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Comparison between spreadsheet and specialized programs in calculating the effect of scale deposition on the well flow performance

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Formation damage is an undesirable operational and economic problem that causes a reduction in the productivity, skin damage, and decrease in well performance. Formation damage occurs during the various phases of oil and gas recovery from subsurface reservoirs including production, drilling, hydraulic fracturing, and work over operations. Formation damage assessment, control, and remediation are among the most important issues to be resolved for efficient exploitation of hydrocarbon reservoirs. Such damage is caused by various adverse processes, including chemical, physical, biological, and thermal interactions of the formation and fluids, deformation of formation under stress and fluid shear. This paper systematically presents an analytical model developed for predicting productivity of reservoir with incidence of scale deposition in the vicinity of horizontal and vertical wellbore. The objective of this study is comparison among the spreadsheet, Kappa Ecrin Saphir program, and Halliburton Wellford Pan System software in calculating the effect of scale deposition on the flow performance for several types of wells. The results of vertical, horizontal wells were close using Kappa Saphir and PanSystem, but far using the Excel program.

Key words: Productivity, scale, skin, well, software.

INTRODUCTION

Scale deposition, unlike other types of deposition, is a complex crystallization process (Urayet, 2000). The formation rate of an initial scale layer and its subsequent rate of growth are determined by the interaction of several rate processes: nucleation, diffusion, chemical reaction, and molecular ordering of the scale crystal lattices, etc. Most, though not all, mineral scale-forming constituents are inversely soluble (their solubility's tend to decrease with increase in temperatures) (Urayet, 2004; Schlumberger, 1998). Therefore, when these super-saturated solutions come into contact with heat transfer surfaces, they precipitate solids due to their lower equilibrium solubility. There are two types of scale deposition organic and inorganic (Ramey, 1992). Once a solution becomes supersaturated and nucleation occurs, the conditions best suited for crystal growth of the particular scale constituent will be the conditions most ideal for scale formation.

Formation damage or skin effect can be found from the analysis or well testing results (pressure build-up "and draw down tests) the damage can also be investigated by analyzing Production logging surveys. Production logging is a useful tool for detecting zones that are not contributing to the total flow systems (Economides and Notle, 1898). Formation damage can be detected by comparing the average permeability for the well, determined by draw down tests (Matthews and Russell, 1987), with the undamaged permeability away from the

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wellbore determined from pressure build up analysis. Two straight-line portions obtained from a pressure build up test is an indication of wellbore damage surrounding the well (Unneland and Statoil, 1995).

MATERIALS AND METHODS

The oil companies use several methods to calculate the skin factor: 1- spreadsheet is usually used, but it takes a lot of time and accuracy of less 2- programs designed to reduce time and increase accuracy of the results (Ahmed and McKinney, 2005).

Spreadsheet (MS Office Excel)

A modern spreadsheet file consists of multiple worksheets (usually called by the shorter name sheets) that make up one workbook, with each file being one workbook. A cell on one sheet is capable of referencing cells on other different sheets, whether within the same workbook or even, in some cases, in different workbooks. A spreadsheet is essentially just one table, whereas a database is a collection of many tables with machine-readable semantic relationships between them. Spreadsheets are often imported into databases to become tables within them, but it lacks the relational structure of a database.

Kappa Saphir

The Saphir methodology has always been based on the Bourdet derivative as the main diagnostic tool; matching the measured data to the model, taking into account the detailed production history. The ever-increasing processing power of PCs has enabled KAPPA to aggressively expand the technical capability of Saphir. This has resulted in the development of fast numerical models, that has naturally extended to the rigorous solution of nonlinear problems. Saphir is now available only in the non-linear variant known as Saphir NL. When actively maintained under the current pricelist, Saphir NL also includes the well performance analysis module Amethyste as a free add-on. In a minifrac analysis component was developed and the slug-test option was reintegrated. Substantial improvements in the analytical and numerical models were added to better address unconventional formations. An improved Perrine method addresses multiphase flow and material balance correction has been added to the de-convolution. The Rubis sector now allows the Saphir NL numerical model to start from a dynamic state of a Rubis simulation as next: data loading and editing, Data QA/QC and datum correction, Test design, Extracting ΔP and de-convolution, Specialized plots, Analytical models, Numerical models, Use of Rubis sectors, Multilayer analysis, Optimization and sensitivity analysis, AOF / IPR, Minifrac analysis, Slug and Pulse, Formation tests, Reporting and exporting.

EPS PanSystem

PanSystem is a powerful tool for: Preparing and editing Well Test Data from conventional gauges and wire line formation testers. Analyzing and history matching Transient Well Test Data using Analytical and Numerical methods. Analyzing and history matching long-term Flowing Pressure and Production Data using Pressure Decline Analysis (PDA) methods. Analyzing and history matching wireline formation tester probe or packer data simultaneously with observation probe data Computing Well Deliverability/ Injectivity and Forecasting long-term production.

The Well and Reservoir is initialized via the Well and Reservoir Description (Numerical) sub-menu option from the PanSystem Dataprep Menu. The actual Numerical Simulation is performed within PanMesh; this is accessed via the Numerical sub-menu option from the PanSystem Simulate Menu. Deliverability in PanSystem provides the following two methods for calculating the Deliverability/Injectivity of a Reservoir: Using the fitting to measured Test Point Data method for Oil and Water Fluid Types involves the program fitting the Vögel IPR relation to up to three measured flowing/injection Pressures and Rates. For Gas and Condensate Fluid types, the Deliverability curve is computed either using the Darcy (B) and Non-Darcy (F) Flow Coefficients estimated by an LIT Analysis of measured flowing/injection Pressures and Rates, or using the C-coefficient and n-exponent obtained from a simplified C&N Analysis of measured data.

