Data-driven Rock-Physics inversion of Seismic Pre-Stack data for CO_2 Monitoring

King Abdullah University of Science and Technology
جامعة الملك عبدالله للعلوم والتقنية

Miguel Corrales, Matteo Ravasi, Hussein Hoteit.

Deep Imaging Group (DIG), Physical Science and Engineering Division (PSE), KAUST

Deep imaging group

ABSTRACT

Due to the high global energy demand, CCS and CCUS projects became targets to mitigate net CO_2 emissions. In this context, we are facing the need to characterize and monitor the CO_2 plume in saline aquifers. Our study aims to obtain the petrophysical properties of a reservoir before and during carbon dioxide injection. To achieve this, we propose a data-driven approach to rock physics inversion that uses a rock-physics model with optimal basis functions to invert band-limited seismic data for rock properties directly. Our new approach promises to be more robust and efficient than the traditional two-step-inversion process from the seismic gather to elastic parameters and then petrophysical properties.

INTRODUCTION

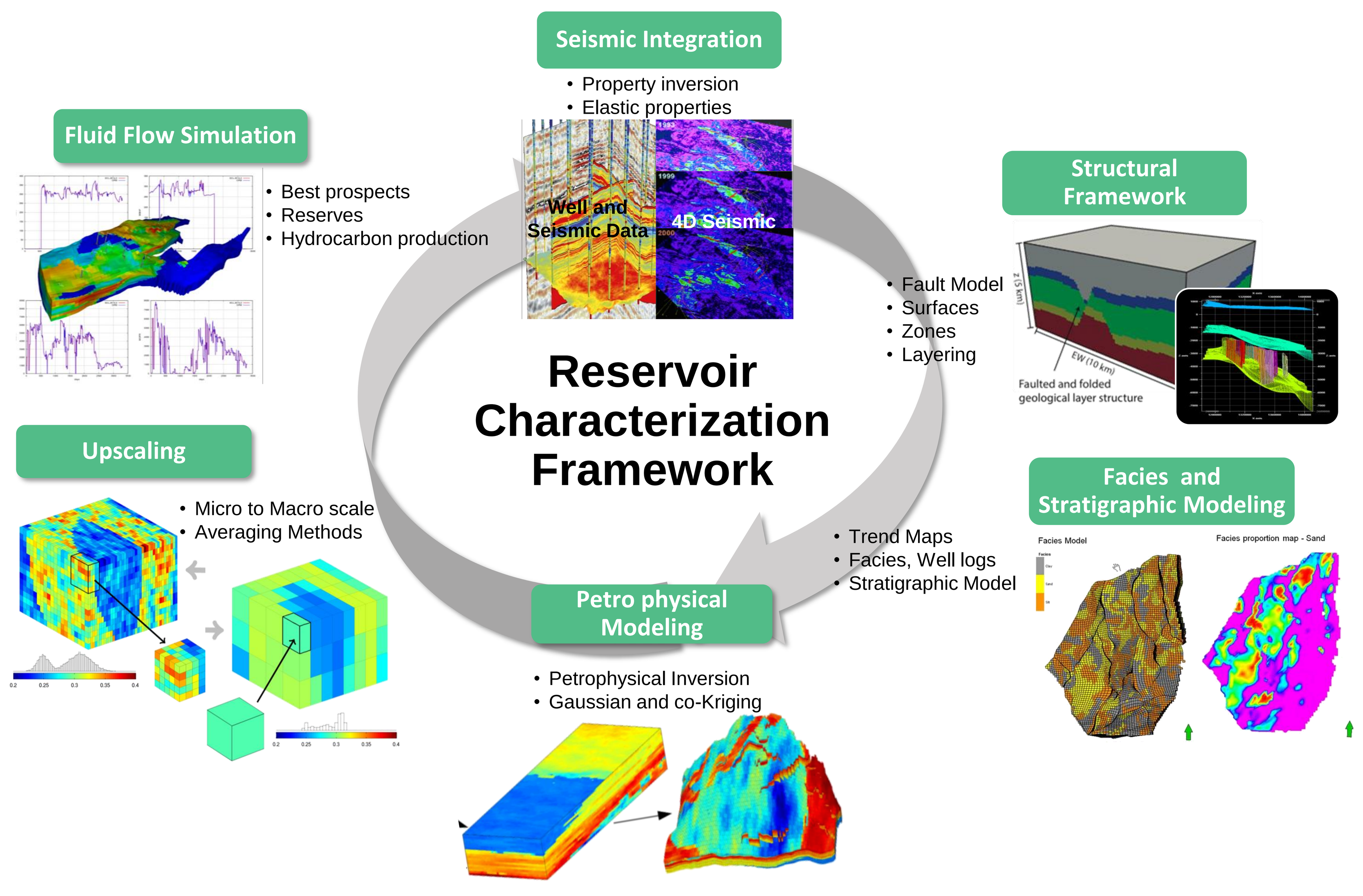
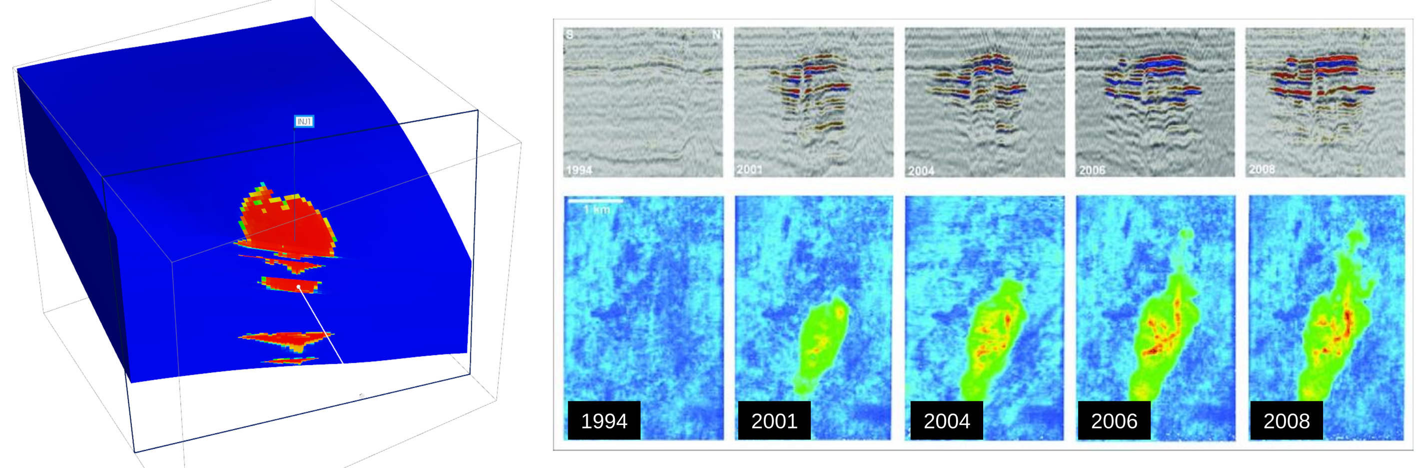


