Integrated Fracture Characterization and Associated Error Evaluation Using Geophysical Data for Unconventional Reservoirs*

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Abstract

This study discusses a new workflow for fracture characterization using microseismic and seismic data along with independent reservoir information (such as well log data). The framework is ideally suited for unconventional environments such as Monterey Shale where modern technologies such as the use of hydraulic fracturing and passive seismic monitoring allow application of the proposed workflow.

In this article, we demonstrate how reservoir property estimates can be made from such studies by using an artificial neural network (ANN) based property modeling approach to independently combine the different properties estimated from passive seismic data (such as phase velocities and associated rock properties) as well as property maps obtained from conventional seismic data using attribute analysis. New fracture identifier properties have been defined and the models have been used to characterize fracture zones, reservoir connectivity and reservoir compartmentalization for a representative unconventional reservoir. Production/injection trends have been used to validate the said observations. In order to circumvent the issue of data with multiple scales (low resolution passive and high resolution active data), Sequential Gaussian Simulation (SGS) has been used to improve the final property estimates and independently, error analysis has been carried out to better quantify the final results and enhance definition of the uncertainties in the analysis and interpretations made.

The proposed method allows for improved understanding of shale and other unconventional reservoirs through fracture mapping (Figure 1) and provides a workflow for improved volumetrics of the reservoir through the use of reservoir simulators and history matching. It also provides a valuable framework for pseudo 4D characterization where a single 3D seismic survey can be used as the basis to characterize the reservoir in time lapse fashion using new information collected in time through passive seismic data as well as new well logs being obtained.

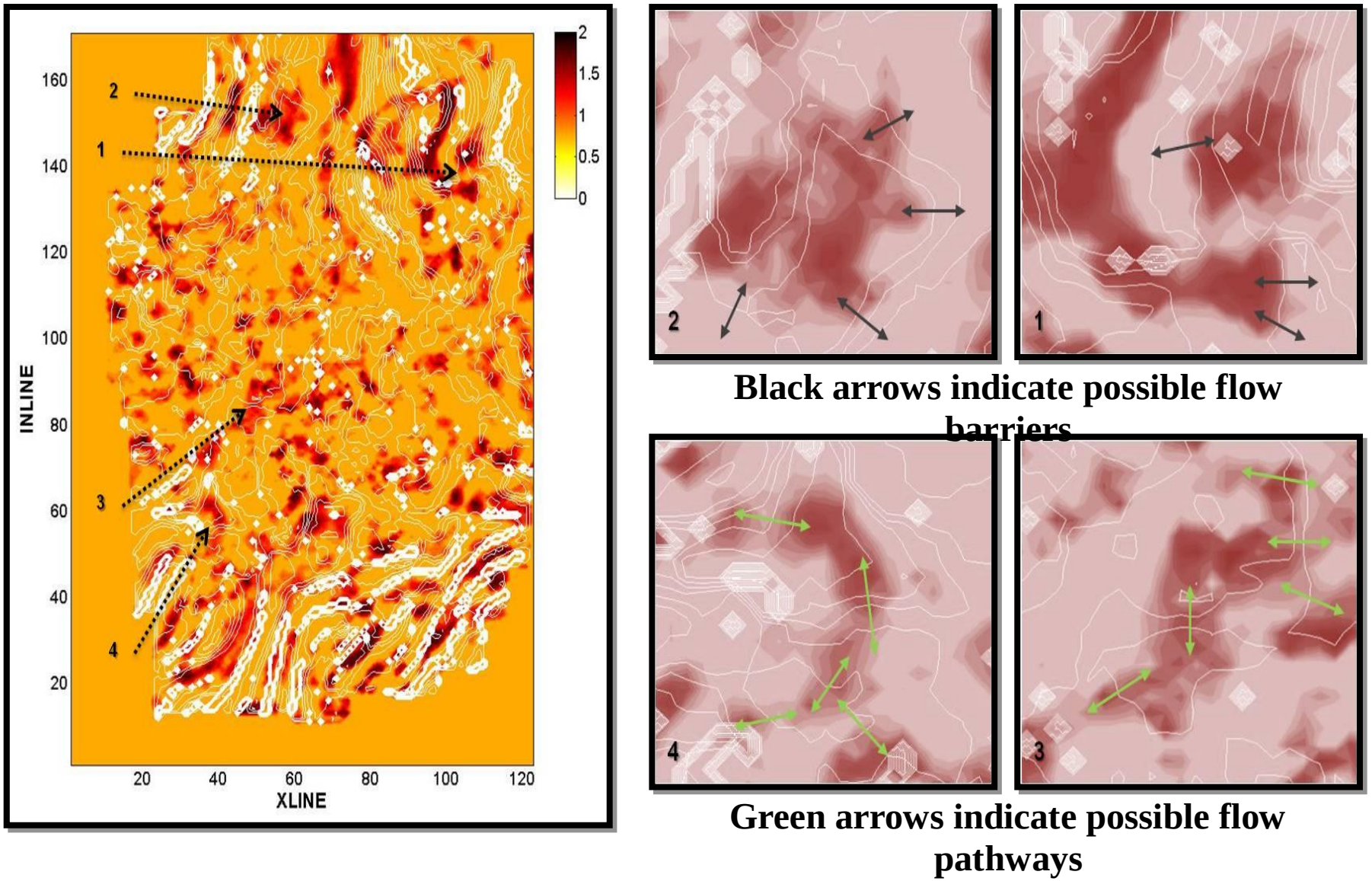

Figure 1. Fracture Zone Identifier (FZI) attribute and edge discontinuity maps (1000 m from reference) with reservoir connectivity analysis.