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Study porous pressure and cracking pressure in well NS 13, Southern Iraq

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***Abstract*— In this study we examined the behavior porous pressure and cracking pressure in well NS 13 as it is the only well which the two cavity logs, second and third are available.**

We used interactive petrophysics 3-5 program prepared by Schlumberger company, for calculate pore pressure and cracking pressure by feeding the program with the sonic log readings which are IAS file format, and also the pressure was calculated using the drilling operations for the purpose of comparing and discussing the results to arrive at the best solution to avoid problems that occurred during drilling the previous wells from the loss of drilling fluids, and reservoir flow, and bad cement production lining , and give suggestions, which contribute to solving the problem.

I. INTRODUCTION

The pre knowledge of graduation pore pressure and cracking pressure play a major role in the correct choice for laying the liner that allows a successful section for be drilled without cracking Formation.

Pore pressure, mud weight and cracking pressure gradient are used together to choose mooring of liner. In the event that the pressure was not evaluated correctly, it leads to numerous drilling problems such as, the loss of the drilling fluid cycle, well outbreak, Pipe line jamming well cavity instability and financial costs (2).

Porous pressure can be predicated through several methods including the use of open well logs readying, or seismic survey information or through drilling available that are recorded during the drilling of well and can obtain well information that can be used as a realistic value for calibrate the account as well as obtaining a real value of the cracking pressure by performing certain checks during drilling such as leak test, which is implemented to know maximum mud density can be used in drilling the next cavity without cracking occurring in the lining shoe that has the examination in this study, well logs are used for predict porosity pressure and the results well be compared to the drilling changes of reach the best results

The importance of knowing formation pressure gradient in term.

1. Choosing the point of liner seated and the mud density during the drilling process
2. To avoid kicks or outbreaks and mud leaking or loss of drilling fluids cycle, and stubborn drilling pipes as a results of differential pressure or of the cave wall of the well.
3. To reduce of drilling time.
4. To change the depth of lining during drilling if a necessary to reduce drilling problems and reach the specified depth. The value of pore pressure or formation pressure gradient ranges between 0.433 - 0.465 psi / ft for normal [9].

For over pressure gradient > 0.433 - 0.465 psi/ft.
For under pressure gradient < 0.433 - 0.465 psi/ft.

II. STUDY AREA

Nasiriyah oil field is located to the east of the Euphrates river about 38 km northwest of Nasiriyah city as shown in Figure (1). The dimensions of the field are 34 km long and 13 km wide. The structure is a longitudinal anticline with the northwest-southeast axis direction. The flanks' dip is a gentle slope toward the northeast and southwestern about (1°-2°). The field is located in the south of Iraq between latitudes (34° 80' -34° 60') N and longitudes (57° 50' -60° 10') E.

