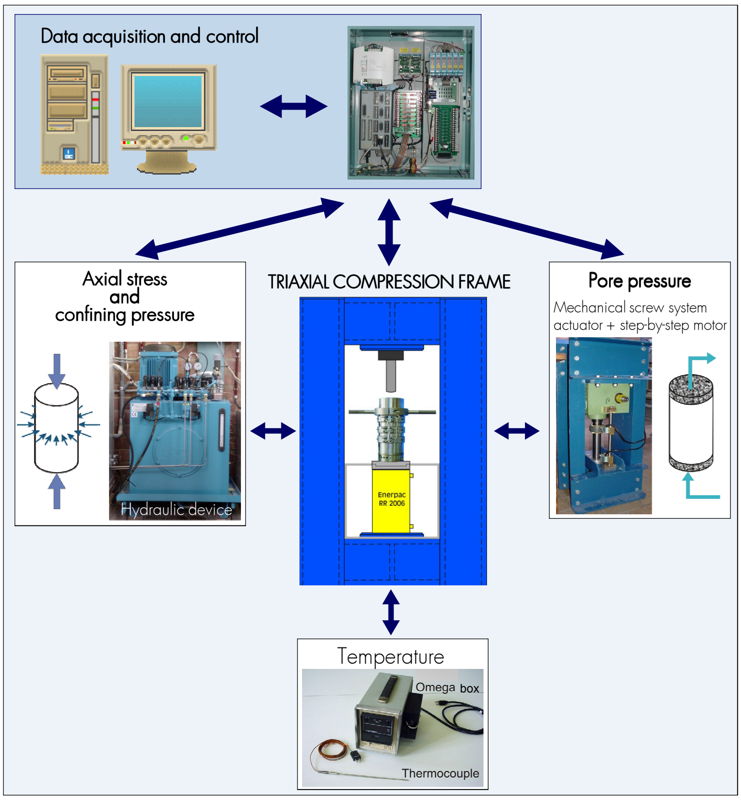
Development of an automated triaxial compression system to study the behaviour of saturated porous rocks in high depth conditions

Ir Fanny DESCAMPS, Ir Hughes LEGRAIN, Prof. Jean-Pierre TSHIBANGU

The testing device is organised around a triaxial cell mounted on a compression frame. It is composed of :

- an hydraulic bench for the conventional triaxial testing ($\sigma_2 = \sigma_3$) up to 700 bar;
- a pore pressure control system for pressures up to 700 bar and allowing flow rates of a few ml/day to few ml/min;
- a temperature control device (heating jacket and thermocouple) for temperatures up to 232°C;
- an automated acquisition and control system for test driving and data processing.



Thermo-poro-elastoplastic behaviour :

$$\Psi = \Psi(T, \varepsilon_{ij}, m, \varepsilon_{ij\,p}, \phi_p, \chi_i)$$

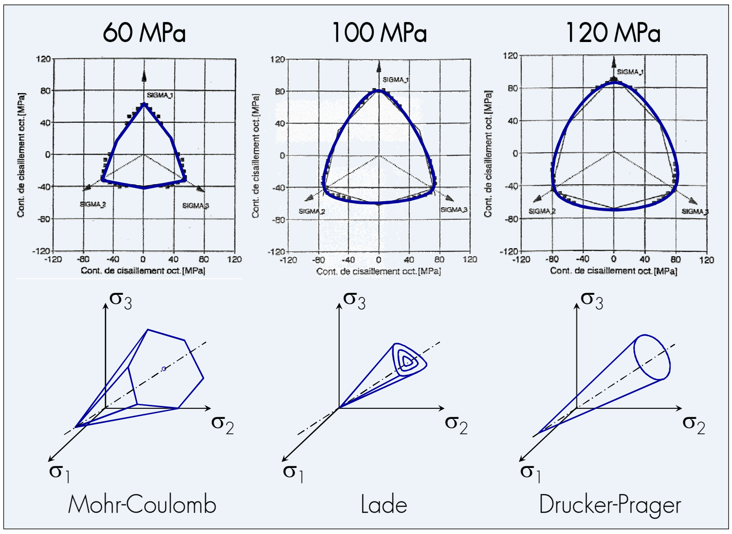
$$[\sigma] = [\sigma^0] + \lambda\ \mathrm{tr}[\varepsilon - \varepsilon_\mathrm{p}] + 2\,G[\varepsilon - \varepsilon_\mathrm{p}] - b\,M\left(\frac{m}{\rho_{fl}^0} - \phi_p\right)[1] - 3\,\alpha\,K\,\theta[1]$$

