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* Pore pressure prediction of some selected wells; Insight from the Southern Pletmos Basin, Offshore South Africa.

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1. Introduction.

Pore pressures are the fluid pressures in the pore spaces in the porous formation. Therefore, an accurate prediction of pore pressure is an essential in reducing the risk involved in a well or field cycle. This has formed an integral part of routine work for exploration, development and exploitation team in the oil and gas industries. Several factors such as sediment compaction, overburden, lithology characteristic, hydrocarbon pressure and capillary entry pressure contribute significantly to the cause of overpressure. Hence, understanding the dynamics associated with the above factors will certainly reduce the risk involved in drilling and production.

2. Aims and objectives.

This study aimed to investigate and accurately predict the pore pressure of the Sub-surface overpressure and normal pressure zones of some selected drilled wells GA- W1, GA-N1 and GA-AA1 in order to avoid risk involving in drilling well such as mud loss, lost of circulation, and blow-out as well as other drilling hazards in Pletmos, Basin, and Offshore South Africa.

3. Materials and Methodology

The wireline logs data in LAS format.

Seismic data in SEG-Y format.

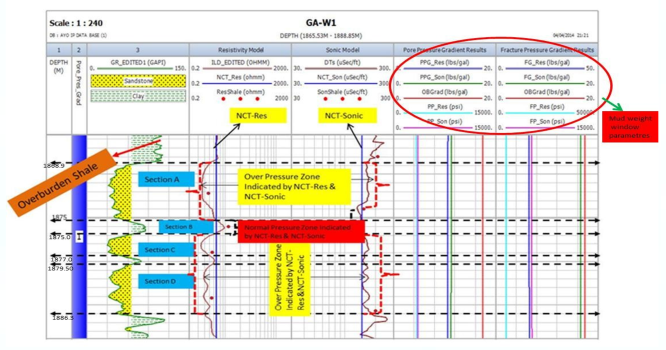
Interactive Petrophysics (IP) Software.

Kingdom suite Software (Seismic Micro-Technology SMT).

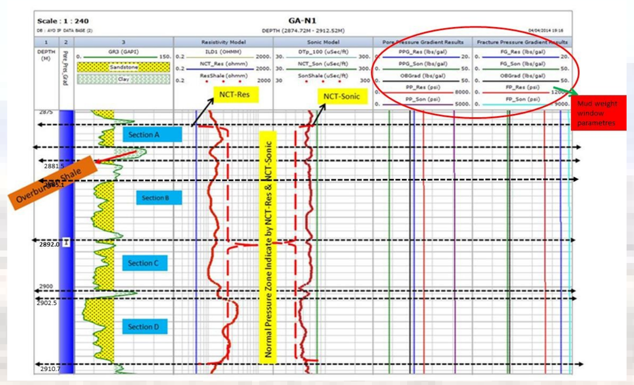
Eaton's resistivity and sonic equivalent depth dependence method with normal compaction trendline (NCT) was used for this study to calculate the following parameters such as pore pressure gradient, fracture pressure, fracture gradients, effective stress, as well as mud weight and the overburden gradient. Also, the extraction of the tomography grid map of the pore pressure from seismic data by using interval velocity volume method. Eaton (1972, 1975) equation to predict pore pressure gradient in shale using log: Ppg=OBG-(OBG-Png)(R/Rn)n. Where Ppg (formation pore pressure gradient); OBG (overburden stress gradient); Png (hydrostatic pore pressure gradient (normally 0.45 psi/ft depend on water salinity); R is the shale resistivity obtained from the well logging; Rn is the shale resistivity at the normal (hydrostatic) pressure; and n is the exponent varied from 0.6 to 1.5, normally n = 2.

4.Results

Well GA-W1, depth ranges 1868.7 m – 1888.85 m.



Well GA-N1 depths range from 2876.70 m – 2912.36 m.



Well GA-AA1, depths range from 3532.78 m to 3550.77 m.