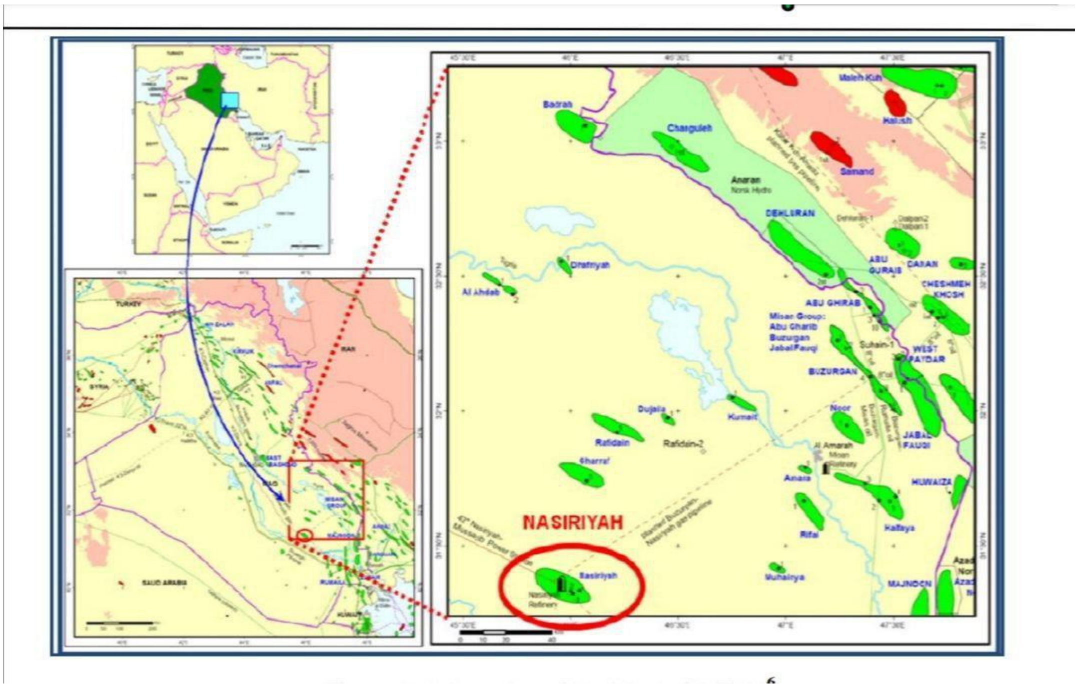

Fig.(1): represents the location of study area

III. ANALYSIS METHOD

In this study the following methods of analysis were adopted:

A. Log electrical.

Sonic log: the principle of the method is that the compaction of the shale increase with the deep increase, therefore the wave transmission time through the shale decrease and this analysis is done after drilling operations figure (2).

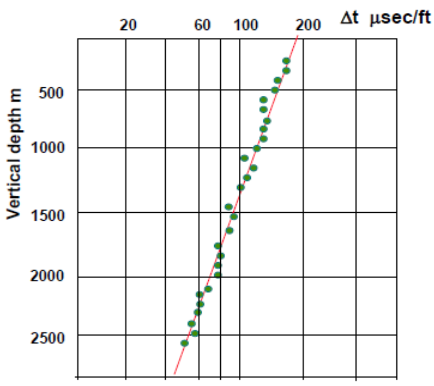

Fig.(2): represents Δt versus vertical depth

B. Drilling parameters.

(dc Exponent) Drill ability index

It is one of the experimental methods to control pressure while digging (1).

This system is designed by shrilly (10) , this method indicates the ability to drill shale formation and depends on the rate of penetration (ROP) . The ROP decreases from the surface downward with increasing depth due the high compression of the sediment. The ROP is affected by the density of the clay pits so we well divide the calculated value into mud density.

C. The method of work

Pore and cracking pressure were calculated in two ways as follows:

The first ways are using the IP program and the working method is summarized as follows:

1- The average density of formations with depth though the sonic log using the AGIP Bellotic method (3) of compression formations and using the following equation (6):

Rho = 3.28-Dt / 89………. (1)

Dt: travel time through

The sonic log

Rho: Density of Rock in Ib/gal

: overburden gradient was calculated as the following equation (2)

OBGrad=Rho×0.433……… (2)

Where:

OBGrad: overburden pressure in psi/ft.

Rho: Density of Rock in Ib/gal

0.433: Normal Pressure Gradient in psi/ft- sonic log reading used to determination the porosity with depth and determine the wave transmission time during rock Formation.

3- Sonic log reading used to determine the porosity with depth and determine the wave transmission time during rock formation.

4- Define the shale area to infer the natural direction of the shale porosity with depth as a result of compression

5- The Eaton (8) method used for calculate the pore pressure gradient by the sonic log reading for the second and third cavity for (NS, 13) well as shown in figure (3):

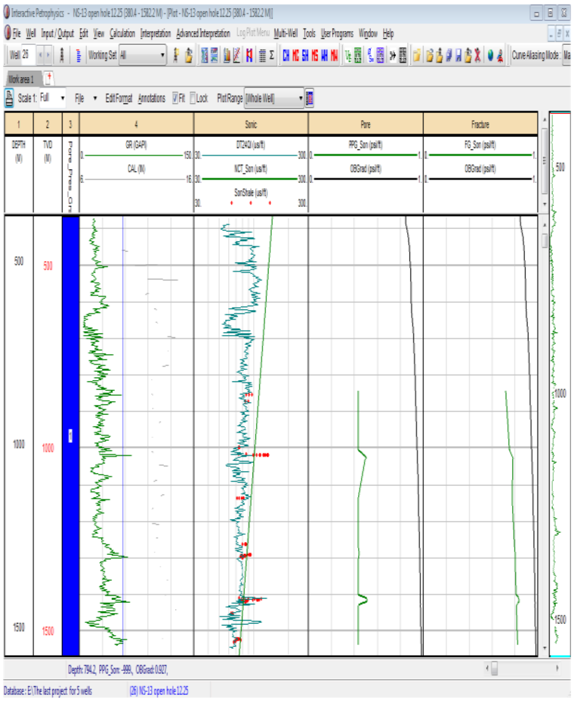

Fig.(3):Pore pressure and cracking pressure by sonic log

Sonic log is certified to provide close quantitative evaluations of pore pressure because they are unaffected by the size of cavity, the temperature of formation, or the porous water salinity. The ratio between the normal reading of sonic log in compacted shale and the calculated value in the measured depth is used for calculate the gradient pore pressure, as shown in the equation below (6).

