SPE 115324

Model Building with Difficult Faults

K.S.Hoffman, SPE, J.W. Neave, and E.H. Nilsen, Roxar, Inc.

This paper was prepared for presentation at the 2008 SPE Annual Technical Conference and Exhibition held in Denver, Colorado, USA, 21–24 September 2008.

Abstract

Many of the commonly used fault modeling techniques can adequately handle simple structures – even when those structures contain large numbers of faults. It is not the sheer number of faults that is often the stumbling block, but rather the complexity of the fault/fault relationships. Common configurations such as a Y intersection formed by a synthetic/antithetic fault pair can be difficult to model due to the limitations of the framework-building technique. Often the truly difficult situations, such as listric faults, low angle faults, or crossing conjugate faults, are not even attempted – which means that the resulting reservoir models do not correctly represent the subsurface.

Our technique for building a fault framework provides a comprehensive solution for modeling any type of fault shape or fault intersection. Listric faults and Y-intersections, for example, must be treated as special cases with pillar-based methods, and a nested-Y structure is nearly impossible to model with this technique. Low angle faults and low angle intersections also pose problems for pillar-based methods; the low angle intersection can distort the shape of one or both faults. Crossing conjugate faults can create half-Y faults, which neither the pillar method nor the binary tree method can model.

The concept of compound relationships used in our approach, where faults are divided into sections based on their relationships with all faults which touch or cross it, allows independent manipulation of each small section of a fault. In this way, even the complex truncations of crossing conjugate faults are easily handled. The solid models and reservoir grids that are created based on these frameworks incorporate all of the complexity of the interpretation. These models provide a better basis for reservoir management decisions and can be shared by all of the disciplines within an asset team.

The advances in fault modeling shown here provide a comprehensive solution to handle all type of faults and fault intersections without any of the compromises previously necessary. The flexibility of the technique reduces cycle time for building the framework and allows for more in-depth investigation of reservoir properties.

Introduction

One of the common workflows used in exploration and production today is to build a three-dimensional computer model of a field or basin. This model – or sometimes, a series of models – may have several purposes: to understand and communicate the structural framework, distribute facies or petrophysical properties, calculate volumetrics, use as a basis for well planning, or use for reservoir simulation, to name just a few purposes. The key component in all of these applications is the basic structural framework; all subsequent calculations depend on it. Although this would appear to be an obvious point, shortcomings in framework-building software often result in models that are a simplification of the true structure.

Some of the techniques used for creating a three-dimensional fault network were originally designed based a certain set of assumptions that are no longer valid – for example, that all faults are normal, that only thin reservoir sections would be modeled, or that only a limited number of faults would be used. This has led to a situation where certain types of fault configurations or geometries are treated as special cases. In some circumstances, the application of such special-case methods or the work-arounds necessary to force the modeling to honor the interpretation are too complicated or time-consuming to include in an “evergreen” workflow – one that must be continually updated as new data become available. One of the “solutions” is often to simplify the model – to leave faults out, or to modify the faults so that the special-case scenario is avoided. This of course has a deleterious effect on the subsequent modeling; the removal or modification of faults can affect the distribution of properties and the compartmentalization of the reservoir. Achieving a history match during flow simulation may require changes to the simulation model that have little or no basis in the geologic model, changes which are done simply to recapture the effect of faults that had been removed or modified in the structural framework. In that case, not only are the geological and simulation models a poor representation of the subsurface, but the models may also conflict with one another.