EVEGAS Project

(**E**uropean **V**alidation **E**xercise of **GAS** Migration Model)

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EVEGAS PROJECT

Title:	**EVEGAS (European Validation Exercise of GAS migration model through porous media**
Contractors:	**GEOSTOCK (France)**
Major Subcontractor:	**Bertin & Compagnies (France)**
Associated Contractors :	**ANDRA (France),CIMNE (Spain),ARMINES (France), INTERA(UK), CEN (Belgium), SIMOCO (UK)**
Other Participants:	**GRS (Germany)**
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Project Leader :	**T. MANAI (GEOSTOCK (France))**
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A. OBJECTIVES AND SCOPES

The EVEGAS project aims at the verification and validation of numerical codes suitable for simulating gas flow phenomenon in low permeability porous media.
Physical phenomena involved in gas generation and gas flow are numerous, often complex, and may not be very well described.
The existing numerical codes cannot represent all the occurring possible phenomena, but allow a good trade-off between simplicity and representativity of such phenomena.
Two phase flow (Gas and Water) appear to be the most consequential phenomena in gas migration and pressure sizing.
The project is organised in three major steps:

1)A simple problem with analytical solutions

This is a necessary first step which allows assessing the accuracy of numerical solutions in function of given parameters. Such a quantitative evaluation of the numerical codes, will be useful to interpret deviations that might occur in simulating more realistic test cases.

2)A few problems based on laboratory or in-situ experiments

Such tests will aim access to the following information:

- the accuracy of the numerical solutions (**assuming the existing of good and representative experimental data**).

3)A 3-D repository scenario involving the following aspects

- a repository design
- a source of gas
- rock characteristics
- fluid characteristics.

B. WORK PROGRAM

The project is divided into five work packages (denoted WP) each of them involving one or several tasks.
The first work package (WP1) is dedicated to the analysis of selected numerical codes. Such analysis will be of paramount importance in describing test cases.
It includes examination of the problems that can be simulated and of the numerical schemes and solving methods used.
The next work packages (WP2, WP3, WP4) are related to the three levels of test cases. Each work packages includes four tasks as follows:

- T1: general and detailed specification (GDS) of the test cases
- T2: general and detailed definition (GDD) of the test cases
- T3: simulation of the test cases by participants
- T4: analysis of results and reporting.

C. PROGRESS OF WORKS AND RESULTS

State of advancement

The last year was dedicated to the following work packages and tasks :

-Code analysis (WP1)
-First level test cases specification and definition (WP2T1, WP2T2)
-First level test cases simulation by participants (WP2T3)
-First level test cases simulation results analysis and reporting (WP2T4)
-Second level test cases specification and definition (WP3T1, WP3T2)

WP1,WP2T1,WP2T2,WP2T3,WP2T4,WP3T1 and WP3T2 was accomplished

Progress and results

C1. CODE ANALYSIS(WP1)

C1.1.Comments

C.1.1.1.Codes objectives

The six considered codes have been initially designed for different purposes, and then extended in order to take into account new problems. This initial design or main scope appears in the documentation, and also explains that a number of features only appear into one or two of them.

This paragraph presents the vocation of the codes, but this should not be interpreted as limitations of the ability of each of them to treat the problems addressed to in the EVEGAS project.
Only the two codes SUNIDJ and BRIGHT are dedicated to the problem under concern, namely gas migration related to radioactive waste disposal, and they are also the most recent among the six analysed codes.
For SUNIDJ the problem is that of the migration of a gas (H_2) produced at one location (point or finite volume) of a porous medium saturated by a liquid, and with the assumption that the overall problem is an isothermal one.
It can be noticed that this code explicitly tries to apply petroleum engineering based approaches to solve this actual problem.
For BRIGHT the point dealt with, is that of the sealing joints of repository wells dug in salty formations. As the joints are filled by compacted salt aggregates, the problem is to ensure that no migration may occur, neither toward the atmosphere nor toward the surrounding water, due to some thermal (not gas) release at the repository location.
GENESYS and ECLIPSE have been initially designed to study gaseous and liquid petroleum production, with some emphasis put on phase changes, miscibility phenomena, and on the fractured nature of the porous media. They of course consider multispecies and heat transport.
TOUGHII and PROFLOW are generic codes, i.e. not really dedicated to some specific problem, the former, whose name is an acronym of "Transport of Unsaturated Groundwater and Heat" has been mainly used for hydrogeology studies including some phase changes and multispecies considerations, the latter, as also indicated by its name, aims general fluids transports in porous media.
The high degree of generality of a code like PORFLOW, makes it a multipurpose tool which can deal with various physical problems, with the drawback that the description of the problem remains to be done.
In the same way, the codes issuing from petroleum engineering, and which as such have been highly developed, are now also multipurpose tools (for example even gas-storage problems can be treated by option modules), having their own language.

