WTNP112 - Resaturation of a column

Summary:

The test presented here makes it possible to check the good performance of the operators used for the resolution of the equations of a flow in unsaturated medium. This test corresponds to test 3.1 of the plan of qualification of the project ALLIANCES [bib1]. It represents the resaturation of a column.
1 Problem of reference

1.1 Geometry

The studied field is a semi medium infinite horizontal. In practice it measures 3m.

\[ \text{Coordinates of the points (} m \text{)}: \]

\[
\begin{array}{ccc}
A & 0 & 0 \\
B & 3 & 0 \\
C & 3 & 0.1 \\
D & 0 & 0.1 \\
x & & B \\
\end{array}
\]

1.2 Properties of material

One gives here only the properties whose solution depends, knowing that the command file contains other data of material (moduli of elasticity,…) who finally do not play any part in the solution of with the dealt problem.

**Liquid water**

- Density \( (kg.m^{-3}) \): 1000
- Viscosity: 1

**Homogenized parameters**

- Permeability \( K \): 1,625E-5 \( m/s \)
- Porosity: 0.3
- Isotherm of sorption

\[
S(P_c) = 0.1833 + \frac{0.81667}{1 + (2.9227P_c)^{2.0304}}^{0.5075}
\]

- Relative permeability

\[
k_r(P_c) = \epsilon^{(7.3P_c)}
\]

\[
= \epsilon^{\frac{2.5}{2.5(0.82-0.18^{1.97}) + \frac{0.49}{1}}}
\]

**Initial state**

- Pressure: \( P_c^0 = 1.15m \)

1.3 Boundary conditions and initial

They are expressed on the capillary pressure:

\[
P_c(x,0) = P_c^0 = 1.15m
\]

\[
P_c(0,t) = 0 \text{ and } P_c(3,t) = 1.15m
\]
One is in condition of Richards: \( P_{atm}(x,t) = 1 \text{atm} \)

2 Reference solution

The reference solution is the semi-analytical solution of Philips [bib1].

2.1 Bibliographical references

1) Project Alliances plan of qualification, note ANDRA CNT-ASCS 02-075B
3 Modeling A

3.1 Characteristics of modeling A

Modeling THHD in plane deformations. 40 element \( Q8 \)

3.2 Results

The table below presents the profiles of pressures capillary and saturation along the bar and each hour: One intercalates between the 2 profiles, that corresponding to the semi-analytical solution of Philips.

![Pression capillaire le long de la colonne](image)
3.3 Value tested

<table>
<thead>
<tr>
<th>X (m)</th>
<th>Time (s)</th>
<th>PREI Aster</th>
<th>Capillary pressure (Philips)</th>
<th>Relative error</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>36000s</td>
<td>0.461</td>
<td>0.460</td>
<td>0.2%</td>
</tr>
</tbody>
</table>

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4 Modeling B

4.1 Characteristics of modeling B

Modeling THHD in plane deformations. 80 elements $Q^8$

4.2 Results

The table below presents the profiles of pressures capillary and saturation along the bar and each hour, as for modeling A one intercalates the semi-analytical solution of Philips:

![Graph showing pressure distribution along a column](image-url)
4.3 Value tested

<table>
<thead>
<tr>
<th>$X (m)$</th>
<th>Time (s)</th>
<th>PRE1 Aster</th>
<th>Capillary pressure (Philips)</th>
<th>Relative error</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>36000s</td>
<td>0.459</td>
<td>0.460</td>
<td>0.1%</td>
</tr>
</tbody>
</table>

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5 Modeling C

5.1 Characteristics of modeling C

Modeling THH2D in plane deformations. 80 Q8 elements. It is exactly the same case as modeling B but with a structure THH2D and a coefficient of infinite Henry. The purpose of this modeling is only to bring back itself to a structure of data THH2D who is that known by Alliances.

5.2 Results

The results are obviously the same one as for modeling B.
6 Modeling D

6.1 Characteristics of modeling D

Modeling HMD in plane deformations. 80 Q8 elements. It is exactly the same case as modeling B but with the mixing rate LIQU_GAZ_ATM specific to the modeling of Richards (equivalent to modeling unsaturated with gas pressure imposed). One is blocked in mechanics.

6.2 Results

The results are obviously the same one as for modeling B.