PSCrossflow Mitigation through Geomechanic Investigation in Mature Panda Field, West Java Basin, Indonesia*

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Abstract

Breakouts and tensile fractures are drilling induced features that occur due to different stress applied in the well. Besides acting as a stress indicator, those two features could act as a fluid conduit between formations. Those features have the potential to become a pathway for cross flow, especially when the well components such as casing or cementing have deteriorated due to its age.

Panda Field is a mature oil field that located in Ciputat Sub-Basin, West Java Basin, Indonesia. Main producing reservoir from Panda Field is a fractured basement reservoir with low-grade metamorphism. Acquired image logs from the development wells have shown not only the presence of open fractures but also breakouts and tensile fractures all over the reservoirs. The formation pressure in Panda Field has been depleted throughout the production in an order of hundreds psi. Secondary or tertiary recovery is going to be required to maintain the production rate. Those recovery methods often require injection of fluid into the reservoir. However, drilling induced features that deform borehole geometry and could not be completely sealed by cement are susceptible to becoming a pathway from the perforation to other intervals. Therefore, minimizing both drilling induced features in reservoir becomes essential in drilling new development well or selecting suitable old well as a candidate for secondary or tertiary recovery.

Geomechanic investigation was used to predict potential crossflow in production wells. The investigation method started by creating a geomechanic model for each well. Then the stress magnitude and orientation were used to model the occurrence of borehole breakout and tensile fracture calibrated with existing image log. The calibrated parameters were then used to create a well prognosis. Several scenarios using variety of mud weight were used to do a sensitivity analysis. The result is able to create a window where mud weight has to be maintained when going through the reservoir. This crossflow mitigation is one of well integrity analysis to make sure that the wells are being drilled without extensive damage to the reservoir and could be utilized for further field development, such as improved oil recovery or enhanced oil recovery.

Reference Cited

Zoback, M.D., D. Moss, and L. Mastin, 1985, Well Bore Breakouts and In Situ Stress: Journal of Geophysical Research, v. 90, p. 5523-5530.

CROSSFLOW MITIGATION THROUGH GEOMECHANIC INVESTIGATION IN MATURE PANDA FIELD, WEST JAVA BASIN, INDONESIA

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INTRODUCTION

Panda Field is located in Ciputat Sub-Basin, onshore West Java Basin, one of the rift complexes or half grabens in edge of Sundaland. The half graben formed in N-S direction and filled with tertiary sediments which underlie with cretaceous or older metamorphic and meta-sediment rocks.