For semi-theoretical derivation using results from Transient Well Test Analysis (k, S) and Extended Drawdown Analysis (A, CA), for Oil and Water Fluid Types, the Productivity Index (J) is calculated from the semi-steady-state inflow equation, and the Vogel IPR relation applied. For Gas and Condensate Fluid Types using the LIT Method, the Darcy Flow Coefficient (B), is calculated from the semi-steady-state inflow equation and the Non-Darcy Flow Coefficient (F), is derived from a Rate versus Skin analysis of Transient Well Test Data to allow the Deliverability curve to be calculated. For the C and n Method the "stabilized deliverability" is estimated from a theoretical stabilized Flow Rate, derived from the C-coefficient and n-exponent . Production Forecasting for Oil, a semi-theoretical approach is used. For Gas, a theoretical approach is used (for example, LIT and C&n). This predicts Flow Rate versus Time for the current Reservoir Model (that is, Infinite, Semi-Infinite or Closed System), assuming constant Bottom-Hole Flowing Pressure (BHFP), or constant Wellhead Pressure (in which case, an Eclipse-compatible VFP File must be imported to model the Tubing Performance. File is the data used by the program is stored in a number of files. Every file must have a name which will allow the operating system to refer to it. There are different types of file, each storing different types of information. From these two methods Flow Regimes can be identified and the various Well and Reservoir parameters derived. During Analysis, results from any particular plot can, if desired, be transferred to the Reservoir Description (that is, Model Parameters) set using the Confirm toolbar option. In this way, the Reservoir Description can be built up and continually updated as the Analysis proceeds. Up to six different Interpretation Models can be stored in a single (*.PAN) file. The latest status of every plot invoked (that is, lines fitted, results, Flow Regimes, etc.) is written to the (*.PAN) file by the File Save or File Save As options. Subsequent recall of the file will reinstate all plots so that the Analysis can be resumed from where it was left off. If users have more than one Pressure and/or Flow Rate channel to choose from (for example, two Pressure Gauges were run), they can change their selection at any time by returning to Dataprep Gauge Data (TPR) Preparation and selecting a different Column Name in the Master File/Columns section.

RESULTS AND DISCUSSION

The aim of this paper is the comparison of spreadsheet and two other specialized programs Kappa Ecrin Saphir and Halliburton Wellflo PanSystem in the calculation of the Effects of scale deposition on well flow performance for several types of wells and compares these results to the results of the company. Ten wells were selected of the total wells in the field where it was a choice of five

Table 1. All results of well N1 and company result.

Software	Skin (value)
Kappa Saphir	54.213
EPS PanSystem	56.8612
MS Office Excel	77.43
Company	**Skin (value)**
Mellitah OIL and GAS B.V.	57.33

Table 2. All results of wells and company result.

Well	Type	Skin			
		Kappa Saphir	EPS Pansystem	MS Office Excel	Mellitah B. V.
N6	HORI. OIL	39.15	37.77	44.48	16.80
N7H	HORI. OIL	12.92	13.21	18.34	12.50
N8H	HORI. OIL	6.84	7.02	19.21	7.00
N9H	HORI. OIL	4.13	4.77	11.70	4.13
N10H	HORI. OIL	2.59	1.96	9.25	2.40
N14	VERT. OIL	281.43	281.74	317.40	287.60
N18	VERT. OIL	192.78	192.16	181.44	193.50
N15	VERT. OIL	138.23	140.84	154.65	140.00
N1	VERT. OIL	54.21	56.86	77.43	57.30
N16	VERT. OIL	45.65	45.01	49.37	42.00

vertical and five horizontal wells.

The following workflow has been followed to perform the interpretation:

(i) Data preparation for each well.
(ii) Import gauge data from the excel file (pressure).
(iii) Remove noisy data.
(iv) Define flow periods (for softwares only).
(v) Define well, layer and fluids parameters (for softwares only).
(vi) Define reservoir thickness (for softwares only).
(vii) Define PVT to find PVT fluid parameters (for softwares only).
(viii) Plot flow periods and assign flow rate for each period.
(ix) Analyze the buildup using the pressure derivative on the log-log plot.
(x) Analyze the buildup using the semi-log pressure plot (Horner plot) and define or confirm the following parameters:

(a) Extrapolated pressure P*.
(b) Kh permeability thickness product.
(c) Radius investigation.
(d) Skin pressure drop.
(e) Skin factor.

(xi) Verify the analysis made on build-up data on the draw down periods.

The results obtained by software's calculation are shown in Table 1 and Figure 9.

We calculate the skin of the several wells using the three programs and compared the results given by the company, which was calculated using manual methods (Excel); the results are in Table 2 for all wells.

Conclusion

Calculated results of the skin using the programs and manual methods (Excel) for ten wells compared with company results. The skin obtained from vertical wells show that the results are similar between the company's results and that obtained from Kappa Saphir and PanSystem, while the horizontal wells results were close in four wells using Kappa Saphir and PanSystem to company results, and far using the Excel program. Generally high values result obtained from the Excel program in most wells Figures 1 to 8.

