Evaluation of Mud Weight Using Safe Mud Window Concept Based on Well Log Data: A Case Study of Well OP-002 in the North Sumatra Basin Area, Indonesia

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Evaluation of Mud Weight Using Safe Mud Window Concept Based on Well Log Data: A Case Study of Well OP-002 in the North Sumatra Basin Area, Indonesia

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Abstract

In the drilling operation of well OP-002 which is located in the North Sumatra Basin at a depth interval of 2887 - 3186 m occurred partial loss, and caving at a depth interval of 500 - 1650 m, where the drilling problem is caused by the use of inappropriate mud weight. Safe mud window analysis is carried out by processing well log data to build PPFG (Pore Pressure Fracture Gradient) and 1D Geomechanics model using several calculation methods. Furthermore, the results of the calculation of pore pressure and fracture gradient are validated with well test data from the well OP-002, so the safe mud window can be determined, and can be used as a basis in the analysis of the drilling problems that occur. The optimum mud weight can minimize wellbore instability, with a limit value that must be greater than the collapse pressure, but not exceeding the minimum insitu stress limit. From the results of the mud safe window analysis, it can be concluded that at a depth interval of 500 - 1650 m caving occurs, because the density value used is smaller than the shear failure gradient, and at a depth interval of 1619 - 2829 m, the density value used is greater than Shmin. To overcome this problem, a mud wight with a safe mud window concept is recommended, namely the selection of the optimum mud weight to be used must be greater than the pore pressure and shear failure gradient and does not exceed the minimum horizontal stress and fracture gradient values.

Keywords: Mud Weight, Safe Mud Window, Well Log

INTRODUCTION

Precise and optimal mud weight planning in drilling operations is very necessary because one of the functions of drilling fluids is to control the pore pressure. In addition, proper mud weight planning can avoid drilling problems that cause an increase in the value of NPT (Non-Productive Time). One of the drilling problems is due to the planning of the mud weight that is not optimal which causes the instability of the borehole which is characterized by the formation of a cave on the borehole wall.

In planning the mud weight, several parameters must be considered, including the mechanical properties of the rock being penetrated and the pore pressure profile. In general, the mud weight is designed based on the pressure range window, but caving often occurs which causes the pipe stuck. Based on these conditions, the safe mud window concept is used, namely by adding the shear failure gradient parameter in the pressure window.

LITERATURE REVIEW

Many correlations and models have been developed for the prediction of abnormal pressure of various parameters (Hottman & Johnson 1965; Matthews & Kelly 1967; Pennebaker 1968; McClendon 1971; Zamora 1974; Eaton 1975). The method has limitations; for example, some models can only be used in clean shales (Table 1).

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Table 1. The pore pressure prediction method can only be used for clean shales (Basuki 2017)

Pore Pressure		
Lithology	**Prediction**	**Measure**
Sand	✖	✓
Carbonates	✖	✓
Shale	✓	✖
Salt	✖	✖

Some pore pressure prediction methods only can be applied to the pressure generated by the under-compaction mechanism or some of them do not apply in unloading formations. Therefore, the researchers tried to use AI (Acoustic Impedance) from seismic data to predict pore pressure with good precision. To predict the pore pressure, four input parameters are used, namely: depth, Gamma Ray log, density log, and soniclog.

Some literature show that the parameters used to predict pore pressure from well log data. Most methods require both normal and abnormal trends, to estimate pore pressures.

PPFG and Geopressure Model Prediction Method

a. Overburden Gradient Prediction Calculation

The formation overburden stress gradient (OBG) in onshore drilling can be estimated to vary from 1.0 – 1.1 psi/ft (0.0227–0.025 MPa/m). But in this study, OBG was calculated from the density log (RHOB) data. Because the density log data does not start from the surface/seabed, so in some equations, calculation of the pseudo-RHOB shallow section by integrating the LWD / wireline RHOB log data.

b. Pore Pressure (PP) Prediction Calculation

There are several methods for predicting pore pressure calculations, namely: Equivalent Depth, Eaton's, and Bower's methods.

- **Eaton's Method:**

In the prediction of the pore pressure of well OP-002 using Eaton's method, where Eaton's exponent which is matched with the actual MW is 3.5 (Eaton's exp: 3.5). Mathematical equation Eaton's method used:

$$PP = OBG - (OBG - PP)_N \left(\frac{DT_N}{DT_O}\right)^x \quad \text{.......................................} (1)$$

where;

PP = Pore Pressure Gradient (psi/ft or lb/gal),
OBG = Overburdent Gradient (psi/ft orlb/gal),
PP_N = Normal Pore Pressure Gradient (psi/ft or lb/gal),
DT_O = Observed Interval Transit Time(msec/m),
DT_N = Normal Interval TransitTime (msec/m),
x = Eaton Exponent(dimensionless).

