KURC public report
15th April 2016

This public report presents to potential consortium participants the work performed during the first phase of the KAPPA Unconventional Resources Consortium (KURC-1). It also presents the work done in 2015 and Q1-2016 for the second phase of the project (KURC-2).

1 – Short history

The initial idea for the first phase of the consortium (KURC-1) was to gather 10 participating companies for an 18-month project between mid-2011 and end 2012. The initial budget was 1 M€ and no second phase was considered. The technical goal was to develop additional models and workflows to address the interpretation and forecast of production data in unconventional plays, mainly for shale oil and shale gas, increasingly for CSG. This was done with technical developments applied to production data provided by consortium members.

The project attracted more interest than initially anticipated, and 28 members have joined the consortium as of today. As of today, KURC represents a little less than 3.5 M€ of cumulative budget. With these additional funds the project was incrementally extended and the list of developments widened. The main, last KURC-1 deliverable of the KURC Application was in January 2014, but some residual developments continued towards the end of 2014.

Anadarko	CNPC	ExxonMobil	Pioneer
Apache	ConocoPhillips	Halliburton	Saudi Aramco
Baker	Continental Res.	Hess	SGS
BG	CPC	Marathon	Shell
BHP	D&M	Noble	Statoil
Caspian W.S.	EP Energy	Petrobras	TOTAL
Chevron	Encana	Petronas	YPF

Internation Oil Companies	*National Oil Companies*	*Independents*	*Services and Consultants*

In 2014 all members expressed interest in starting a second phase of the consortium (KURC-2). However the drop in the oil price and resulting budget cuts have reduced the number of participants, though all of them have indicated that they would return as soon as budgets allow. Nevertheless the KURC-2 project has started, albeit at a slower speed. The one-year program has been extended to two years with the same content. KURC-2 is now scheduled to be completed at the end of 2016, but it may be extended by another year.

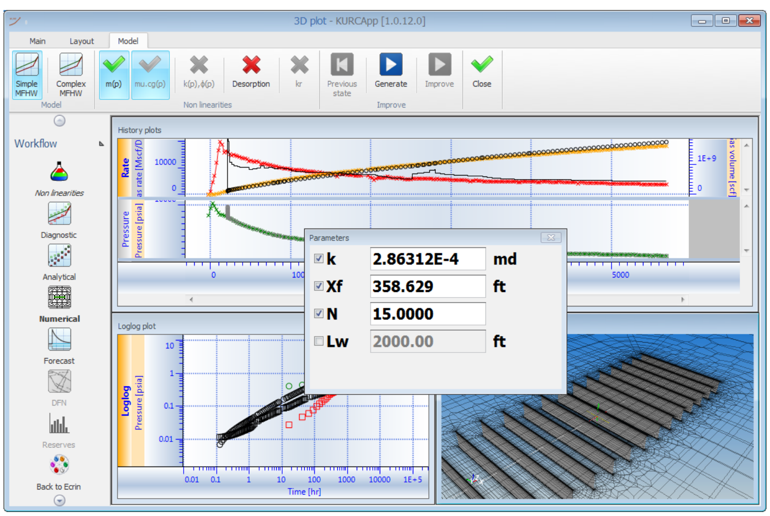
2 – List of KURC-1 technical developments

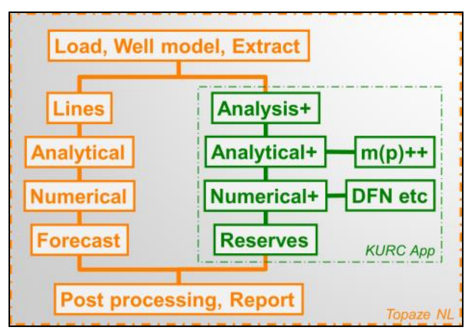
The open to-do-list for the first phase of the consortium can be summarized as follows:

- Create a workflow using improved analysis methods and models
- Implement fast analytical and numerical models for bounded SRV and trilinear geometry
- Reduce the difference between successive models using pseudofunctions
- Implement automatic final nonlinear regression on the numerical model
- As a result of the four points above, reduce the process down to minutes
- Develop more complex analytical and numerical models, both for diffusion and geometry
- Initiate the model with initial water saturations and simulate water flowback
- Use additional information to constrain more complex models (e.g. microseismics)
- Challenge the basic assumption of SRV using Discrete Fractures Networks (DFN)
- Develop the modeling tools to allow 'technically proper' reserves booking
- Test and adapt developments from experience in participant data
- Package all this in a 'KURC-1 application' compatible with the Ecrin suite
- Fast numerical model for bounded SRV and trilinear
- Nonlinear regression on numerical models
- Import Microseismic interpretations and results of fracture simulation
- Add statistical analysis in the calculation of the EUR

3 – The KURC Application (KURCApp)

Most of these developments were integrated in the KURC Application. KURCApp is called by Topaze NL which transfers the data and the active model. The specific workflow is executed and the resulting analyses are returned to, and stored by, Topaze NL. A screenshot of the application and the parallel workflow are shown below.





KURC Application (left) – Schematic of the Topaze NL + KURCApp workflow (right)

As shown in the schematics KURCApp includes (1) additional analysis tools; (2) additional analytical models; (3) enhanced pseudopressures, pseudotimes and material balance functions to get analytical models much closer to numerical models; (4) additional numerical models; (5) models using Discrete Fractures Networks (DFN); (6) a 'Reserves' module calculating a statistical EUR.

4 –KURC-1 developments integrated in KURCApp…

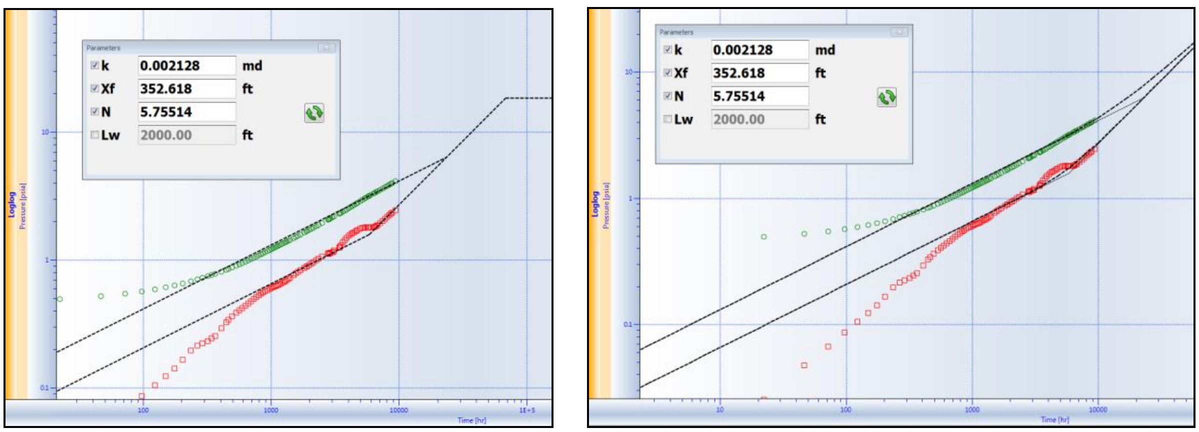
…and to be integrated in KAPPA Workstation (Saphir NL, Topaze NL, Rubis) in Q2-2016 (§8)

4.A – Diagnostic

Loglog is the diagnostic plot of choice. Combination lines account for the initial linear flow (two parallel half slopes), pseudo-PSS if the SRV (unit slope) and the never-reached level of IARF in order to define permeability (horizontal line). The four lines are automatically redrawn vis-à-vis each other and can be interactively modified by the engineer.

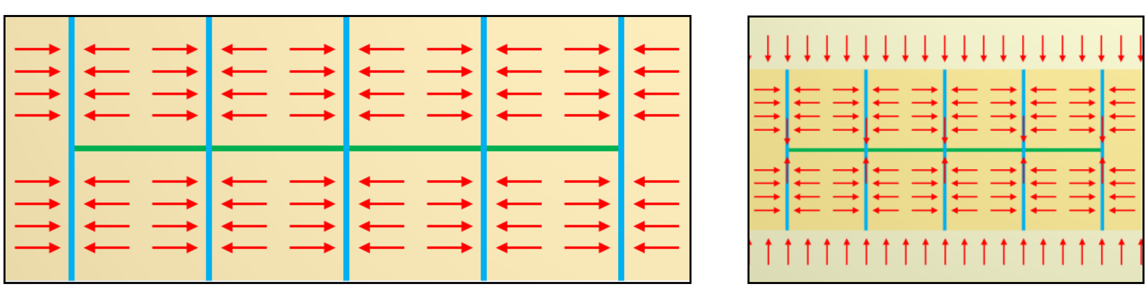
From this, an automatic calculation of N, Xf and k is done and dynamically updated. At this stage, in order to allow continuous adjustments, a non-integer value of N is allowed. When, on a new case, a default position of these four curves is suggested by KURC (as in PTA in Saphir NL).

