REVIEW ARTICLE

Challenges and Technologies in Reservoir Modeling

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Abstract. Reservoir modeling is playing an increasingly important role in developing and producing hydrocarbon reserves. In this paper, we provide a brief overview of some main challenges in reservoir modeling, i.e., accurate and efficient modeling of complex reservoir geometry and heterogeneous reservoir properties. We then present modeling techniques we recently developed in addressing these challenges, including a method for generating constrained Voronoi grids and a generic global scale-up method. We focus on the Voronoi gridding method, which is based on a new constrained Delaunay triangulation algorithm and a rigorous method of adapting Voronoi grids to piecewise linear constraints. The global scale-up method based on generic flows is briefly described. Numerical examples are provided to demonstrate the techniques and the advantage of combining them in constructing accurate and efficient reservoir models.

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Contents

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1   Introduction

The upstream oil industry involves finding hydrocarbon deposits, developing them, and producing the hydrocarbons for commercial use. Over the past few decades, numerous technological advances in the oil industry, e.g., remote detection and identification of hydrocarbons, extended reach drilling, and polymer flooding, have increased the success rate of finding reserves, made it possible to develop them and improved the recovery from existing resources. In addition, advances in computing capabilities have enabled geologists and engineers to model the reservoirs with increasing accuracy. In order to meet the ever increasing global hydrocarbon demand, heavy capital investments and continuous technological advances are required.

Various technologies used to understand a prospective reservoir provide information at many different scales. Core plugs are a few inches in size. Well logs can detect properties within a few feet around the well. Seismic imaging covers a huge volume, but its typical resolution is limited to a few meters vertically and tens of meters horizontally. Limited by time and capital, direct sampling of reservoir rock and fluid properties is sparse. Therefore, geologic interpretations based on seismic information and understanding of sedimentary processes are used to interpolate or extrapolate the measured data in order to yield complete reservoir descriptions. Information provided by these technologies is incorporated into reservoir models. Constructing reservoir models has become a crucial step in resource development as reservoir modeling provides a venue to integrate and reconcile all available data and geologic concepts.
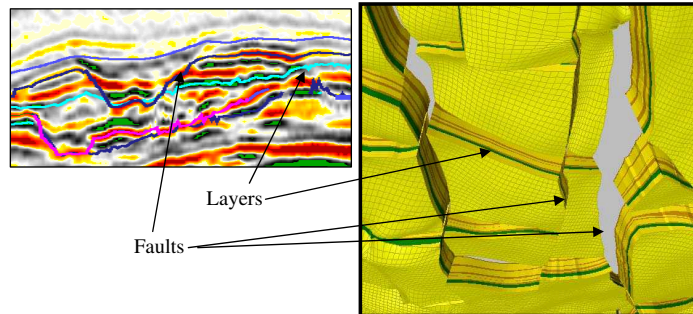

Figure 1: Subsurface structural geometry: faults and stratigraphic layers. Left: seismic image of subsurface. Right: reservoir model with multiple faults.

One of the key challenges in reservoir modeling is accurate representation of reservoir geometry, including the structural framework (i.e., horizons/major depositional surfaces that are nearly horizontal, and fault surfaces which can have arbitrary spatial size and orientation), and detailed stratigraphic layers (Fig. 1). The structural frameworks delineate major compartments of a reservoir and often provide the first order controls on in-place fluid volumes and fluid movement during production. Thus, it is important to model the structural frameworks accurately. However, despite decades of advances in