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Multidisciplinary inversion in earth models.
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ABSTRACT
Now that Earth Modelling tools are used routinely by most petroleum companies, efforts are under way to adapt multidisciplinary data inversion techniques to better constrain these models by geological, geophysical and dynamic data.
A new approach has emerged for building 3D geological models. This approach, known as Multi-Point Statistics (MPS), uses a radically new concept as compared to variogram-based approaches. The geologist first builds a “training image”, that is a representation (in 3D) of what he expects the geological architecture of the modelled field to look like. Then, MPS extracts the statistical patterns from this image and reproduces them when generating a 3D realisation of the reservoir, whilst matching well data and other constraints such as non-stationary trends. Stanford University has played a key role in the development of MPS.
Increasinly, the integration of seismic data is performed using stochastic approaches. Thanks to a technique known as geostatistical inversion, a large number of high-frequency acoustic impedance realisations are generated which all match the 3D seismic data. From these realisations, uncertainty figures can be obtained about the spatial distribution of high and low acoustic impedance streaks in the reservoir. Universities such as Edinburgh, Heriot-Watt, Trondheim or Stanford play a key role in these developments.
The use of geostatistical realisations is also spreading to the generation of models constrained by dynamic data. One of the new approaches naturally linked to multi realisation concept is the Ensemble Kalman Filter (EnKF). EnKF has already given quite promising results on a number of studies. It can be used to generate reservoir models matching production data with spatially continuous 3D fields like porosity and permeability constrained in each grid cell. We are working closely with Norwegian universities such as Trondheim, Bergen, Texas A&M or Oklahoma, who are priogressing very rapidly on this topic.
The importance of rock physics is becoming stronger and stronger, as it provides the link between the geological, the seismic and the dynamic domains. With many fields reaching maturity and hence a critical stress state, we should also expect geomechanics to play a growing role in Earth Modelling applications.
The benefits of such multidisciplinary integration can be measured in terms of more realistic models of the subsurface which are consistent with all available data and conceptual views in all domains, adding significant value to a large range of complex fields, including deeply buried high pressure and high temperature North Sea fields in the UK.