Shear-wave velocity estimation techniques: a comparison

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Summary

Shear-wave velocity prediction techniques are compared for six wells located in Central Alberta. Each well has a full suite of logs, including shear velocity data. The main purpose of this study is to establish calibration guidelines and to examine the limitations of the various estimation methods.

Introduction

The absence of recorded shear-wave data in most cases imposes severe limitations in seismic interpretation and prospect evaluation. Even when shear logs are directly available their quality is often poor. The accuracy of the shear velocity estimation schemes is especially important AVO modeling. Recently, a number of studies have been published on various aspects of deriving accurate shear velocity information (e.g. Reilly, 1994; Armstrong et al., 1995; Henning and Powers, 2000; Li et al., 2000). In this study, the availability of high-quality shear logs provides an excellent opportunity to test and compare the performance of shear-wave velocity estimation techniques.

Methods and results

The most common method of shear velocity prediction is defined by Castagna et al. (1985). The parameters of the linear relationship between V_P and V_S were derived from worldwide data. This empirical relationship became known as the mudrock equation or the "ARCO mudrock line". However, the estimated values from the mudrock line are for water-saturated silicate rocks only. In gas charged zones the mudrock equation underestimates V_S due to the decrease in V_P. Krief et al. (1990) suggested another linear relationship between the squares of P and S-wave velocity. It is important to note that the regression coefficients are different for distinct lithological zones. If lithology logs such as Spontaneous Potential (SP) and Gamma Ray (GR) logs are present, the derived sand-shale trend further constrains the estimated V_S values.

Besides the prediction schemes, local mudrock lines were also derived for each well. The input data for the regression consisted of measured V_P and V_S curves. The results are summarized on Figure 1. For easier overview, the predicted and measured V_S values are displayed using crossplots of V_S and V_P (Fig. 2). In each case the mudrock equation predicted higher V_S values than the measured ones. Excluding the carbonate and pay zones the average RMS error was 21.1 %. The Krief method exhibits comparable prediction errors. The locally-calibrated coefficients are significantly lower than that of the ARCO mudrock line (Fig. 2). Even the local mudrock line predicts the V_S values with an average RMS error of 10.5 %. Using the SP log as a constraint in the estimation scheme, the prediction error was further reduced (8.3-8.9 %).