$$G_{PP} = G_{ob} - (G_{ob} - GN) \times \left[\frac{\Delta t\ Normal}{\Delta t\ OBSERVED}\right]^{a} \quad \text{......... (3)}$$

GPP: pore pressure gradient of a given depth(psi/ft.)
Gob: overburden pressure gradient of a given depth(psi/ft.)
GN: normal pore pressure gradient (0.433 psi/ft.)
Δt n: normal shale travel time (micro-seconds/ft.)
Δt O: observed shale travel time (micro-seconds/ft.)
a: exponent coefficient, its normally 3

6- the Eaton method (6), used to calculate the cracking pressure gradient as shown in the equation below:

$$FG = \frac{\upsilon}{1-\upsilon}(Gob - Gpp) + Gpp \quad \text{.......... (4)}$$

(FG = formation fracture gradient (psi/ft.
Gob = overburden pressure gradient (psi/ft.)
Gpp = pore pressure gradient (psi/ft.)

To calculate poisons ration for depth (0 - 4999) ft as in the equation below

$$\upsilon = 0.2007142857 - [7.5 \times 10^{-9} \times (Depth)^2] + [8.0214286 \times 10^{-5} \times (Depth)] \ldots \text{ (5)}$$

Cracking pressure and pore pressure measurements are used from leak of test depth to calculate poisons ratio.

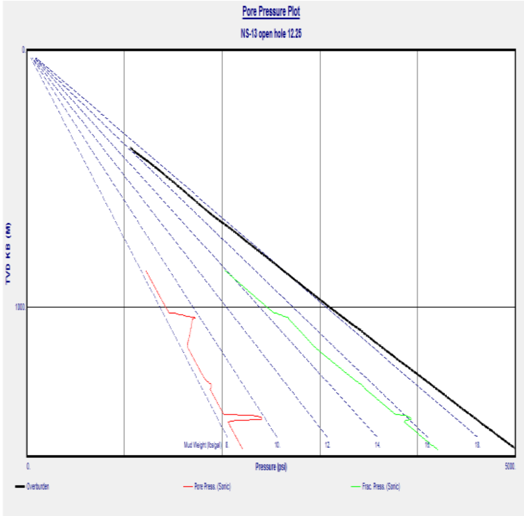

Fig. (4): Chart for pore pressure and cracking pressure versus depth

Cracking pressure and pore pressure versus depth which shown that the pore pressure of formation is normal as shown in Fig 3,4

7- the result from IP program drawn by excess as shown in figure(5) :

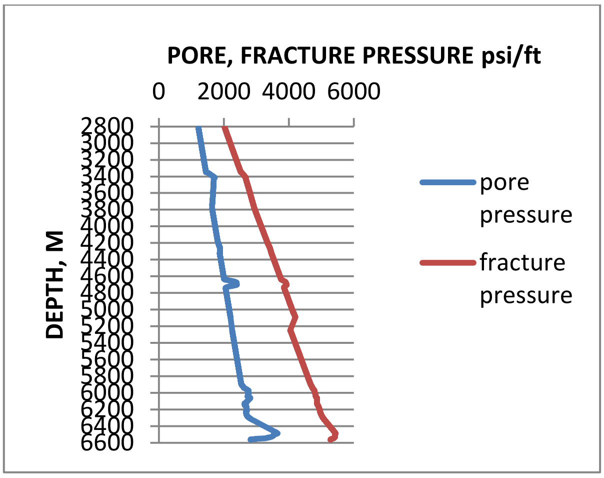

Fig. (5): pore pressure and cracking pressure versus depth (first way calculating)

The second way. (drilling parameter)

1- Jordan and Shirley (10) modified Bingham's equation (4)(dc Drillability index) as indicated in the following equation:

$$dExp = \frac{\log \frac{R}{60N}}{\log \frac{12W}{10^6 B}} \quad \text{....... (6)}$$

