Bridging static and dynamic modeling: an application to high energy geothermal reservoir modeling

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Simon LOPEZ[1], Gabriel COURRIOUX[1], Riad SANCHEZ[1&2], Konstantin BRENNER[2], Roland MASSON[2], Antonio GUILLEN[2], Bernard BOURGINE[1], Christelle LOISELET[1], Philippe CALCAGNO[1], Cécile ALLANIC[1]

1: BRGM, 2: INRIA/Université de Nice

When mass and energy transfers are involved, bridging static and dynamic modeling in a seamless way is a milestone to build reliable conceptual models of the subsurface in order to efficiently exploit its resources or use it as a storage space (energy, gas, waste…). Our purpose here is to be able to build interactive conceptual models of high energy geothermal reservoirs. As these reservoirs are always located in complex geological settings (faults and fractures are ubiquitous features) and involve the circulation of hot brines over a wide range of thermodynamical parameters, we must be able:

> #1 to quickly build structural models involving geological bodies of any shape and with the occurrence of discontinuities,
>
> #2 to produce conformable meshes of such models,
>
> #3 to perform multiphase thermo-hydraulic simulations with phase change on these meshes without numerical artefacts.

Over the years, iso-potential surface mapping has proved an efficient framework to achieve goal #1 and it is now implemented in several commercial softwares (e.g. GeoModeller). Yet, when it comes to goal #2 the implicit nature of surfaces make volumic meshing a non-trivial task. We recently used the Computational Geometry Algorithms Library (CGAL) to build conformal simplicial (tetrahedral) meshes that exactly match any geological 3D object and its boundaries or internal 2D features such as fault surfaces. A crucial issue of this process is to provide the mesher with sharp features of dimension 1 (surface intersections) to avoid local over-refinement (or even crash of the algorithm). Finally, to reach goal #3 we used the Vertex Approximate Gradient finite volume scheme which has been adapted to model mass and energy over any polyhedral meshes with the possibility to take into account objects of codimension 1 such as fault surfaces which may act as corridors for fluid flows.

We think that the proposed workflow and computing tools can be easily adapted to any other thematic field than geothermal reservoir modeling both for engineering purposes and the simulation of geological processes over very large timescales.