Figure 1. Reservoir characterization framework. The elastic and petrophysical properties inversion are the main objective of this study.

CO_2 Monitoring Approach



Schematic of CO_2 injection　　CO_2 Plume Migration - Sleipner

Figure 2. CO_2 monitoring approach to estimate the petrophysical properties from a seismic gather.

WORKFLOW

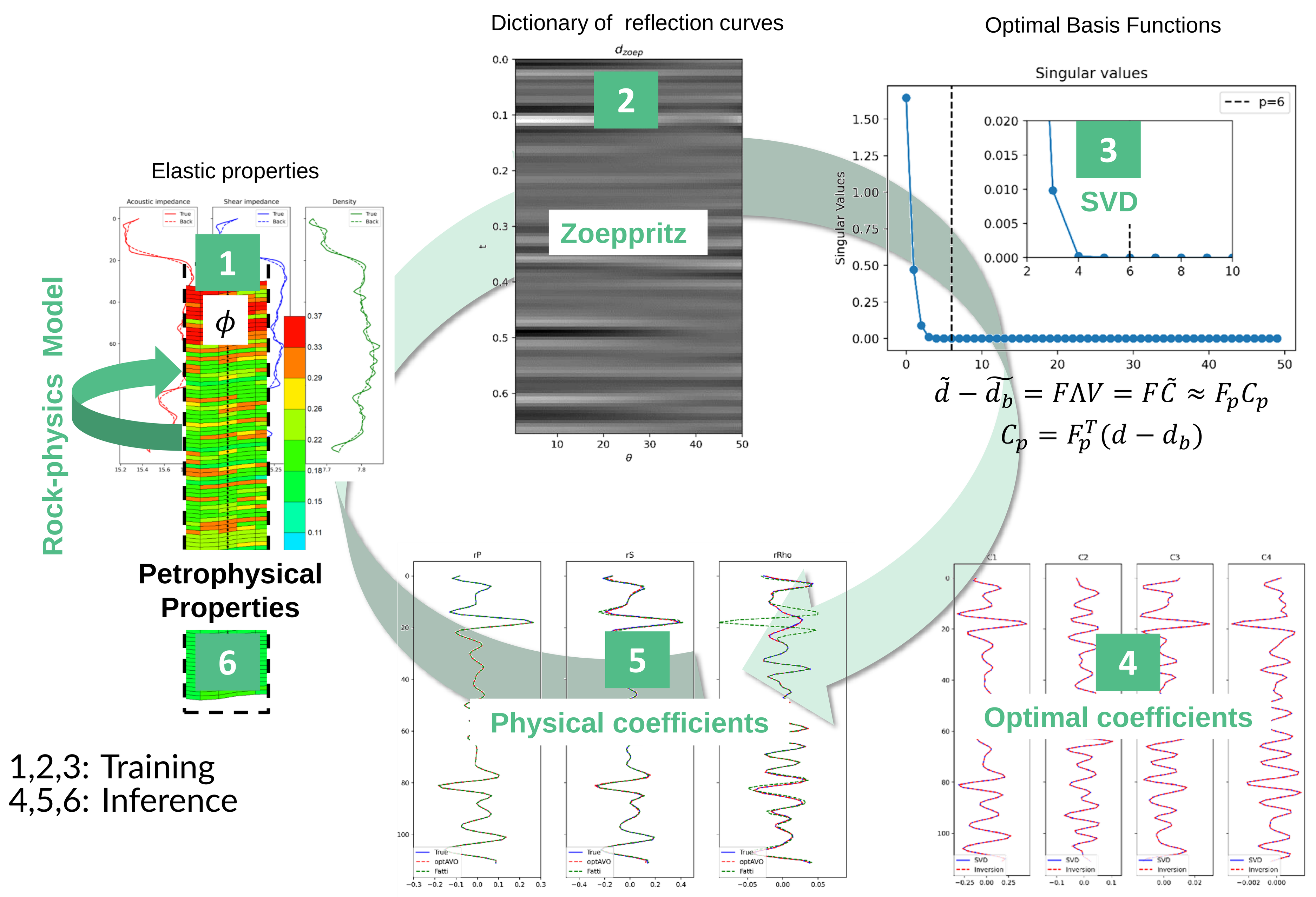


Figure 3. Proposed workflow to obtain the Optimal Basis functions coupled by Rock-physics model.

EXAMPLE DATA-SET

2D Profile -Smeaheia Dataset (Gassnova and Equinor)

