Time-lapse AVO inversion: model building and AVA analysis

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ABSTRACT

A time-lapse model for a small portion of the Pikes Peak area has been built. Elastic parameters are selected based on well logs that are close to the survey area. The synthetic P-P and P-S seismic data generated from the model are being tested by proposed time-lapse inverse algorithms being developed.

The AVA sensitivity analysis conducted in this study assist in calibrating elastic parameters used in building the time-lapse model. The modulus attributes $\lambda\rho$ and $\mu\rho$ computed from sonic logs help in discriminating lithology, while resistivity and porosity logs give an indication about expected fluid type in the reservoir.

WELL LOG ANALYSIS

- The heavy oil in Pikes Peak field is produced from the sand of the Waseca Fm.
- The modulus attributes $\lambda\rho$ and $\mu\rho$ computed from the dipole sonic logs (Fig.1) assist in lithology discrimination.
- Cross-over of porosity logs (Fig.2) indicates gas presence due to CSS process.

BUILDING OF TIME-LAPSE MODEL

- Previous work shows amplitude build-up in the seismic section due to the gas accumulating (gas exsolved from oil phase) due to the (CSS) process.
- The model consists of three layers. Elastic parameters for the top and bottom layers were held constant over lapsed time.
- Elastic parameters of the middle (reservoir) layer was allowed to be varied over three lapsed time. P-wave was decreased at rate of 500m/sec , while S-wave and density values were decreasing at small rate compared to P-wave.
- Figure(3) shows a time-lapse model for a small portion of the Pikes Peak area, while figure (4) is a plot for synthetic logs generated from the model.

AVA REFLECTIVITY MODELLING

- Well log data in combination with Zoeppritz equations are used to model changes in P-P and P-S reflectivity with incidence angle at the top of Waseca formation (Fig. 5). The interface is a shale/sand contact.
- For P-P reflectivity model, critical angles decrease from (~41°) for the base model to (~37°) of the monitoring (2) model in the AVA sensitivity analysis.
- The AVA for P-S reflectivity model shows an increase in critical angle from (~40°) for the base model to (~45°) of the monitoring (2) model.
- No polarity reversal experienced for given angle range for both models

SYNTHETIC GATHERS

- P-P and P-S synthetic gathers for the time-lapse model are generated using CREWES "SYNGRAM" tools. Simulated gathers are the result of convolving a Ricker wavelet of (60Hz) dominate frequency with AVA reflectivity series.
- Synthetic P-P and P-S gathers (figures 6-8) are in consistent with AVA reflectivity modeling.
- Amplitudes build-up are obvious in produced gathers of monitoring models that simulate accumulated gas, which exsolved from oil-phase due to the CSS process.

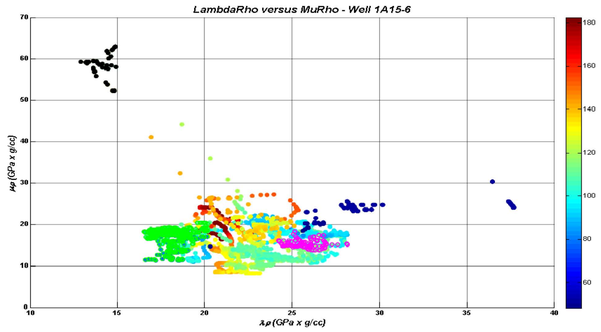

FIG. 1. *LaméRho* versus *MuRho* for Well 15A-6, Pikes Peak field. Data are colored by Gamma ray. Data for upper Quaternary, Viking, and Waseca formations are colored in solid green, black and magenta respectively .

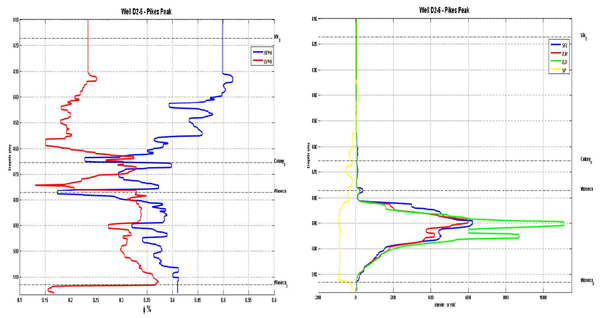

FIG. 2. Well D2-6: Left: Neutron- & density- porosity logs. Right: Resistivity & SP logs.

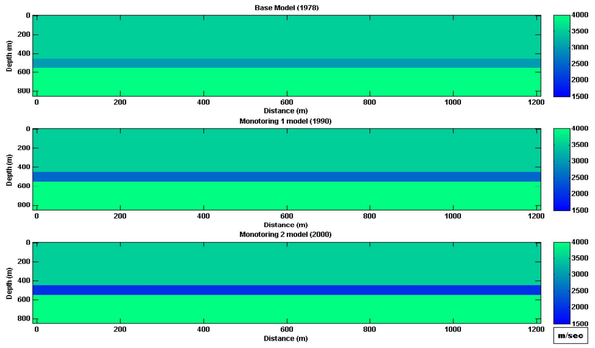

FIG. 3. Time-lapse model for the Pikes Peak field.

