Internship

Implementation of S-FEM in Code_Aster finite element software

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Actual sedimentary basin codes used in petroleum industry to better locate oil and gas fields, the amount of hydrocarbons available and the overpressure zones, are based on a simplified mechanics and are therefore incapable of capturing horizontal stress field gradients characterizing regions of high and complex deformation. In order to improve predictions made by these codes, actual prototypes try to remove this limitation by means of a hydro-mechanical formulation of the problem based on a coupling between the sedimentary basin code, adopting a finite volume formulation, and a mechanical code, adopting a finite element approach.

The meshes actually used in these calculations are well suited to the finite volume approach but are sources of problems when adopted for the finite element calculation, especially for 3D models with faults. Several constraints coming from the flow calculation (finite volume method) make it necessary to adopt a mesh containing elements with a poor aspect ratio and a distorted or warped geometry. These elements could make the mechanical solver (finite element method) to fail. The adoption of one mesh for the flow calculation and a different mesh for the mechanical calculation could be a solution to this problem but it wouldn't be practical in several cases because, even if we don't consider the problems deriving from field projection between the two meshes, the complex geometry of the sedimentary basin (horizons and fault network) would lead to the creation of finite element meshes containing a too high number of elements.

The S-FEM (smoothed finite element method), a recent methodology combining meshfree methods with FEM, could be a possible solution to all these problems. A compatible strain field is built using the displacements only and the information coming from neighboring elements. This avoids the calculation of displacement derivatives and reduces the problems coming from poor aspect ratios or badly shaped elements.

The goal of the internship is the development of the S-FEM in Code_Aster, the free finite element solver developed by EDF R&D (France) actually used in sedimentary basin hydro-mechanical coupling at IFPEN. After a review of the several S-FEM models available, the student will implement the chosen model in Code_Aster and will test it on the mesh of problematic basin models. The student will work in the Geophysics-Geomechanics Department of IFPEN (France) in collaboration with FH Aachen University in Germany. The internship duration is 20 to 24 weeks.