At this stage the parameters may be corrected in order to account for different normalized pseudopressures accounting for PVT, desorption, pressure dependent permeability, etc. The high pressure gradients are also accounted for using specific pseudotime functions adjusted to linear flow.



Analysis using straight lines (left) and the SRV bounded model (right)

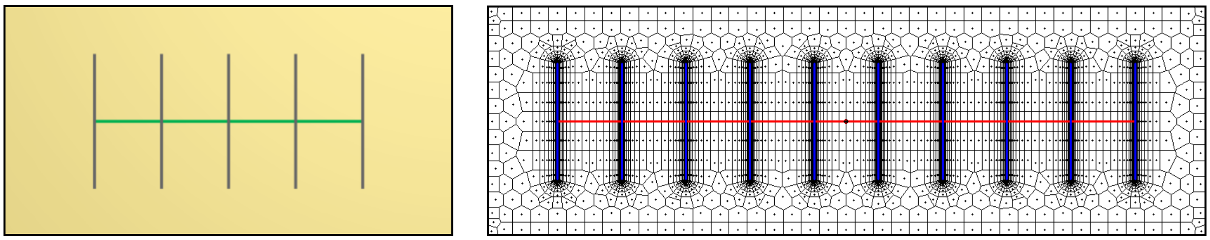
To complement this the engineer can also use simplistic analytical models such as the SRV bounded (if no flow beyond the SRV is detected at this time) or the trilinear model. These are not really considered as models but more as 'glorified' straight lines that do not only show the flow regimes but the transitions between them. When moving any of the four flow regime loglog lines theses very fast models are dynamically corrected, a little as if they were splines. These models are also corrected by pseudofunctions.



Bounded SRV (left) and trilinear (right) analytical models

4.B – Standard models

Regarding the analytical and numerical models of the standard multifrac horizontal well, as they were implemented and presented in the initial set of papers; we would start with the analytical, corrected for pseudofunctions, run a nonlinear regression and switch to the numerical model, on which a final nonlinear regression would be run. All these actions, starting from the result of Level A, would take only minutes unless the engineer took the decision to override it.



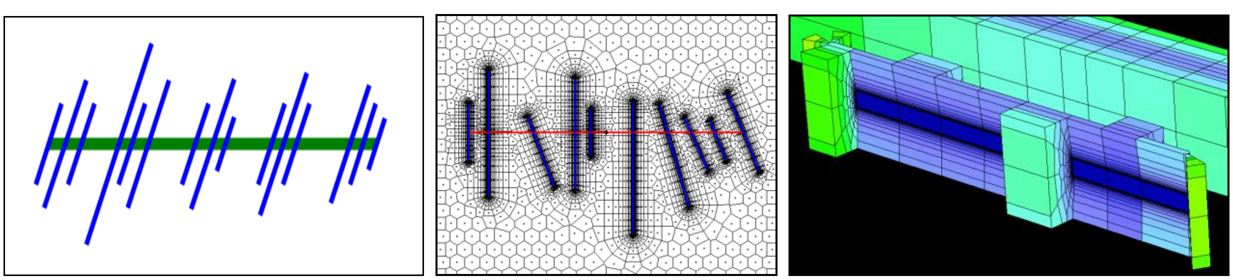
Standard analytical (left) and numerical (right) models

It is also possible in level B to carry over the simplified models of level A (bounded SRV and trilinear). In this case the simplified analytical model is also complemented by a very fast numerical version for the same geometry which incorporates complex behaviors (PVT, multiphase, stress, desorption, etc) and can be generated and regressed upon in a couple of seconds. This simplified representation may be 'the' answer if the model is sufficient, or it may just feed the initial parameters of the standard simplified model.

4.C – Complex (but SRV compatible) models

In these models we are still considering that the totality of the production comes from the SRV defined as a slightly inflated version of the bulk volume physically restrained by the hydraulic fractures. This is the assumption in common with level B models, which will generally be used as the first version of the level C models. The complexity of the model can address the <u>geometry</u> or the <u>diffusion</u>.

One can have a more complex <u>geometric</u> representation of the hydraulic fractures, which can be defined, analytically and/or numerically, with individual lengths, angles, intercepts to the horizontal drain, limited entry and conductivity. Analytical models are restrained to parallel fractures, though not necessarily orthogonal to the horizontal drain. As the problem becomes even more under-defined than the simpler one it is necessary to inject additional information to constrain it. This could be using the fracture report or by the import of the microseismic events.



Complex analytical (left) and numerical geometries in 2D (center) and 3D (right)

These models also account for the more complex diffusion effects which may or may not be analytically applied using pseudofunctions. In order to address all possible cases, including the DFN representation of level D, four numerical models were implemented. Apart from the table below they are not developed in this public report:

<table>
<tr><th></th><th>Dbl-ϕ</th><th>Diff</th><th>Micropores</th><th>Small fiss</th><th>Large fiss</th><th>Hydraulic fracs</th></tr>
<tr><td>Model 1</td><td>No</td><td>No</td><td colspan="3">K - ϕ - Kr/Pc - s</td><td>Cf - w - ϕ - Kr/Pc - s</td></tr>
<tr><td>Model 2a</td><td>Yes</td><td>Yes</td><td>τ</td><td colspan="2">K - ϕ - Kr/Pc - s</td><td>Cf - w - ϕ - Kr/Pc - s</td></tr>
<tr><td>Model 2b</td><td>Yes</td><td>Yes</td><td>K* or τ - ϕ</td><td colspan="2">K - ϕ - Kr/Pc - s</td><td>Cf - w - ϕ - Kr/Pc - s</td></tr>
<tr><td>Model 3</td><td>No</td><td>No</td><td colspan="2">K - ϕ - Kr/Pc - s</td><td>Cf - w - ϕ - Kr/Pc - s</td><td>Cf - w - ϕ - Kr/Pc - s</td></tr>
</table>

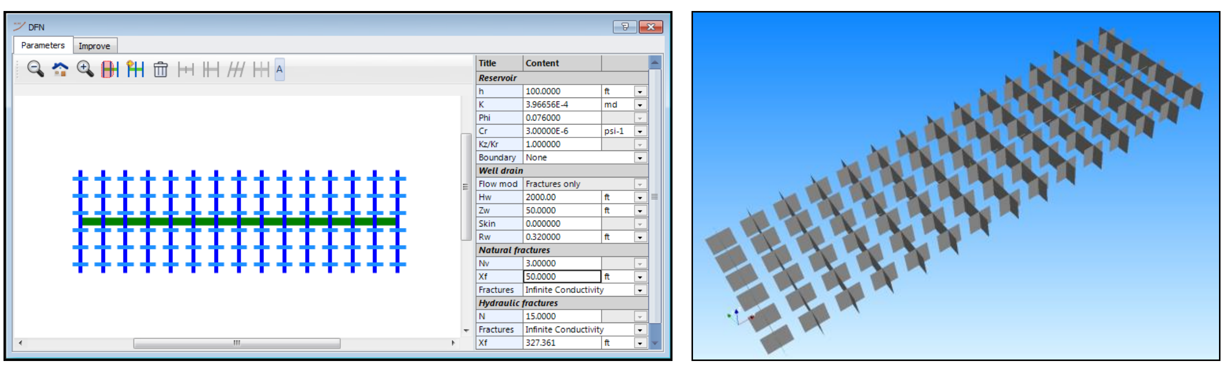
Diffusion models

4.D – Discrete Fracture Networks (DFN)

