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Normal Resistivity Trends for Geopressure Analysis in Mexican Offshore Wells

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Abstract

The normal compaction trend and the pore pressure gradient play a very important role in oil wells design for drilling operations. It is essential understand the physical principles originating these pressures and evaluate the models of quantification for a particular gepgraphycal area. In this paper, we show the results from our analysis of geopressures in 11 (eleven) offshore wells drilled in the Offshore Area in Gulf of Mexico from PEMEX. Our work focuses in the normal compaction trends using curves of Resistivity Logs. Moreover, the Eaton´s model was regionalized in order to defining the magnitude of the pore pressure with high precision. From those results we inferred that the accuracy of the predictions depends of slope from normal compactions trend. Finally, using the profiles of real pressure data, we built a "Pore Pressure Cube" for the area of study, which simplifies the quantifications of pressures during the process of planning and design of the wells.

Introduction

There are several mechanisms originating abnormal pressures. This phenomenon is related to physical, geological, geochemist and mechanical processes. Frequently is difficult to establish what phenomena is the most important for a particular geological frame due to their dependences in the abnormal pressures origins. Between the causes of abnormal pressures, referred in the literature[1], we picked up the following:

1. Compaction disequilibrium
2. Tectonic stress
3. Aquathermal expansion
4. Mineral transformation
5. Hydrocarbon Generation
6. Thermodynamic effects
7. Osmosis
8. Hydraulic head

From our point of view the main cause cited of abnormal pressure behaviour is sediment compaction disequilibrium. Present work focuses in the identification of compaction changes. Our approach considers Terzaghi[2] theory, and Hottman & Johnson[3] Log Analysis method in order to define changes in the shale compaction trend and we exploit Eaton´s[4] Pore Pressure Equation for resistivity logs. We describe pore pressure results using Eaton equation considering resistivity compaction trends from Mexican offshore wells. Further, we analyze resistivity compaction trends and defined a series of trends that we call "overlay graph" of resistivity trends. Finally, we define a new alpha exponent for Eaton's equation; such changes in the exponent allow us to define pore pressure behaviour with more accuracy, this fact was successfully validated using resistivity logs from several offshore wells.

Pore pressure results with original Eaton's exponent

From previous works in pore pressure prediction to offshore Mexican wells[5,6]. We found that original Eaton equation for resistivity and transit time "overestimate" pore pressure than results obtained from well real measures.

In figure 1, the red line at right, show pore pressure with 1.2 Eaton exponent; green lines; in same figure, show ECD and mud weight used to drill well. We can see that pore pressure is higher than real mud weight.

From this analysis we already verified that when we used original Eaton exponents, predicted pore pressure is higher than real. We considered that those coefficients in the Eaton equation must be adjusted to obtain more accurate results for Mexican Offshore wells.

Resistivity compaction trends analysis

In 1965 Hottman y Johnson[3] developed a relationship between logs response and abnormal pressures in shale. In brief, they were reasoning that well compacted shale rock with less quantity of water (less porosity) is more resistive than a less compacted shale rock. Then they concluded that a sequence of normally compacted sediments should have a normally increasing shale resistivity trend. Then, any shale resistivity decrease from the established normal trend indicates the presence of abnormal pressure zone.

We define from a gamma-ray log the shale points to translate on a resistivity curves for all wells in analysis. In figure 2, we show typical behavior of normal resistivity trend