ACKNOWLEDGEMENT

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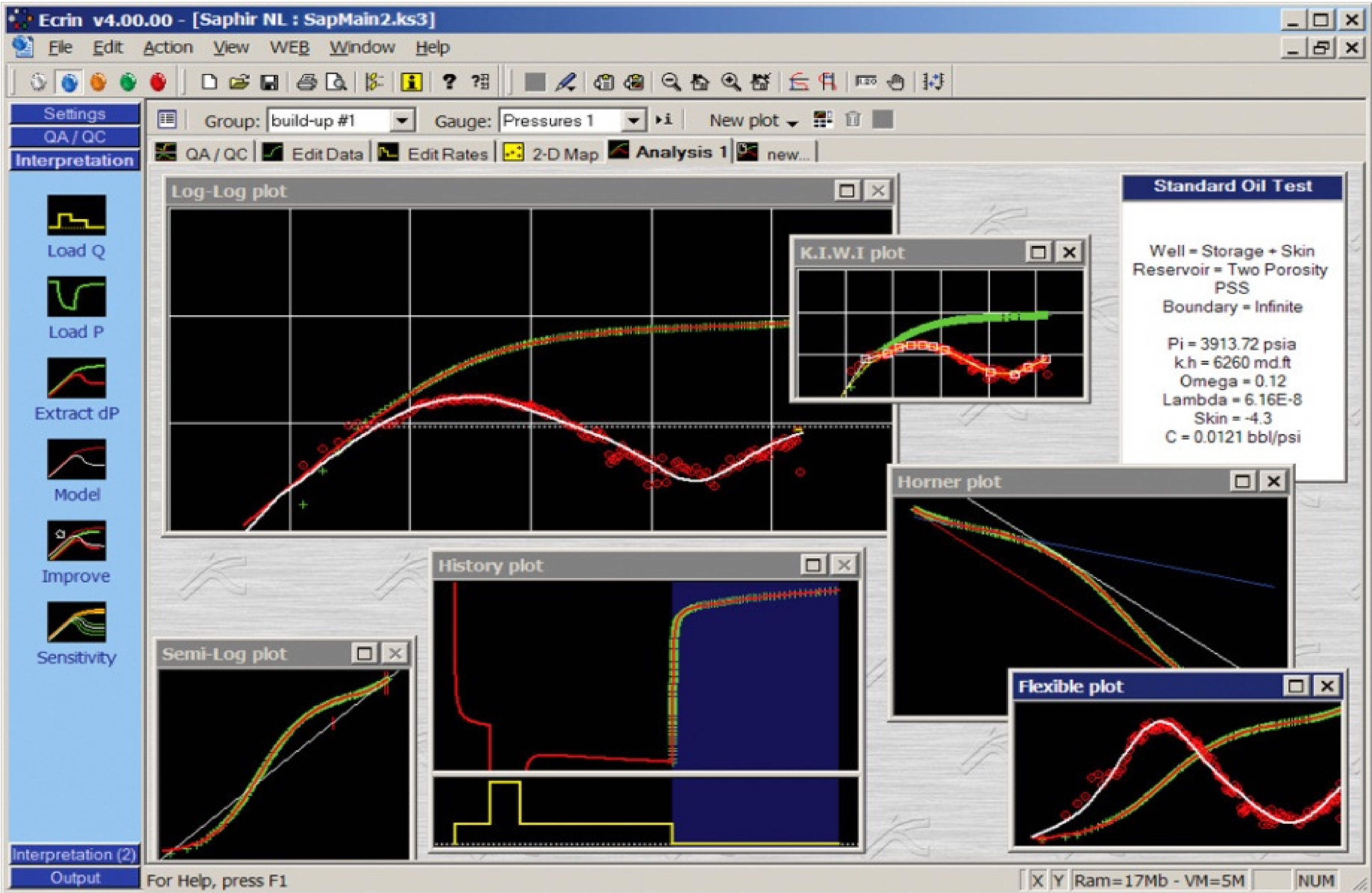

Figure 1. Saphir main window.