Where:
d Exp: DRILLABILITY INDEX
R: (ROP) Rate of Penetration in ft/hr
N: Rotary table rotation number (RPM)
W: weight on bit in lbs
B: bit diameter in inch

2- The calculated dExp is corrected to obtain dc EXP value as in the following equation

$$dc\ Exp = d\ Exp \times \frac{Normal\ Formation\ pressure}{Actual\ Mud\ Weight} \quad \text{....... (7)}$$

3- The pore pressure gradient is calculated according to the following formula

$$G_{PP} = 9\left(\frac{d}{dc}\right) - 0.3 \quad \text{...... (8)}$$

4- pore pressure is calculated using the following equation

$$PF = G_{PP} \times D \times 0.052 \quad \text{...... (9)}$$

Where:

PF: Formation Pressure in psi

D: interested depth in ft

5- Mathew and Kelly in Eaton (8) for calculating the cracking pressure is adopted using the following equation:

$$FG = \left(\frac{PF}{D}\right) + \left(\frac{Ki \times \delta}{D}\right) \quad \text{....... (10)}$$

Where:

FG: Fracture gradient at the point of interest in psi/ft

PF: formation pressure at the point of interest in psi

D: depth of interest in ft

δ: Matrix stress at the point of interest in psi

Ki: Matrix stress coefficient of the depth at which the volume of (J-would be normal matrix, dimensionless)

δ 》 is calculated from the following formula

$$\delta = P_{overburden} - FP \quad \text{....... (11)}$$

Ki is calculated using the chart figure of Mathew and Kelly as shown in figure (6)

Where the value is extracted by entering the Di value calculated by the following equation

$$Di = \frac{\delta}{0.535} \quad \text{........(12)}$$

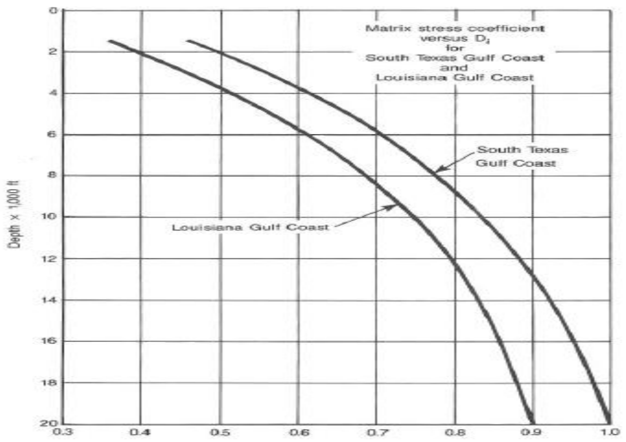

Fig. (6): Matrix stress coefficients of Matthews and Kelly

6- calculation of cracking pressure through the following equation (8)

$$F = 0.052 \times D \times FG \quad \text{...... (13)}$$

Where:

F: fracture pressure in psi

FG: Fracture gradient at the point of interest in psi/ft

D: depth in ft

7- hydrostatic pressure of cement is calculated by the following equation (7)

$$P_{hyd\,T} = P_{hyd\,1} + P_{hyd\,2} + P_{hyd\,3} + P_{hyd\,4} \quad \text{...... (14)}$$

Where:

P hyd 1: Hydrostatic pressure of cement

P hyd 2: Hydrostatic pressure of displacement Mud ($2m^3$))

P hyd: Hydrostatic pressure of cleaner liquid ($1m^3$))

Phyd4: Hydrostatic pressure of remaining distance to surface

$$P_{hyd} = MW \times H \times 1.422 \quad \text{....... (15)}$$

Where:

MW: Mud weight in gm/cc

H: Depth in m

8- then plot the results from the above calculation using the Access program as in figure (7)

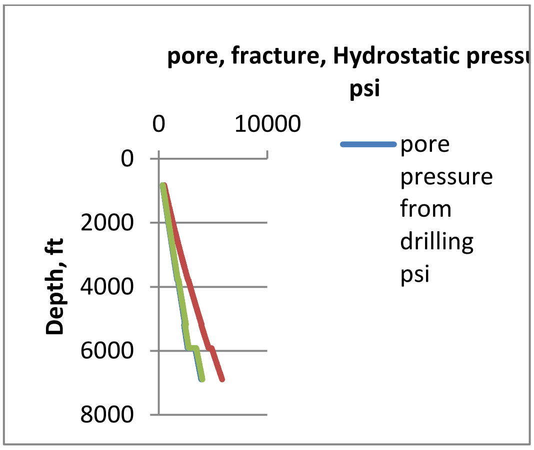

Fig. (7): Chart the result pressures from second way calculation

9- the results from IP program and results from the second method are drawn to comparison using Excel as shown in figure (8)