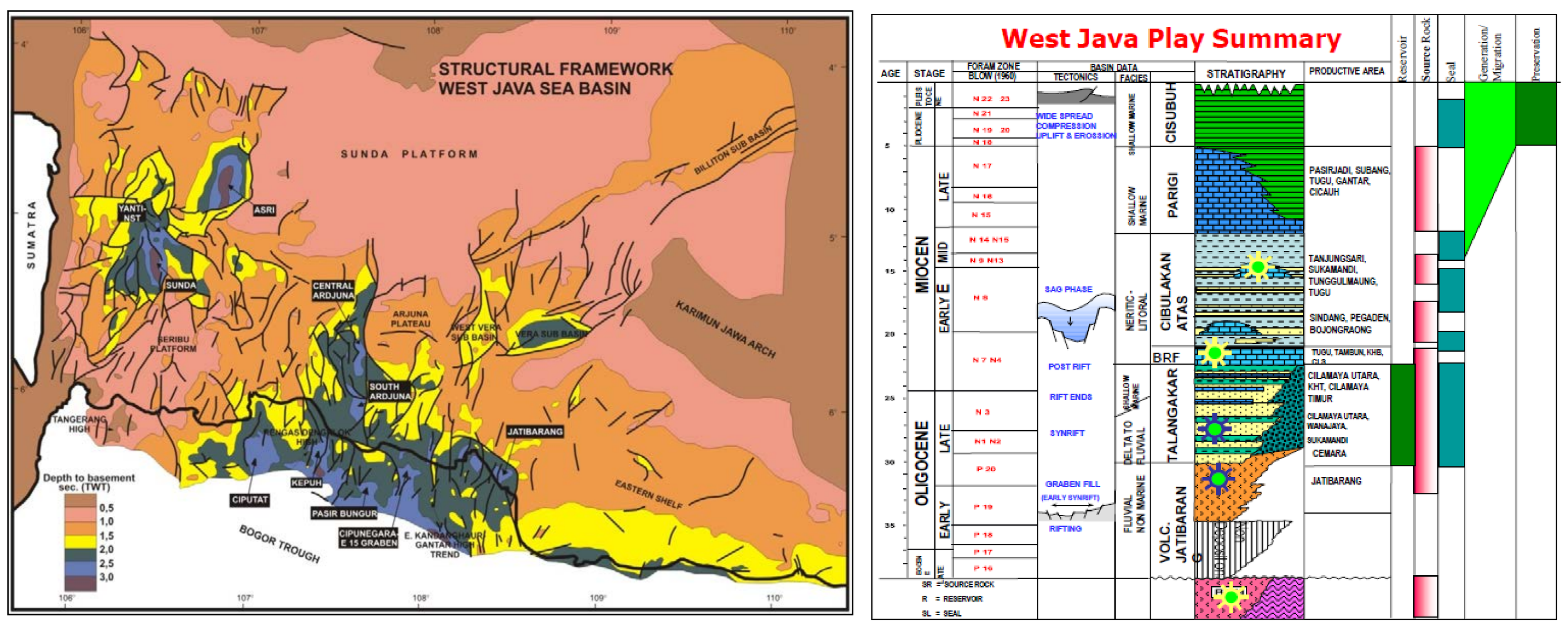

Figure 1. Structural framework and regional stratigraphy of West Java Basin

STUDY AREA

In 2007, Boscha-01 well was drilled and encountered hydrocarbon both in tertiary sediments and also in fractured meta-sediment basement. The formation test in the basement shows that oil was flowing 3096 bopd and gas was flowing 3920 mmscfd for one hour. The well was plugged and abandoned as discovery oil and gas well.

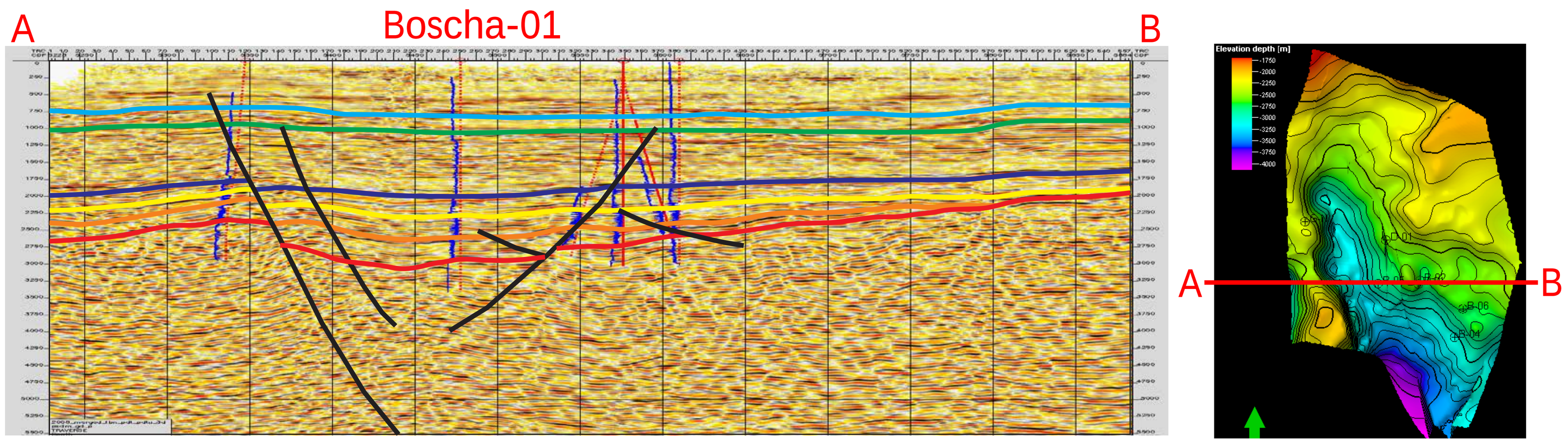

Figure 2. W-E Cross section of Panda Field through Boscha-01 Well

DATA

Data that being used are image log, weight mud, and wireline log, in Boscha-01 well. Basement lithologies in Boscha-01 wells are crystalized limestone and dolomite. In the basement, the image logs shows many vugs, conductive fractures, resistive fracture, tensile fractures, breakouts, and the combination of those features. For the purpose of simulation, we focused on a breakout in depth 2868 m.

