3-D Geocellular Modeling

INTRODUCTION

Production geologists are increasingly using computer-based, 3-D geocellular modeling packages to represent the reservoir geology. The models replicate the 3-D structure of the reservoir, with the stratigraphic envelope, reservoir sublayers, and faults all represented in three dimensions. The reservoir volume is divided into a 3-D mesh of cells, a typical geocellular model having hundreds to millions of cells in it. Typical cell dimensions in models are about 0.5–2 m (2–6 ft) thick and 50 × 50 m (164 × 164 ft) areally.

For each cell, a lithofacies type and rock properties such as porosity can be assigned. Geostatistical applications allow the entire 3-D grid to be populated with values extrapolated from well control. A cell gets a single value for each reservoir property only. It is also possible to calculate new attributes within a model using appropriate equations. Thus, for instance, the oil in place for each cell can be calculated using the rock and fluid properties assigned to it. The computer can then calculate the oil in place for the entire reservoir by summing up the values in all the cells.

WHY 3-D MODELS ARE REPLACING A 2-D REPRESENTATION OF THE RESERVOIR

Formerly, the main method of representing the reservoir geology was to map the structure and rock properties in two dimensions using mapping software. The use of 2-D mapping is a crude method of capturing the reservoir geology. It is impractical to represent small-scale heterogeneity with 2-D isochore maps as it would be necessary to produce a large number of maps to do so. Similarly, the rock property maps are grossly simplified. The mapping algorithms use an averaging method to interpolate values between the wells, and, as such, any small- to medium-scale reservoir variation is mostly lost. By contrast, the cellular nature of 3-D models allows a heterogeneous reservoir to be given a chopped up rough-looking character between the wells.

THE GRAPHICAL BENEFITS OF 3-D MODELS

Once a 3-D model has been built, it is possible to display the various reservoir surfaces, faults, and wells on the computer screen in 3-D graphics. These can be selected, moved, and rotated in 3-D using the computer mouse cursor. There is something remarkable about the ability to visualize the structure of the reservoir so easily on a computer. It is an excellent tool for showing non-geologists in the company what the reservoir looks like. 3-D reservoir models aid communication between the disciplines. Those who are not inducted into the mystery of geological jargon or who do not share the geologist’s innate spatial ability to look at 2-D images and see them in their 3-D context can still visualize and understand the major subsurface issues by looking at these models. Many of the larger companies have a dedicated visualization room where 3-D models can be inspected on a large display screen. These have a particular benefit for well planning, often reducing the time taken for this by a significant amount. Many packages also allow interactive well planning with instant visualization of the chosen well path (Figure 133).

Any item of data can be displayed on the screen by 3-D modeling software, including isochores, facies, and rock property grids. Well correlations can also be brought up on screen along with the various horizon tops picked by the geologist. Seismic data can be imported and shown in 2-D and 3-D. Statistical applications are provided for the analysis of rock properties and for applying arithmetical and logical operations on the data.

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