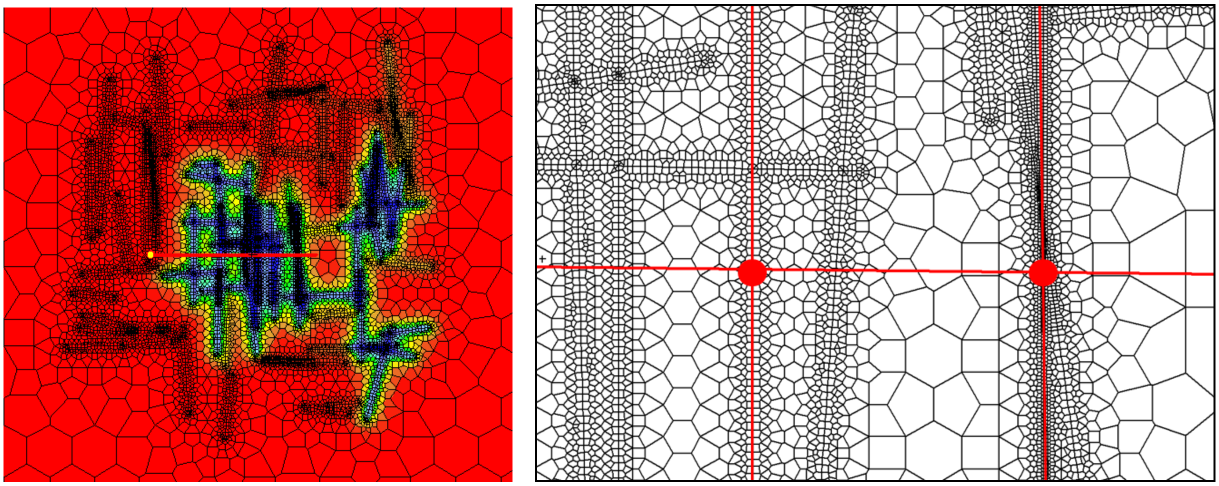
Here we question the assumption of a homogeneous equivalent reservoir and integrate natural fractures in the diffusion process. The critical question is whether the diffusion and production of an unconventional well could be coming from a wider area defined by natural fractures than those that were opened during the well stimulation.

The first level of DFN is available analytically and numerically. As a parameter, it includes the number, length and conductivity of a primary set of fractures orthogonal to the horizontal drain, which may correspond to the hydraulic fractures, and a second orthogonal set of natural fractures which can connect to each other or, as in the figure below, only covering a part of the area separating the primary fractures.

These simple models, whether analytical or numerical, have the advantage of being uniquely defined by a limited series of parameters, and they enable us to quickly investigate our qualitative options in terms of bulk volume, number of fractures and porosity.

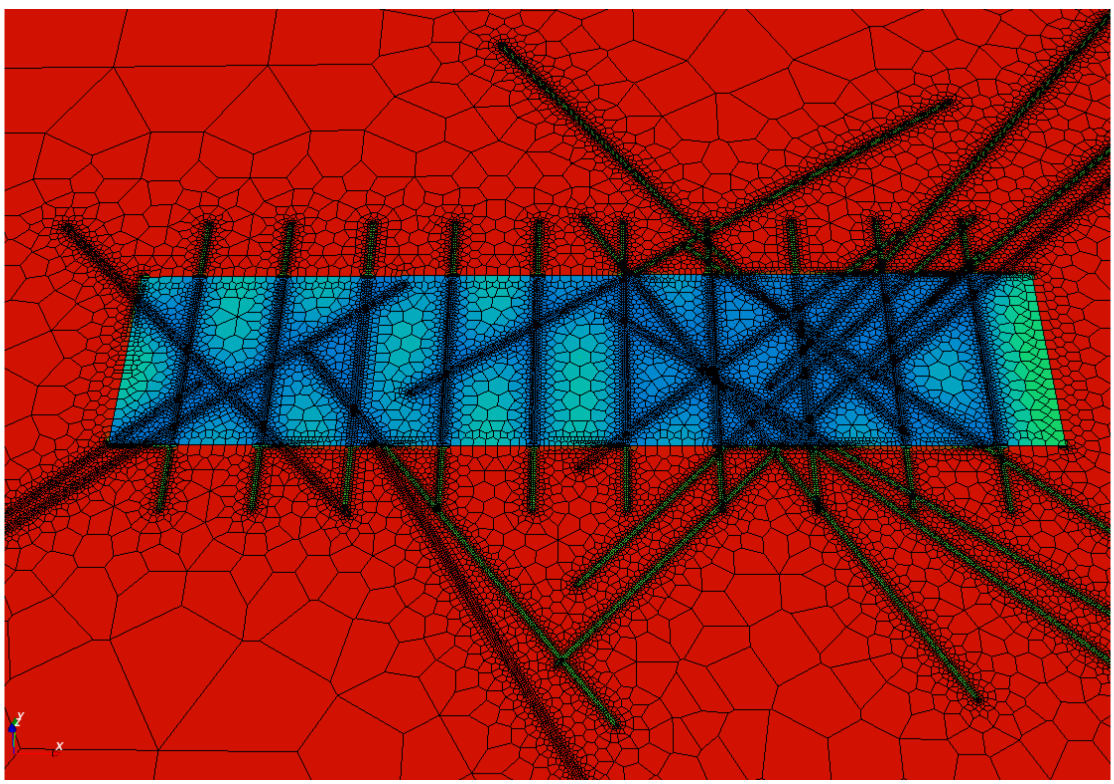


Simplified DFN analytical (left) and numerical (right) representations



Complex numerical DFN: general view (left) and close-up (right)

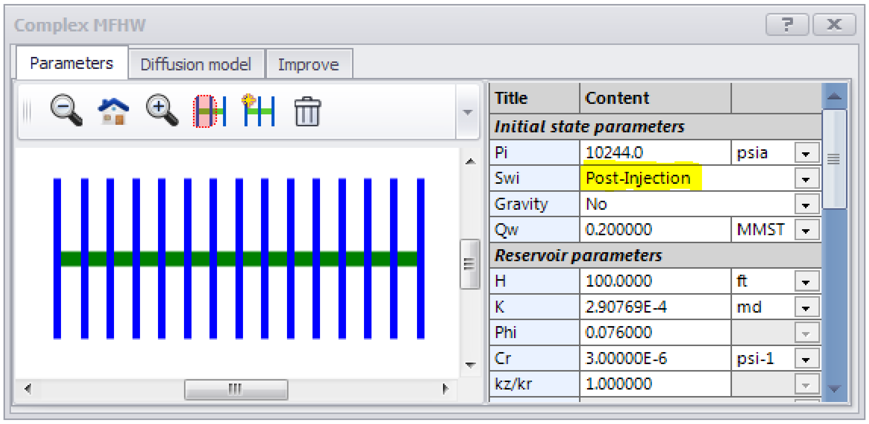
The complex DFN model is only numerical and requires the import of a 2-D DFN representation from a third party application. The 2D Voronoi grid is automatically created, and the model can account for a heterogeneous initial water distribution. The gridding algorithm was finalized and validated on a number of synthetic and real cases. Horizontal anisotropy was also included. The DFN was also combined with SRV limits.



Combination of DFN and SRV limits

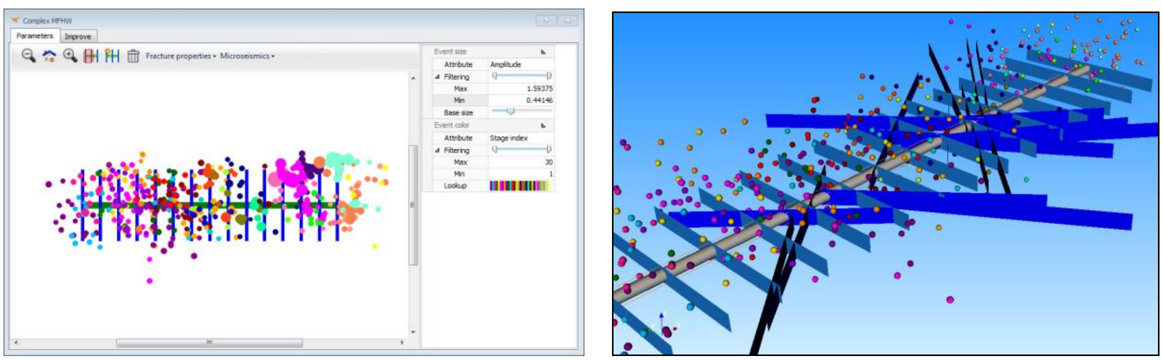
4.E – Other developments

Flowback analysis: There is an option to initialize the simulation with an increased water saturation in and around the fractures, based on the volume of water injected during the stimulation phase.



