Universitetet i Stavanger

FACULTY OF SCIENCE AND TECHNOLOGY

FINAL EXAM: MPE 350 Well Test Analysis

DATE: February 18, 2010

DURATION: 4 hours

“TOOLS” ALLOWED: Standard simple calculator

THE SET CONSISTS OF: 3 problems on 10 pages (total)

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Problem 1

A 36 hours flow test (drawdown) was performed on a new oil well at a rate of 900 Sm^3/d to determine well and flow properties and the presence of nearby faults. Use the input parameters in Table 1, the reduced set of pressure data in Table 2, and the plots on the last four pages to answer the questions and carry out the analyses below.

a) Fig. 1 shows a loglog plot of the drawdown data. What flow regimes can be identified from the data? Indicate the range of each flow regime (time at start and end of each).

b) Use early data consistent with Fig. 2 to estimate the initial formation pressure and determine the real and dimensionless wellbore storage.

c) Fig. 3 shows a semilog plot of the drawdown data. Use representative data points from Table 2 and information from the preceding point to determine the semilog slope m, p_{1hr}, kh, k, S and Δp_S.

d) Fig. 4 shows a square-root-of-time plot of the drawdown data. Assume that the well is located between parallel faults and use representative data points from Table 2 in a linear-flow analysis to determine the distance between the faults analogous to determination of fracture length from linear-flow data to a fracture.

e) Use information from either Fig. 1 or Fig. 3 and results above to determine if the well is located near the middle of the “channel” between the faults or near one of the faults. Also give an estimate of the minimum area “seen” during the test.

Table 1 – Input parameters for Problem 1

Formation thickness, h	=	41	m
Porosity, ϕ	=	0.31	
Viscosity, μ	=	0.48	cp
Total compressibility, c_t	=	$1.4\text{x}10^{-4}$	bar^{-1}
Volume factor, B	=	1.36	Rm^3/Sm^3
Wellbore radius, r_w	=	0.108	m

Table 2 – Pressure data for Problem 1

Time (hrs)	Pressure (bar)	Time (hrs)	Pressure (bar)
0.002	449.8818	0.506	448.7511
0.004	449.7778	0.637	448.7369
0.006	449.6858	0.802	448.7228
0.008	449.6044	1.010	448.7088
0.010	449.529	1.271	448.6949
0.013	449.4475	1.600	448.6812
0.016	449.3616	2.015	448.6675
0.020	449.2746	2.537	448.6539
0.025	449.1902	3.193	448.6402
0.032	449.1124	4.020	448.6263
0.040	449.0439	5.061	448.6117
0.051	448.9863	6.372	448.5963
0.064	448.9396	8.021	448.5797
0.080	448.9025	10.098	448.5614
0.101	448.8732	12.713	448.5412
0.127	448.8495	16.005	448.5188
0.160	448.8296	20.148	448.4937
0.201	448.812	22.607	448.4801
0.254	448.7958	25.365	448.4657
0.319	448.7805	28.461	448.4504
0.402	448.7656	36.000	448.4164

Problem 2
Consider a long rectangular drainage area produced at simple depletion from a single vertical well. Based on the well and formation parameters listed in Table 3, answer the questions below.

a) Determine the drainage area given the information that the bottom-hole pressure dropped 4.38 psi during 250 hours of production at 1650 STB/D under stable conditions (pseudo-steady state).

b) If the rate was kept constant from the start at 1650 STB/D and the observed pressure drop was based on the pressures 6994.49 psi at 6001 hrs and 6990.11 psi at 6251 hrs, what must the initial pressure have been if the formation shape factor C_A is 4.7?

Table 3 – Formation and well parameters for Problem 2

Formation thickness, h	=	82	ft
Permeability, k	=	105	md
Porosity, ϕ	=	0.17	
Viscosity, μ	=	1.12	cp
Total compressibility, c_t	=	$2.7\text{x}10^{-5}$	psi^{-1}
Volume factor, B	=	1.53	RB/STB
Wellbore radius, r_w	=	0.354	ft
Skin value, S	=	7.8	

Problem 3
The following data have been taken from a flow-after-flow (FAF) test of a gas well with low static pressure 129.7 bar.

q_{sc} (Sm^3/d)	p_{wf} (bar)
354000	123.9
456000	120.7
561000	116.7
643000	113.0

Use the information above to carry out the analyses below.

a) Determine the deliverability and AOF potential of the well by using LIT analysis and direct computations without plotting (assume that the data to be consistent such that computations can be based on any chosen representative data points).

b) Determine the deliverability and AOF potential of the well by using simple loglog analysis (back-pressure equation) and direct computations without plotting (assume the data to be consistent such that computations can be based on any chosen representative data points).

