WTNP118 - Gravitating rebalancing of the saturation of a column

Summarized:

The test presented here makes it possible to check the good taking into account of gravity for the modelization of unsaturated flows. This test represents a column initially uniformly désaturé. There is no loading: only gravity is driving evolution.

This test will be the object of a case test Alliances.

1 Problem of reference

1.1 Geometry

the studied field is a bar of $3\,m$.

Coordinates of the points (m) :

$A(0;0)$ $C(3;0.1)$
$B(3;0)$ $D(0;0.1)$

1.2 Properties of the material

One takes data here bringing back to a quasi-unit problem. The units then do not have any more physical meaning.
Gravity is taken in the meaning of x positive (which corresponds as a result to the vertical axis).

Liquid water	Density $(kg.m^{-3})$ Viscosity $(Pa.s)$	1 1
Gas	Viscosity $(Pa.s)$	1
homogenized Parameters	Gravity $(m.s^{-2})$ Isothermal $K(m^2)$ Permeability Porosity of sorption relative Permeability	$g=(9{,}81\ ;0\ ;0)$ 1.0.5 $S_{we}=\frac{1}{\left[1+\left(\frac{P_c}{1}\right)^{1,5}\right]^{1/3}}$ $kr_w(S)=1$ $kr_{gz}(S)=1$

1.3 Boundary conditions and initial

One is out of null flux everywhere. Initially the medium is désaturé with a saturation of $S=0,5$ on the group of the field what corresponds to a capillary pressure:
$Pc=3,6\,Pa$.
One measures an initial gas pressure of $1\,Pa$.

1.4 Time step

One models $1\,s$ in the following way:
- of 0 with $0,1\,s$: 5 time step
- of $0,1$ with $1\,s$: 9 time step

1.5 Reference solution

To the steady-state one must carry out the hydrostatic equilibrium.
It is necessary thus that $\Delta P_{lq}=\rho\,.\,g\,.\,\Delta x$
With the data which one lays out that thus gives us $\Delta P_{lq}=9,81*3=29,43\,Pa$

2 Modelization A

2.1 Characteristic of the modelization To

the studied modelization is HHD in plane strains. The mesh is composed of 80 Q8 elements.

2.2 Functionalities tested

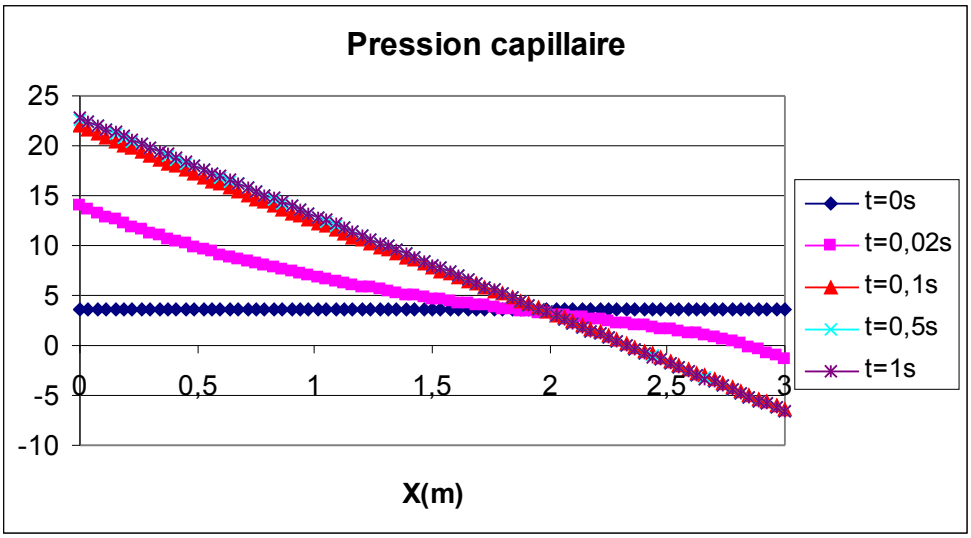
This modelization makes it possible in particular to check the use of temporal function PESA_MULT introduced into card THM_DIFFU. This function is added in factor of terms PESA_X, PESA_Y and PESA_Z, and makes it possible to make gravity dependant on time.

2.3 Results

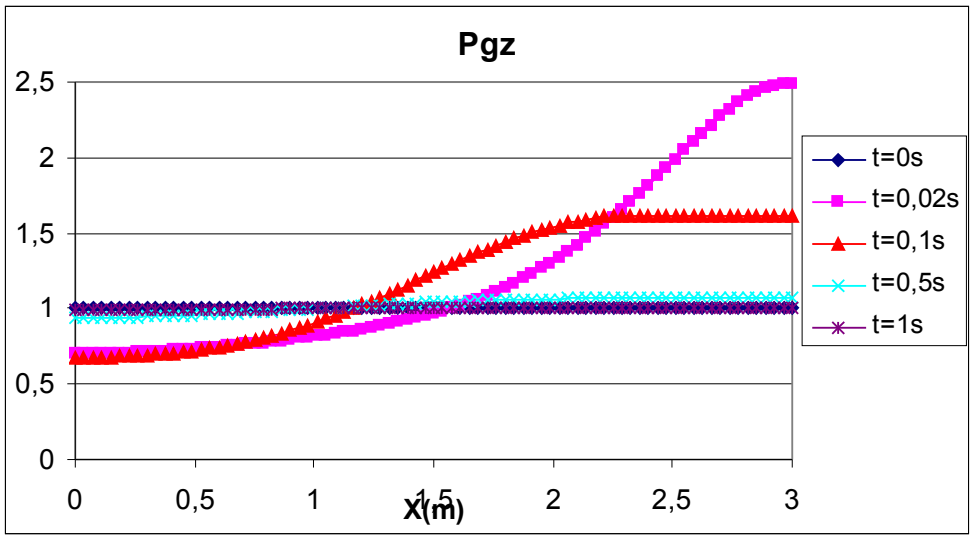
the figures below present the profiles of pressures capillary, gas pressures and saturation along the bar for various times. One observes the rebalancing well to reach a steady-state (nothing any more moves afterwards $0,5\ s$).
A this steady-state and in Pa :

