GEOLOGICAL REALISM CONTROL IN THE PROCESS OF OIL AND GAS FIELD MODELS AUTOMATIC HISTORY MATCHING

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Geological and hydrodynamic simulation is process of computer models, creating of which are used to simulate fluid flowing (generally oil, water and gas) through porous media. Models are used by oil and gas companies when deciding on the developing new oil or gas fields in order to evaluate their investment attractiveness, also to forecast fluid production and reservoir pressure distribution by the way of development strategy choosing. Modeling is associated with a number of problems and limitations. Firstly, field model, creating and correction, is a time-consuming process, which includes many inputs (coring) which are very expensive. This process named adaptation. In addition, the models are based on data full of uncertainties, among which facies distributions, seismic, production data. Taking into account these uncertainties, the model (geological and hydrodynamic) needs correction, which becomes possible with the appearance of reference data in the form of information on the production of fluids, water cuttings, reservoir pressures, wells or wellheads, etc. This process is called history matching. History matching of production required, reducing the value of the objective function (irrelevance square between measurements and modelling results). In developing automated computing tools, this process of history matching has become possible.

There are two ways of history matching, the first way is deterministic and second is stochastic. Deterministic methods include traditional optimization approaches. One optimal model of the hydrocarbon field can be obtained by using deterministic methods. The objective function gradient and his direction are computed during history matching and after one single solution can be found. However, automatic history matching is an inverse problem of modeling, and there may be several model realizations that satisfy the history of field development. Thus, finding a single solution often excludes finding the right solution, and this can be adversely demanding on the further results of decisions.

Stochastic methods require significant computing costs, but stochastic algorithms have wider distribution due to the rapid evaluation velocity of computer calculations. These methods have three major advantages:

- In the result of history matching, one series of the equally possible realizations is created and all of these realizations can be physical and geological defensible.
- These methods allow forecasting uncertainties of prediction by comparing model results of all realizations.
- The interesting representative model lies between all realizations.

The most wide using stochastic algorithms [5]: (Simulated Annealing); (Genetic Algorithm); (Polytope); (Scatter & Tabu Searches); (Neighborhood (Kalman Filter).

One of the realizations of the software product for auto-adaptation is Raven (created by the division of Epistemy Ltd. University Heriot Watt). Stochastic methods of automatic history matching are used by Raven. It allows automatically history matching and evaluating assess of the degree of uncertainty of the data. Software testing is carried out by specialists of Petroleum Learning Center at the National Research Tomsk Polytechnic University.

Consider the process of synthetic history matching model of water-oil production and bottom hole pressure with 1 production and 1 injection well. [6] Stochastic methods history matching are used in the Raven Software. Approximately 10000 iterations were applied on small model and five the best iterations were sampled. Amount of iterations is controlled by the user. History matching was based on the water and oil current production rate, bottom-hole pressure for the production well and at the current water injection rate and bottom hole pressure in the injection well (Fig. 1). Adaptable parameters are the thickness of the interlayers, vertical and horizontal permeability, phase permeability, skin factor.