STANDARD EQUATIONS

$$p_D = \frac{kh}{18.66 qB\mu}\Delta p$$ (SI units, oil)

$$p_D = \frac{kh}{141.2 qB\mu}\Delta p$$ (field units, oil)

$$p_D = \frac{p_r kh}{0.06563 q_{sc} Z_r \mu_r T_r}\Delta p$$ (SI units, gas at high pressure)

$$p_D = \frac{p_r kh}{711 q_{sc} Z_r \mu_r T_r}\Delta p$$ (field units, gas at high pressure)

$$t_D = \frac{0.000355 kt}{\phi\mu c_t r_w^2}$$ (SI units, oil and gas)

$$t_D = \frac{0.000264 kt}{\phi\mu c_t r_w^2}$$ (field units, oil and gas)

$$C_D = \frac{C}{2\pi\phi h c_t r_w^2}$$ (SI units, oil and gas)

$$C_D = \frac{5.615 C}{2\pi\phi h c_t r_w^2}$$ (field units, oil and gas)

$$\frac{t_D}{C_D} = \frac{0.002232 kht}{\mu C}$$ (SI units, oil and gas)

$$\frac{t_D}{C_D} = \frac{0.0002951 kht}{\mu C}$$ (field units, oil and gas)

$$C = \frac{qB}{24}\frac{t}{\Delta p} = c_{wb} V_{wb}$$

$$\Delta p = m' t = \frac{qB}{24C} t$$

STANDARD EQUATIONS (Contin.)

$$m = \frac{21.49 qB\mu}{kh} \qquad \text{(SI units)}$$

$$m = \frac{162.6 qB\mu}{kh} \qquad \text{(field units)}$$

$$S = 1.151\left(\frac{p_i - p_{1hr}}{m} - \log\frac{k}{\phi\mu c_t r_w^2} + 3.098\right) \qquad \text{(SI units, drawdown data)*}$$

$$S = 1.151\left(\frac{p_{1hr} - p_{wf,s}}{m} - \log\frac{t}{t+1} - \log\frac{k}{\phi\mu c_t r_w^2} + 3.098\right) \qquad \text{(SI units, buildup data)*}$$

*) Field units: replace 3.098 by 3.23.

$$\Delta p_S = \frac{m}{1.151} S$$

$$r_{inv} = 0.0286\sqrt{\frac{kt}{\phi\mu c_t}} \qquad \text{(SI units)}$$

$$r_{inv} = 0.0246\sqrt{\frac{kt}{\phi\mu c_t}} \qquad \text{(field units)}$$

$$d = 0.01412\sqrt{\frac{kt}{\phi\mu c_t}} \qquad \text{(SI units)}$$

$$d = 0.01217\sqrt{\frac{kt}{\phi\mu c_t}} \qquad \text{(field units)}$$

$$p_i - \overline{p} = \frac{m}{1.151} 2\pi t_{DA}$$

$$p_{ws}(\Delta t) = \overline{p} \quad \text{when} \quad \Delta t_e = \frac{\phi\mu c_t A}{0.000355 k C_A} \qquad \text{(SI units)}$$

$$p_{ws}(\Delta t) = \overline{p} \quad \text{when} \quad \Delta t_e = \frac{\phi\mu c_t A}{0.000264 k C_A} \qquad \text{(field units)}$$

STANDARD EQUATIONS (Contin.)