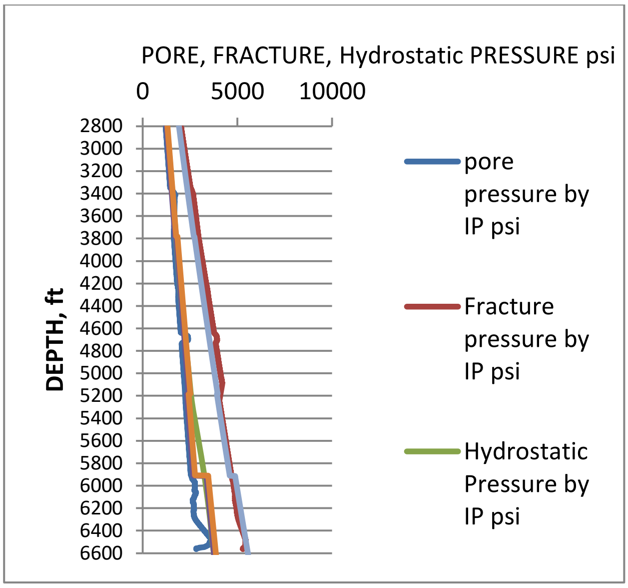

Fig. (8): chart the expected pressures from the two ways

IV. Analysis of the Results

From the indicators of drilling operations, from the data calculated during drilling operations and from the geological work data in NS well 13(5,11) the following was determined:

1) At the depth (430 - 630 m) from the geological work indicators or explanations of porosity and density logs, note the high porosity in Dammam Formation which range

from 33% - 36% especially after about 30 m from the top of Formation in which the dolomite begins to appear.

The appearance of dolomite continues until the end of the Formation as well as it appears with limestone and anhydrite, chert also appears with it before the end of the Formation and presence of the dolomite that leads to secondary porosity in this Formation so it has the ability to lose drilling mud. The value of pressure Formation(PP) ranges between (637.77 - 934.40) psi , and hydrostatic pressure(Phy) ranges (690 - 966 .645) psi and cracking pressure(FP) (906.499 -1368.271) psi from the observation of the value of the pressure, it appears that the probability of loss of drilling mud is weak in the case of drilling and building mud cake because the value of cracking pressure (FP) is much greater than the value of hydrostatic pressure (phy) and this is clear from the observations of drilling process, and there was no indication of a loss mud during the drilling process in the Dammam Formation.

2) At depth 850 - 1140 m this depth due to the Umm Ridma Formation and characterized by high porosity that extends along the Formation where the loss of drilling mud occurs except in some places that contain anhydrate. cases of sulfur water flow were recorded in this Formation at depth 1140 m .

The value pressure Formation (PP) was recorded between (1260.77 - 1690.836) psi and phy (1304.204 - 1749.16) psi and FP (1906.526 - 2663.853) psi. It is noted that layer pressure and hydrostatic column for drilling mud are very close, this gives the possibility of flow in both directions in the case of high porosity layer, as well as channel and cracks were identified from the mud of log operations as it was observed in the occurrence of the following process in this Formation.

3) depth (1455 - 1490) m

This depth is due to Hartha Formation which characterized by high porosity as wash out regions were recorded as shown in figure (9) as thus its loss ability is very large as in the beginning of Hartha Formation at depth 1446 m and 1488 m.