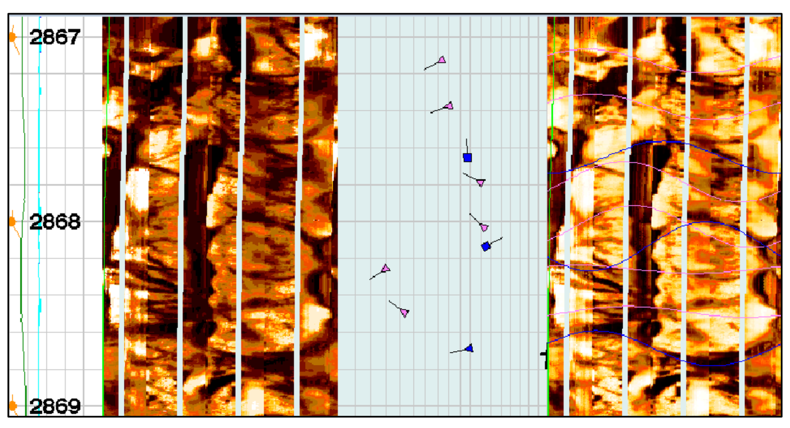

Figure 3. Image log of Boscha-01 well, depth 2868 m (9409.45 ft). Image on the left is static image log, and on the right side is dynamic image log

METHODOLOGY

The equation used for simulation is based on assumption that the reservoir rock is thick, homogeneous, and isotropic (using equation from Kirsh, 1898 and Jage, 1961):

$$\sigma_r = \frac{1}{2}(S_H^* + S_h^*)\left(1-\frac{R^2}{r^2}\right) + \frac{1}{2}(S_H^* + S_h^*)\left(1-4\frac{R^2}{r^2}+3\frac{R^2}{r^2}\right)\cos 2\theta + \frac{\Delta P R^2}{r^2} \quad \text{(eq.1)}$$

$$\sigma_\theta = \frac{1}{2}(S_H^* + S_h^*)\left(1-\frac{R^2}{r^2}\right) + \frac{1}{2}(S_H^* - S_h^*)\left(1+3\frac{R^2}{r^2}\right)\cos 2\theta - \frac{\Delta P R^2}{r^2} \quad \text{(eq.2)}$$

$$\tau_{r\theta} = -\frac{1}{2}(S_H^* + S_h^*)\left(1+\frac{2R^2}{r^2}-3\frac{R^4}{r^4}\right)\sin 2\theta \quad \text{(eq.3)}$$

$$\tau_0 = (1-\mu^2)^{1/2}\left[\left(\frac{\sigma_\theta-\sigma_r}{2}\right)^2 + \tau_{r\theta}^2\right]^{1/2} - \mu\left(\frac{\sigma_\theta+\sigma_r}{2}\right) \quad \text{(eq.4)}$$

Legend:
σ_r= radial stress
σ_θ= circumferential stress
$\tau_{r\theta}$= tangential shear stress
R= radius of the hole
r= distance from the center of the hole
θ= azimuth measured from the direction of S_H^*
ΔP= difference between the fluid pressure in the borehole and in the formation

RESULT

Geomechanic investigation was used to predict potential crossflow in production wells. The investigation method started by creating a geomechanic model for Boscha-01 well. Then the stress magnitude and orientation were used to model the occurrence of borehole breakout and tensile fracture calibrated with existing image log. The calibrated parameters were then used to create a well prognosis. Several scenarios using variety of mud weights were used to do a sensitivity analysis. The result is able to create a window where mud weight has to be maintained when going through the reservoir. This crossflow mitigation is one of well integrity analysis to make sure that the wells are being drilled without extensive damage to the reservoir and could be utilized for further field development.