Fractured wells:

$$m' = \frac{0.6236qB}{hx_f}\sqrt{\frac{\mu}{k\phi c_t}}$$ (SI units)

$$m' = \frac{4.064qB}{hx_f}\sqrt{\frac{\mu}{k\phi c_t}}$$ (field units)

$$S = \ln\frac{2r_w}{x_f}$$ (fracture with infinite conductivity)

$$S = \ln\frac{er_w}{x_f} = \ln\frac{2.718r_w}{x_f}$$ (fracture with uniform flux)

Reservoir limit analysis:

$$m' = \frac{0.04167qB}{\phi c_t Ah}$$ (SI units)

$$m' = \frac{0.2339qB}{\phi c_t Ah}$$ (field units)

$$p_0 = p_i - \frac{18.66qB\mu}{kh}\left(\frac{1}{2}\ln\frac{4A}{e^{\gamma}C_A r_w^2} + S\right)$$ (SI units)

$$p_0 = p_i - \frac{141.2qB\mu}{kh}\left(\frac{1}{2}\ln\frac{4A}{e^{\gamma}C_A r_w^2} + S\right)$$ (field units)

$$e^{\gamma} = e^{0.57721\ldots} = 1.781\ldots$$

Gas tests:

$$q_{sc} = C(\overline{p}^2 - p_{wf}^2)^n$$ (simplified deliverability, p^2 formulation)

$$\overline{p}^2 - p_{wf}^2 = aq_{sc} + bq_{sc}^2$$ (LIT based deliverability, p^2 formulation)

$$\text{AOF} = \frac{1}{2b}\left(-a + \sqrt{a^2 + 4b\overline{p}^2}\right)$$ (LIT based AOF, p^2 formulation)