Flowback analysis dialog

Import of microseismics data: Events can be loaded and displayed in the 2D map of the complex MFHW and DFN models. They can also be displayed in the 3D plot module. These generic, generation 5 developments were not included in the consortium expenses.



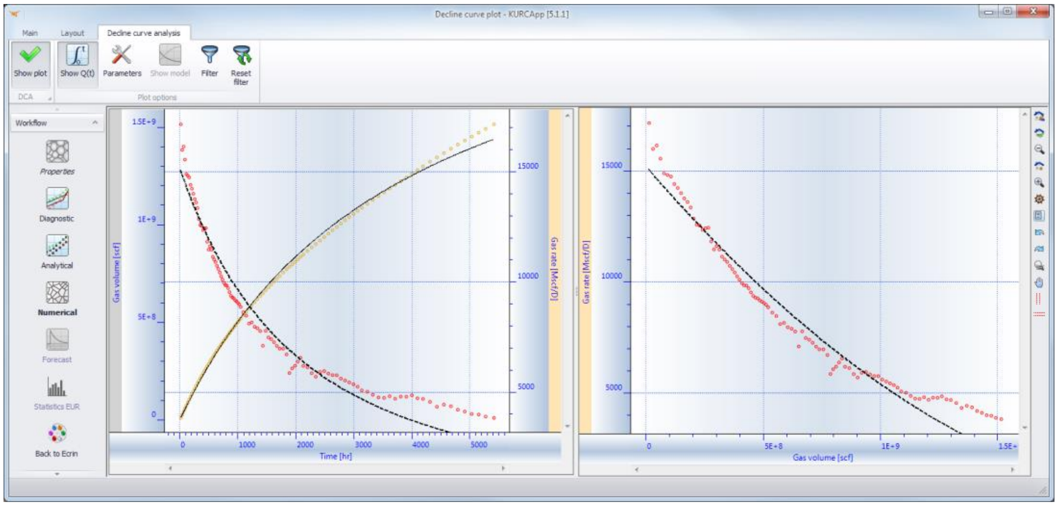
2D (left) and 3D (right) display of microseismic events

Improve: this is an automatic non-linear regression option for history matching. Numerical proxies were used to accelerate the regression on simple and complex models. For complex MFHW where fractures have been independently redefined, a global regression parameter (Xmf) was added, allowing us to vary simultaneously the half-length of all the fractures by applying the same multiplying factor.

Statistics EUR: This option provides an uncertainty analysis of the EUR forecast. First, an EUR surface response derived from successive non-linear regressions performed on selected values of the uncertain parameters is generated. The response is then stochastically sampled to obtain reliable statistics on the EUR and on the regression parameters.

Diffusion: Klinkenberg effect in the matrix has been integrated in the numerical complex MFHW model and the numerical DFN model.

Decline curves: This set of facilities, primarily developed for the generation 5 version of Topaze NL and Citrine, was added at marginal cost to the KURC-1 application as a 'goodie'.



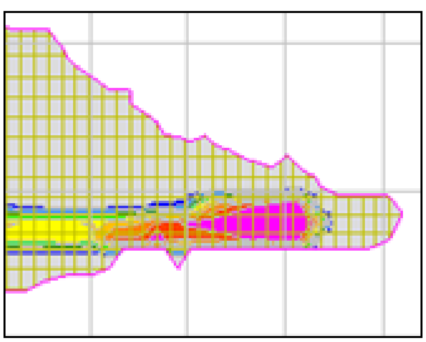
Decline curves

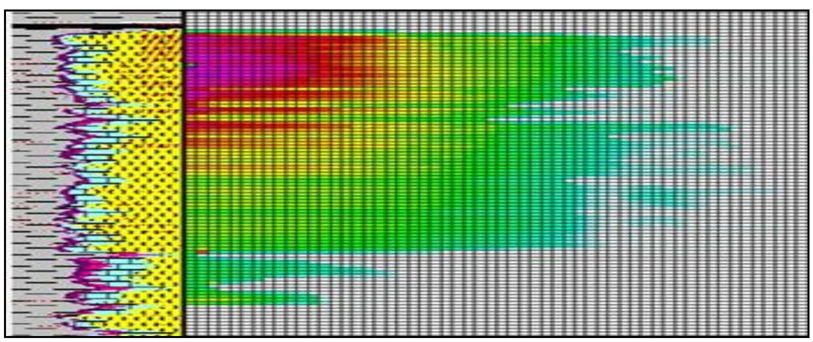
5 –KURC-1 developments NOT integrated in KURCApp…

These features are currently being integrated in KAPPA Workstation (see §8)

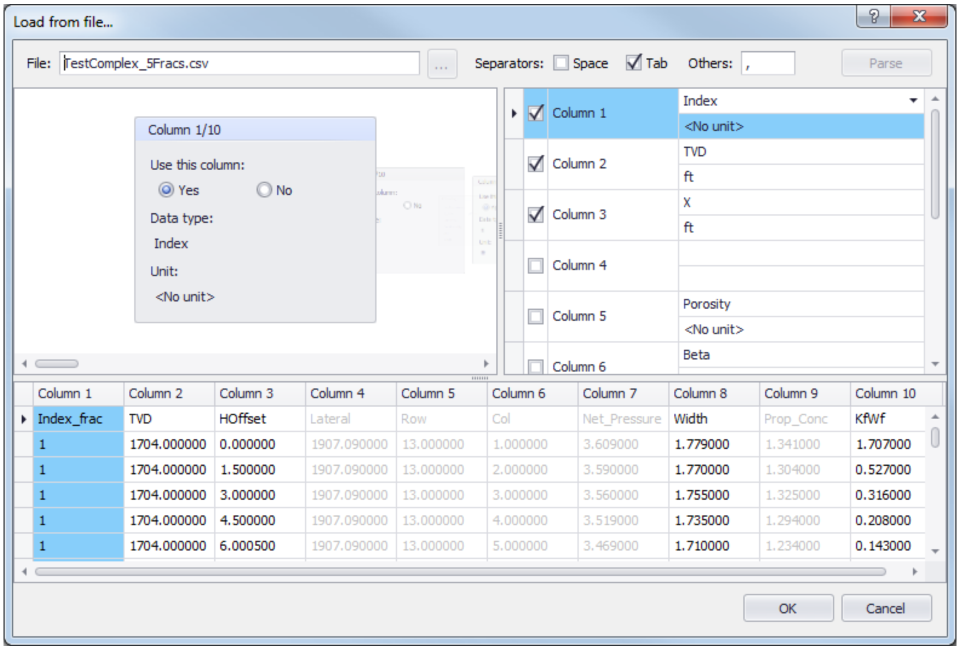
5.1 – Initialization from fracture design software

Geometric and petrophysical properties of hydraulic fractures can be initialized directly from the outputs of fracture design software. The XML Stimplan output format and a general .csv format (compatible with Gohfer ascii outputs, for instance) are supported.





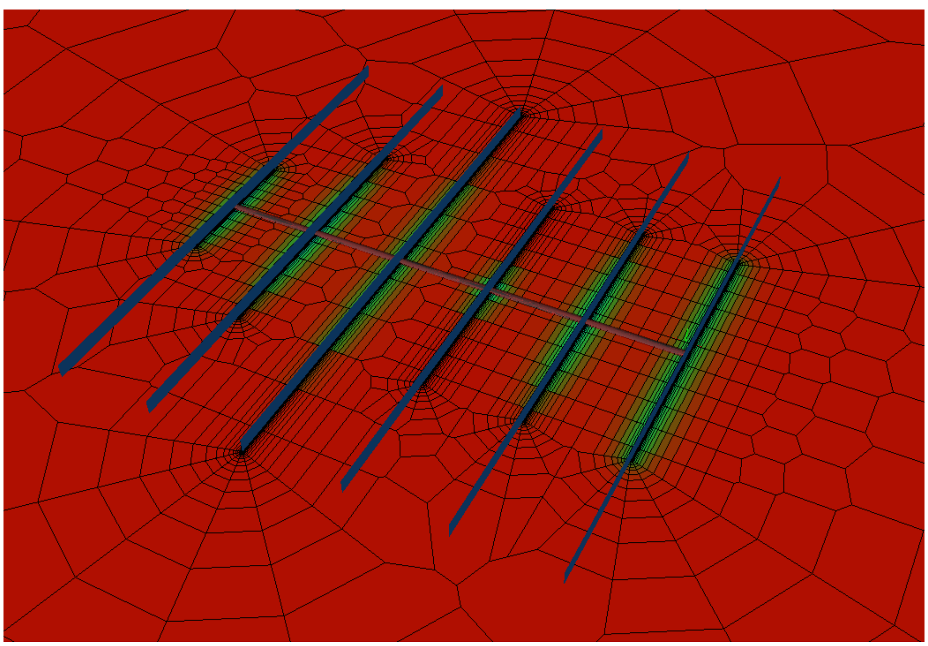
Outputs from fracture design software: Stimplan (left) and Gohfer (right)



Load option for complex CSV format files in KAPPA Workstation

After the loading process, each fracture plane has a heterogeneous width distribution and possibly heterogeneous distribution of conductivity, porosity and Forchheimer coefficient.

