

The Complex Systems Modelling Platform (CSMP) becomes Open Source

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Abstract

Multi-physics simulation of complex geologic systems needs to express dynamic behaviours manifesting as plumes, convection cells and-or fracturing and faulting. The “playing field” is the geomodel. Instabilities emerge across multiple length scales and create unique complex patterns and intricate statistical distributions. The Complex Systems Modelling Platform (CSMP++) employs a space-time adaptive collocated finite element – finite volume discretization of geomodel to simulate such subsurface behaviour, with a focus on geo-energy systems. The current code application programmer interface uses policy-based class design, and elements, nodes and other data structures implemented as class templates. This discretisation amounts to arrays of structures and polymorphic classes as opposed to structures of arrays common in procedural finite element codes. This represents a trade-off between versatility and data-driven approaches that the team of developers has settled on in view of their needs for THMC simulation of geo-energy systems.

In this workshop, I will introduce CSMP with code and application examples also reviewing its journey alongside that of C++, discussing its pros and cons and why it is strong alternative to other simulation tools for coupled geologic processes. I will also address why the current ETHZ - Heriot Watt - Melbourne - Berlin team changed from a closed code - open community to an open-source model, with a central public github site that will be powered up in a boot camp before the end of this year. And I will try to convince you to join this effort!

In 2026, CSMP underpins multiple simulators, integrating functionality that has enabled computational geoscience research published in 250 peer-reviewed journal articles, including *Science* and *Nature Geoscience*.

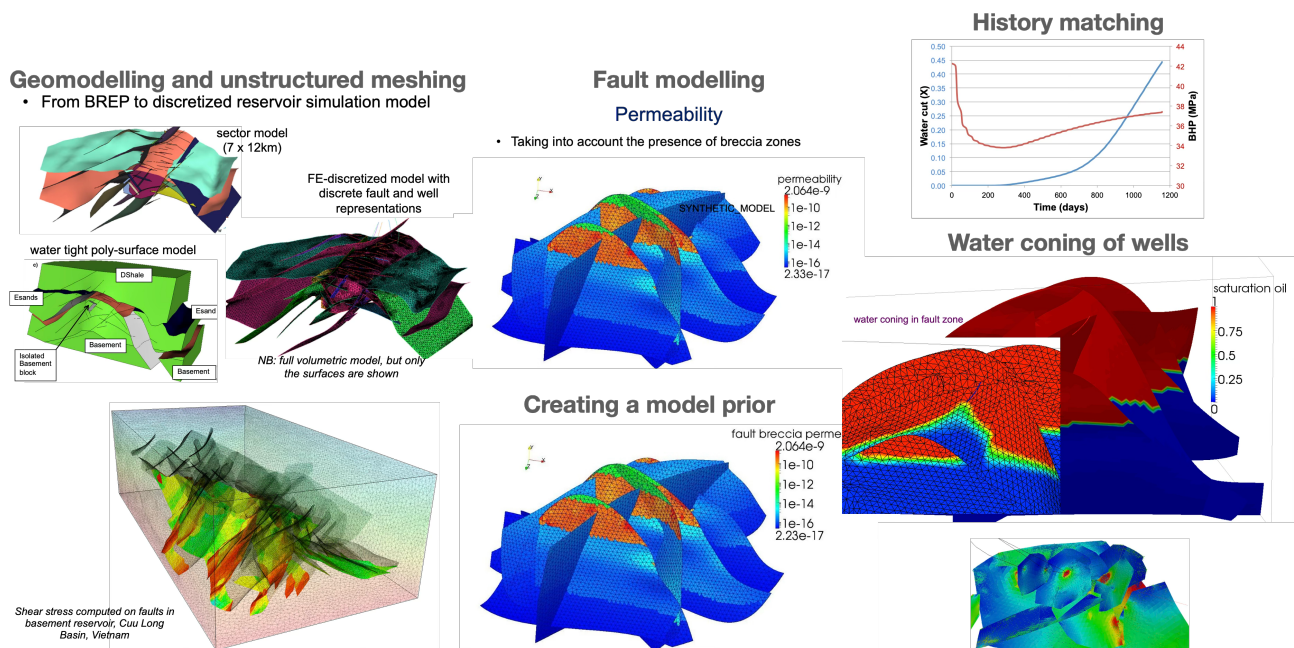


Figure 1: CSMP applied to coupled THM multiphase flow modelling of hydrocarbon migration / production from deforming faults in crystalline basement rocks in the Cuu-Long Basin, offshore Vietnam. Lower left: actual model (>100 faults & >20 wells); other: simplified reservoir geometry for illustration purposes.

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