C1.1.2.Entrance levels

This paragraph presents at which level of the modelisation process, is defined the documentation of each code, as indeed a code results from the modelisation of a class of problems.

The terms of the problem consist, firstly in the description of the whole set of taken into account phenomena, this defining the physical modelisation or set of physical hypotheses, and secondly in the set of questions concerning the studied process.
This is ***the first entrance level*** of a given problem.
BRIGHT is the only code to start from this first level, this making easier the search of the used physical hypotheses. SUNIDJ partly starts from this level but the asked questions, i.e. the quantities to be defined, are not clearly presented.
Once the physical problem is well and completely posed, it has to be translated mathematically; this leads to express equations: definition equations for the quantities, equations translating the used general physical principles, and some equations representing specific phenomena.
This is ***the second entrance level***.
At this level, the equations are written directly together with the boundary conditions (BC) and the system state equations at some initial time (IC). This implies that a first selection has been made among the various quantities, to define those which are considered as unknowns and those which are considered as parameters. By many aspects SUNIDJ is defined at this level.
In order to go towards the problem resolution, the former equations, BC and IC are most often mathematically transformed by substitution, addition and so on, to achieve a restricted set of equations and principal unknowns completed by compatible BC and IC, and to which are joined secondary equations and unknowns.
This is ***the third entrance level***, at this third level, the objective is to solve a mathematically well posed problem rather than to deal with physical interpretation.
Three of the studied codes use this entrance level:

- this level is natural for PORFLOW with respect to its generic vocation
- and as regards TOUGHII and GENESYS, it is probably because they are under development for a longer time and that the two first levels must have been published earlier.

Finally, as the equations are solved numerically, they have to be discretized, and often linearized, in a way which takes into account algorithms and computers constraints.
This is ***the fourth entrance level***, which is the only one used in the supplied ECLIPSE's documentation.

C1.1.3.Main physical hypotheses

The analysed codes are related to:

- flows, therefore to fluids displacements and to migrations when relative displacements occur
- in a porous unsaturated medium, therefore containing somewhere a minimum amount of at least two fluids
- with mass and thermal transfers
- with time dependency
- in a limited spatial domain.

In this spatial domain, Newtonian mechanics and ordinary thermodynamical principles are applied, hence the necessary conservation of mass, momentum and energy.
These quite general hypotheses are as hidden as are those which concern the macroscopic continuity of the media, which is necessary to define thermodynamical quantities, or the continuity of movements which allow to define partial and total derivatives. In a way or another, all the codes deal with multiphase flows.
The studied flowing fluids either are each considered as a specific fluid like in PORFLOW, or can be most often considered as fluids having two phases (liquid and vapour).
It must be noticed that for petroleum engineering originated codes, only the main fluid can have two phases.
As these flows take place in a porous material, there are indeed three phases.
All the codes consider at least one solid phase (porous material), and at least two different fluids, therefore they are multispecies.
All the codes can also treat imbibition and drainage problems with at least one wetting fluid (or phase) and at least one non-wetting fluid (or phase).

But for BRIGHT, which studies the complete medium i.e. the porous material plus the fluids, the porous material is assumed to be perfectly rigid, with usually isotropic and locally homogeneous properties.
PORFLOW, GENESYS and ECLIPSE have options for some non-isotropic properties like permeabilities.
The heterogeneity linked to fractured porous material can be taken into account by GENESYS and ECLIPSE.
The mass transfers are taken into account for phase changes, and species displacements.
The thermal transfers generally occur via the solid phase, but can also concern the primary fluid, though it is limited by the hypothesis of local thermal equilibrium.

Two exceptions must be outlined:

- on one side SUNIDJ considers no thermal transfer
- at the opposite side BRIGHT studies the local thermo-hydro-mechanics interdependencies.

For all the codes, at least the principal unknowns are assumed to vary in space and time, therefore all of them can treat unsteady problems.
The spatial domain is rather poorly defined, it is more or less assumed to be infinite, with specific areas for gas sources (but for BRIGHT), or for liquid sources (but for BRIGHT and SUNIDJ), or for thermal sources (but for SUNIDJ).

