



CYDAR

A Software for Conventional and Special Core Analysis

Type of experiment

- ☐ customized
- ☐ 2 fluids injected
- ☐ 1 fluid injected
- ☐ SDM Pco0
- ☐ SDM Pco0
- ☐ spontaneous
- ☐ gravity
- ☐ centrifugation
- ☐ porous plate

Displacement

- ☒ drainage
- ☐ imbibition

Local pressure taps
nb of sensors (max 20): 0

drainage

Initial saturation

- ☒ water saturation
- ☐ uniform
- ☐ drainage profile
- ☐ imbibition profile

Immobile 3rd phase
saturation: 0.000 frac.

Centrifugation

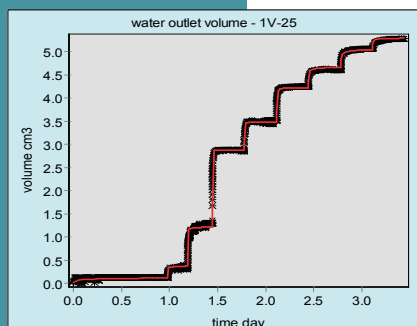
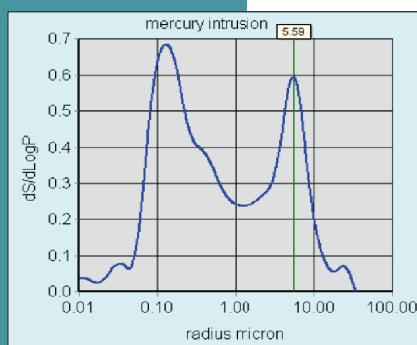
length unit: cm

- ☐ R min: 14.14
- ☒ R max: 24.14
- ☐ cR: 15.14

porous plate: e
R liquid surface (optional): 24.1

pressure on liquid surface:
1.000 bar

geometrical parameter b
 0.557





CYDAREX

is a spin-off company of the French Institute of Petroleum (now IFPEN) and was created in 2005 by Roland Lenormand. CYDAREX specializes in the domain of core and cuttings analysis, provides consulting and training services, commercializes DarcyLog™ and DarcyPress™, and develops the software for interpretation of SCAL experiments CYDAR™.

CYDAR

has been developed in collaboration with core analysis specialists, with two main objectives:

- > **To be user-friendly:** This is achieved by using Windows environment with an intuitive graphic interface, like any Microsoft software. CYDAR can be used with no specific knowledge in numerical simulation or reservoir engineering.
- > **To be accurate and powerful:** CYDAR uses the most recent methods developed and tested in research laboratories, and published in the proceedings of the Society of Core Analysis.

CYDAR contains the following modules

- > Mercury injection and withdrawal (MICP)
- > Absolute permeability
- > Two-phase flow experiments
- > Electrical measurements for saturation and resistivity index
- > Steady-state and unsteady-state relative permeability
- > Centrifuge capillary pressure and relative permeability

CYDAR is currently used by more than 40 companies and institutions world wide.

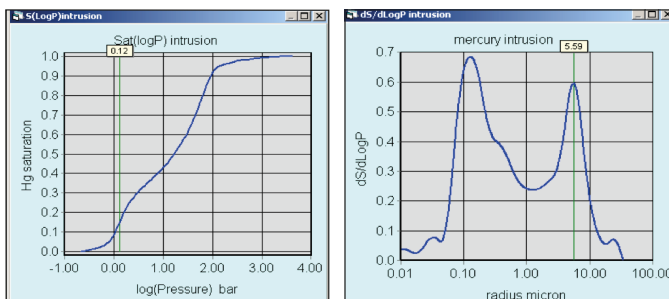
CYDAR Modules

■ Mercury injection (MICP)

Mercury injection is used to calculate capillary pressure for initializing reservoir simulations (J Leverett function) and to determine the pore size distribution (EOR and rock typing). Entering data takes just a few minutes and computation is instantaneous.

Main features include:

- > ASCII files generated by experimental apparatus can be opened directly,
- > powerful data smoothing using spline functions,
- > calculation of three types of pore size distributions,
- > J Leverett function, reservoir transition zone, and water cut,
- > estimation of permeability (Swanson and other correlations).

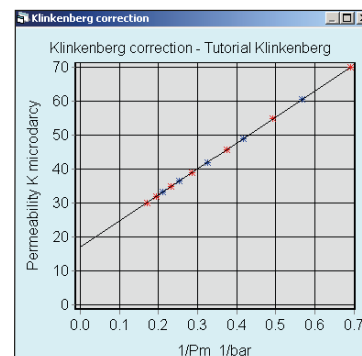


■ Absolute permeability

In laboratories, absolute permeability is often calculated using a spreadsheet in Microsoft Excel. However, the use of CYDAR minimizes the risk of errors, improves quality control, and calculations are performed numerically without approximations.

