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An interactive geological basin model: supporting the fast-track assessment of large-scale subsurface potential in the context of the ecological transition

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Deep subsurface dynamic models allow simulating the interaction of multiple physical processes at regional and geological scale. In the past three decades, O&G industry developed so called Basin and Petroleum Systems Models to improve the prediction of hydrocarbons accumulation and reduce risks of exploration wells failure. By simulating the geological history of a sedimentary basin from its origin, these thermo-hydro-mechanical and chemical (THMC) models provide at present day a balanced distribution of static and dynamic properties of a huge volume of rocks.

For the last years, one of these THMC simulators has been extended to more generic application, such as geothermal potential assessment of sedimentary basins, large scale aquifers systems appraisal for massive CO_2 sequestration or quantification of present-day methane seepage from shallow biogenic gas production.

At the basin scale, data to describe the subsurface are very diverse and scattered and the uncertainty of representativeness of basin geological models is large, especially if one expects to obtain results in quantitative terms on connected pore volumes, temperatures, pressures, stress or fluid composition.

This scarcity of data requires geoscientists to describe alternative scenarios that are compatible with the observational data. The description of a 4D model (3D structure through geological time) of a sedimentary basin is a long and complex task and the creation and analysis of multiple digital scenarios is therefore almost impossible in reasonable timeframe.

We have developed and proofed the concept of interactive basin model that allows simulating while interpreting, hence comparing scenarios while interpreting. In the concept implementation, the processes of surface and subsurface data analysis, 3D scenario model building, simulation

parameters setup, THMC simulation, results visualisation and analysis and scenario comparison is performed in a single “real-time” loop.

The concept also allows the incremental building of a geological basin model. Therefore, one can start by building a coarse model of the full sedimentary basin that is continuously watertight and consistent. Then by visualising the result of the simulation in terms of present-day temperature, pressure, stress, and fluid chemistry fields compared instantaneously with the available data, it can be improved to a more complete and consistent representation. This interactive loop avoids the need for costly and complex inversion and allows the geologist to quickly explore the consistency of his or her assumptions.

Ultimately, this interactive modelling protocol based on advanced multi-physics simulation tools should become an essential weapon for rapidly defining the basis for assessing the potential, risks and balances between human activity and the nature of an often poorly documented deep underground.

It is complementary to specific tools for data analysis or uncertainty and risk assessment, such as specialised simulators like reservoir or aquifer models.