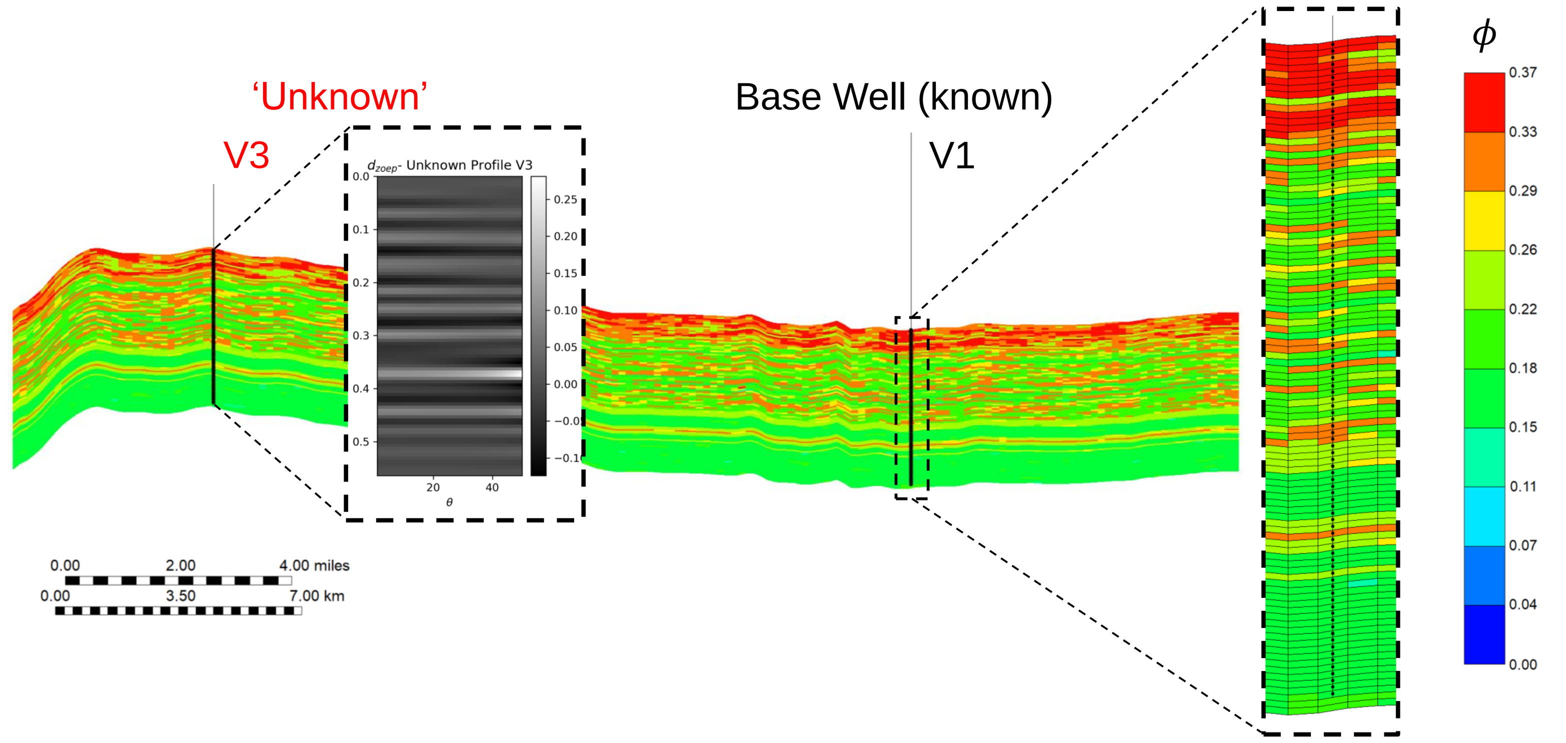


Figure 4. Example data-set for petrophysical inversion, 1D and 2D examples.