C1.1.4.Hypotheses related to the porous medium

A porous medium is characterised by:

- a geometrical quantity (porosity)
- a behaviour law with respect to local constraints (rheological law)
- and a quantity which defines the interactions between solid and fluid phases (permeability).

This last quantity implies the selection of a law of flow in the porous medium.

It can be noticed that other characterisations of the porous medium could have been done, like those based on fractal approaches.
Only BRIGHT offers a geometrical model for the porosity; an idealised geometry of salt grains and open pores is characterised by three parameters, the total porosity of the open pores is computed locally, and can vary in time and space.
Generally, the porosity is defined by a single parameter, constant in time, and which may vary in space inside the studied domain.
In order to have this scalar quantity everywhere defined, the concepts of homogenisation, representative elementary volume or effective quantity, are used. All these concepts consist in computing a local mean value, which will be all the more precise as the medium will be homogeneous.
Petroleum engineering originated codes also define a **dual porosity in order to represent (to model) the fractures**, therefore at each point two porosities are defined, and through an option these can be used to build an average value or pseudo-porosity.
The porous medium is generally assumed to be rigid; BRIGHT is the only code to really take into account the deformability of the medium with respect to local constraints, temperature and geometrical definition of the medium.
The permeability concept can only be defined with respect to the law of flow in porous medium, generally Darcy's law. But as this law is used independently for each fluid or phase, this requires to introduce concepts of intrinsic permeability (related to the porous medium alone) and of relative permeabilities (related to the different fluids or phases).
It must be pointed out that for very little porous media, the independent use of Darcy's law for each fluid may be doubtful, as some effects like Knundsen's ones are not described, though they may be important in this case.
The intrinsic permeability is usually represented by a scalar quantity, which is an average over values in several directions or values in the vicinity. In fact it is an effective permeability.

For PORFLOW the permeabilities can be defined with respect to the three main directions, and for ECLIPSE one permeability is considered along the main flow direction, and another one is considered orthogonal to it.
ECLIPSE and GENESYS consider one permeability for the matrix and another one for the fractures, with an option to deduce from them an average value, which defines an effective intrinsic permeability.
The relative permeabilities are assumed to be functions of the saturations in all the codes, with several available selections for these functions which can be derived from arrays of value or from empirical laws. These relative permeabilities are usually the one of the main source of non-linearity in the equations.
For example, in TOUGHII, some available functions are: linear law, power law, Brook-Corey's curves, Grant's curves, functions of Flatt-Klikoff, Sandia, Vermia...
The associated phenomena such as residual saturation of the wetting phase, hysteresis are also dealt with but the way it is done is not documented.
The Klinkenberg, i.e. the dependency of the relative permeability with respect to the local pressure level, may also be taken into account in all the codes.
The global permeabilities (intrinsic permeability x relative permeability) are therefore also dependent of the saturations and of the capillary pressure.
This capillary pressure, which is well defined only in the case of one solid phase, one non-wetting phase and one single wetting phase, is a function of the characteristics of the porous medium (porosity), of the permeabilities and of the saturations.
As for relative permeabilities, several empirical laws can be used to define the capillary pressure.
For example, in TOUGHII, some available laws are: linear law, Dickens's function, Trust model, functions of Milly, Leverett, Sandia, or Brooks-Corey's relationships.
It must be outlined that, everything related to relative permeabilities and capillary pressures, in a porous medium with numerous fluid components, is still to be studied, and therefore that only a priori models can be used for such cases. Moreover available data concern almost exclusively, either the couple water-air or the couple liquid-gas for the petroleum.
And last, it can be noticed that the saturation vapour pressure of a fluid is not the same in a free open space that in a porous medium. **This effect is taken into account by TOUGHII (Kelvin's law) and by BRIGHT**.

C2.FIRST LEVEL TEST CASES(WP2T1,WP2T2)

C2.1.Objectives

The prediction of gas migration in the context of radioactive waste disposal requires to take into account quite a lot of simultaneous phenomena, such as interactions of gas with liquids, thermal transfers, capillary pressure effects..., all of these phenomena occurring in a more or less known porous media, which may present gradients of properties.
In order to have realistic predictions of gas migration, it is essential to have a good physical knowledge of all these phenomena, and it is also essential to use numerical schemes able to deal with the mathematical modelling of these phenomena, with the maximum accuracy and with as small side-effects as possible.
For example when physical diffusion is an important phenomenon, it is essential that the so-called numerical diffusion is negligible with respect to the physical one.
On another hand, to be effective, the numerical prediction has to use reasonable computing resources on current computers, and in fact computational modelling is always a trade-off between available resources and some desired accuracy.
Therefore, to establish these compromises users have to get some insight of how the accuracy evolves as a function of the used computational resources.

