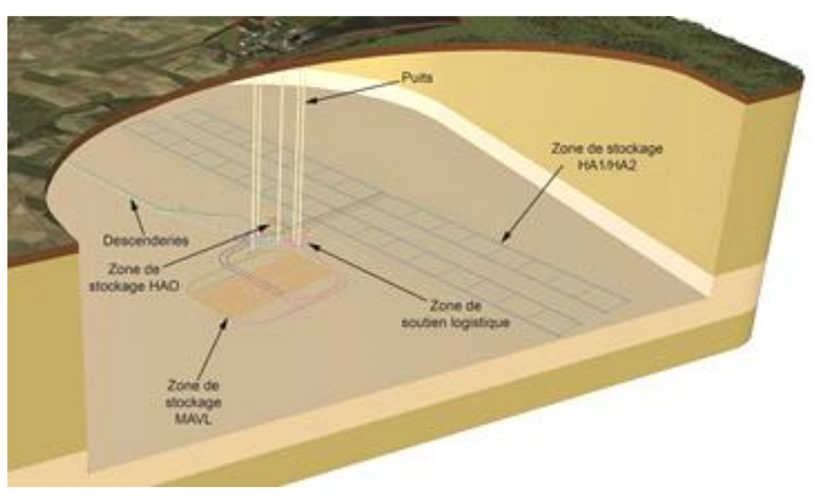
R&D in code_aster
Numerical modelling of geomaterials

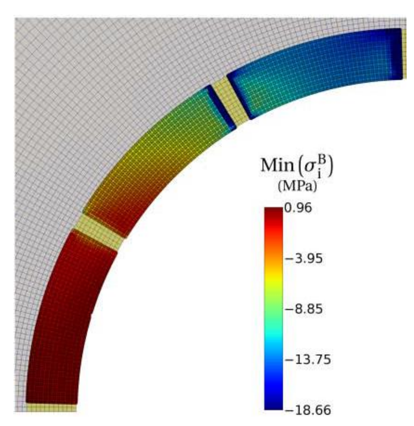
CONTEXT

Nonlinear geomaterials ; concretes, clays, rocks …
Subjected to hydraulic, thermal, and complex mechanical loads

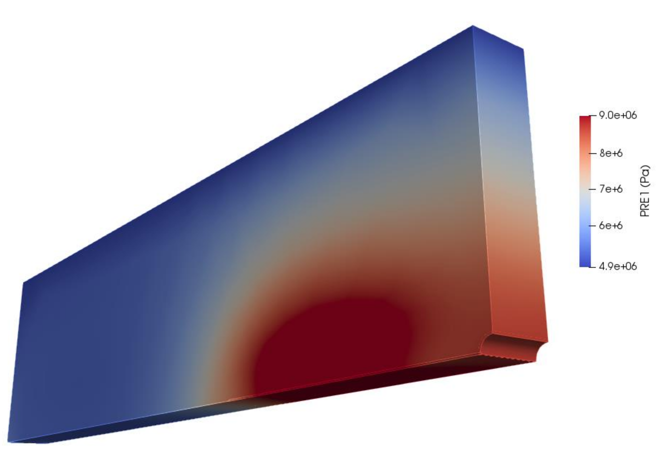
Main applications : radioactive waste geological disposal, dam buildings, civil engineering structures, etc.



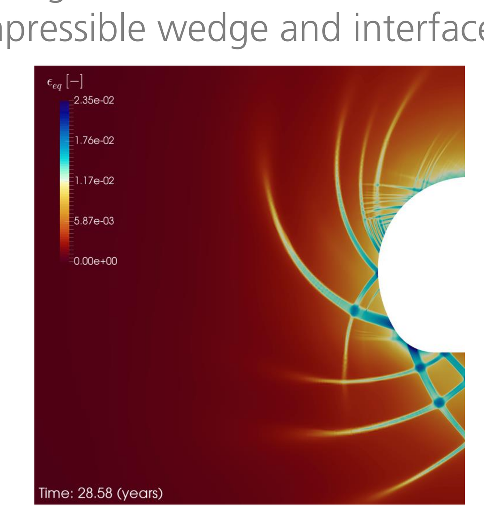
CIGEO concept (Andra)



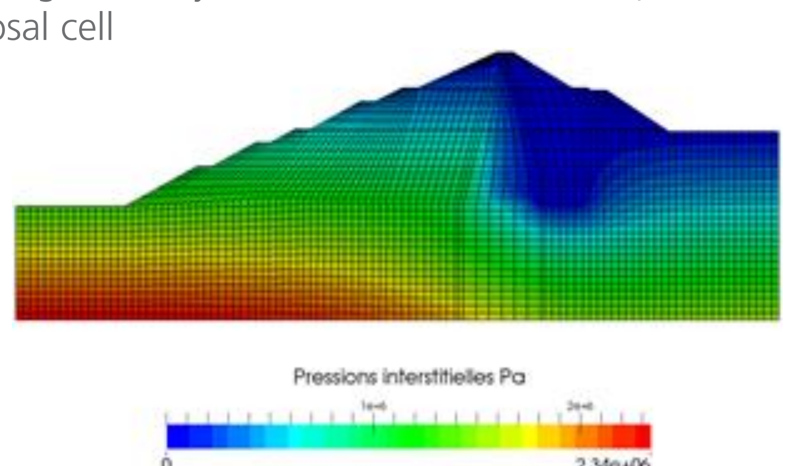
Modelling of concrete installation with compressible wedge and interface



