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Title Building Geostatistical Models Constrained by Dynamic Data - A
Posteriori Constraints
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Preview Abstract

This paper describes one solution to the problem of constraining geostatistical models by well-test results which has been obtained within the frame of the HELIOS research project conducted by Elf and IFP in the field of reservoir engineering.

To do so, a numerical simulation program devoted to the simulation of well-tests has been coupled with a nonlinear constrained optimization program to make an inversion loop. The resulting software package provides the reservoir engineer with a tool to compute the set of optimal facies or rock-type properties and the well skin which give the best fit between the simulated and the measured well pressure during the test duration. Any petrophysical facies or rock-type property can be assigned either a constant value everywhere or a Gaussian distribution defined by its mean and its standard deviation.

On one hand the numerical program is able to compute not only the pressure and its derivative but also the gradients of this pressure with respect to the petrophysical facies or rock-type properties and with respect to the well skin. The gradients used by the optimization program to control the search algorithm can also be used as a stand alone diagnosis tool to analyze the simulation results.

Several examples are given which show the efficiency of the various algorithms. These examples also demonstrate the wide range of applicability of the software package to analyze and to interpret well-tests as well as to integrate dynamic data in geostatistical modeling.

As a conclusion, the paper sets forth several new research axes to extend this work toward the inversion of the shape of the geostatistical images themselves.

Introduction

Geostatistical modeling of reservoir heterogeneity is now widely used by geoscience engineers to fill in reservoir simulation grids. These geostatistical models are made of facies pixels or geologic objects and are built by using simulation algorithms that reflect the main statistics of the geology of deposits. Integration of dynamic data together with the geology enhances the quality of the geostatistical modeling and provides the reservoir engineer with a better basis for reservoir simulation and management. The uncertainty of simulated production scenarios is then reduced, allowing more realistic economic evaluations.

In this paper the dynamic data considered are restricted to well-test results. However, the tools and the methodology presented here apply to other dynamic data including field-production data.

The problem of constraining geostatistical simulation by well-test results can be considered in two different ways:

- The geostatistical simulation algorithm can be modified in order to integrate the dynamic data into the numerical processing. The purpose is to generate a facies model that features a given average permeability within the investigation area of each well. Several attempts have been presented, which use simulated annealing or sequential simulation. This is an "a Priori" process.
- Once a geostatistical grid has been generated, the petrophysical parameters of the grid can be computed so that the corresponding numerical well-test model matches the well-test behavior. This is an "a Posteriori" process that applies to pixel or objet based geostatistical modeling as well as to deterministic modeling. More generally, the inverse problem of finding the field properties such as permeabilities and porosities by matching the field behavior is known as History Matching and has received a great deal of attention for long time.