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Quantitative Integration of 3-D Seismic Data, Geological Information, Production Data, and Well Logs into Hydrocarbon Reservoir Models Amenable to Dynamic Prediction of Fluid Production

We have developed a set of computer algorithms for the efficient and consistent integration of 3-D seismic data, well logs, geological information, and reservoir production data, into petrophysical models that can describe and predict the static and dynamic behavior of hydrocarbon reservoirs. Integration of measurements is achieved in the form of a quantitative 3-D cellular petrophysical model that is readily amenable to numerical simulation of multi-phase fluid flow under specified production regimes. Data integration and model update are performed via global inversion techniques driven by joint probability density functions (PDFs) governing the link between the underlying petrophysical model and the seismic elastic parameters. The inversion algorithms make explicit use of both post- and pre-stack 3-D seismic data. However, the main thrust of our work is to constructively integrate the lateral amplitude variations of 3-D pre-stack seismic data with the high vertical resolution available from well logs. To our knowledge, currently there is no such algorithm available to the oil industry. Examples are shown of the performance of our inversion algorithms when applied to synthetic reservoir models and noisy production and 3-D seismic data. These examples provide a quantitative assessment of performance, construction, stability, and non-uniqueness for the inversion algorithms in the presence of noisy data. Finally, we show preliminary results of the application of our inversion algorithms to the construction of a static reservoir model using a complete data set acquired in an active, hydrocarbon-producing field in the Gulf of Mexico.