On the picture below, dark blue fracture planes correspond to the full computational domain (grid) of the fracture design simulator. Inside each plane, only a small portion actually corresponds to an opened fracture zone (width > 0). As shown below, the KAPPA grid automatically adjusts to these effectively stimulated plane portions. The flow simulation also accounts for heterogeneous conductivity distribution along fracture planes, as visible from the resulting pressure field below.

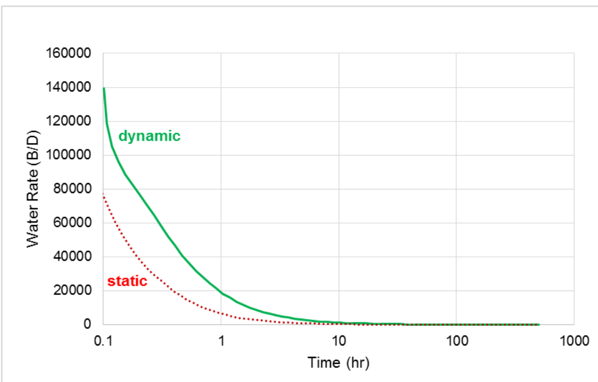


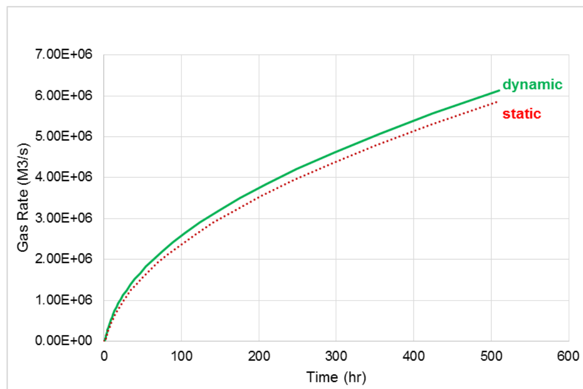
Simulation with complex fractures in KAPPA Workstation

5.2 – Simulation of the water flowback

The initialization of water saturation and pressure fields were improved by simulating the injection of the fracture water in the final system. This 'dynamic' initialization method predicts higher early-time flowback rates compared to the original 'static' method. This is partially explained by the excess pressure associated with stimulation. However, the shape of the 'flooded' zone around each fracture (stadium shape for the static method vs. elliptical for the dynamic method) also has a strong influence on recovery.

Later time gas recovery also seems to be quite dependent on the initial state. The primary cause of discrepancy is the different shape of the flooded zone depending on the initialization method.





Water rate (left) and gas cumulative (right) flowback from dynamic and static methods

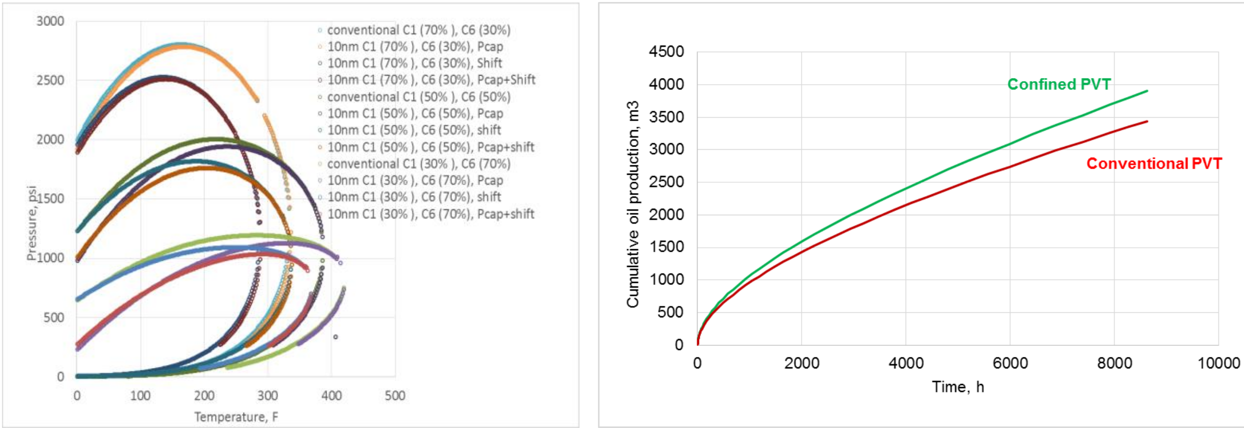
We also tested two dynamic initialization approaches: the first one considers simultaneous injection in all the fracture planes, while the second simulates successive injections. The difference between both approaches on production rates was not found to be significant.

5.3 – Confined PVT

Laboratory experiments, and hence standard input PVT data, characterize the bulk fluid behavior without considering the impact of confinement. When the size of the pores approach the order of magnitude of the size of the hydrocarbon molecules, the behavior of the fluid under confinement can deviate considerably from the bulk fluid. In particular, for a given composition of a hydrocarbon mixture, the phase behavior obtained in a laboratory PVT cell may be considerably different from the behavior in a confined environment: the phase envelop is shifted, leading to different values of the saturation pressure and an apparent bubble or dew point 'suppression effect'.

An option was developed to account for the dependence of the PVT to the pore size. The vapor-liquid equilibrium algorithm (compositional flash) has been modified to account for capillary pressure and critical properties shift under confinement.

This new flash has been combined with our compositonal simulation kernel. A uniform value of the pore radius is assumed in the matrix, where confinement effects on PVT occur. The fractures (hydraulic and natural) correspond to unconfined zones.



Left : Phase envelopes obtained using the standard (conventional) flash and the confined flash (including capillarity and critical properties shift) in pores of 10nm radius
Right: Cumulative oil production simulated using confined and conventional PVT

6 – List of KURC-2 technical developments

The KURC-2 project started in January 2015 and is scheduled to be finalized in December 2016. It may have to be extended another year given the current scope of developments. This section briefly summarizes the action items that constitute the current scope of the KURC-2 project. We separate these action items into four categories:

Development features fully completed:
- Extension of all numerical models to multi-well simulations, including DFN
- Extension of all numerical models to multilayer simulations
- Use of injection controls and other complex well schedules for flowback analysis

Features completed in the technical kernels but as outstanding items to be plugged into the interface of KAPPA Workstation:
- Stochastic generation of DFN realizations, constrained to microseismic events
- Analytical and numerical models accounting for stimulated zones around the fractures

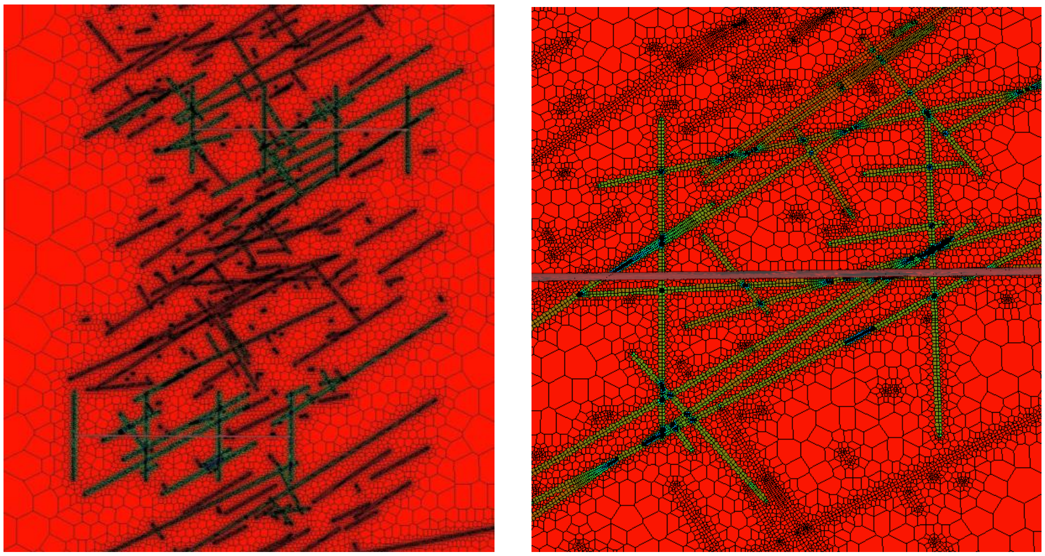
Development features started and to be completed in 2016:
- Gridding and numerical simulation of 3D DFN
- Fast marching method to select DFN realizations compatible with interference times

