Petroleum Geostatistics

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The European Association of Geoscientists and Engineers (EAGE) Petroleum Geostatistics conference first assembled in Toulouse in 1999. The 2015 meeting in Biarritz was only the third such gathering, the second being in Cascais in 2007. With an 8-year ‘time step’, it is hardly surprising that the conference series has not converged thematically or conceptually to some dull steady-state consensus. Rather, each of its iterations has provided researchers and other interested parties with a compact, lively snapshot of the state of play within the domain. The Biarritz meeting continued very much in this vein, despite difficult times for the industry.

Participants were treated to a good sprinkling of papers from areas such as unconventional, property modelling on unstructured grids, value of information and geomechanics. New insights and developments were presented in evergreen fields of research and development such as stochastic solutions for geophysical and production inverse problems, which show considerable maturity compared with 2007. One factor in this has been the increased sophistication of prior geological models through the use of methods such as latent variables and variational inference. Multiple-point geostatistics (MPS) models have been strengthened by further adapting techniques from image analysis and texture modelling.

While the papers covered in this special issue are not an exhaustive sample of the conference content, they do a reasonable job of capturing the variability of the presentations.

Olivier Dubrule reconnects us with a long-standing unsolved problem in geostatistics, namely which variogram models may be used for indicator variables. He shows

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that most models used to fit variograms of continuous variables are not valid—or realizable—for indicator variograms. In one dimension, the theory of continuous Markov chains can be used to derive realizable indicator variogram models. Dubrule concludes by discussing a number of approaches for producing realizable models in two or three dimensions.

Eidsvik et al. consider the problem of value of information (VOI) for complex spatial applications. This is of considerable interest in petroleum applications where information gathering can be very costly and time consuming. After a brief introduction to the problem which concludes that a full VOI calculation can be very demanding in real-world cases, they present approximation methods for efficient evaluation of VOI, allowing practitioners to consider creative spatial information-gathering schemes. They include two applications, the first to electromagnetic resistivity data while the second considers the option to gather seismic data with a value function incorporating fluid flow simulations.

In practice, facies geometry can be a dominant variable controlling the distribution of both reservoir and flow properties. There are many ‘solutions’ to geophysical ill-posed inverse problems, but when applied to problems which depend on variables not explicitly involved in the inversion, for example, reservoir connectivity for fluid flow problems, only those with a suitable model of facies geometry are likely to have good predictive power. Grana et al. look at a Bayesian approach to a generic one-dimensional geophysical inversion using a multivariate Gaussian mixture distribution for the continuous variables, a stationary first-order Markov chain for the discrete variable (facies) and a Gaussian linear likelihood function. The method allows for simulation of multiple realisations from the posterior distribution.

When full physics models are computationally expensive, it can be prohibitive to directly investigate the impact of parametric uncertainty on the model result. This is typically the case for fluid flow and geomechanical reservoir simulations. Surrogate models, which provide an approximation to the full physics model at a small fraction of the cost, are commonly used to estimate the uncertainty. Response surfaces, which are the most commonly used surrogate methods for flow at this time, typically make their estimations time step by time step. By contrast, Bottazzi and Della Rossa use functional kriging to directly predict coherent output curves over a range of time as an approximation of the full physics. They apply their surrogate model to examples from geomechanics and fluid flow.

Chugunova et al. present an efficient practical approach to model explicitly in space a fracture network with a multipoint geostatistics method and then to use this explicit fracture representation in the dynamic simulation by demonstrating the application on the Palaeozoic siliciclastic reservoir. A new but simple idea is to use faults as conditioning data for fracture network modelling in order to take into account the spatial relation between fractures and faults, which significantly impacts reservoir dynamic response.

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