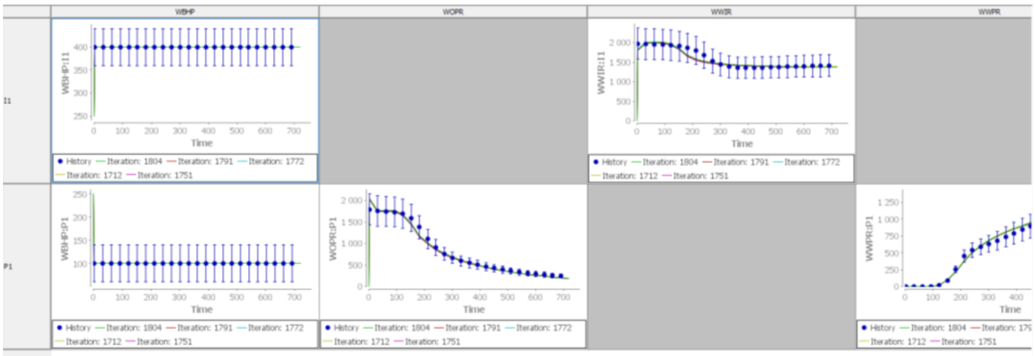

Fig. 1 Results history matching are carried out by Raven software

A relatively wide distribution in automatic history matching receives a control of geological realism. The modern approach of geological realism during history matching is geological background generating which based on the internal relationships between genetic associated parameters such as channel deep and thickness. Further, this information is used in order to control geological realism of formation facies during the history matching process. Process history matching can be significantly increased by using a modern approach. Also the approach allows creating equal possible and valid realizations of the reservoir model. It supports better development, forecasting.

Sedimentary rock geometry determination and facies distribution in them is one of the most important issues during reservoir modelling. It is impossible to do without an analysis of the sedimentation environment in which the geological body was formed.

Sedimentary model creating is the difficult process and statistical methods of distribution and line property evaluation do not have enough efficiency due to: a) data set is not enough (core and crops) and their quality is not high especially seismic information; b) geological information is extremely diverse and difficult to take into account. This information can include lithology, sedimentology data and petrophysical property distribution etc.; c) the statistical correlation between geologic and nonlinear variable and not known with sufficient accuracy; d) data has different inaccuracy level.

In connection with these problems, methods of machine learning have been widely used in the process of creating a priori geological information (the geometry of sedimentary bodies, the distribution of facies). Many methods of machine learning allow creating complex, non-linear distributions of multiple properties on the basis of distributions of available training models. Number of equal possible realizations is not limited.

For instance, the learning process based on real fluvial systems and deep-water deposition environments is considered in the [2], [1]. Trained algorithms based on a large amount of input information, including geological borehole data, seismic images, create possible geological models of reservoirs on the principle of similarity to modern sedimentary environments. Support Vector Method [2], Neighbourhood Algorithm [1], Kernel Lerning Algorithm [3] has enough efficiency.

Thus, in [2], as a preliminary information, a set of training images associated with the geometry and facies distribution of braided river systems was used (Fig. 2). The series of geological and hydrodynamic models were created based on these training samples. After model results comparing with real data, reference models were chosen which are used to farther prediction.

In the geological and hydrodynamic modeling of oil and gas fields, automatically history matching with prior geological allowing is the efficiency tool for multi equal possible models creating. Also, it allows geological realism control and it ultimately gives opportunity to allow optimal solution of oil and gas field development. Matching learning methods are advanced for prior geological creating.

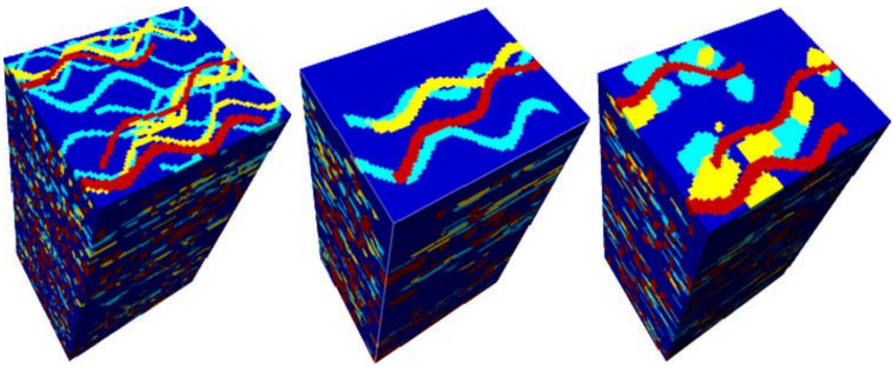

Fig. 2 Three equal possible realizations of fluvial channel deposit distribution geometry

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