Pore Pressure Calculation

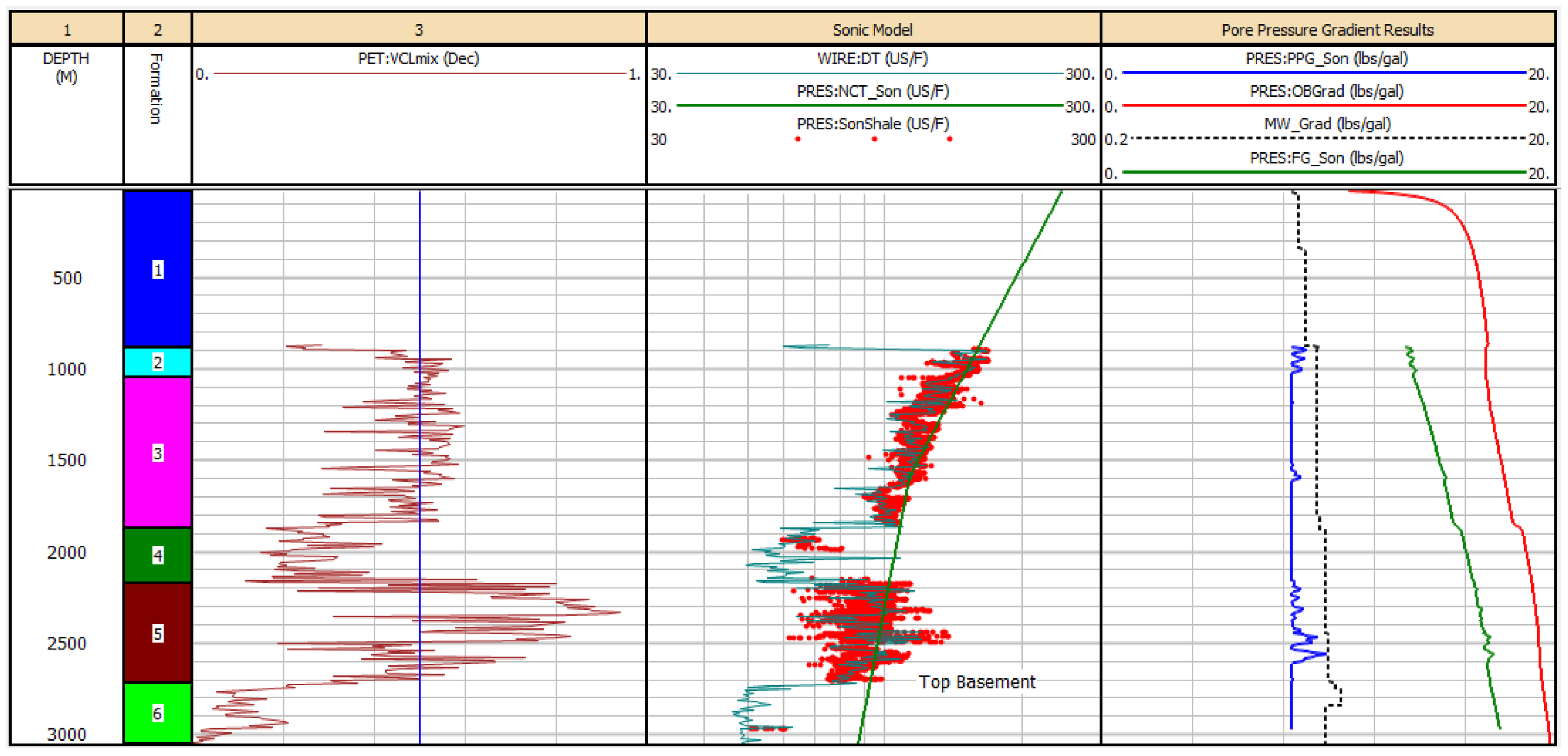

Figure 5. Calculating pore pressure, fracture gradient and overburden pressure. Overburden pressure is obtained by integrating density log with respect of depth. The pore pressure is estimated using Eaton's.