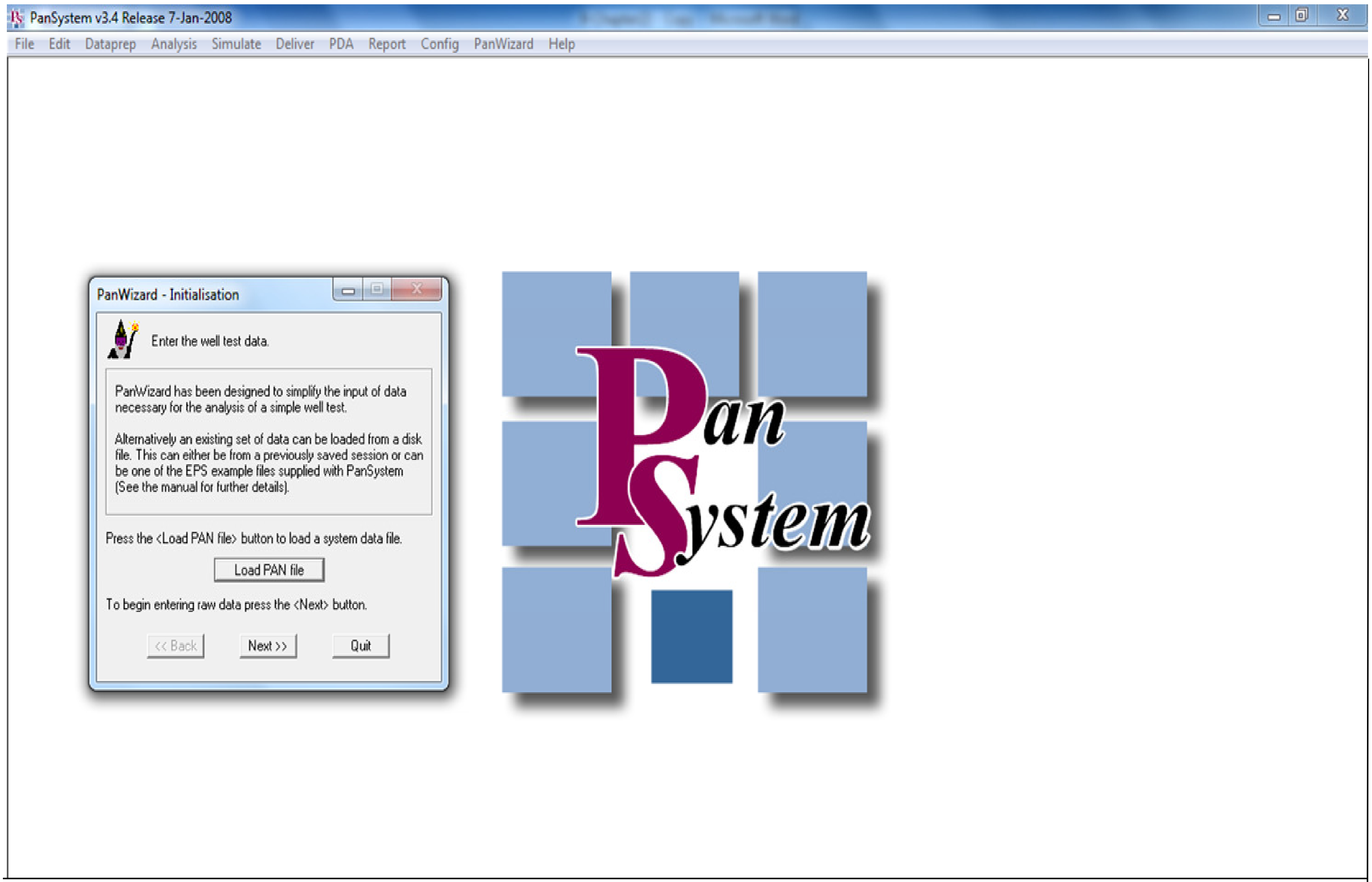

Figure 2. EPS PanSystem main windows.

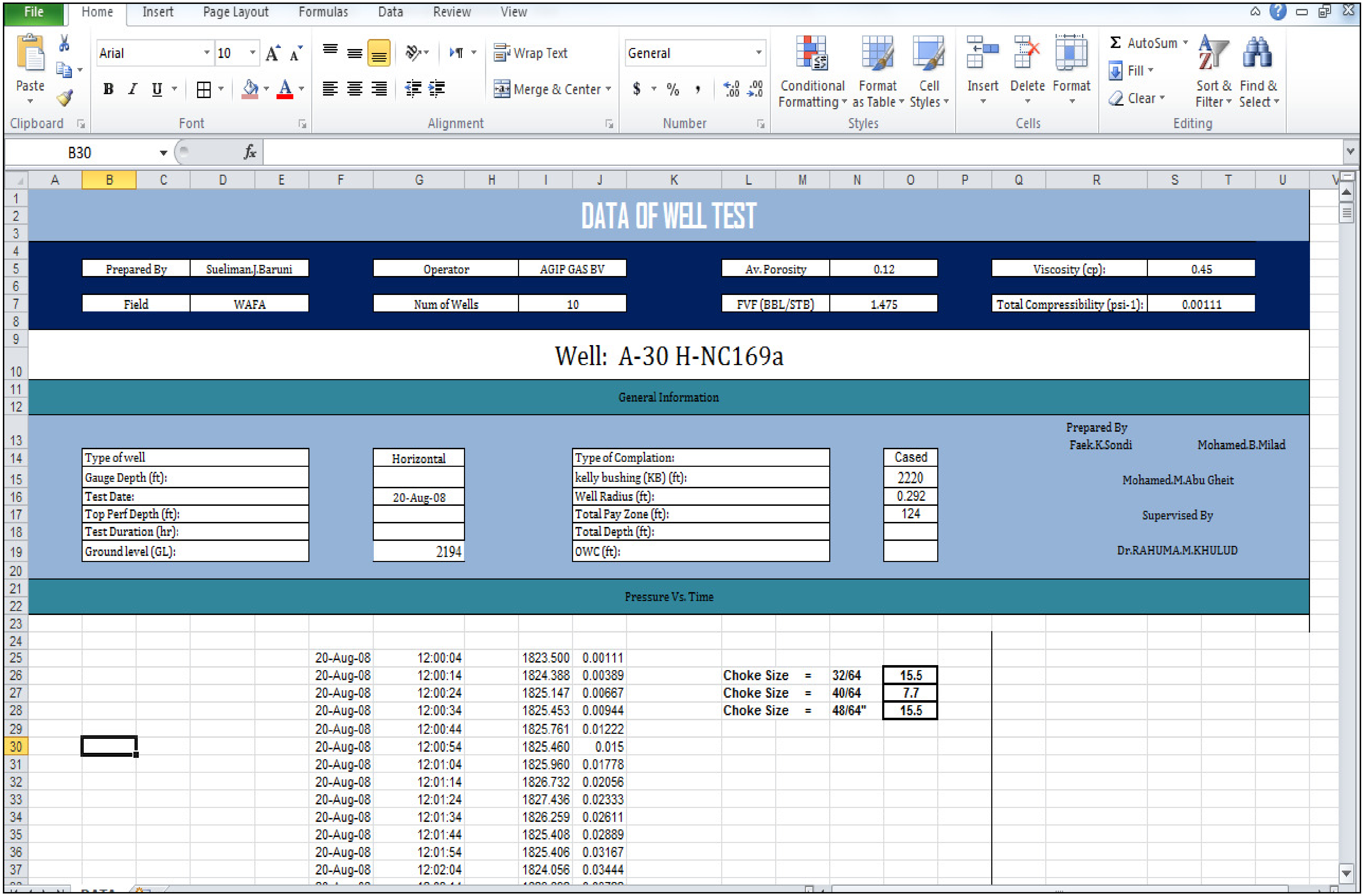

Figure 3. The data preparation.