Main features include:

- > gas and liquid permeability steady-state and pulse decay,
- > determination of inertial coefficient (Forchheimer correction),
- > determination of Klinkenberg correction,
- > Klinkenberg coefficient calculation from correlations.

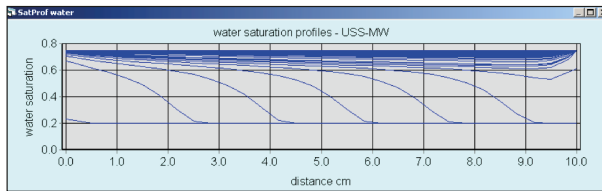


Two-phase flow experiments

CYDAR can simulate most two-phase flow experiments, such as:

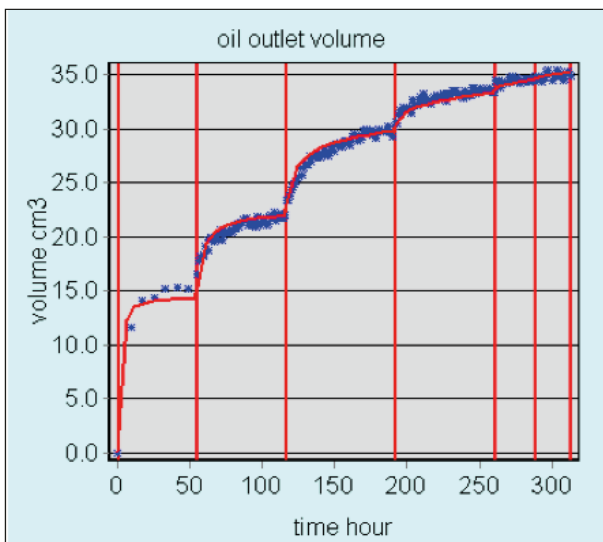
- > relative permeabilities K_r in steady-state and unsteady-state,
- > semi-dynamic method,
- > spontaneous displacements (immersion of a sample into a fluid in drainage or imbibition),
- > gravity flow,
- > porous plate (with pressure drop inside the porous plates),
- > centrifuge displacements in drainage and imbibition.

Simulations are performed on a one-dimensional sample, either homogeneous or with heterogeneities. Heterogeneities include permeability and porosity continuous profiles, or composite samples. Hysteresis between drainage and imbibition is also taken into account.



Most laboratory experiments are preset in CYDAR, and boundary conditions, which are specific to each experiment, are adjusted accordingly. In addition, non-programmed experiments can be simulated by setting inlet and outlet boundary conditions.

The two-phase flow module can be used to design an experiment when most properties of the sample are known, or to determine parameters from measurements (inverse calculation). For all experiments, K_r and P_c curves can be adjusted by manual or automatic history matching. The simulated results (production, saturation profiles, and pressures) are compared to experimental data; the difference is minimized in an optimization loop.



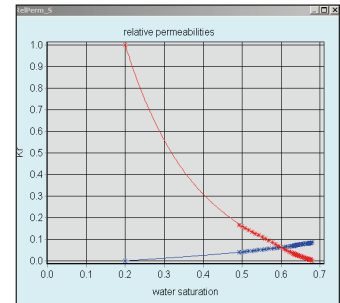
Relative permeabilities

Determination of relative permeabilities K_r is a main objective of special core analysis. It is now well recognized that numerical interpretations accounting for capillary effects are absolutely necessary.

Relative permeabilities can be determined by history matching of transient experiments in steady state (SS) and unsteady state (USS) displacements, centrifuge, semi-dynamic method.

Main features include:

- > K_r models include Corey, Modified Corey, or LET functions,
- > for USS displacements, analytical calculation using JBN or Jones and Roszelles methods,
- > for SS displacements, analytical calculation assuming uniform profiles,
- > for SS and USS, numerical simulation with capillary pressure, and determination of K_r using manual or automatic optimization (history matching).