C2.2.Detailed objectives

Once the physical model has been established, i.e. the set of equations is defined, the user which faces an existing tool can only act on the following features:

- mesh definition
- time step choice
- numerical scheme selection if several of them are available.

It is the objective of these tests specifications to get some insight of how costs, accuracy and side-effects evolve with respect to these features, avoiding the intrinsic difficulties of physical modelling which has to be addressed by another set of test cases.

C2.3.Test cases selection

C2.3.1.Numerical difficulties

To select significant test cases, one has to consider the main numerical difficulties related to gas migration modelling, which apart from boundaries conditions, are:

- no linearities related to relative permeabilities and capillary pressure evolutions with respect to saturations
- large gradients like in the vicinity of saturation fronts
- coupling of equations.

Another difficulty, at least for finite differences approximations, is the fact that, for fully 3-D flows, it is impossible to have meshes aligned with the flow characteristics, and that this leads to a loss of accuracy called axes effects.
It must also be stressed that, in order to have reasonable computational costs, it is necessary to use implicit solvers which use to smear solutions (numerical diffusion) especially in the case of non-linear equations.
Significant test cases have to address these difficulties.

C2.3.2.Constraints

The constraints which have been taken into account to select these level one test cases are:

- compatibility with all the numerical tools used in the project
- no physical modelling difficulties
- availability of analytical solutions in order to have a firm basis for accuracy assessment.

C2.3.3.Selection

The basic test case which has been selected, is the 1-D immiscible displacement of one fluid by another one with the following assumptions:

- uniform and constant densities
- uniform permeability
- analytical properties.

This case is well known as the **Buckley Leverett** case and it exhibits several interesting features:

- as far as the capillary pressure is neglected there is an analytical transient solution
- there is a discontinuity of the saturation profile, i.e. an infinite gradient.

In order to address the objectives presented in § 2.2, computations will be performed on several 2-D meshes with several time steps.

C3 Result simulation analysis(WP3T4)

C3.1 Mesh size effect

This effect is to be analysed by comparing the results of the cases:

- 1.01 (dx = L/10)
- 1.02 (dx = L/20)
- 1.03 (dx = L/40),

or

- 1.08 (dx = L/10)
- 1.09 (dx = L/20)
- 1.10 (dx = L/40).

C3.2 Irregular mesh effect

This effect is to be analysed by comparing the results of the cases:

- 1.03 (dx = L/40)
- 1.04 (dx = L/10 for $x < 0.4$ L and dx = L/40 for $x > 0.4$ L),

or

- 1.10 (dx = L/40)
- 1.11 (dx = L/10 for $x < 0.4$ L and dx = L/40 for $x > 0.4$ L).

For the chosen parameters, the saturation front is located in the region $x > 0.4$ L where the mesh spacing is L/40.

C3.3 Mesh orientation effect

This effect is to be analysed by comparing the results of the cases:

- 1.02 (dx = L/20)
- 1.05 (dx = L/20 ,the mesh lines at 45 degrees from the front propagation direction)

or

- 1.08 (dx = L/20)
- 1.12 (dx = L/20 with the mesh lines at 45 degrees from the front propagation direction).

C3.4 Time step effect

This effect is to be analysed by comparing the results of the cases:

- 1.02 (dx = L/20 dt = t0/15)
- 1.06 (dx = L/20 dt = t0/30)
- 1.07 (dx = L/20 dt = t0/60),

or

- 1.08 (dx = L/20 dt = t0/15)
- 1.13 (dx = L/20 dt = t0/30)
- 1.14 (dx = L/20 dt = t0/60).

The value of t0 is such that the front is approximately located at x = 0.6 L, and is the reference time at which all the results are analysed.

C3.5 Capillary pressure effect

This effect is to be analysed by comparing the results of the cases 1.01 to 1.07 with the results of the cases 1.08 to 1.14.

C3.6. Criteria

C3.6.1 Front location

The front location can be classically defined by three points:

- the point where a value close to the front top is reached
- the point where a value close to the front foot is reached
- the point where the mid height value is reached.