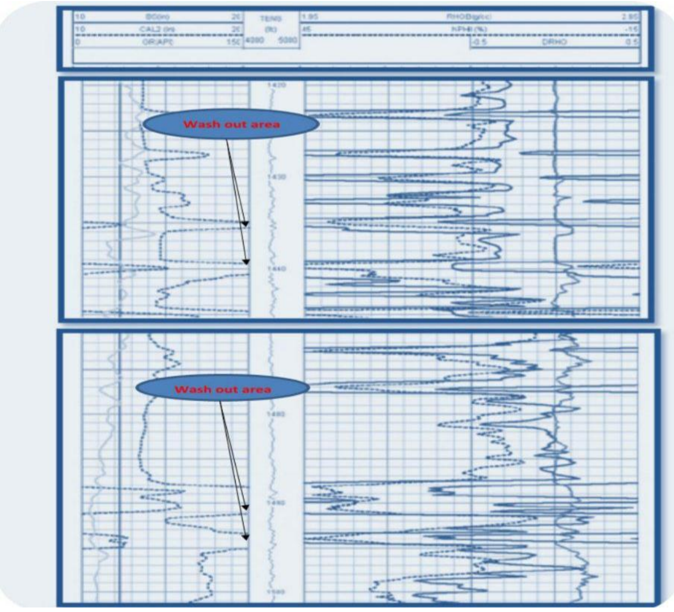

Fig.(9)- wash out plot

The value of PP was recorded ranges (2240.928 - 2294.834) psi

Phy (2315 - 2371.47) psi

FP (3586.801 - 3689.404) psi

From the pressure values it was found that the phy is more than PP in value close pressure.

So the occurrence of runoff sulfur water from the Tayarat layer and the occurrence of the loss due to the imbalance of pressure in the case of loss of the Hartha Formation continues by the drilling fluid until the pressure become balanced, this is causing decrease in the top cement surface which led to use the cement suspension method behind the lining after the completion of the cement Processes in order to take advantage of the properties of liquids and not to allow the cement mortar to invade the layers, by closing the outbreak group and the cement head

4) At depth (1920 - 2090 m) from the indications of geological action it was observed the restricted area (1996 - 2058 m) is a weak layer with average oil content, in general, the well kick is possible and the possibility of losing mud if the applied pressure is more than reservoir pressure.

The value of pressure recorded at depth 1920, PP (3585.853) phy (3684.09) FP (5253.752) psi and at depth 2096 m PP (3865.998) phy (3881.731) FP (5829.077) psi , it is noted that PP and phy are very close this gives the possibility of flow in both directions in the high porosity layer which leads to loss in the case of cement due to applied pressure by cement mortar column (5000 psi) . From the index of cracking pressure extended for depth 33m from the top of formation, it is close to the value of hydrostatic column of the cement mortar, this leads to cracking of layer into areas of high permeability and the loss in the mishrif areas and the free pipe line has been recorded in NS 13, for this reason the cement suspension method was taken in subsequent wells where it is used for help in the Formation of complete insulation cement discs, reduced the degree of bad cement.

V. CONCLUSIONS AND PROPOSALS

From matching the results of the log data analysis to the results of the drilling data and from the geological description of the Formations in the field of Nasriyah, we conclude that the value of the pressures resulting from the first and the second methods on drawing through the excel program we find that the results are close and the areas of loss and runoff and their causes have been determined accordingly the following proposals were presented to avoid the cases of loss and runoff and the bad cement of the productive lining that occurred during the drilling of wells.

- The first proposal:

It includes changing the liner smoothing depth according to the nature of the layers from geological point of view in terms of the solidity and the ability of the layer to lose and run off in order to avoid the bad cement in the production lining through the following: -

a: The liner 20" is sitting on the top of Dammam.

b: The liner 13 3/8" is sitting on the top of the Shiranish.

c: The liner 9 5/8" is sitting after 5m from the top of Kifil.

d: The shortened lining 7 is relegated to total depth. As shown in the figure (10).

- The second proposal:

1- There is no indication of loss during operations of the Dammam layer at depth (430 - 630m)

2-Loss and flow processes occur at different depths from (850 - 1140m) it was controlled by using the drilling method under the pressure balance between the formation pressure and the mud pressure so we suggest the following: -

a- Withdraw and change the precision before entering the Tayrat layer (12 - 50m) and using precision (RC - 527) without Nozzles (W.O.N) for drilling Tayrat and Hartha.

b- We dig Al- Hartha with lowest values of drilling parameters and using drilling mud (mw=1.12g/cc, μ=66cp) for the purpose of using mulled and excavated rocky rage to treat porosity and high permeability, as well as the use of treatment materials to the losing of . drilling mud are used.

C- When cemented the first stage of the second cavity, cement with density 1.75 gm/cc treated with hardening accelerators materials is used.

d- The drilling fluid is rotated with the density (1.12-1.13g/cc) and viscosity 60 cp over the area D.V to get rid of the excess cement and then close the annular void and the valves of the cement head directly.

e- Complete the cement for second layer by using cement with density 1.6gm/cc treated with hardening accelerators materials for four hours.