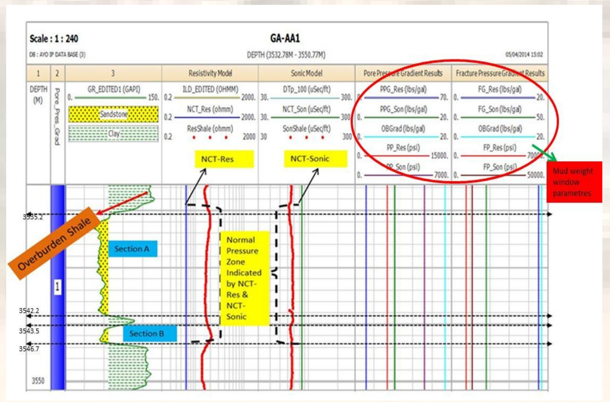


Figure 2a, b & c: the resistivity and sonic transit time velocity model of Eaton's equivalent depth dependence method with NCT (Normal compaction trendline) to estimate pore pressure from Well logs and seismic data for wells respectively.

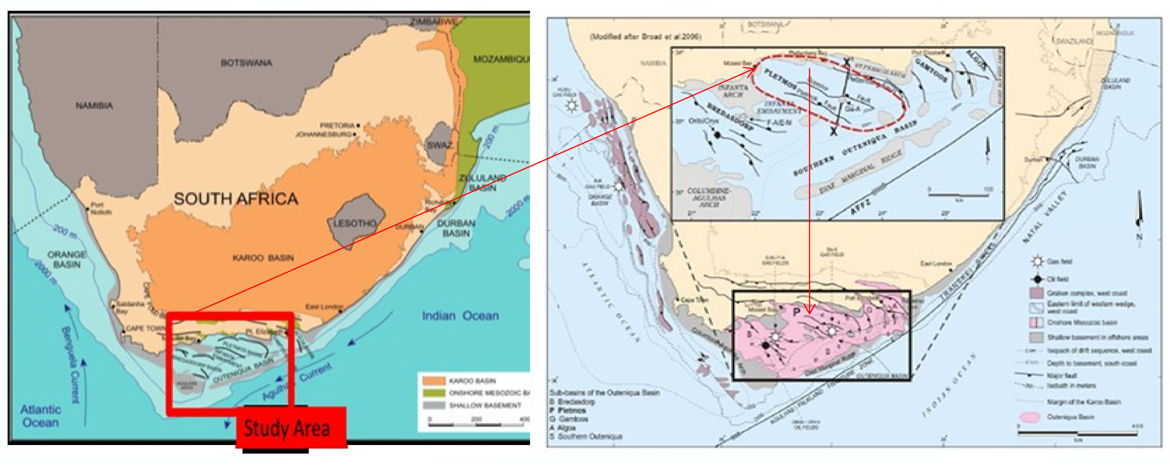


Figure 1.Western, Eastern and Southern Offshore zones of South Africa and Location map of the Pletmos sub-basin (Petroleum Agency SA brochure 2003), respectively.

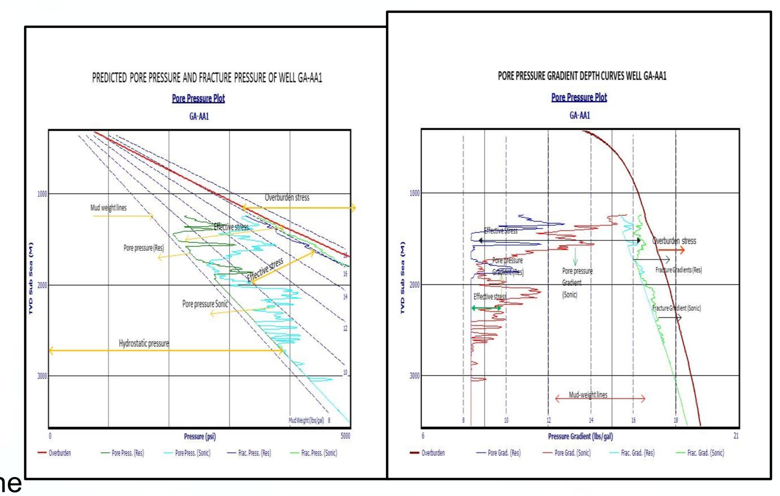


Figure 5: Predicted pore pressure, fracture pressure and Pressure gradient depth curves for well GA-AA1.

5.Interpretations and Discussions

The normal compaction trendline (NCT) is the optimum fitted linear trend of the measured overpressure and normal pressure formation i.e. between the hydrostatically pressured and geopressured formation (transition zone).