SHmax Prediction

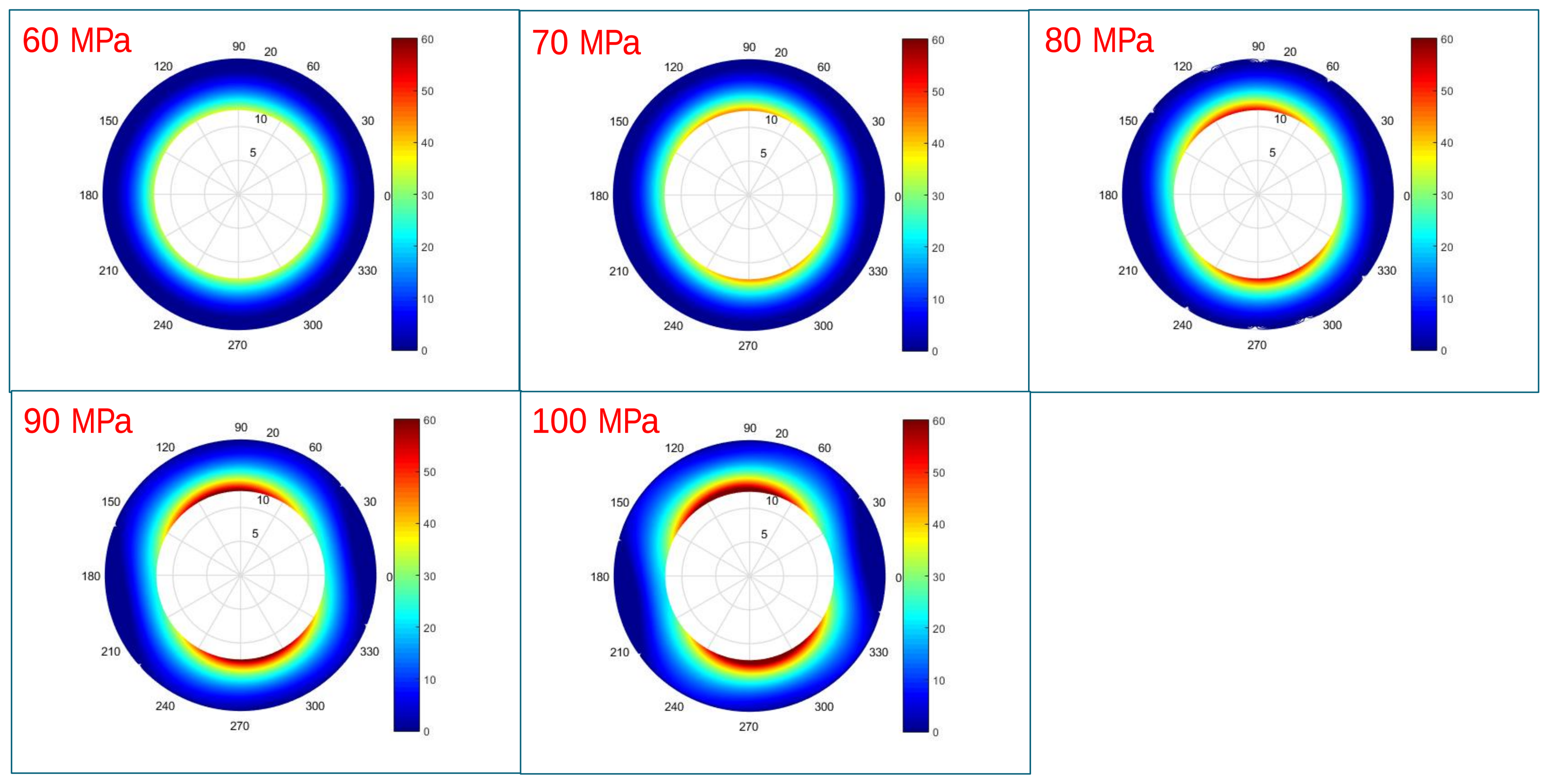

Figure 6. Predicting SH max using combination of breakout width and the equation. Shmax used for the weight mud simulation is 90 MPa. The red number shows the applied SH max to the simulation.