3-Loosing operations backflow of cement in the mishrif Formation because of cracking layer due to the high hydrostatic column of cement, therefore we suggest implementing the cement process in the production lining with the following specifications: -

a- The cementation process begins with a pumping drilling mud with density 1.30g/cc securing fill the annular void from the depth 1050m to the surface of the well.

b- Pumping cleaning fluid (1m³).

C- Pumping of mud separator used for cementation process (2m³).

d- Pumping mortar of cement with density (1.8 g/cc) and added the hardening accelerations materials, secure rate previous time 4 hours.

e- Pumping the cement for depth 1200m under surface replace of 1000m.

f- These applications are carried out to ensure that the hydrostatic pressure value of the cement mortar higher than of cracking pressure of the layer and higher than the value of the reservoir pressure to ensure that the runoff reservoir fluid doesn't occur or invade the layer from the cement mortar.

j- Drilling stopped at five meters after the disappearance of the last evidence of oil to avoid the invasion of cement mortar to the watery area.

4-The pressure expected from the sonic log should be compared with the formation pressure produced by the scheme (DXC) that was formed when drilling wells, therefore we recommend doing a leak of test to get a true value of the pressure formation and compare it to the expected pressure from the sonic log.

5-We recommend changing the quality of cement to better quality than used in previous cementation and to pay attention to the additives used in the composition of a cement mortar as well as the use of cement lining with safe metal from rust as a result of poor storage, and making sure of matching the specification of the country of origin and activating the role of control and quality control.

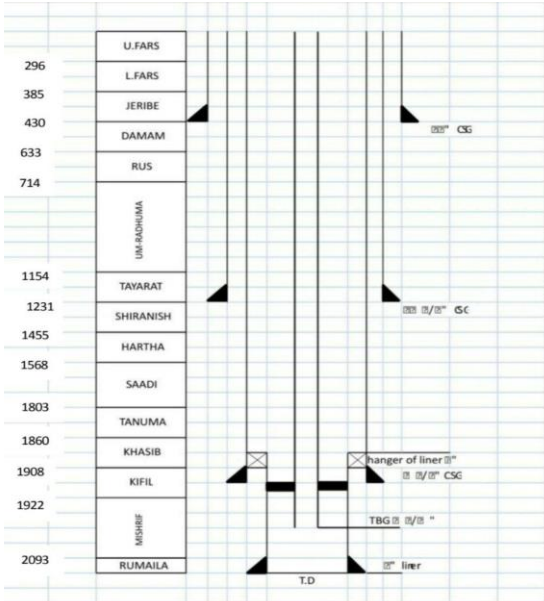

Fig.(10):Proporsal for design the lining

REFERENCES

1- Anderson, R.A, Ingram, D.S, Zanair, A.M. 1973, Determining fracture pressure gradients from well logs SPE 4135, journal of petroleum Technology, V25, P1259-1268.

2- Asquith G.B & Gibson, C.R , Basic Well log analysis for geologists , AAPG methods in exploration , 1983 .

3- Bellotti , P.&GIiacca , D, 1978 , AGIP , pressure evaluation improves drilling program . oil and Gas Journal , V76, No . 37 ,P76-85 .

4- Bingham . M.G , 1964 , A new approach to determining rock drillability , oil and gas journal V62 , 46 P173-179.

5- Data sonic log Ns-13 for Baker HUG HES Company.

6- Eaton ,B.A,1975 . the equation for geopressure prediction from well logs, 5544, 50th Annual Fall Conference, SPE of AIME, September 1975.

7- Eaton , B.A , 1972 , The effect of overburden stress on geopressure prediction from well logs ,SPE 3719 ,Journal of petroleum Technology , August 1972 .

8- Eaton , B.A , 1969 Fracture gradient prediction and its application in oilfield operations , SPE 2163 , Journal of petroleum Technology , V21 , p1353-1360 .

9- Hawker , D.P, 2000, system cuts formation gas guesses , American Oil & Gas Reporter V43 , 12 , P118-122.

10- Jordan , J.R & Shirley , O.J , 1966 , Application of drilling performance data to overpressure detection , SPE 1407 , journal of petroleum Technology , V28 , 11 ,1387-1394.

11- The results of data log drilling analysis for NS13.