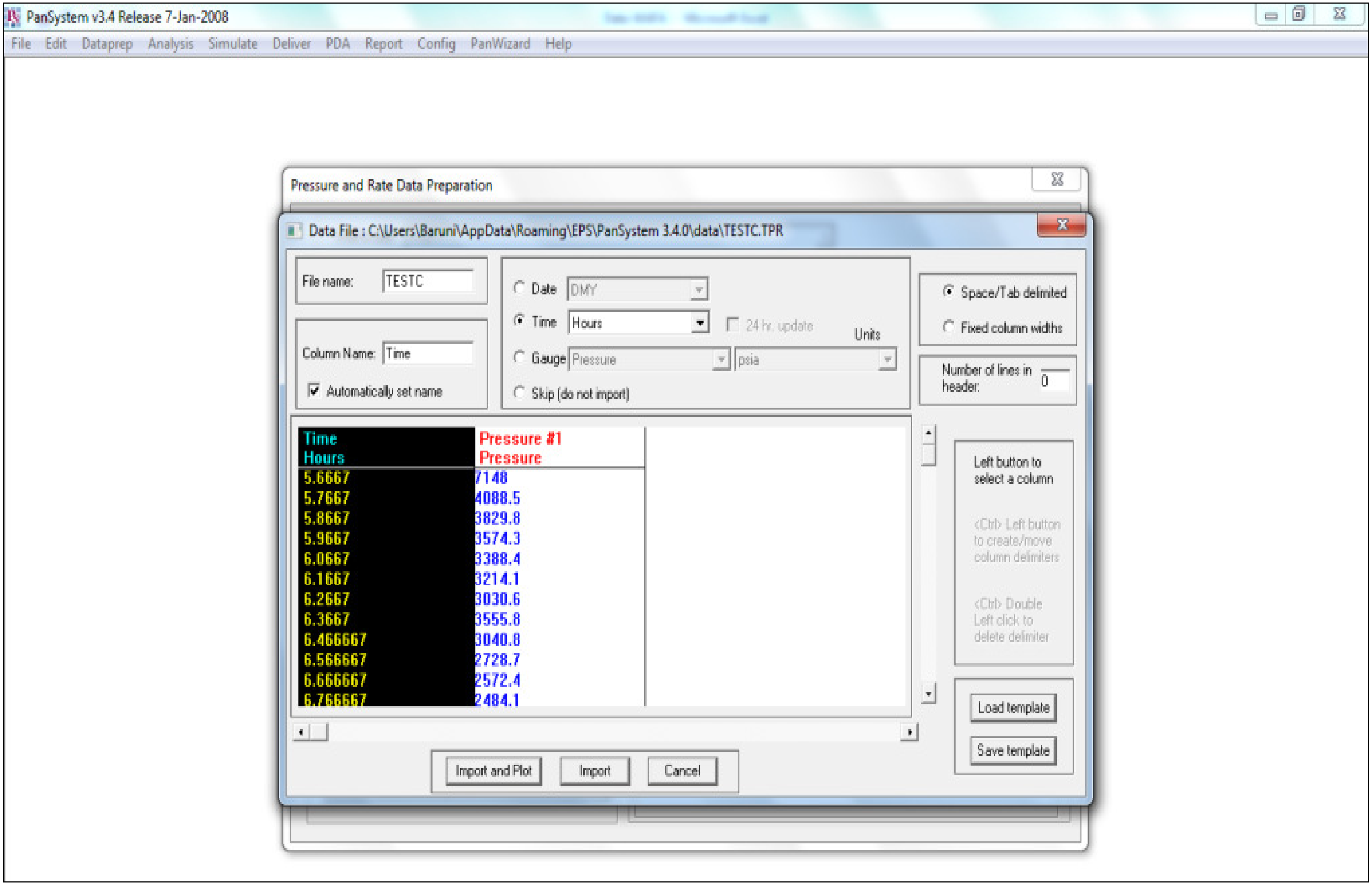

Figure 4. Define data (Pansystem).