Mud Weight Simulation

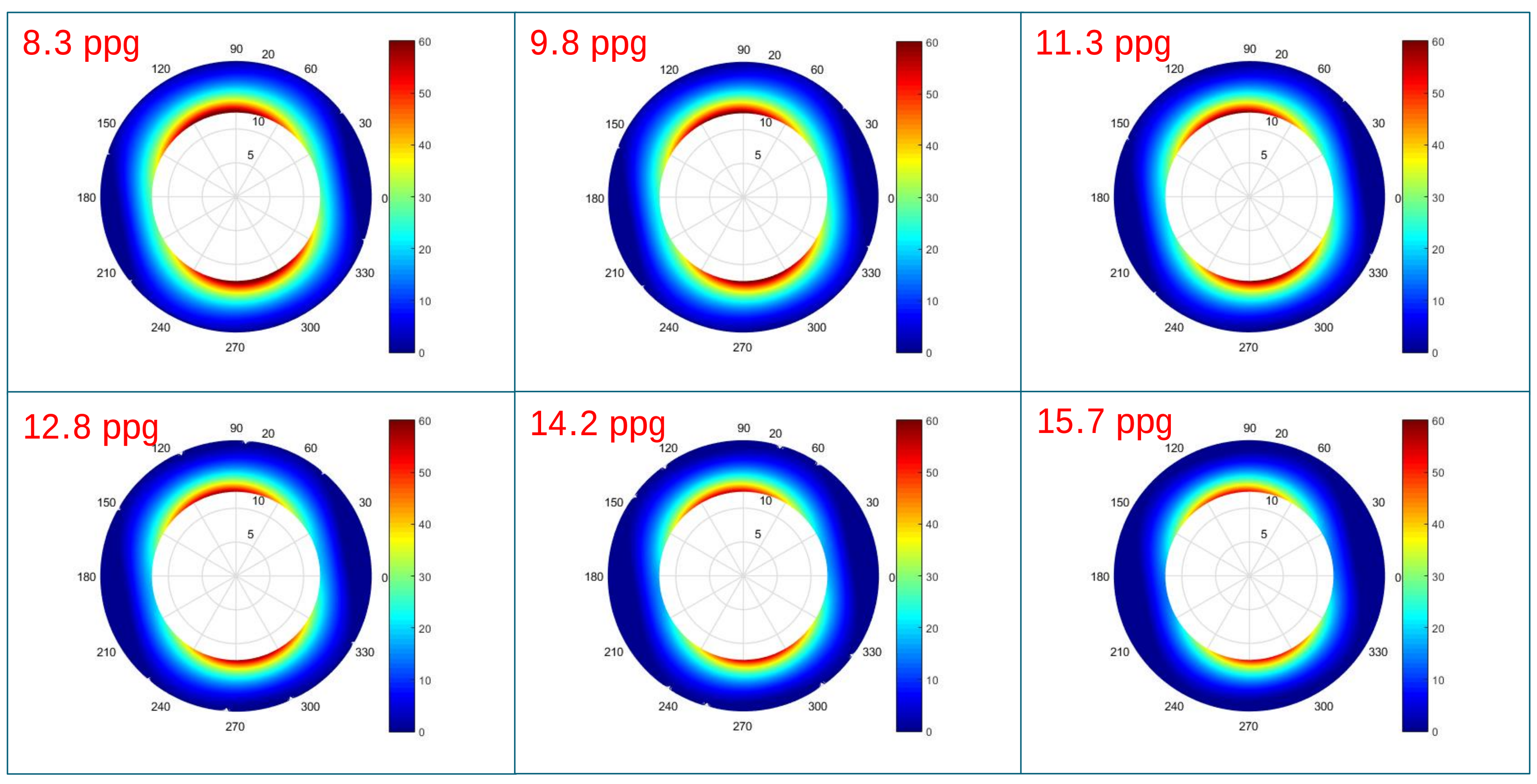

Figure 7. Simulation of different mud weight applied to a same borehole condition. The red number shows the mud weight used in the simulation.

REFERENCE

Zoback, M.D., Moss, D., and Mastin, L., 1985, Well Bore Breakouts and In Situ Stress, Journal of Geophysical Research, Vol. 90, Pages 5523-5530