The shale resistivity logs decrease or increase from the established normal compaction trendline (NCT) which are designed to detect the abnormal pressure (overpressure) and normal pressure zone of the wells as applied by Zhang (2011). The decrease of the shale-resistivity behind the established normal-compaction trend line (NCT) indicates the overpressure zones. Also, the deviations of the shale-resistivity logs from the established normal compaction line towards the high values scale indicate the normal pressure zone .This procedure was applicable to the wells.

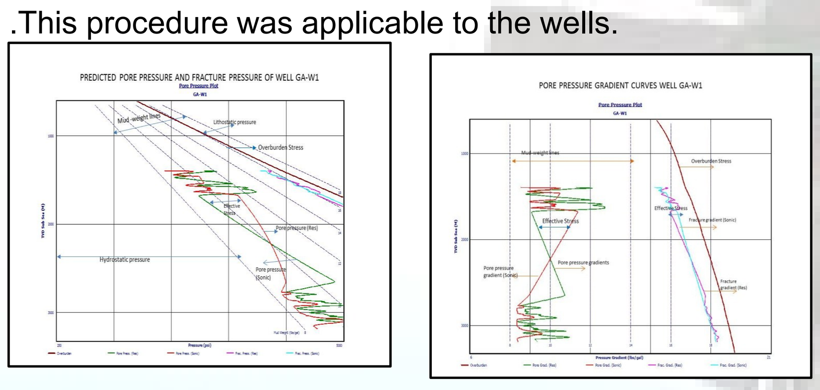


Figure 3: Predicted pore pressure, fracture pressure and Pressure gradient depth curves for well GA- W1

Mud weight window parameters calculated for Well GA-W1.

Interval depths for well GA-W1 are sub-divided into reservoir sections A, B, C and D, at depths 1868.73 m – 1875.40 m, 1875.40 m – 1876.7 m, 1876.7 m - 1880.3 m and 1880.3 m – 1887.3 m respectively.

The *overburden gradient* of well GA-W1 at intervals depths A, B C and D is 17.5 lbs/gal (2.09 g/cm³).

The *pore pressure gradient (PPG-res)* calculated for well GA-W1 is 10.6 lbs./gal (1.27 g/cm³), which used to determine the mud weight required for the formation.

The fracture pressure-resistivity (FP-res) of well GA-W1 is 5,267 psi or 12.15 g/cm³, also known as a formation fracture pressure gradient in (g/cm³).

The *fracture gradient* which is the maximum mud weight required in drilling a well, and is 16.5 lbs./gal (1.98 g/cm³) for well GA-W1.

*The effective stress.*is pore pressure is 3,406 psi average (equivalent to 7.85 g/cm³) of the well formation minus overburden stress is 17.5 Ibs/gal (2.09 g/cm³), thus (i.e. 2.09 g/cm³ – 7.85 g/cm³ = -5.76 g/cm³).

The predicted pore pressure encountered, are 3,401 psi, 3,405 psi, 3,407 psi to 3,412 psi for interval depth reservoir sections A, B, C and D respectively.

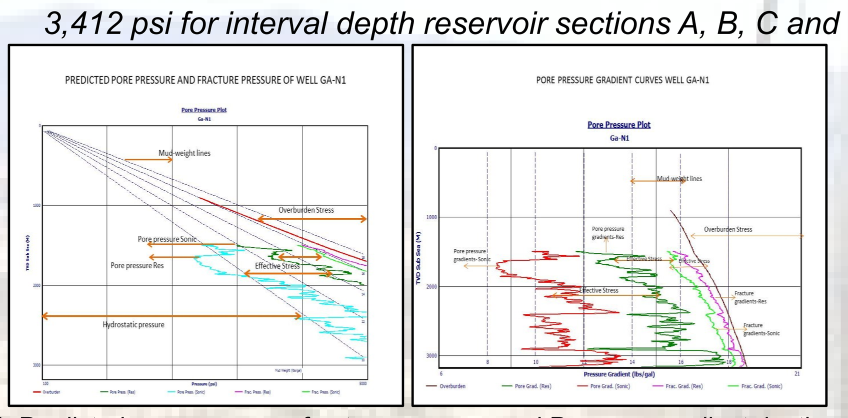


Figure 4: Predicted pore pressure, fracture pressure and Pressure gradient depth curves for well GA-N1.

Mud weight window parameters calculated for Well GA-N1.

The interval depths of well GA-N1 are sub-divided into four reservoir sections: A, B, C and D at depths 2876.70 m -2880.10 m, 2880.10 m – 2881.7 m, 2892.2 m - 2900.6 m and 2900.6 m – 2912.36 m, respectively.