Development features to be started:
- Interfacing with a geomechanical simulation software (subject to approval)
- Well model with countercurrent flow for CSG application

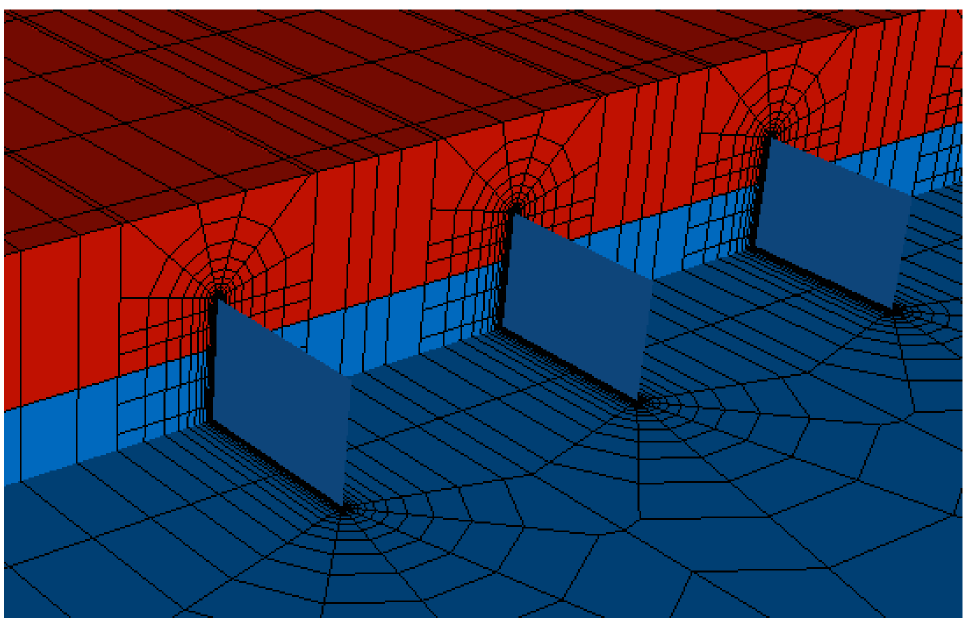
7 – KURC-2 developments

7.1 – Multi-wells simulations

All the KURC-1 numerical models have been extended to multiple wells and multiple layers simulations. In particular, the numerical DFN can now be used to study well interference.



Simulation of two wells interfering through a connected DFN:Pressure field (left) global view and (right) closeup on the top well



Multiple fractures horizontal well in a layered system

Not surprisingly, the computational time increases rapidly with the number of wells and natural fractures, and can become problematic for manual history match. We are now working on the performance of our linear solver to address this issue.

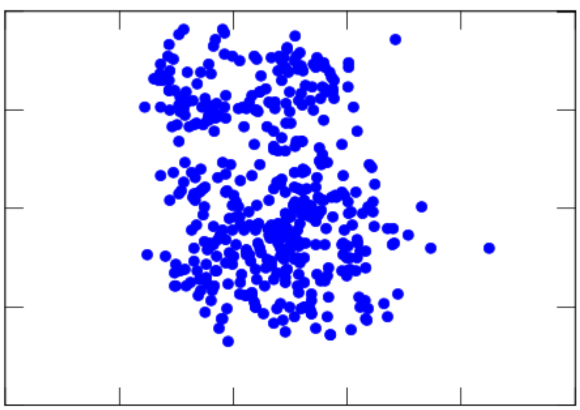
7.2 – DFN realizations constrained by microseismics

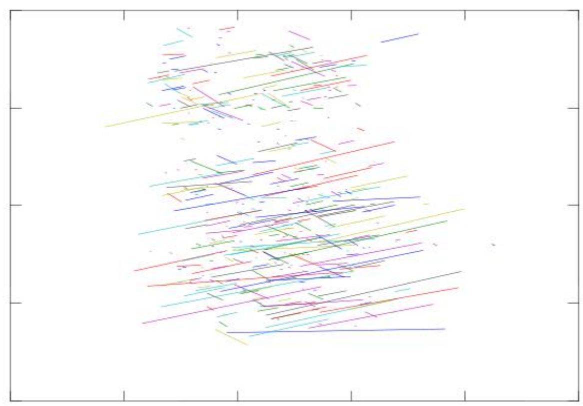
In KURC-1, one could load complex DFN geometries generated by a third-party application. In the context of KURC-2, we developed a stochastic generator of DFN realizations, constrained by microseismic events.

The main required input comprises some statistical information on the fracture distribution (number of sets, orientation, length and aperture distributions per set, etc.), usually obtained from cores or analogs. Another, optional input is the collection of microseismic events that will be used to constrain the realizations.

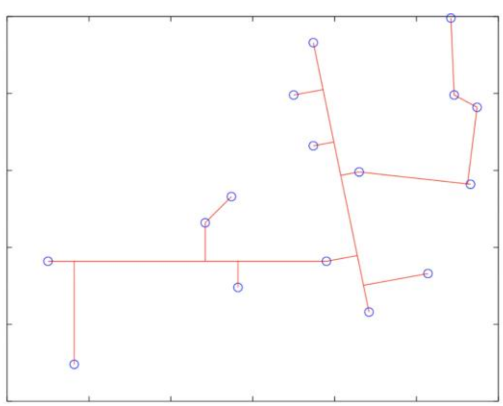
In order to constrain the realizations to the microseismic events, the algorithm assumes that recorded events only correspond to shearing mechanisms associated with the opening of pre-existing, natural fractures. For each event, an independent fracture is generated by drawing the fracture set. If the strike of the event is known, the length (power law), the strike and the dip (Fisher distribution), as well as the position of the fracture relative to the microseismic event may be used as a constraint.

If available, information about the source mechanisms (tensile vs. shearing) and about the uncertainty on the event locations can be incorporated.





A simple 2D deterministic generator was also developed based on the position of hydraulic fractures, event locations and event times. This allows us to generate a (single) network representation compatible with the estimated position of hydraulic fractures and the chronological order of the events.

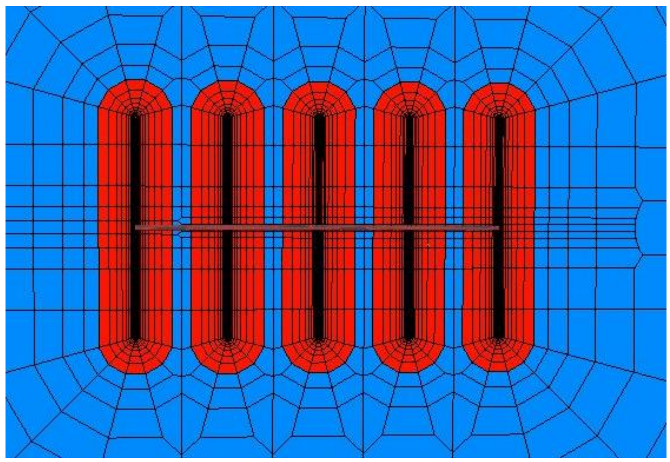


7.3 – Stimulated zones

New models including stimulated volumes around hydraulic fractures were developed.

- The KURC-1 trilinear analytical model was extended to include several 'inner' and 'outer' zones with various mobility contrasts.

- The complex MFHW numerical model was extended to incorporate stimulated zones around each fracture, simply defined by a uniform 'stimulation radius', and permeability/porosity multipliers of the stimulated zone. The grid is automatically adjusted to honour the stimulation radius, as shown below. This will be available for both simple and complex MFHW numerical models.