The later definition, has been chosen as it doesn't depend too much on the front spreading. It is built from the supplied results by linear interpolation.

C3.6.2 Front spreading

As numerical models use discretised representations, the saturation front spreading has been defined by the number of cells on which it is spread, and also by the distance between the points corresponding to saturation levels
s1 and s2 defined by :

$$\begin{cases} S_1 = S^f_{min} + 0.1(S^f_{max} - S^f_{min}) \\ S_2 = S^f_{min} + 0.9(S^f_{max} - S^f_{min}) \end{cases}$$

where S^f_{min} is the minimum (initial) saturation, and S^f_{max} the saturation value at the front.

C3.6.3 CPU evolution

The tests have been performed on different computers having different architectures, moreover as the objective related to this criterion is mainly to define whether the CPU cost is proportional to the number of nodes or grows faster, the raw CPU cost have been normalised by the CPU cost of the test case 1.01, for each software.

C3.6.4 Memory evolution

The memory requirements are not very much dependant on the computers, so the memory sizes are absolute values.

C3.7. Presentation of the results

C3.7.1 Status of cases

The table below shows the status of the cases with the following conventions:

- D stands for Done
- F stands for done but obviously False
- C stands for done but not converged.

TOUGH corresponds to the use of TOUGH by ANDRA and TOUGH.b by GRS.

Tableau 1.

case	TOUGH	TOUGH.b	ECLIPSE	SUNIDJ	PORFLOW	GENESYS	BRIGHT
1.01	D	D	D	D	F	D	N
1.02	D	D	D	D	F	D	N
1.03	D	F	D	D	F	D	N
1.04	D	D	D	D	F	D	N
1.05	N	N	N	N	N	N	N
1.06	D	D	D	D	F	D	N
1.07	D	D	D	D	F	D	N
1.08	D	D	D	D	F	D	D
1.09	D	D	D	D	F	D	D
1.10	D	N	D	D	F	D	D
1.11	D	D	D	C	F	D	D
1.12	N	N	N	N	N	N	D
1.13	D	N	N	D	F	D	D
1.14	D	D	D	D	F	D	D

C3.7.2 Comments on the cases

As it can be seen from table 1, there are no results for the case 1.05 and only one for the case 1.12, so these cases are not taken into account for the analysis.

Generally speaking the specified time steps have not been used as such, they have instead been used as maximum time steps together with some automatic time step control, and it seems that these 'maximum' time steps have not been reached in any test cases.

C3.7.2.1 TOUGH

It has appeared that TOUGH cannot deal with arbitrary fluids and properties in fact it can only take into account predefined standard fluids like air and water together with their usual properties, and moreover only one single liquid phase can be computed at a time.

These restrictions of use have lead to the definition of specific physical values input, compatible with the objectives of the test cases, but inducing different results. For the analysis, the main difference is that for the basic cases the saturation front height is about 0.1 and is about 0.95 for the test performed using TOUGH, and also that there are no gradients near the input side at the opposite of the basic case.

The specific input parameters are:

- permeability 3.10^{-12} m^2
- water viscosity 1.10^{-3} $kg/m.s$
- air viscosity 1.810^{-5} $kg/m.s$
- filtration velocity 1.10^{-8} m/s

These features must be kept in mind, when looking at the results.

C.3.7.2.2 TOUGH.b

See previous paragraph for the test cases definition. The case 1.03 is obviously false, probably because of a bad input value. For unknown reasons there are two missing cases : 1.10 and 1.13.

C.3.7.2.3 ECLIPSE

For unknown reasons one case is missing : 1.13. The cases with capillary pressure (1.08 to 1.14) look strange, this may be due to some mistake in the boundary conditions.

C3.7.2.4 SUNIDJ

Some computations have been performed several times, using different numerical options, especially some test cases have been performed using one or two (left and right) saturation value per node. Only the cases with two saturations per node have been analysed.
The case 1.11 failed to converge for unknown numerical reasons.

C.3.7.2.5 PORFLOW

All the cases are obviously false because there is no front in the computational domain, this may be due to some mistake in the input values.

C3.7.2.6 GENESYS

No remarks.

C3.7.2.7 BRIGHT

The cases without capillary pressure (or with a neglectible one) have not been done.
The cases with capillary pressure have been done using an initial water saturation value which is not neglectible, i.e. 0.03 for a front height of about 0.1. The corresponding theoretical saturation profile has been taken into account for the analysis.