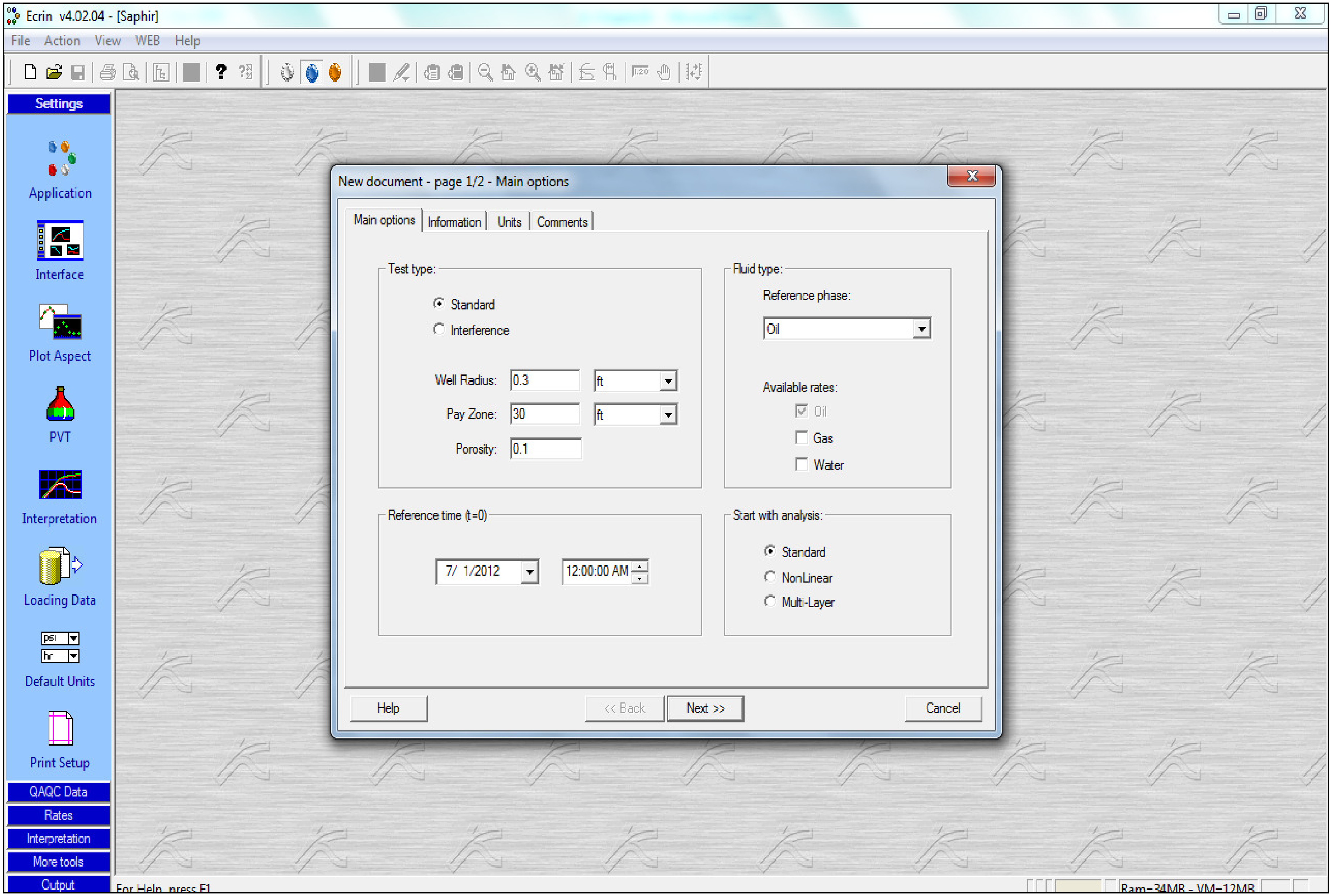

Figure 5. Define data (Ecrin Saphir).