Fig. 1

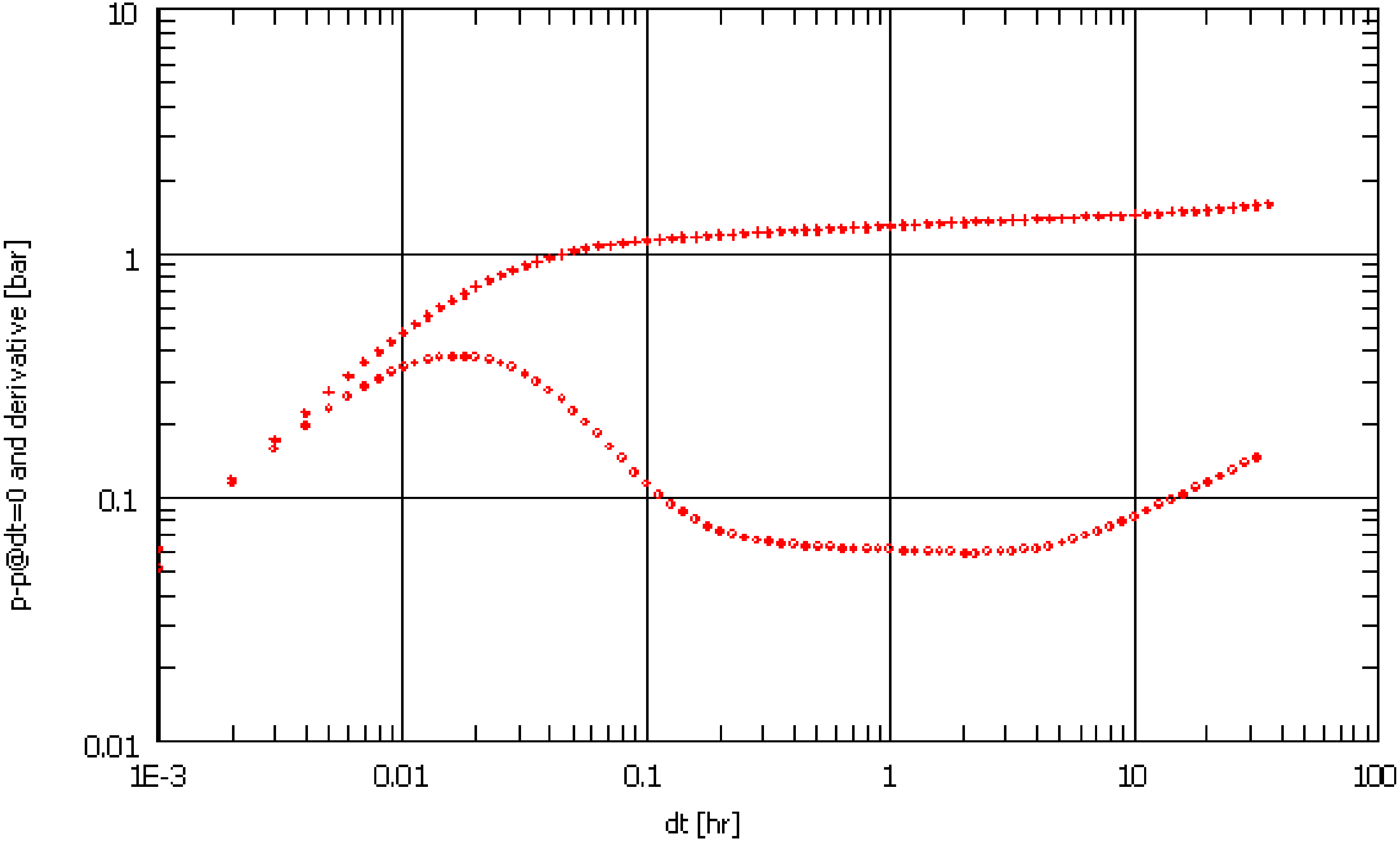

Fig. 2