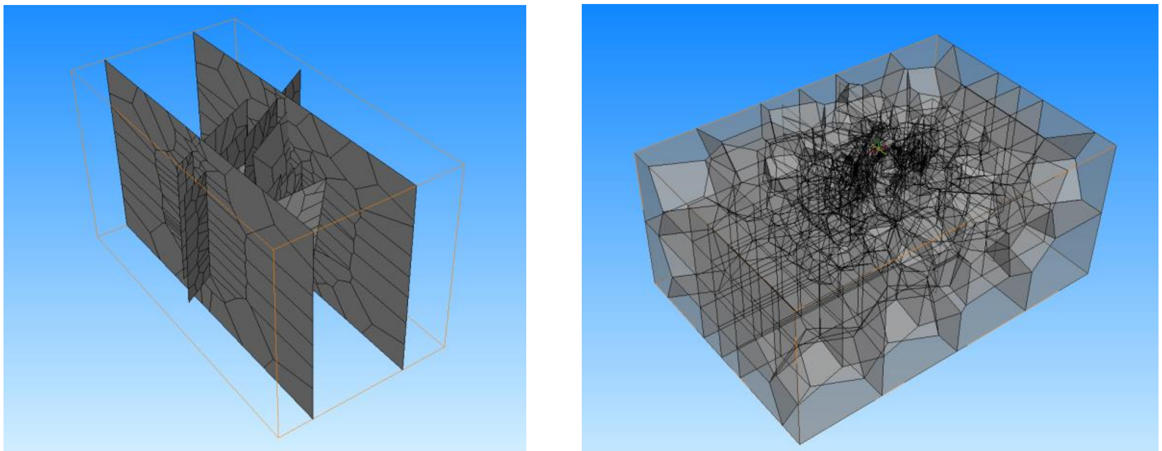
7.4 – 3D DFN

In addition the DFN simulation capabilities were extended to 3D.

The first part of this project consisted of developing a specific 3D gridding algorithm:

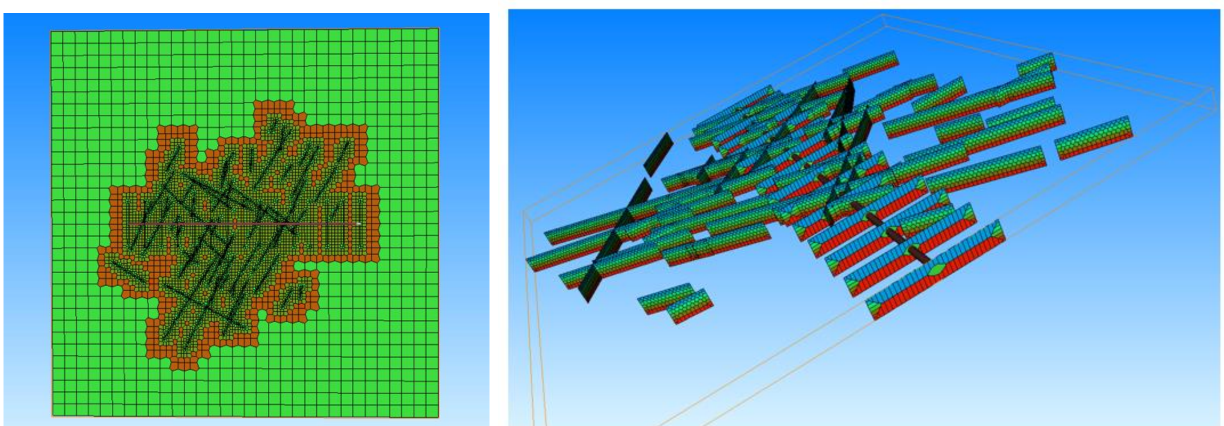
- All the intersections between 3D fractures are derived
- Each fracture is gridded independently using a 2D voronoi grid constrained to the geometry and potential intersections of the fracture
- All the independent 2D fracture grids are assembled into a 3D grid representing an accurate discretization of the network (as shown below)
- The network grid is finally embedded inside a 3D voronoi 'matrix' grid, refined in the vicinity of the fractures, but not constrained to the fracture planes (as shown below).

This option is limited to a single flat layer.

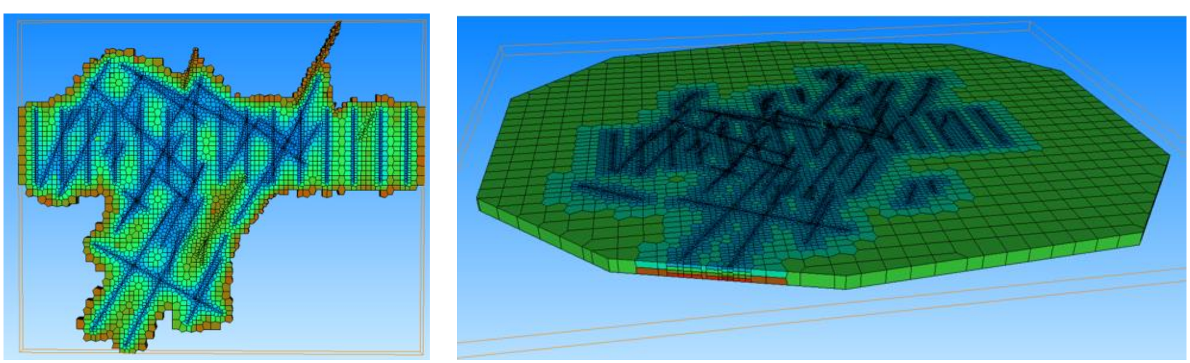


3D "Network" grid based on assembled 2D fracture grids (left) and 3D "matrix" grid in which the network grid is embedded (right)

The second part of this project consisted of connecting the two grids (matrix grid and embedded network grid) and deriving all the transmissibility values. Fluxes between the 'matrix' grid the embedded 'network' grid are derived by assuming a linear flow between the fracture cells and the matrix cells they connect. This part has just been finished and we can now run complete simulations. The testing phase has just started.



3D DFN case with 59 fractures. Matrix and network grids.

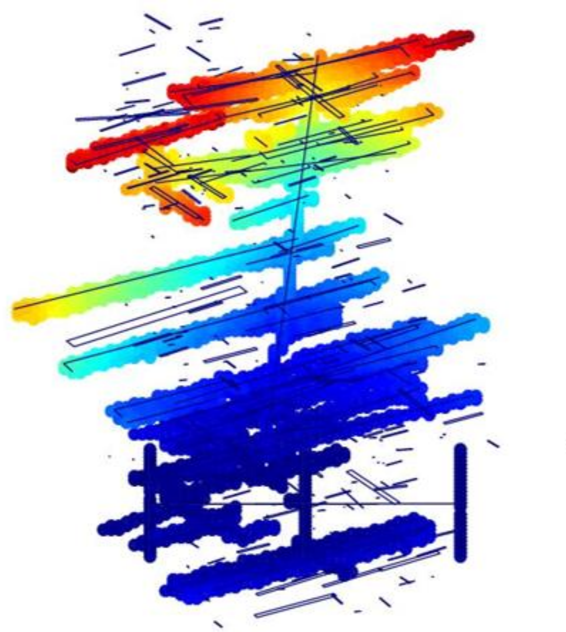


Depleted cells after one year of production / Non-rectangular reservoir boundaries

7.5 – Interferences and fast marching method

A fast marching method (FMM) algorithm was developed. It allows us to evaluate pressure propagation times within the fracture network. The implementation is valid for both 2D and 3D, with the key assumption that the flow is limited to the network along the fracture planes, and the contribution of the matrix is considered negligible. This assumption should be valid as long as we consider short interference times within the network, at a time scale where the matrix contribution is considered negligible.

In the figure below, three hydraulic fractures are connected to a 2D discrete fracture network. The colour gives the propagation time along the connected part of the network when the well is operated. Disconnected parts of the medium are automatically captured.



The goal is to use this fast method to quickly evaluate different DFN realizations and select only those compatible with observed well interference times.

We have started to test this approach with several DFN scenarios. The method successfully rules out clearly incompatible DFN realizations, e.g. those for which the natural fracture network does not connect the two wells. It may also create a representative ranking of the different realizations, based on interference times. However, the quantitative agreement between interference times obtained with the fast marching algorithm and those obtained with a full DFN simulation quickly decreases as the permeability of the matrix increases. The information obtained using this sole method hence remains mostly qualitative.