- **Bower's Method:**

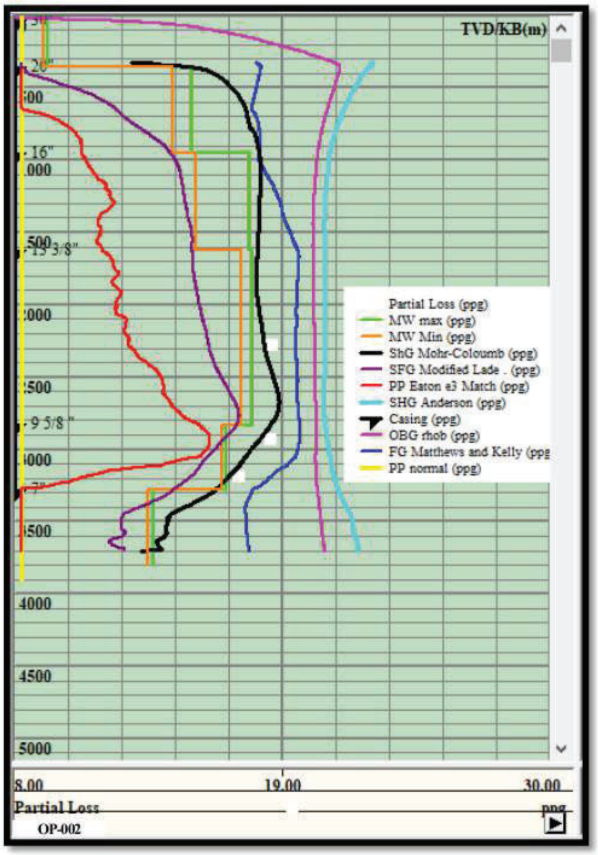

Figure 14. Mud Weight Recommended on Well OP-002

CONCLUSION AND FURTHER RESEARCH

Conclusion

1. The drilling operation of well OP-002 encountered caving problems at a depth interval of 500 - 1050 m (hole trajectory 16" and 13 3/8") due to the dynamic MWactual < SFG. To overcome this problem, the mud weight must be changed, namely on the hole trajectory 16" to 14.49 - 15.33 ppg, and the hole trajectory 13 3/8" to 15.45 - 17.65 ppg.
2. In section 2 caving problems occur at depth intervals of 1050 – 1650 m, but the dynamic MWactual condition is greater than SFG, so the caving problem in this section is estimated due to drilling through the brittle formation.
3. In sections 3, 4, and 5 partial loss occurs because the dynamic MWactual value is greater than the Shmin value, which causes fracture formation and partial loss. To overcome this problem, the mud weight must be changed, namely on the hole trajectory 9 5/8" to 17.36 - 17.76 ppg, and the hole trajectory 7" to 16.57 - 16.7 ppg.
4. Range mud weight is an MWstatic and MWdynamic limit, where the MWstatic value is not less than the lowest MWrecommendation value and MWdynamic is not higher than the highest MWrecommendation.

Further Research

1. In Section 2 at a depth interval of 1050 - 1650m even though the MWactual dynamic is > SFG, caving problems occur which are thought to be due to drilling through a brittle formation.
2. To ensure that brittle formation does not occur at a depth interval of 1050 – 1650 m, it is recommended that further research of mineralogical analysis (XRD) be carried out.

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Conflicts of Interest

The authors declare no conflict of interest regarding the publication of this paper.

REFERENCES

Barliana et al. 1999. "Changing Perceptions of a Carbonate Gas Reservoir: Alur Siwah Field, Aceh Timur, Sumatra." *Indonesian Petroleum Association*.

Basuki, Don. 2017. "Geopressure Prediction." in *Workshop Pertamina (Persero)*.

Eaton, Ben A. 1975. "The Equation for Geopressure Prediction from Well Logs." *SPE Annual Technical Conference and Exhibition*. doi: 10.2118/5544-MS.

Hottman, G. E., and R. K. Johnson. 1965. "Estimation of Formation Pressures from Log-Derived Shale Properties." *SPWLA 6th Annual Logging Symposium 19652*:717–22.

Matthews, W.R. and Kelly, J. 1967. "How to Predict Formation Pressure and Fracture Gradient." *Oil and Gas Journal, 65, 92-1066*.

McClendon, Rehmand. 1971. "Measurement of Formation Pressure from Drilling Data." *SPE Annual Technical Conference and Exhibition* 3601.

Pennebaker. 1968. "An Engineering Interpretation of Seismic Data." *SPE Annual Technical Conference and Exhibition* 2165.

Seismic Atlas. 2008. "Compilation of Seismic Images of Geological Features in Southeast Asia Basins, Related to Ydrocarbon Potential of This Region. Countries Covered in This Atlas: Indonesia, Malaysia, Brunei, Philippines, Thailand, Vietnam."

Wibowo, H. B. 2020. "Evaluasi Mud Weight Pada Pemboran Sumur HBW-1 Dengan Safe Mud Window Concept." Thesis, Teknik Perminyakan, FTM, UPN "Veteran" Yogyakarta.

Zamora, Mario. 1974. "Practical Analysis of Drilling Mud Flow in Pipes and Annuli." *SPE Annual Technical Conference and Exhibition* SPE-4976-M.

Zhang, Jincai. 2013. "Borehole Stability Analysis Accounting for Anisotropies in Drilling to Weak Bedding Planes." *International Journal of Rock Mechanics and Mining Sciences* 60:160–70. doi: 10.1016/j.ijrmms.2012.12.025.

Zhang, Jincai. 2019. *Applied Petroleum Geomechanics*.

Zoback, Mark. 2007. "Reservoir Geomechanics." in *Cambridge University Press*.

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