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A Highly Parallel Billion Cell Basin Simulator

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ABSTRACT

Basin modeling, also known as petroleum system modeling, tracks the evolution of a sedimentary basin and its fluid content over geological time scales of hundreds of millions of years. It has become an invaluable tool for the exploration geoscientists to assess risks before drilling exploratory wells. In this work, we have developed a highly parallel basin simulator to model large basins with fine-grid resolution. The simulator includes the modeling of the generation, expulsion, migration, and trapping of hydrocarbons using a grid as fine as a reservoir simulation grid. The massively parallel simulator is capable of running basin models with billions of grid cells covering over half a billion years of geologic history in a few hours using the Darcy migration method. The in-house basin simulator has been developed by taking advantage of the data structures and several parts of an existing parallel reservoir simulator. It uses unstructured grids, handles erosion, and takes into account hundreds of different lithological facies. The simulator currently uses a black-oil fluid description with capillary and gravity forces, plus multiple relative permeability and pressure, volume, temperature (PVT) regions. Two types of hydrocarbon migration models have been implemented: Darcy and Invasion Percolation. Due to the uniqueness of the new algorithm, both methods run nearly at the same speed. The developed simulator has been implemented on real cases involving complete horizontal and vertical heterogeneity with nearly 350 lithology types and 550 million years of basin evolution, formation of layers, hydrocarbon generation, migration and trapping using grid block dimensions varying from 1000 m down to 250 m areally, which are the reservoir simulation grid sizes for large systems. The simulator has been successfully applied to simulating gigantic basins with fine grids and long depositional history.