We have started to develop a new workflow which incorporates this method inside a selection loop which alternates FMM runs with full 'calibration' runs. In this loop, fast FMM runs operate as proxies to evaluate the realizations, from which a very small number are selected and re-evaluated with full runs in order to get an accurate value of the interference time, until a satisfactory realization is found. This workflow is still under development and test.

7.5 – Technical project to interface with geomechanical software

An important aspect of the KURC-2 development plan is to interface our numerical simulation kernel with an external geomechanical software. The objectives are:

- To initialize production scenarios based on realistic, complex fracturing simulations.

- To use accurate pressure and saturation fields in the initial state of the flow simulation.

- To account for complex geomechanical processes associated with stress redistribution.

We had cross-training and several discussions with one software vendor (name not provided in this public report) and we ended up with three possible integration scenarios:

- *Scenario 1: Initialize a production simulation from a complex fracture simulation*.
  This is a necessary preliminary step to enable the automatic exchange of information between codes (ex: model setup, grids, zone types, variables, input/output format…). In this scenario, KW provides the DFN geometry and injection schedule to the geomechanical software. A geomechanical model is created; the extent of stimulated fractures and their aperture are calculated, then passed back to KW. Matrix flow is not accounted for in the geomechanical software. Fluid pressure in the fractures is also transmitted from the geomechanical software to KW. This will serve as a test for Scenario 2.

- *Scenario 2: Stress changes from production (one-way coupling)*
  KW provides the grid and initial fluid pressures (in fractures and matrix) at some injection time. A geomechanical model is created; fluid pressure increments are passed from KW to the geomechanical software in both matrix and fractures, then the mechanical deformations induced by the imposed fluid pressure changes are calculated by the geomechanical software. The objective of this phase is to provide an evaluation of the computational speed and of the feasibility of Scenario 3.

- *Scenario 3: Fully (2-way) coupled simulation of unconventional production.*
  In addition to Scenario 2 mechanical information is calculated and passed back from the geomechanical software to KW. The task includes setting up and running, in step increments, a full production simulation case. KW will use the mechanical information received from the geomechanical software to update fracture aperture, fracture permeability and reservoir permeability; it then calculates and passes on to the geomechanical software the new fluid pressure increments for the step.

Even though Scenario 3 is the main target, enabling basic communication through scenarios 1 and 2 could be a way to address re-fracturing or the stimulation of a new well in the vicinity of existing production wells. The two first scenarios should enable us to simulate a sequence where at the end of a production period the resulting information is sent to the geomechanical software and a new fracturing simulation is performed. Data is then sent back for a new simulation.

8 – Integration of KURC developments in KAPPA Workstation v5.12

Any new feature developed in KURC is contractually exclusive to KURC members for a period of three years starting from the time it was made available to the members. This exclusivity period is therefore defined feature by feature. After three years from release KAPPA will have the right to provide access to these features to non-KURC members.

This right is not an obligation and KAPPA wants to keep indefinite privileges to KURC members for as long as the program exists. The table below lists the KURC features, the date it has been or will be available to members, and the current KAPPA intention related to these features. KAPPA reserves the right to change its position at any time.

KAPPA Workstation v5.10 was commercially released on 29th March 2016. This includes the update of Saphir NL, Topaze NL and Rubis in our Generation 5 environment. It also includes the release of Azurite, a new module on Formation Testing.

We are now targeting for the fourth quarter of 2016 a version 5.12, with a beta or gamma version to be presented at the SPE ATCE in Dubai.

This version will integrate the KURC features, both in terms of features that will be released for all users (KURC_Flag=0), for KURC-1 members only (KURC_Flag=1) or to KURC-1+KURC-2 members only (KURC_Flag=2). The KURC_Flag is a feature of the FlexLM and bitlock protection that will selectively open the relevant features.

The KURC application was only called by Topaze NL and constituted an alternative branch of the Topaze NL workflow. One of the main improvements in KAPPA Workstation is that KURC models will be available whenever applicable to Saphir NL, Topaze NL and Rubis.

Even though the KURC application was developed under the G5 environment we could not integrate the KURC features in this initial release. To do so would have delayed the first release of Generation 5 to the end of 2016. Conversely, now that v5.10 is out, the integration of the KURC features will be the top priority of our development team.

The table below lists the KURC-1 features which have passed the exclusivity time **and** that KAPPA has decided to integrate in its standard versions of Saphir NL, Topaze NL and Rubis.

Rubis has no diagnostic nor analytical capability, hence the red boxes.

The Saphir NL '?' are features that are not required in a PTA workflow and may present a problem of early time accuracy given the short PTA durations. They will be integrated if there is no such problem.

Type	Feature	KURC	Saphir NL	Topaze NL	Rubis
Diagnostic	Generalized pseudo-pressures	0	x	x	-
	New diagnostic tools		x	x	-
Analytical	Complex MFHW analytical model		x	x	-
	SRV bounded and trilinear analytical models		x	x	-
Numerical	Multiple k(p), f(p)		x	x	x
	Water as in immobile phase		x	x	x
	Dimensional input for double porosity		x	x	x
	Complex MFHW numerical model		x	x	x
	multilayer complex MFHW		x	x	x
	Dynamic injection and water flowback analysis		?	x	x

The second table below lists the KURC-1 features which have not passed the exclusivity period **or** that KAPPA has, in any case, decided to restrict to KURC-1 members. The SRV-Trilinear numerical models will not be in Rubis because they are single well 1-D models, only used for analysis / regression and incompatible with the Rubis workflow.

Type	Feature	KURC	Saphir NL	Topaze NL	Rubis
Analytical	Conjugate fractures MFHW analytical model	1	x	x	-
Numerical	Multiple KrPc		x	x	x
	Complex diffusion models		x	x	x
	Post-injection initial state		x	x	x
	SRV / Trilinear MFHW numerical models		x	x	-
	DFN single well		x	x	x
	Microseismics data load & display		x	x	x
	Confined PVT		x	x	x

The last table below lists the KURC-2 features which have naturally not passed the 3-year exclusivity period and are therefore reserved for KURC-2 members. Three complex DFN models will require a Rubis license, but will be accessible to Saphir NL and Topaze NL, given the right privilege, through its Rubis numerical features. The implementation of a dual-diffusion analytical model to simulate DFN's has not been taken yet and will require participants' approval, as is the Geomechanical coupling which will require that participants accept Itasca as a non-paying, technically contributing participant.

Type	Feature	KURC	Saphir NL	Topaze NL	Rubis
Diagnostic	Selection of DFN realizations based on interference time	2	?	x	-
Analytical	Analytical trilinear model with SRV around fractures		x	x	-
	Dual-Diffusion model (Chen & Raghavan)		?	?	-
Numerical	DFN multiple wells		?	x	x
	Numerical complex MFHW with SRV around fractures		?	x	x
	multilayer DFN		(Rubis)	(Rubis)	x
	Generation of stochastic DFN constrained to microseismics		(Rubis)	(Rubis)	x
	3D DFN		(Rubis)	(Rubis)	x
	CSG well model		?	x	x
	Geomechanical coupling		?	?	?

9 – KURC membership and fees

KURC-1 membership only is no longer available although joining KURC-1 is a pre-requisite to join KURC-2. As a result two solutions are offered:

- Non-members may join directly KURC-1+KURC-2 for a total fee of 200,000 € (two hundred thousand euros)
- Existing KURC-1 members who have not done so yet may join KURC-2 for 50,000 € (fifty thousand euros)

The following services and products are delivered to KURC-1 + KURC-2 participants:

- For new members, access to all previous KURC-1 technical reports and update notes
- For new members, one free license of KAPPA Workstation with Saphir NL, Topaze NL and Rubis (but not Azurite) for **three years**
- Access to the KURC-2 reports and update notes
- Participation in the KURC videoconferences
- Vote on development priorities
- For former KURC-1 members, extension of their access to the free license for one more year or a cumulative total of three years (whichever is the most favorable choice)
- Access to the KURC features application for each active commercial license of Topaze NL (Generation 4) and each active commercial license of Topaze NL, Saphir NL and Rubis (Generation 5)
- Exclusivity as described §8

If you are interested please send a mail to unconventional@kappaeng.com.

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