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Switching the Light on in the Subseismic Space: from Reflection Seismics to Deformation Prediction

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One of the most important questions that drives applied and fundamental research is how stress is transfered and accommodated. Stress is often very heterogeneous over time and space, and it is accommodated over a wide range of scales. In sedimentary basins, stress is mainly accommodated by faulting. Large-scale, sub-surface faulting is typically identified by the interpretation of 2-D or 3-D seismic data, whereas small-scale, subsurface faulting is identified by spatially isolated 1-D well data. Faulting at meso-scale size usually cannot be recognized, neither on seismic data nor well data. However, faulting below the limit of seismic resolution plays an important role in any type of reservoir or tectonic setting. It can strongly control fluid flow and thus act as permeability barrier. Therefore, the so-called subseismic deformation has a significant importance in hydrocarbon reservoirs, diagenetic transformations, tectonic trigger mechanisms, and reservoirs used for e.g. geothermal energy or gas storage.

Increased resolution of subtle tectonic lineaments is currently achieved by (1) cutting edge acquisition techniques (shear-wave seismics, cross-hole applications), (2) advanced processing techniques (e.g. reflection imaging, tomography), (3) numerical modelling studies, and (4) attribute analyses (e.g. coherency, connectivity). With both physical and statistical components under consideration, some important challenges still remain. These encompass quantitative deformation and fracture analysis, predictions for the genesis of structures and their evolution over time, and the separation of distinct events from a finite stress history.

To bridge the scale-gap, geomechanical workflows are developed, which principally require the 3-D coverage of a region. Using high-quality data sets, the combined method of e.g. detailed coherency analysis and 3-D retro-deformation, validated by FMI-data where well-coverage exists, is a promising and powerful tool to predict the amount of small-scale fractures and to make assumptions about a possible opening or reactivation of fractures during deformation.