$$[\sigma] = [\sigma^0] + \lambda^0\ \mathrm{tr}[\varepsilon - \varepsilon_\mathrm{p}] + 2\,G[\varepsilon - \varepsilon_\mathrm{p}] - b\,(p - p^0)[1] - 3\,\alpha^0\,K^0\,\theta[1]$$

$$p = p^0 + M\left\{-b\,\mathrm{tr}[\varepsilon - \varepsilon_\mathrm{p}] + \left(\frac{m}{\rho_{fl}^0} - \phi_p\right)\right\} + 3\,\alpha_m\,M\,\theta$$

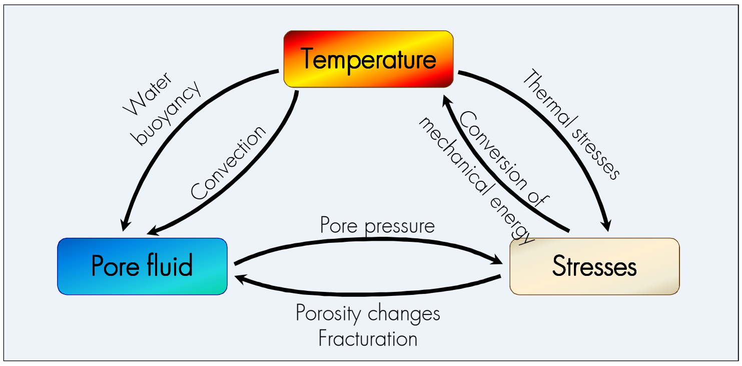
$$S = S^0 + m\,s_m^0 + 3\,\alpha\,K\ \mathrm{tr}[\varepsilon - \varepsilon_\mathrm{p}] - 3\,\alpha_m\,M\left(\frac{m}{\rho_{fl}^0} - \phi_p\right) + C_\pi\,\frac{\theta}{T^0}$$

Effect of the confining stress on the limit envelopes (Tshibangu 1994) :



- Choosing the more convenient failure criterion : Mohr-Coulomb, Lade, Drucker-Prager,…
- Performing triaxial tests with pore pressure and temperature control allows to extend this method to conditions that are reprensentatives of high depth (e.g. petroleum industry).

Thermo-hydro-mechanical coupling in geomaterials :



- Studying the evolution of the parameters of the governing laws with confining pressure, pore pressure and temperature.
- Development of non-linear behaviour models.

$[\sigma^{(0)}]$, (initial) stress tensor
$[\varepsilon^{(p)}]$, (plastic) strain tensor
$p^{(0)}$, (initial) pore pressure
m, change in fluid mass content
$\phi^{(p)}$, (plastic) porosity
$S^{(0)}$, (initial) entropy
$s_m^{(0)}$, (initial) massic entropy of the fluid
$T^{(0)}$, (initial) temperature; $\theta = T - T^0$

$\lambda^{(0)}$, G, (undrained) Lamé's coefficients
$K^{(0)}$, (undrained) bulk modulus
b, Biot's coefficient
M, Biot's modulus
α, α_m, α^0, coefficients of thermal expansion
C_p, specific heat of the fluid for constant p

Mining Engineering Department - 53, rue du Joncquois – 7000 Mons – Belgium
Tél.: +32 65 37 45 17 – Fax: +32 65 37 45 20 – www.mecaroc.fpms.ac.be