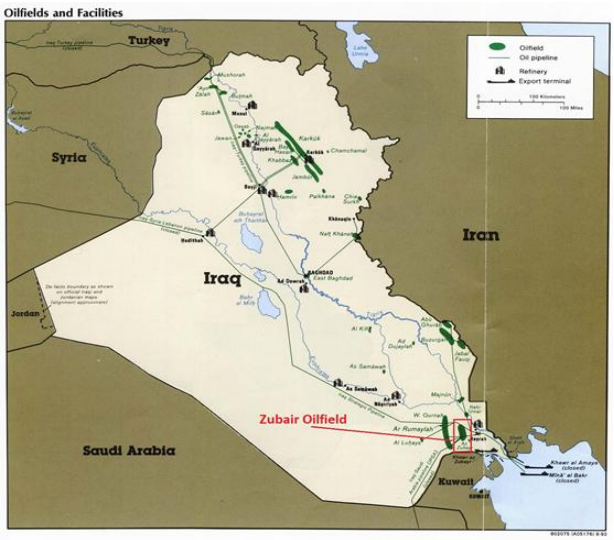

Figure1. *Study area*

3. STRESS ORIENTATION

Measurements of stress orientation depend largely on the axes of S_{hmin} and S_{Hmax} as the vertical stress (S_V) is supposed to be in vertical direction. Principal stress orientation can be defined from wellbore failures analysis for example induced tensile fractures by drilling and borehole breakouts. Reliable in situ stress results showed that the common axes of breakouts is mostly analogous to S_{hmin} direction. Therefore, vertical on S_{Hmax} direction. Breakout in wellbores is related to a natural failure compressive process that happens when the maximum hoop stress around the hole is larger than the rock strength. The azimuth of S_{Hmax} is perpendicular to wellbore breakouts in vertical wells, and parallel to the drilling-induced tensile failures (Zoback, 2007).

4. RELATIONSHIP BETWEEN MINIMUM HORIZONTAL STRESS AND BREAKOUTS

Bell and Gough (1979) were the firsts to relate breakouts to stress. The wellbore breakouts are elliptical in cross section and are aligned in the direction of least horizontal compressive stress (S_{hmin}) (Blumling *et al*., 1983). The breakouts in wellbore occur when the compressive stress concentration around the borehole wall surpasses the formation rock strength (Barton *et al*., 1995).

The breakouts of wellbore are commonly produced by stress concentrations around wellbore; the concentration results from drilling a well into an already stressed mass of rock (Moos and Zoback, 1990). The oriented caliper log (the four arms or the six arms) has been commonly used to indicate the direction of horizontal stress obtained from orientation of the breakouts, that tool gives 2 or 3 measurements for the cross section of borehole along with their orientations (Fjaer, *et al*., 2008). According to Zoback *et al*., (1985), breakout orientation is created along the direction of the minimum horizontal stress. Figure (2) shows an example from one of Zubair oilfields wells where 6 arm caliper was run through Zubair Formation, caliper arms No. 1, 4 gave the highest reading indicating a breakout in 330^o direction (NW-SE)

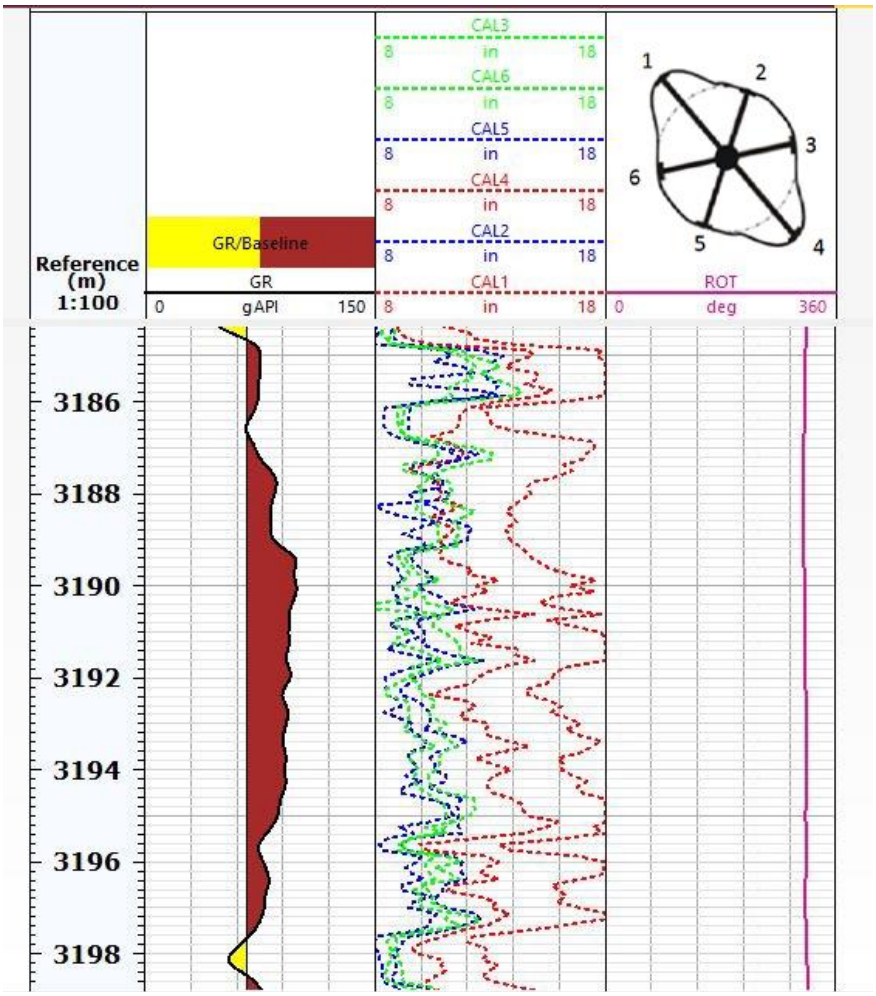

Figure2. *Six-arm caliper log in one of Zubair oilfield wells illustrates breakouts in Zubair Formation,*