The *overburden gradient* for the depths respectively is 18.6 lbs/gal or 2.23 g/cm³.

The *pore pressure gradient* PPG-res of 8.34 lbs/gal is calculated to be 0.99 g/cm³.

The *fracture pressure resistivity (FP-res) or FFG* (formation fracture pressure gradient in (g/cm3).ranges from 8,717 psi to 8,743 psi of 20.11 g/cm³ to 20.17 g/cm³.

The *fracture gradient* is the maximum mud weight required in drilling a well. Thus, the fracture gradient of well GA-N1 is 17.7 lbs/gal (2.12 g/cm³).

The *effective stress* of the well GA-N1 is pore pressure is 4,121 psi which is equivalent to 9.51 g/cm³ for the well minus the overburden stress is 18.6 lbs/gal (2.23 g/cm³) thus, 2.23 g/cm³ – 9.51 g/cm³= -7.28 g/cm³.

The *predicted pore pressure (PP-res) values* 4,098 psi, 4,110 psi, 4,120 psi and 4,133 psi calculated across the interval sections A, B, C and D depth.

Mud weight window parameters calculated for Well GA-AA1.

The total depth interval selection for well GA-AA1 ranges from 3532.78 m to 3550.77 m.

The calculated *overburden gradient (OBGrad) of well GA-AA1 within the total reservoir interval sections A and B is* 18.7 lbs/gal or 2.24 g/cm³.

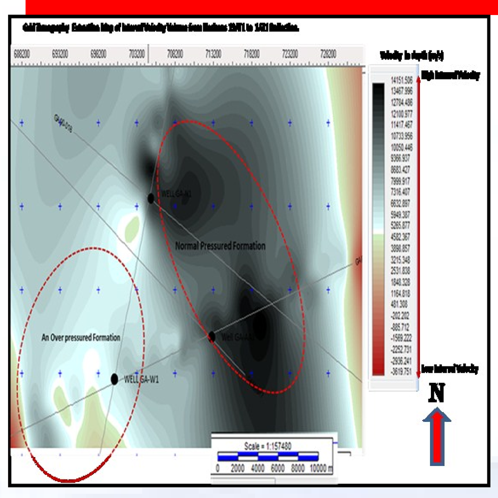
The fracture pressure (FP-res) also known as the formation fracture pressure gradients in (g/cm³) is 10,996 psi or 25.36 g/cm³.

The *fracture gradient (FG-res)* of well GA-AA1 is 18.1 lbs/gal or 2.6 g/cm³ and is the maximum mud weight required to fracture the wellbore formation.

The effective stress is the pore pressure is 5,062 psi or 11.67 g/cm³ in the well formation GA-AA1 minus overburden stress is 18.7 lbs/gal (2.24 g/cm³). Therefore, the effective stress of the well formation is 2.24 g/cm³ – 11.67 g/cm3= -9.43 g/cm³.

The *predicted pore pressure (PP-res)* calculated with IP within the total interval depth sections A and B is 5,062 psi.

6.The Tomography Extraction Grid Map of the Pore pressure from Seismic data Lines.



The tomography map used to delineate the depth imaging of the pore pressure of the overpressure and normal pressure formation of the wells. An overpressure formation was encountered in well GA-W1 and wells GA-N1 and GA-AA1 normal pressure formation was encountered based on increases and decreases with depth of an interval velocity volume in formation.

7.Conclusions and Recommendations.

The pore pressure prediction of the reservoir units encountered in the three drilled wells GA -W1, GA-N1 and GA -AA1 were comprehensively investigated and predicted by means of using the two methods.

The reservoirs interval depths section for the wells has a relatively close maximum mud weight obtained from the two methods used . The values predicted maintain the stability of the holes. No mud loss or lost circulations were experienced during the drilling, as a result of accurate mud weight used.

The predicted pore pressures calculated for the entire interval depth of the sections for the wells from the two methods ranges from 3,401 psi to 3,621 psi (GA -W1), 4,098 psi to 4,12 0 psi (GA - N1), and 5,074 psi 5,083 psi (GA -AA1) were encountered during the drilling.

The tomography extraction grid map also confirming the presence of overpressure and normal pressure formation of the wells.

It is thus concluded that using IP and the methods outlined above from seismic data is a reliable tool for the prediction of pore pressure in wells.

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