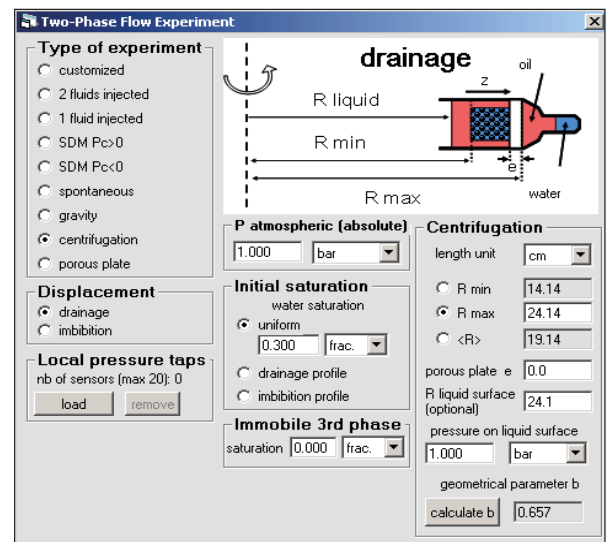


Centrifuge

The centrifuge module converts the average saturation measured during the experiment to local saturation at the entrance of the sample, and additionally allows the evaluation of relative permeabilities.

Main features include:

- > displacements in both drainage and imbibition,
- > choice of several interpretation methods, such as Hassler Brunner, Forbes, and spline functions,
- > relative permeabilities determined by Hagoort method or multistep history matching.





CYDAR main features

All modules in CYDAR share the same features for data processing, graph and table displaying, and exporting results.

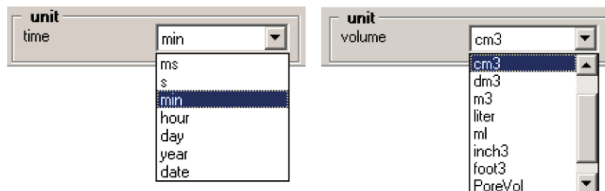
■ Windows environment

CYDAR is developed in Visual Basic, an object oriented language which takes advantage of the familiar Windows environment. Some numerical calculations such as optimization loops use FORTRAN and its powerful IMSL library. However, all FORTRAN DLLs are controlled by CYDAR, and the user interacts only with the graphic user interface. CYDAR does not require a high-performance computer, and runs perfectly on a laptop computer. CYDAR can be installed on Windows XP, Vista, 7, and 8, and does not require an Internet connection.

■ Data input

Several methods are used to input data. A small amount of data can be directly typed in; larger files can be cut and pasted from Microsoft Excel or other applications. Some ASCII files generated by experimental apparatus can also be opened directly (like Autopore for mercury injection). CYDAR can also acquire data during experiments by reading pressure, temperature, and other parameters via USB connections.

For each parameter, the unit can be chosen in input, output, or for graph display.



■ Numerical calculation

Simulations are performed on a 1-D grid. The size of the grid and parameters for the numerical simulation can be adjusted for speed or accuracy.

During numerical simulation and optimization, all variables (flow rates, effluent volumes, pressures, saturations...) are displayed dynamically; and the user can stop the simulation at any time to change parameters.

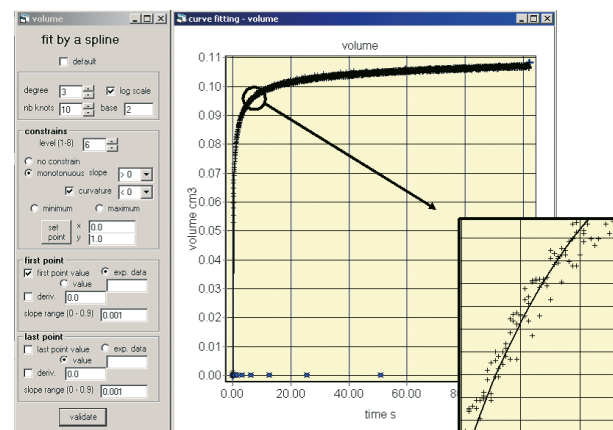
■ Exporting results

Graphs can be printed or copied into the clipboard, and can be cut and paste into a Microsoft Word, Excel or PowerPoint report. Graphs can also be saved as metafile, bitmap, or JPEG files.

For each graph, the corresponding data set can be displayed as a table and copied into Microsoft Excel or other software by a cut and paste.

■ Data filtering & smoothing

Most experimental data are noisy, and an efficient filtering and a smoothing method is required for computation or comparison with simulated results for history matching. CYDAR offers several analytical functions for smoothing such as exponential, power law, and spline functions, the most general and powerful tool available.



■ Graphs

Variables can be displayed as a graph at the end or during simulations. Graph parameters (scale units, log scale, legends, symbols, colours...) can be adjusted.

■ Reporting

All results can be exported as an Excel file. Pre-formatted reports are available, and can be easily tailored by the user. The company logo can be added to the reports.



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