Chemical degradation of a numerical material - Application to a Fontainbleau sandstone
Kajetan Wojtacki, Loïc Daridon, Yann Monerie

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The Context

Summary:

Advanced Morphological Analysis of Sandstone

Objective

is to propose a methodology which allows us to predict the evolution of effective mechanical behaviour of saline aquifers caused by microstructural changes due to CCS.

Advanced Morphological Analysis of Sandstone

The starting point is CT scan of microstructure of Fontainebleau sandstone of size 256x256x256 px, where 1 px = 5.01 microns.

Numerous types of morphological descriptors: porosity, sizing (granulometry), covariance function, connectivity (tortuosity).

Numerical Samples - Generation

The method is inspired by natural formation process of sandstones [Bakke and Øren, 1997] and adjusted in order to respect aforementioned morphological properties:

1. **grain deposit** - monodisperse grains assembly of initial radius 14 px, deposed into 3D box,
2. **triaxial compaction** - bulk volume reduction,
3. **diagenesis** - mixed uniform and random radii increment to obtain desired value of porosity.

Generated samples (red box) are validated a posteriori.

Numerical Dissolution by Morphological Dilation

Chemical dissolution of porous matrix is homogeneous at sample scale [Egermann et al, 2006]. We investigate two different scenarios of dissolution:

- **Isotropic**
- **Percolated Network**

Permeability - Elasticity Coupling

Darcy's law:

\[
K = \frac{\mu Q L}{\Delta P A}
\]

\( K \) - permeability
\( \mu \) - dynamic viscosity
\( Q \) - flux
\( A \) - surface area
\( \Delta P \) - grad. of pressure

Coupling:

\[
P(K) = 1 - \frac{K^3}{\alpha}
\]

\( P(K) \) - computed elastic moduli
\( \alpha \) - resolution
\( P_0 \) - searched value

Elasticity - Periodic Homogenization

Method of numerical, periodic homogenisation:

**problem:** non-periodic geometry.

**solution:** additional layer of homogeneous material associated with fixed point method:

\[
\frac{P_i}{P_0} = P_i^0, \quad P_i \in \left[0,1\right]
\]

CT scan is naturally discretised (regular cubic mesh).

The influence of such discretization on the estimation of elastic moduli is given by [Garboczi and Day, 1995]:

\[
P(M) = P_0 + \frac{a}{M}
\]

\( P(M) \) - computed elastic moduli
\( M \) - resolution
\( P_0 \) - searched value

Graziano et al. 2002