RESULTS

1D Results

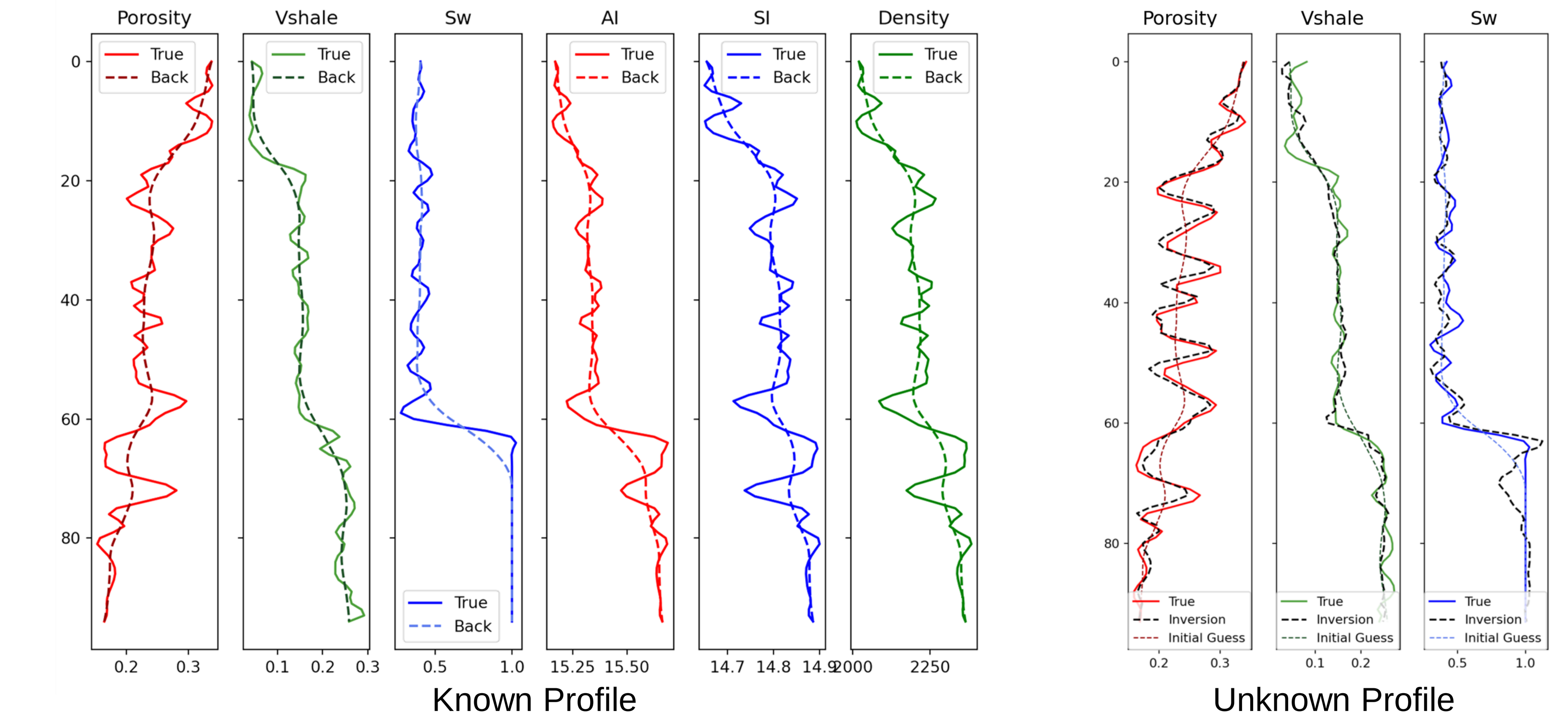


Figure 5. Petrophysical inversion for 1D profile. The known properties correspond to ϕ, V_{sh}, and S_w and the elastic parameters are derived using a Rock-physics model.

2D Results

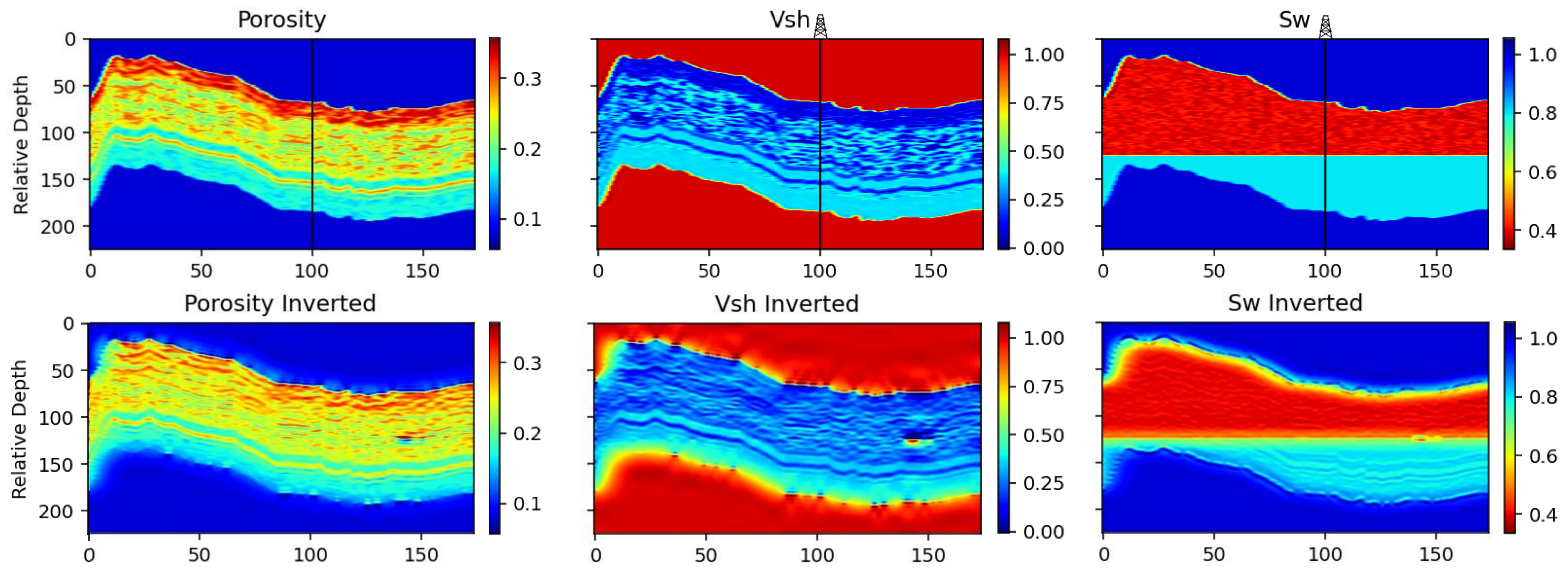


Figure 6. Petrophysical inversion for 2D profile.The black vertical line represents the 1D profile used to obtain the optimal basis function to reconstruct the complete 2D section.

CONCLUSIONS

We have presented a fast and accurate methodology to invert pre-stack seismic data for petrophysical properties directly. Some of the distinguishing features of our methodology are:

- Direct recovering of petrophysical properties.
- Valid for strong contrasts and high angles.
- Reduced need for regularization parameters.
- Computational cost reduced.

However, being this a data-driven approach, the optimal basis functions are expected to perform poorly when used to extrapolate to unseen geological settings.