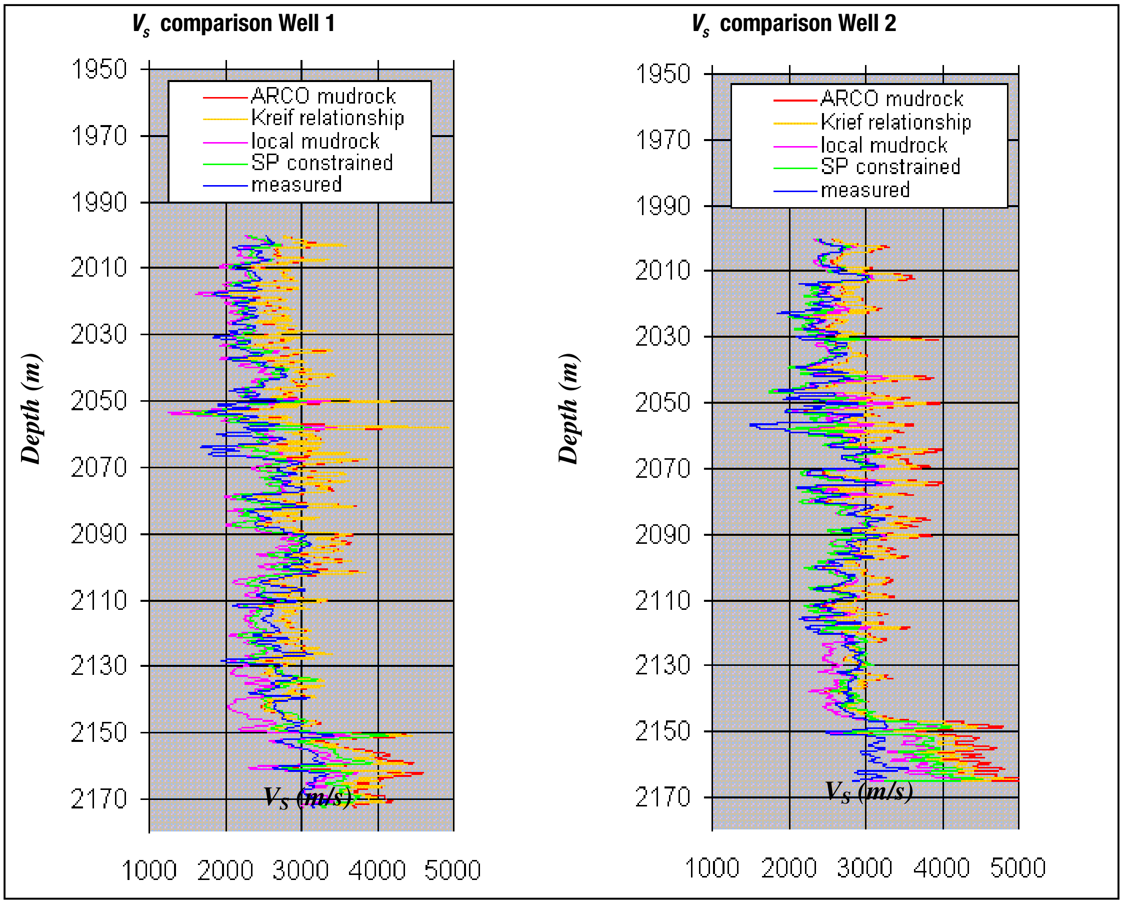

Figure 1: Comparison of shear-wave velocity estimation for wells 1 and 2

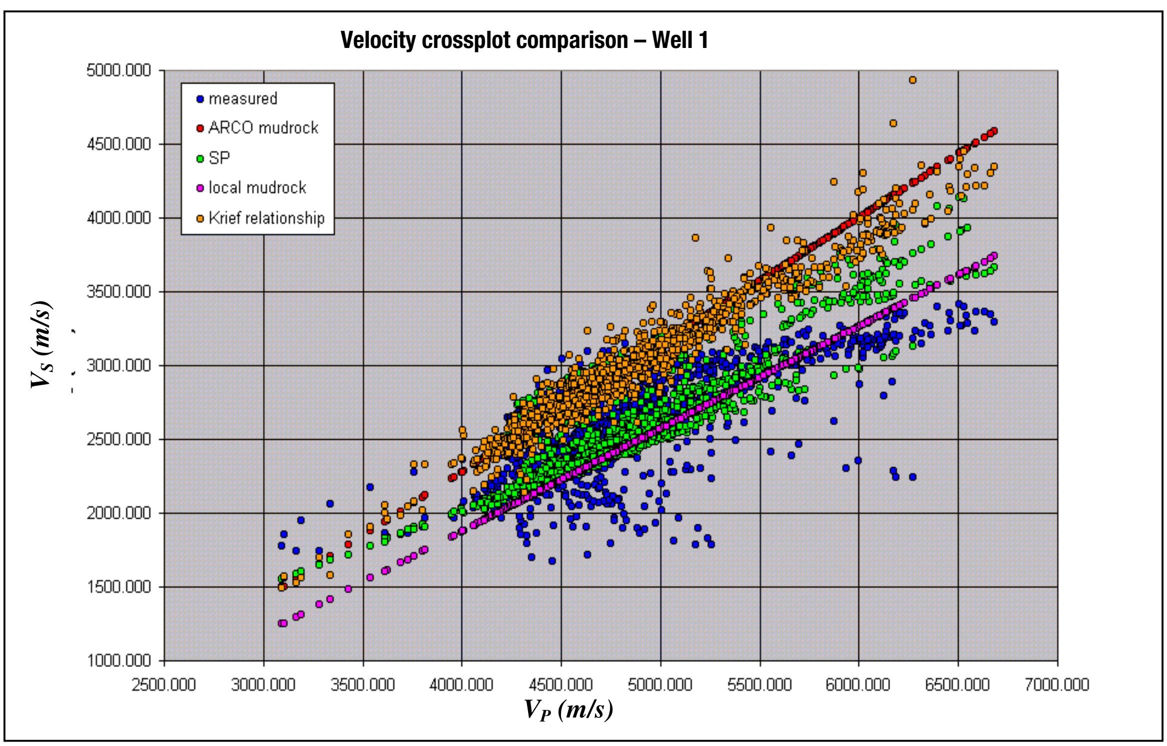

Figure 2: V_P vs. V_S crossplot showing measured and estimated values for well 1

Conclusions

The locally derived coefficients provide closer estimates of the measured values of V_S than that of the global mudrock line. In our comparison, the SP constrained the shear-wave estimation scheme was the most accurate.

Our future work will include applying geostatistical analysis in predicting shear wave velocity. This approach predicts a curve using a multi-attribute transform calculated from the other well logs in the area. The propagation of the S-wave velocity errors to AVO responses will be also investigated.

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