

# **Origin of Overpressure and Pore Pressure Prediction in Carbonate Reservoirs of the Abadan Plain Basin**

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## **Abstract**

This thesis analyses overpressure throughout the Abadan Plain Basin and evaluates pore pressure in this basin using conventional petroleum industry methods, as well as two new proposed pore pressure prediction methods. Overpressures in the Abadan Plain Basin are primarily exist within carbonates, whereas most previously published overpressure analysis has been undertaken in shale-dominated clastic rocks. Overpressure in this basin is encountered in two main zones, primarily the Gachsaran and Gadvan/Fahliyan formations. South-west to north-east oriented thickening and shortening, as result of Arabia-Eurasia collision, has affected the pressure regime within the Gachsaran Formation, but seemed ineffectual to the Gadvan and Fahliyan overpressures.

In order to analyse overpressure origins and test conventional pore pressure prediction methods, a discrimination scheme was applied to remove the impact of lithology on the log recordings, resulting in isolating the minor shale interbeds within, and as a representative of, the carbonate sequences. Disequilibrium compaction was identified as the primary origin of overpressure in the Abadan Plain Basin. Eaton's (1972) pore pressure prediction method was applied on the filtered shale data with an exponent of 1.0 for sonic velocity, 0.1 for resistivity, and 5 for density data. Bowers' (1995) method was also tested and, while it accurately predicted pore pressure in the Gadvan and Fahliyan formations, it underestimates pore pressure in shallower formations.

This thesis also introduces a new 'compressibility method' for pore pressure prediction, developed by the author, that uses porosity-compressibility correlations. This new 'compressibility method' provided reliable pore pressure prediction results in the studied wells. Alternatively, overpressure as a result of sediment compaction is also estimated using Biot's (1941) general theory of three-dimensional consolidation. A generalised compaction model was constructed, and the resulting modelled pore pressure provides a reasonable estimate of observed pore pressure.

## **Statement**

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## List of Symbols

<b>P<sub>h</sub></b> : hydrostatic pressure	<b>cs</b> : an empirical regional correction factor for unconsolidated sediments
<b>σ</b> : stress	<b>P<sub>h</sub></b> : hydrostatic pressure
<b>σ'</b> : effective stress	<b>σ<sub>v</sub></b> : lithostatic pressure
<b>σ<sub>v</sub></b> : lithostatic pressure	<b>σ<sub>max</sub></b> : effective stress at the onset of unloading
<b>σ<sub>max</sub></b> : effective stress at the onset of unloading	<b>γ</b> : exponent
<b>ρ</b> : density	<b>η</b> : empirically derived constant in Gardner's equation
<b>ρ<sub>b</sub></b> : bulk density	<b>B</b> : empirically derived constant in Gardner's equation
<b>ρ<sub>f</sub></b> : fluid density	<b>α'</b> : a coefficient that measures the ratio of the liquid volume squeezed out to the volume change of the soil in an unconfined loading
<b>ρ<sub>ma</sub></b> : matrix density	<b>α</b> : Biot's poroelastic parameter
<b>ρ<sub>shale</sub></b> : shale density	<b>ν</b> : Poisson's ratio
<b>ρ<sub>normal</sub></b> : density of normally compacted shale	<b>G</b> : shear modulus
<b>g</b> : gravitational acceleration	<b>C</b> : compressibility
<b>z</b> : depth	<b>C<sub>b</sub></b> : bulk compressibility
<b>φ</b> : porosity	<b>C<sub>r</sub></b> : rock compressibility
<b>P</b> : pressure	<b>C<sub>bc</sub></b> : bulk compressibility versus confining pressure
<b>GR</b> : Gamma ray	<b>C<sub>bp</sub></b> : bulk compressibility versus pore pressure
<b>Δt</b> : measured interval transit time	<b>C<sub>pc</sub></b> : pore compressibility versus confining pressure
<b>Δt<sub>ma</sub></b> : matrix interval transit time	<b>C<sub>pp</sub></b> : pore compressibility versus pore pressure
<b>Δt<sub>r</sub></b> : pore fluid interval transit time	<b>C<sub>r</sub></b> : matrix compressibility
<b>Δt<sub>normal</sub></b> : interval transit time of normally compacted shale	<b>Q</b> : a coefficient that measures the amount of liquid that can be forced into the sample under pressure while the volume of the sample is kept constant
<b>R<sub>shale</sub></b> : shale resistivity	<b>1/H</b> : a measure of the sample compressibility for a change in fluid pressure
<b>R<sub>normal</sub></b> : resistivity of normally compacted shale	<b>1/R</b> : measures the change in liquid phase content for a given change in fluid pressure
<b>V</b> : sonic velocity	<b>θ</b> : the increment of liquid phase volume per unit volume of soil
<b>V<sub>normal</sub></b> : sonic velocity of normally compacted shale	<b>q</b> : flow rate
<b>V<sub>0</sub></b> : sonic velocity at the surface	<b>A</b> : area
<b>V<sub>max</sub></b> : sonic velocity at the onset of unloading	<b>k</b> : permeability
<b>V<sub>b</sub></b> : bulk volume	<b>h</b> : thickness
<b>V<sub>p</sub></b> : pore volume	<b>μ</b> : viscosity
<b>P<sub>p</sub></b> : pore pressure	<b>U</b> : unloading parameter
<b>A</b> : Bowers' regional parameters	<b>x</b> : Eaton exponent
<b>B</b> : Bowers' regional parameters	