$Pgz(x=0)=0,991\ Pa$ and $Pgz(x=3)=1,014\ Pa$
$Pc(x=0)=22,8\ Pa$ $Pc(x=3)=-6,62\ Pa$

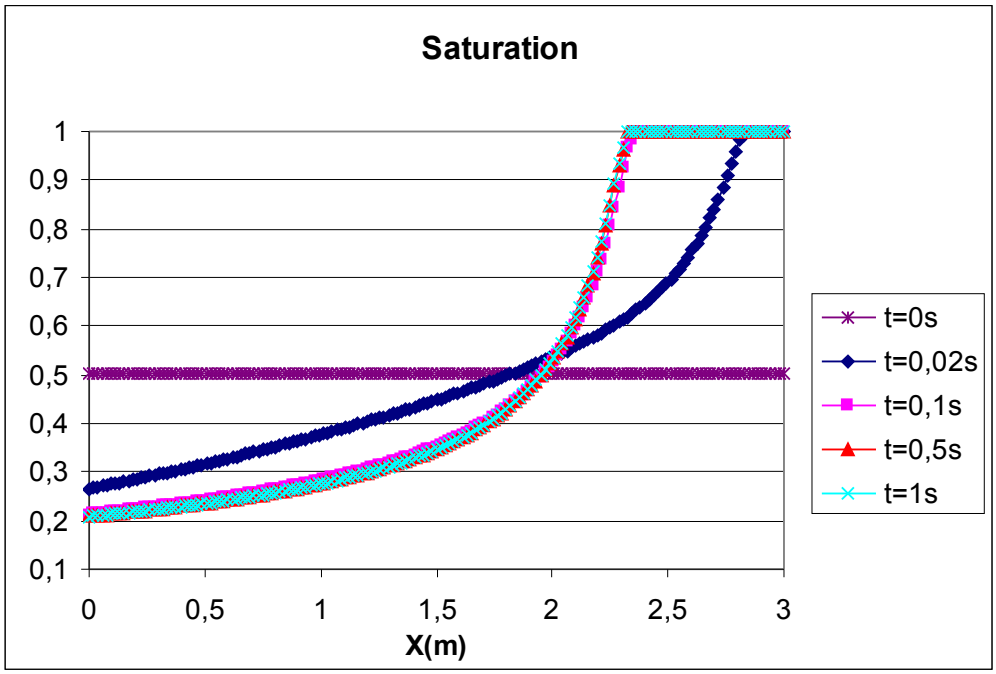
What gives $\Delta P_{lq}=29,44\ Pa$ which corresponds well to the hydrostatic equilibrium.



Appear 2.3-a : profiles of capillary pressure



Appears 2.3-b : profiles of gas pressure



Appears 2.3-c : profiles of saturation

2.4 Value tested

$X(m)$	Time (s)	PRE1 Aster (Pa)	authorized relative Error
0.	0,02	13,94	0.1%
0.	0,1	21,92	0.1%
0.	1	22,79	0.1%

3 Modelization B

3.1 Characteristic of the modelization B

The modelization studied is HH2D in plane strains. The mesh is composed of 80 Q8 elements. The purpose of this variation is only passing by constitutive law LIQU_AD_GAZ_VAPE with gravity. It is exactly the same test as previously but with a coefficient of Henry $K_H = \infty$ and all the coefficients of Fick taken equal to 0.

3.2 Results

the results are of course the same ones as previously:

$X(m)$	Time (s)	PRE1 Aster	authorized relative Error
0.	0,02	13,94	0.1%
0.	0,1	21,92	0.1%
0.	1	22,79	0.1%

4 Modelization C

4.1 Characteristic of the modelization C

The modelization studied is THH2D in plane strains. The mesh is composed of 80 Q8 elements. It is exactly the same case as the modelization B but with a structure THH2D and thus of the thermal (blocked). The purpose of this modelization is only bringing back itself to a data structure THH2D in order to be able to make a case test Alliances of them (only modelization THH2D is known).

4.2 Results

the results are of course the same ones as previously:

$X(m)$	Time (s)	PRE1 Aster (Pa)	authorized relative Error
0.	0,02	13,94	0.1%
0.	0,1	21,92	0.1%
0.	1	22,79	0.1%

5 Synthesis

This case test makes it possible to validate the taking into account of gravity for the saturated cases. The got results are coherent.