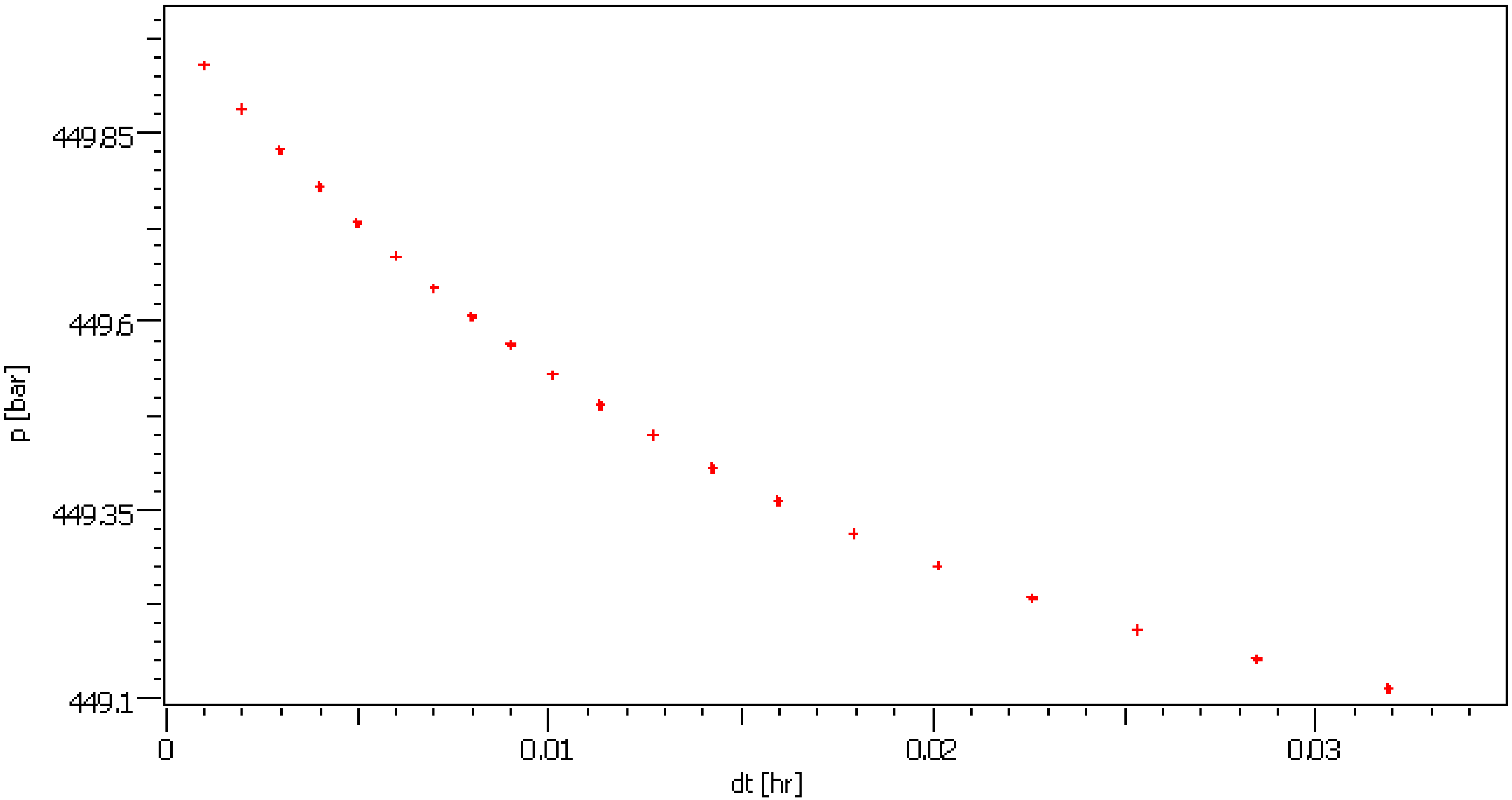

Fig. 3

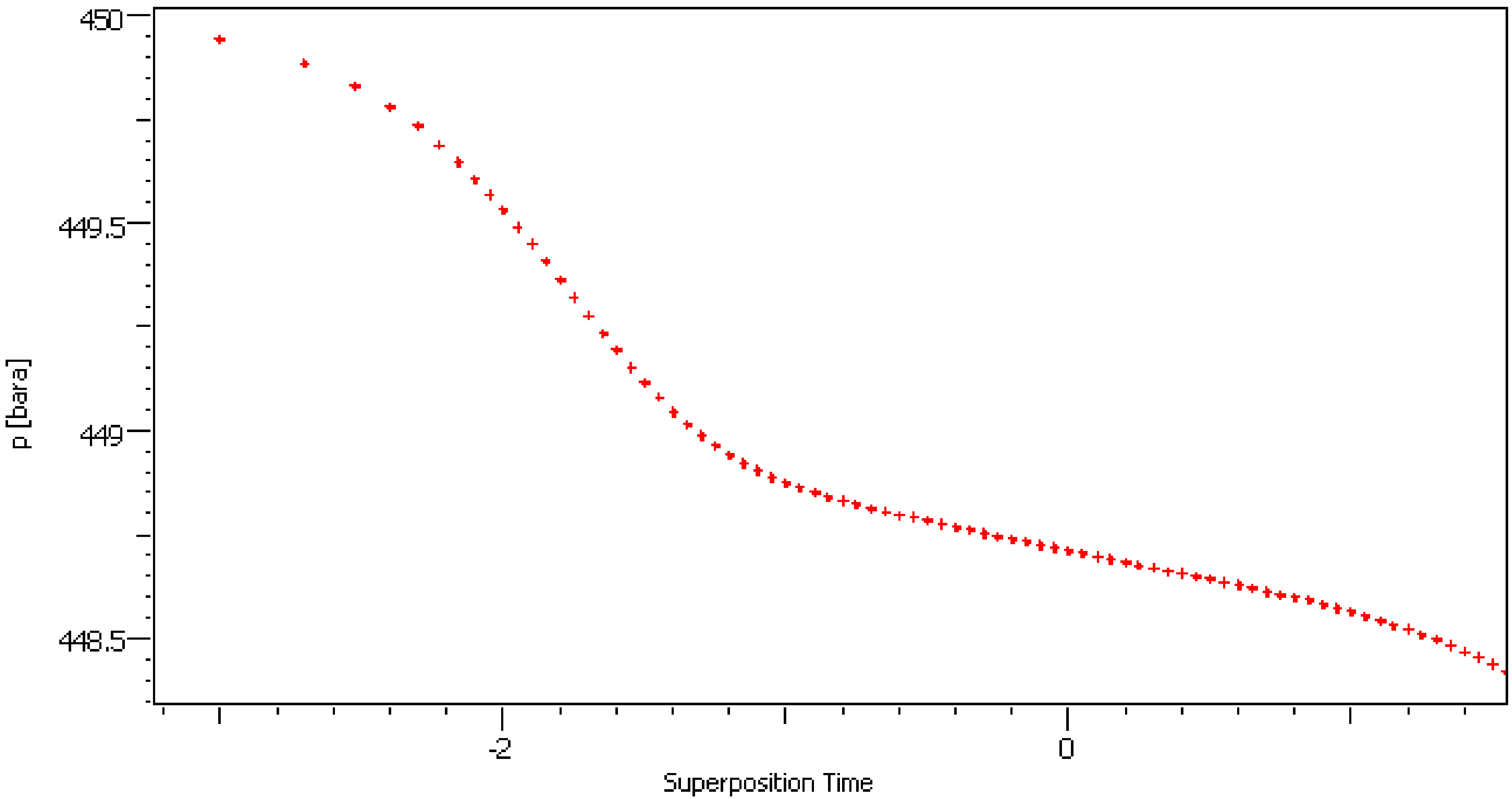

Fig. 4