Figure (3) shows the breakouts orientation obtained from oriented caliper log in ten wells (from well no. 1 to 10) in Zubair oilfield, the results revealed that the breakouts orientation is between 140°-150° (SE) and 320°-330° (NW) which represent the minimum horizontal stress orientation. Therefore, the S_{Hmax} orientation will be about 50°-60° (NE) and 230°-240 (SW) as it is perpendicular to minimum horizontal stress.

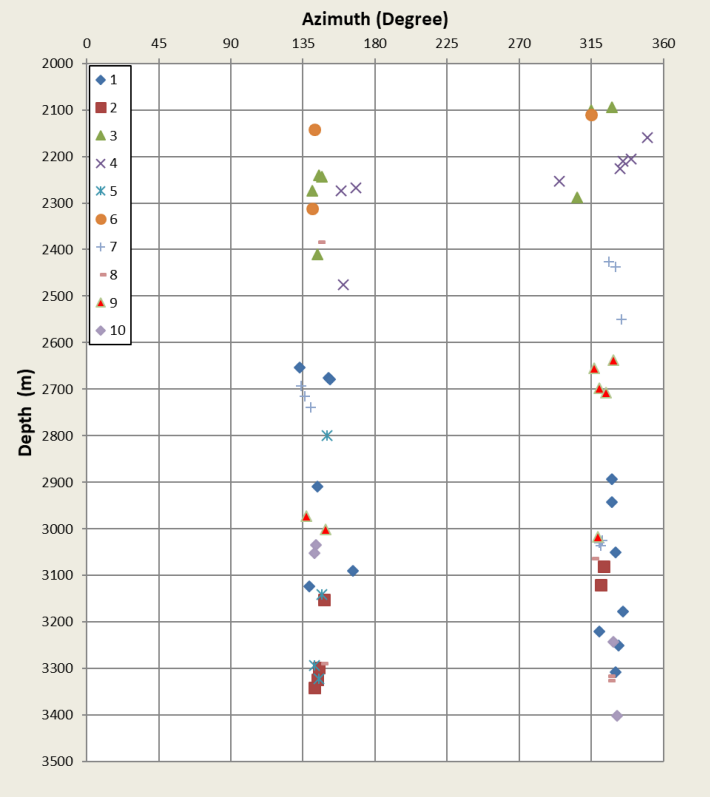

Figure3. *Orientation of the breakouts obtained from ten wells in Zubair oilfield.*

5. MAXIMUM HORIZONTAL STRESS ORIENTATION

The predicted orienation of S_{hmin} extracted from breakouts which is NW-SE gave an indication that the direction of S_{Hmax} is NE-SW in Zubair oilfield (about 40° to 60° from the North). This stress trend had an analogous agreement with the regional maximum horizontal stress direction as demonstrated in figure (4). The present-day regional stress direction is driven from variable kinds of physical data, for example well bore breakouts, earthquake focal mechanisms and fault-slip analysis (Carafa *et al.*, 2015)

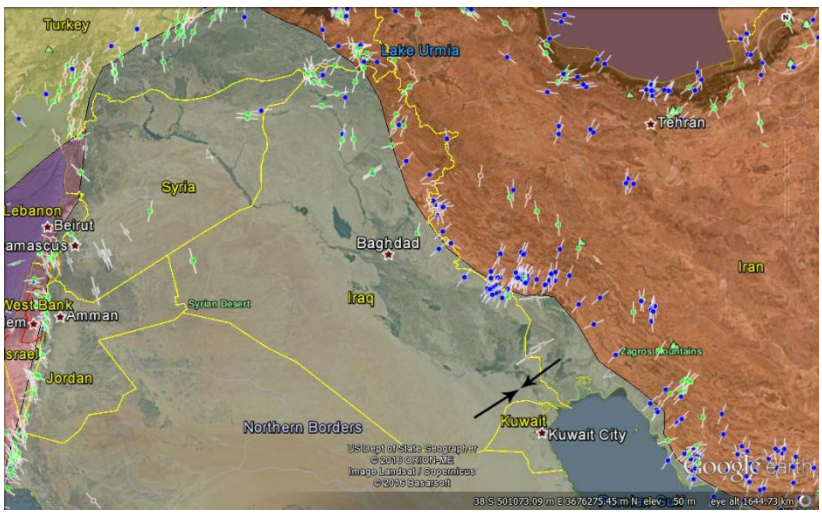

Figure4. *The maximum horizontal stress directions (NE-SW) of Zubair oilfield with respect to the regional stress directions (modified from WSM, 2016).*

6. CONCLUSION

From multi arm caliper log obtained in Zubair oilfield, an identification of pattern of borehole breakouts was recognized. The minimu horizontal stress orientation was determined as 140^{o}-150^{o} (SE) and 320^{o}-330^{o} (NW) leading to conclude that the maximum horizontal stress is about 50^{o}-60^{o} (NE) and 230^{o}-240 (SW).

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