3D modeling of a High Activity waste disposal cell



Example of fracturation around a gallery



Example of KOL Dam Modelling (R&D/CIH)

A fully T.H.M tool with numerous features

- Special constitutive laws for each material (elastic, plastic, viscoplastic …)
- Poromechanical formalism (Biot) for saturated or unsaturated media
- Permeation, diffusion, capillarity phenomena …

SOME PhD THESIS

- R. Fernandes – Modélisation numérique objective des problèmes couplés hydromécaniques dans le cas des géomatériaux – 3SR Grenoble– 2009
- O. Angélini – Etude de schémas numériques pour les écoulements diphasiques en milieu poreux déformable pour des maillages quelconques. Application au stockage des déchets radioactifs – UMLV– 2010
- R. Plassart – Modélisation hydromécanique du comportement des ouvrages souterrains avec un modèle élastoviscoplastique – U. de Lorraine 2011
- S. Raude – Prise en compte des sollicitations thermiques sur les comportements instantané et différé des géomatériaux – U. de Lorraine– 2015
- R. Riedlbeck – Adaptative algorithms for poromechanics and poroplasticity – U. de. Montpellier– 2017
- I. Djouadi – Prise en compte de l'anisotropie sur les comportements instantanés des géomatériaux pour les calculs d'ouvrages – U. de Lorraine – 2018

EDF (now, employed at EDF)

USING IN CODE_ASTER

Modular model (depending on required level of complexity)

`KIT_THM (THHM, HM,` etc.) in `STAT_NON_LINE` and `DYNA_NON_LINE`

Mechanical laws for soils : `'ELAS', 'MOHR-COULOMB', 'CJS', 'HUJEUX', 'CAM_CLAY', 'LETK', 'LKR', 'DRUCK-PRAGER', 'DRUCK_PRAG_N_A', 'VISC_DRUCK_PRAG'`

Mechanical laws For unsaturated swelling materials : `'BARCELONE', 'ELAS_GONF'`

Mechanical laws for concrete : `'MAZARS', 'ENDO_ISOT_BETON'`

Micro Gradient Dilatation model for softening behavior : `*_DIL` (* : `D_PLAN, AXIS, 3D`)

Hydraulic comportments : `LIQU_SATU` (liquid saturated), `LIQU_AD_GAZ_VAPE` (2 components for each 2 phase), `LIQU_VAPEU` (eau liquid and vapor), `LIQU_GAZ_ATM` (Richards), etc.

SCIENTIFIC CHALLENGES

- Highly non linear problems
- Multiphysic problems : Differences in the nature of the variables. Which convergence criterion for Newton method ?
- High-performances computing is required for complex 3D problems (adapted iterative solvers, development of efficient a posteriori error estimators, etc.)
- Long-term simulations (several thousands of years)
- Numerical treatment of diltancy and softening phenomena
- How to calibrate non local approaches ?
- Drying phenomena under low relative humidity (no more capillary phenomena ?)
- New complex poromaterials, coupling with chemical phenomena (ex: bituminized radioactive waste)

SOME PUBLICATIONS

R. Fernandes, C. Chavant, R. Chambon – *A simplified second gradient model for dilatant materials: theory and numerical implementation*- International Journal of Solids and Structures, 45, pp. 5289-5307, 2008.
O. Angelini, C. Chavant. E. Chénier, R. Eymard, S. Granet– *Finite Volume Approximation of a Diffusion-Dissolution model and application to a nuclear waste storage*– Mathematics and Computers in Simulation, 81, pp. 2001-2017, 2001.
S. Raude, F. Laigle, R. Giot, R. Fernandes – *A unified thermo/viscoplastic constitutive model for geomaterials* – Acta Geotechnica, 11, pp. 869, 2016.
S. Cuvilliez, I. Djouadi, S. Raude, R. Fernandes – *An elastoviscoplastic constitutive model for geomaterials: Application to hydromechanical modelling of claystone response to drift excavation* – Computers and Geotechnics., 85, pp. 1488-1507, 2016.
R. Riedlbeck, D. Di Pietro, A. Ern, S. Granet, K. Kazymyrenko – *Stress and flux reconstruction in Biot's poro-elasticity problem with application to a posteriori error analysis* – Computers and Mathematics with Applications., 73, pp. 1593-1610, 2017.
R. Giot, S. Granet, M. Faivre, N. Massoussi, J. Huang – A transversely isotropic thermo-poroelastic model for claystone: parameter identification and application to a 3D underground structure, Geomechanics and Geoengineering, 2018.

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