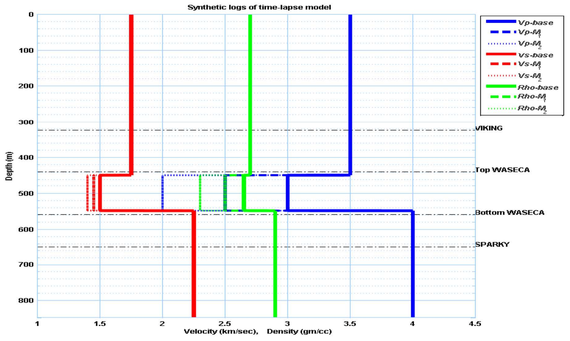

FIG. 4. Synthetic logs for the time-lapse model , Pikes Peak field.

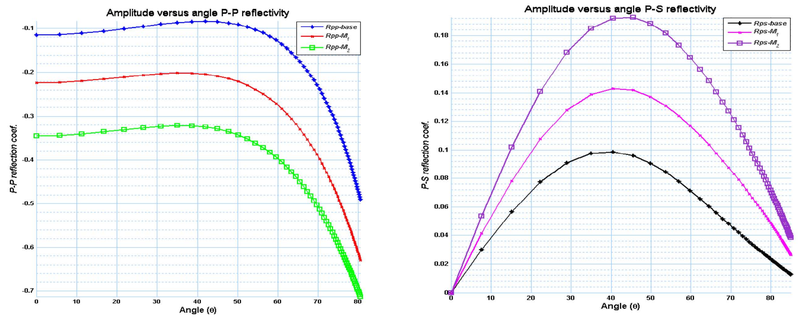

FIG. 5. AVA modelling of P-P and P-S reflectivity for the top and reservoir layers of time-lapse model, Pikes Peak area.

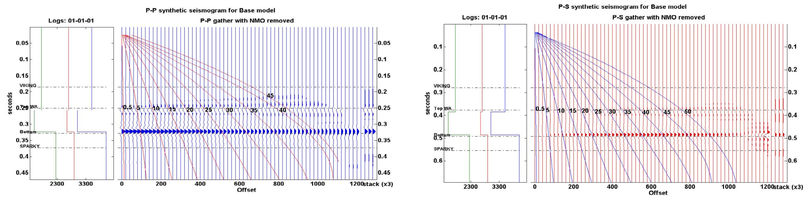

FIG. 6. Synthetic P-P and P-S gathers for the base model of the Pikes Peak field.

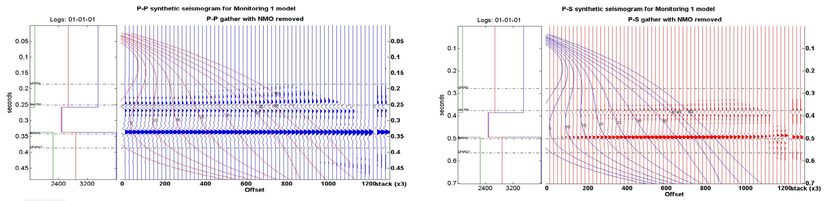

FIG. 7. Synthetic P-P and P-S gathers for the monitoring (1) model of the Pikes Peak field.

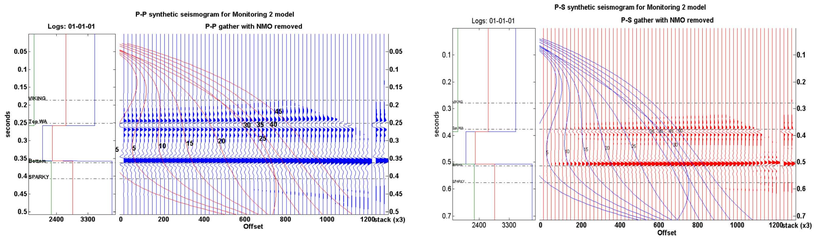

FIG. 8. Synthetic P-P and P-S gathers for the monitoring (2) model of the Pikes Peak field.

FUTURE WORKS

- Computer algorithms for time-lapse AVO inversion are being developed. Synthetic P-P and P-S gathers generated in this study being tested.
- Different constraints are to be used by the proposed inverse schemes in order to test their effectiveness in estimating reflectivity attributes.
- The accuracy of building the time-lapse model will be further investigated using Biot-Gassmann fluid substitution.

ACKNOWLEDGMENT

Authors would like to thank Ken Hedlin of Husky Energy for providing well logs, and all of CREWES sponsors for their financial support.