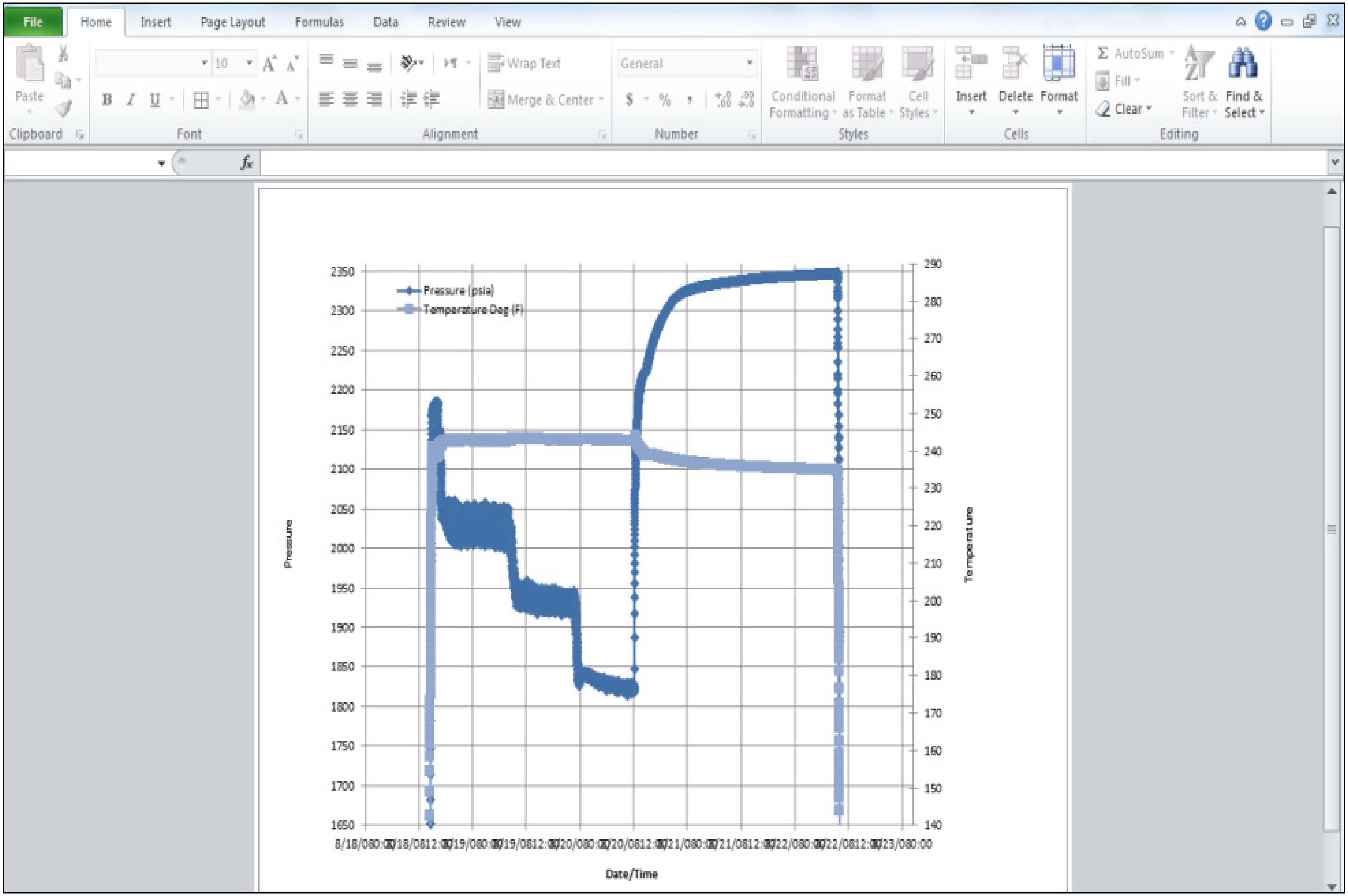

Figure 6. The buildup using the semi-log pressure plot (MS. Excel).

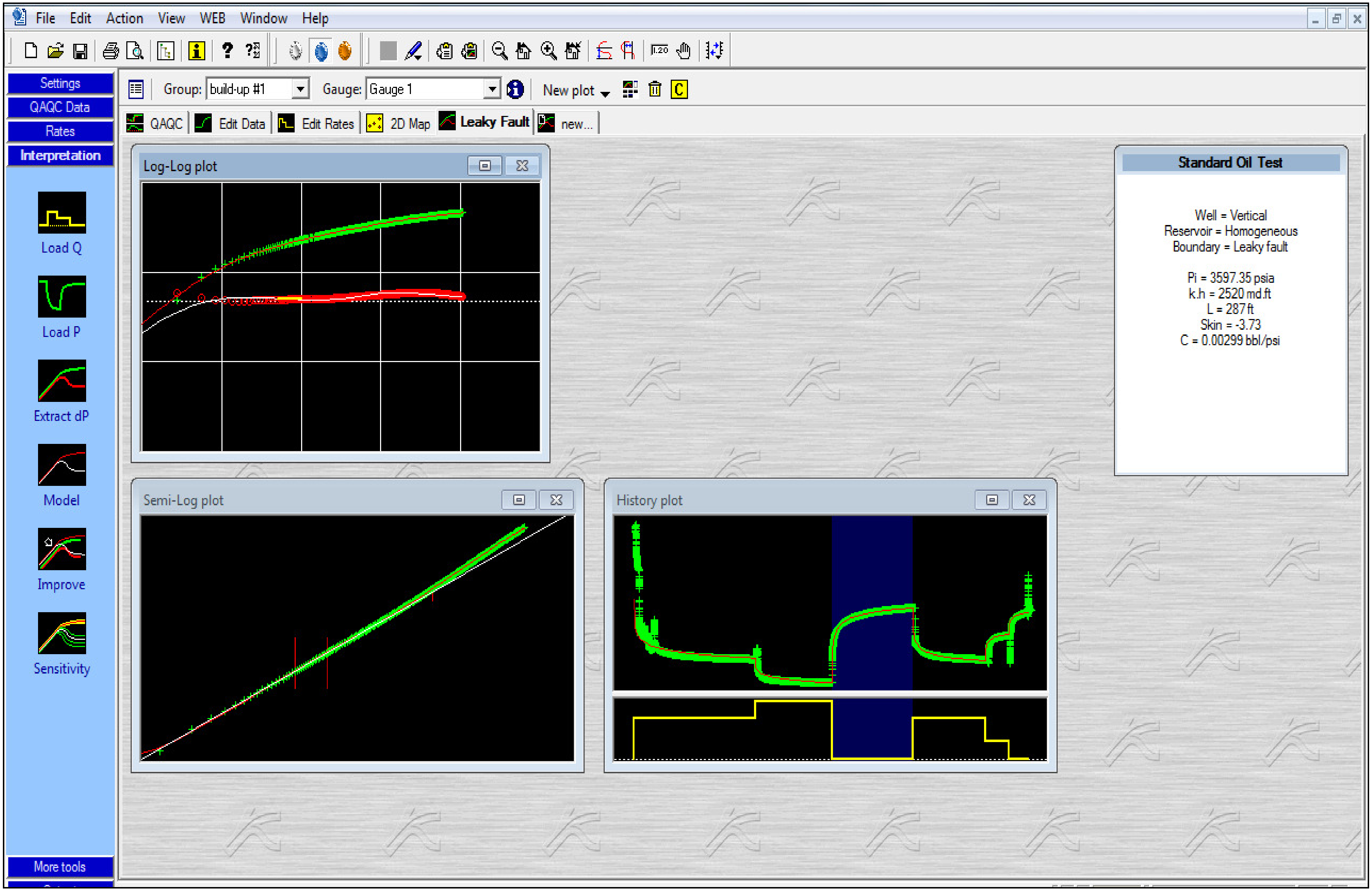

Figure 7. The buildup using the semi-log pressure plot (Ecrin Saphir).