C3.8. Analysis

For this global analysis, the cases which can be considered as false are not taken into account.

C3.8.1 Front location

The front is rather well located for most cases. For the cases without capillary pressure the discrepancy between the numerical values and the theoretical ones are always smaller than half a cell.

For the cases with capillary pressure the discrepancy between the numerical values and the theoretical ones are larger ,but for TOUGH (and TOUGH.b) for which the results are almost identical to those without capillary pressure because of its specific test cases definition. The effect of mesh size can mostly be seen for cases 1.08 1.09 and 1.10, for which it is clear that the finer the mesh the better the results.

The influence of a coarse upstream mesh can be seen by comparing the results of the case 1.04 (resp 1.11) with those of the case 1.03 (resp 1.10). All these cases having the same fine spatial discretization in the neighbourhood of the front (x > 400), the discrepancies only come from the fact that the front has been travelling in a coarse mesh before arriving in the fine one.

C3.8.2 Front spreading

All the numerical tools spread the front over approximately 2 to 3 cells,this being a classical range.

- the first order improvement of the results versus the spatial discretization (cases 1.01 1.02 1.03 and cases 1.08 1.09 1.10)
- the relatively small influence of a coarse upstream mesh.

C3.8.3 CPU evolution

The CPU cost evolution is classically $C = N^P$,where C is the CPU cost, N the number of cells and p an exponent.

Table 2

Software	Exponent P
TOUGH	1
SUNIDJ	3
ECLIPSE	1
PORFLOW	1
GENESYS	2
BRIGHT	2.5

It must be noticed that these values combine the direct effect of computing more nodes, and the induced effect of computing more time steps because usually the finer the mesh the smaller the time step.

When the exponent value is 1., it means that the number of time steps remains unchanged.

C3.8.4 Memory requirements

The memory evolution, is classically $C = N^q$,where M is the memory requirement, N the number of cells and q an exponent.

the values of q **are all close to 1**., this means that the memory requirements are proportional to the number of cells, i.e. that there is no matrix storage.

C3.8.5 Time steps

As explained above, automatic time step control has been used for almost all cases.

The main conclusion which can be derived from the results is that all the used time steps are all smaller than the specified ones. More precisely, the fact that the results of cases 1.02 1.06 and 1.07 (or 1.09 1.13 and 1.14) are identical implies that the effective time steps are smaller than the specified minimum one.

The minimum specified time step (150 days) corresponds to a displacement of 0.88 m ,i.e. 1/28 the cell size for these cases.

C3.9 Analysis of the softwares

This paragraph presents some provisional conclusions about the use of the tested softwares.

TOUGH and GENESYS produced satisfactory results for all cases, taking in mind the restrictions presented above for TOUGH.

ECLIPSE and SUNIDJ produced satisfactory results only for the cases without capillary pressure. For the cases with capillary pressure, it is not possible to know whether their bad results come from mistakes in input data or from the numerical approach.

BRIGHT produced some satisfactory results only for the cases with capillary pressure (with some numerical instability in the vicinity of the front for one case), it would be interesting to know its behaviour for cases with a neglectible capillary pressure.

PORFLOW did not produce any results comparable with the reference solution, hopefully because of mistakes on input data. The only remarks that can be done are that the results are relatively dispersed, and that there are non neglectible numerical instabilities for all the cases with capillary pressure.

It can be noticed that GENESYS and ECLIPSE predict saturation values higher than the theoretical ones in a quite large domain upstream the front and also at the front location.

C4 Second level test case definition and specification (WP3T1,WP3T2)

EVEGAS second level test cases based on laboratory experimental result. A heterogeneous plug made by eight rocks samples (whose length is L_i from different rocks) is maintained in a vertical position and was saturated with water at the initial time and the bottom plug pressure is maintained at 20 bar. The air was injected downward at the plug top at a constant flow rate (150 cm^3/h). The produced gas and water at the plug bottom are monitored by a flash device. The whole experiment apparatus is maintained at a constant temperature (20 °C).

The aim of the second test cases is to simulate the laboratory experiment ,at the above described conditions and configuration, in order to predict water production versus time and water saturation profiles and pressure profiles at some relevant times. Some data related to computing aspect are required.

This second level test cases in the frame of the EVEGAS project should contribute to get information on the predictive numerical model capabilities faced experimental result.