Sandstone and Shale Compaction Curves Derived from Sonic and Gamma Ray Logs in Offshore Wells, North Slope, Alaska - Parameters for Basin Modeling

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INTRODUCTION

Compaction curves for the principle lithologies are essential input for models of basin history. Compaction curves influence estimates of maximum burial and erosion. Different compaction curves may produce significantly different thermal histories. Shale compaction curves provided by borehole imaging packages may or may not be a good proxy for the compaction properties in a given area. Compaction curves in the published literature span a wide range, and their use may introduce significant errors in thermal history modeling (e.g., Johnson et al., 2002).

An abundance of geophysical data for the North Slope from both government and private sources, provides tools with an unusually good opportunity to develop, compare, and select the most appropriate, regionally consistent compaction curves for the North Slope. In this study we examine North Slope compaction curves from sonic transit time and gamma ray data. The objective of our study is to determine reliable compaction curves for the North Slope that provide appropriate thermal histories.

Here we present two sets of compaction curves derived from sonic and gamma ray data from 19 offshore wells in the North Slope Basin.

METHODS

We used well logs to determine porosity and to characterize compaction properties of sediments in the Mackenzie Delta, Canada. We used the same approach to determine porosity, but additionally we used gamma logs to determine a single value of sonic transit time for each sonic transit time measurement.

Gamma Ray Index (GI) and Thermal Maturity

The GI is calculated with sonic transit time (T) to calculate porosity. The shale fraction is assumed to correspond to the position in the North Slope.

\[ GI = (GR - GR_{min}) / (GR_{max} - GR_{min}) \]

\[ V_{sh} = GI \]

Porosity Calculation

\[ \text{Porosity} = 1 - \frac{t_{max}}{t_{min}} \]

\( t_{max} \) and \( t_{min} \) are the sonic transit times for maximum and minimum porosity, respectively.

\[ \frac{1}{x_{\text{shale}}} + \frac{1}{x_{\text{sand}}} = \frac{1}{x_{\text{matrix}}(1 - V_{sh})} + \frac{1}{x_{\text{matrix}}V_{sh}} \]

\( x_{\text{shale}} \) and \( x_{\text{sand}} \) are the sonic transit times for maximum and minimum porosity, respectively.

\( x_{\text{matrix}} \) is the sonic transit time for the matrix.

\( V_{sh} \) is the shale fraction.

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\[ GI = (GR - GR_{min}) / (GR_{max} - GR_{min}) \]

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