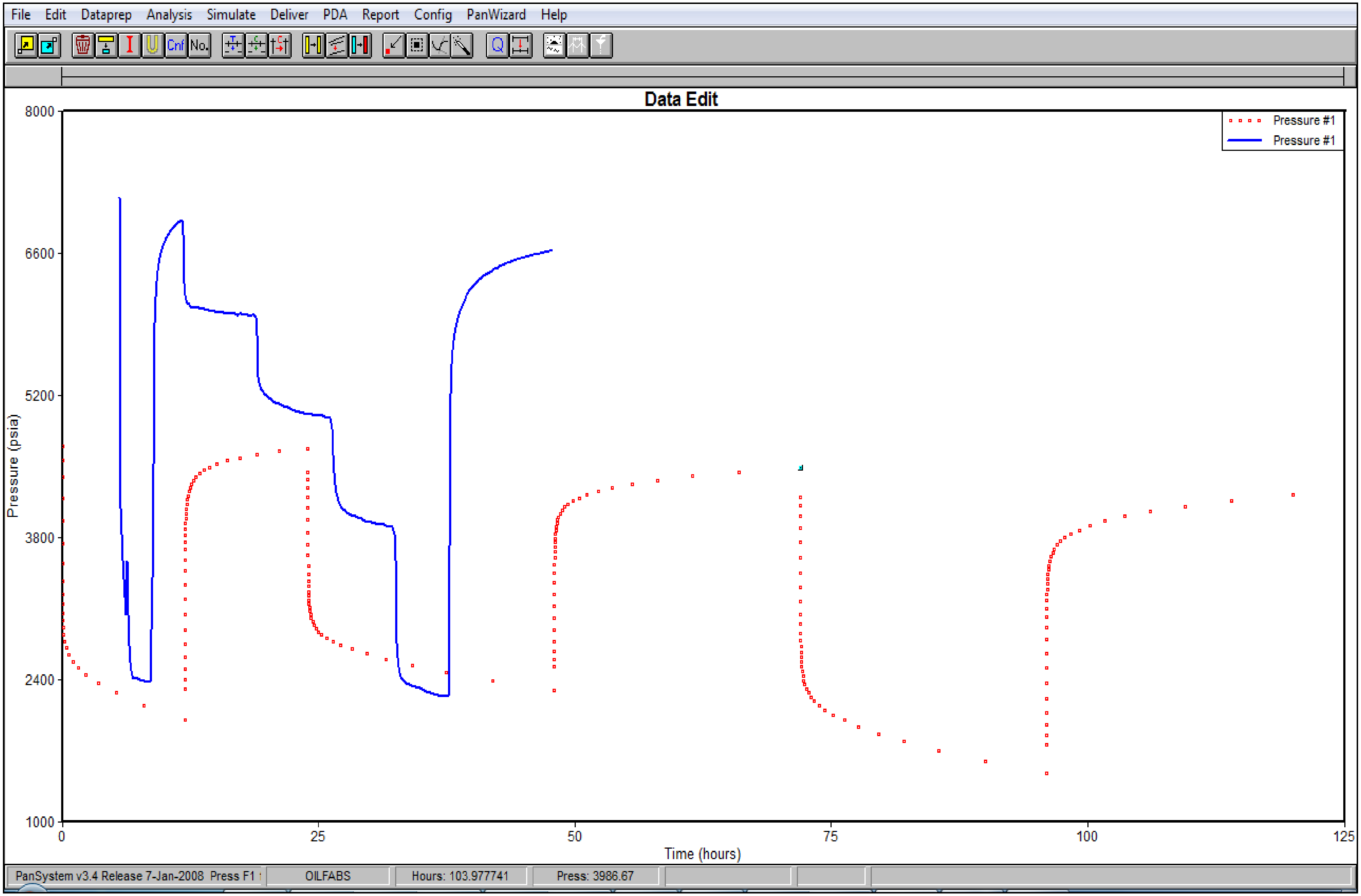

Figure 8. The buildup using the semi-log pressure plot (Pansystem).

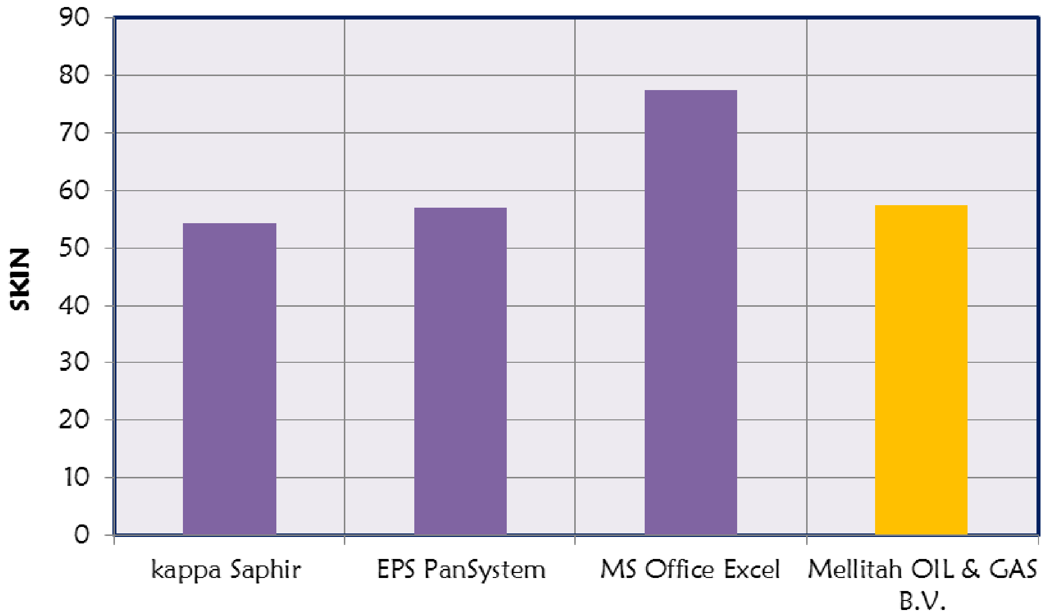

Figure 9. All results of well N1 and company result.

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