Integration of seismic reflection and production data in a geostatistical history matching procedure.

Amilcar Soares  
CERENA, Instituto Superior Técnico, Universidade de Lisboa.  
asoares@tecnico.ulisboa.pt

Subsurface Earth models created during the exploration phase usually accounts for geological knowledge, seismic reflection data and, eventually, well-log data. At the posterior field development phase these reservoir models are updated with production data using history matching procedures. In this traditional approach of reservoir characterization the integration of each type of data is usually performed sequentially in separate and independent workflows, commonly designated as seismic inversion and history matching.

The objective of this paper is to propose a geostatistical approach to integrate geological knowledge, seismic, well-log and production data by coupling both geostatistical seismic inversion and history matching in a unique and coherent model.

Geostatistical seismic inversion is an iterative method to produce a geological consistent subsurface model of elastic properties, porosity, rock facies, which match the real known seismic data. In each iteration, those properties are perturbed (stochastic simulation and co-simulation) until the match is reached through an optimization method based on genetic algorithms driven by the mismatch between real and synthetic seismic reflection data produced during the iterative inversion procedure.

History matching is a highly non-linear inverse problem where the parameters - porosity, permeability, facies - are perturbed until the reservoir’s dynamic response, at the wells locations, have a satisfactory match with the known production data. Geostatistical history matching is one particular class of methods where the perturbation is performed with stochastic simulations and co-simulations to guarantee the geological consistency of the final solutions.

Both iterative inversion methods share a common perturbation framework: in each iteration the properties - velocities, porosity, facies - are co-simulated conditioned to an auxiliary image with the selected “best” parts of previous iteration within the reservoir grid. Capitalizing on this property, this paper proposes a new iterative geostatistical methodology for history matching conditioned to seismic reflection data.

In each iteration, a set of realizations of acoustic impedances (or other elastic property) are simulated. Porosity and permeability cubes are co-simulated with the previous simulated acoustic impedance as secondary variable. The acoustic impedance cubes follows the seismic inversion workflow and each pair of porosity and permeability feeds the geostatistical history matching. The new proposal of this study consists on a joint selection of “best” realizations based on the deviations of both inverse methods, represented in a factorial space (MDS or PCA).
With this approach the final inverted Earth models are geological consistent, and match simultaneously the production data and while generating synthetic seismic reflection data that matches the real seismic. A case study illustrate the proposed joint inversion method.