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Numerical modelling of fluid-rock interactions: Lessons learnt from carbonate rocks diagenesis studies

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Quantitative assessment of fluid-rock interactions and their impact on carbonate host-rocks has recently become a very attractive research topic within academic and industrial realms. Today, a common operational workflow that aims at predicting the relevant diagenetic processes on the host rocks (i.e. fluid-rock interactions) consists of three main stages: i) constructing a conceptual diagenesis model including inferred preferential fluids pathways; ii) quantifying the resulted diagenetic phases (e.g. depositing cements, dissolved and recrystallized minerals); and iii) numerical modelling of diagenetic processes. Most of the concepts of diagenetic processes operate at the larger, basin-scale, however, the description of the diagenetic phases (products of such processes) and their association with the overall petrophysical evolution of sedimentary rocks remain at reservoir (and even outcrop/ well core) scale. Conceptual models of diagenetic processes are thereafter constructed based on studying surface-exposed rocks and well cores (e.g. petrography, geochemistry, fluid inclusions). We are able to quantify the diagenetic products with various evolving techniques and on varying scales (e.g. point-counting, 2D and 3D image analysis, XRD, micro-CT and pore network models).

Geochemical modelling makes use of thermodynamic and kinetic rules as well as data-bases to simulate chemical reactions and fluid-rock interactions. This can be through a 0D model, whereby a certain process is tested (e.g. the likelihood of a certain chemical reaction to operate under specific conditions). Results relate to the fluids and mineral phases involved in the chemical reactions. They could be used as arguments to support or refute proposed outcomes of fluid-rock interactions. Coupling geochemical modelling with transport (reactive transport model; 1D, 2D and 3D) is another possibility, attractive as it provides forward simulations of diagenetic processes and resulting phases.

This contribution is based on several studies that were undertaken on carbonate rocks diagenesis in some of the major reservoir rocks in the Middle East and outcrop analogues in Europe. Here, the main processes at hand are related to fracture-related dolomitization and carbonate dissolution. We would like to present the workflows we have followed and the questioning that resulted for a series of case studies. The way forward, seems evident as the integration of workflows and numerical modelling tools at different scales, bringing better constrains on the boundary data and less uncertainty.