AN INVESTIGATION AND DESCRIPTION OF PRESSURE TRANSIENT DATA OBTAINED FROM A MINI-DST

Bruno Rangel de Sousa, bsousa@dep.fem.unicamp.br
Rosângela Barros Zanoni Lopes Moreno, zanoni@dep.fem.unicamp.br
Universidade Estadual de Campinas. Rua Mendeleyev 200, Cidade Universitária, Campinas/SP BRASIL 13083860

Abstract. *During a well test, a transient pressure response is created by a temporary change in production rate. Well testing has long been a valuable tool for the petroleum industry. The practice continues to be widely used today, but increasingly more situations arise in which conventional well tests (DST, Drill Stem Test) can be impractical due to cost, logistical or environmental constraints. The increased offshore exploration activity, which often implies highly risky and huge operational costs, makes the conventional well testing less attractive in favor of other technologies that can provide some of the key dynamic information about the well-reservoir system throughout relatively quick and less expensive operations. Alternatives to the conventional DST include Wireline Formation Tests that may present a viable alternative to acquire formation fluid samples and pressure transient data. A WFT (commonly known as mini-DST) is actually a small-scale of DST with limited entry and is one of the cheapest options to successfully obtain reservoir parameters. The production rate history of a mini-DST has special features. Because the rate of mini-DST is measured close to the source at a downhole location, it is more accurate than measurement from a DST. A mini-DST can be performed at the flow-unit level with a straddle packer module (isolating a one-meter interval of reservoir) where one or more flow and buildup periods are conducted. The recorded transient pressures are then analyzed to evaluate and characterize the reservoir parameters such as initial/average reservoir pressure, permeability and skin factor and to characterize the reservoir boundary within the radius of investigation. Similar to classic well test analysis, transient pressure interpretation of the drawdown and buildup responses is used to derive the mobility thickness product and skin relevant to the rock volume investigated by the test. This papers aims to investigate and describe the parameters the can be obtained from a Wireline Formation Test (mini-DST) response, presenting a sensitivity analysis of this parameters though a well test software. Simulated tests will be discussed which show that smaller scale pressure transient tests often have an advantage over the full scale well tests (DST) in terms of providing detailed layer flow behavior, vertical connectivity and flow potential. The WFT can also be used to complement and calibrate well testing (DST) results or to acquire sufficient reservoir information when a full well test is not feasible and/or not required. In addition, the understanding of its advantages and limitations will allow the proper use to meet specific objectives and maximize the full potential use of acquired data for field development plans.*

Keywords*: Well Testing, Mini-DST, Petroleum Reservoir.*

1. INTRODUCTION

Wireline Formation Test (WFT) are widely used to measure fluid pressure, perform downhole fluid analysis, and for estimating permeability throughout pressure transient analysis. Many studies about WFT and mini-DST can be founded in literature (Ayan *et al*., 2001; Whittle *et al*., 2003; Kuchuk and Onur, 2003; Onur *el al*., 2004; Xian *et al*., 2004; Coelho *et al*., 2005; Larsen, 2006; Daungkaew *et al*., 2007; Elshahawi *et al*.2008; Onur *el al*., 2004; Bertolini *et al*., 2009; Kumar et al., 2010; Ramaswami *et al*., 2010). Mini-DST test is conducted using a WFT equipped with straddle packers. The use of straddle packers enables to isolate an interval from where production can be induced. A mini-DST is actually a small-scale DST (Drill Stem Test), which provides a limited flow entry. The production rate history of a mini-DST has special features, ie, because the flow rate of mini-DST is measured close to the source at a downhole location, its value are more accurate than that measured at the surface from a conventional well test.

In the last decades, improvements have been introduced in the formation tester, such as the ability of configuring the tool with different modules according to specific objectives of the test. The modules can be placed in almost any position using from higher accuracy quartz pressure sensors to multi-probe modules that can simultaneously monitor pressure as fluid is withdrawn. Straddle packer (mini-DST) module can be combined with one or more single-probe modules to conduct a WFT (Fig. 1). Recorded pressure transients are analyzed to evaluate and to characterize the reservoir for initial/average reservoir pressure, permeability anisotropy, skin factor, reservoir heterogeneity and to confirm communication between reservoir layers.

Ayan et. al. (2001) reported the effectiveness of dual-packer modules in laminated, shaly, fractured, vuggy, unconsolidated and low-permeability formation. Compared to DST, mini-DST is cheaper it has shorter operating time and it avoids any surface-handling of equipments. Figure (2) describes the formation tester configuration used for simulations in the present paper.

In addition to measuring pressure transients at a mini-DST, pressure changes can also be monitored at a single observation probe, what is referred in literature as interval pressure transient test (IPTT) or vertical interference test (VIT) (Fig. 2). The basic concept behind IPTT coupled with a mini-DST is to create a flow rate pulse at packer interval, generally a pressure drawdown, and monitoring the pressure response at the observation probe. Simultaneous pressure transient analyses from both, mini-DST and observation probe, provide vertical permeability determination for the zone between the mini-DST and the observation probe. This analysis from interference test delivers estimates for horizontal and vertical permeability, significantly reducing uncertainties.

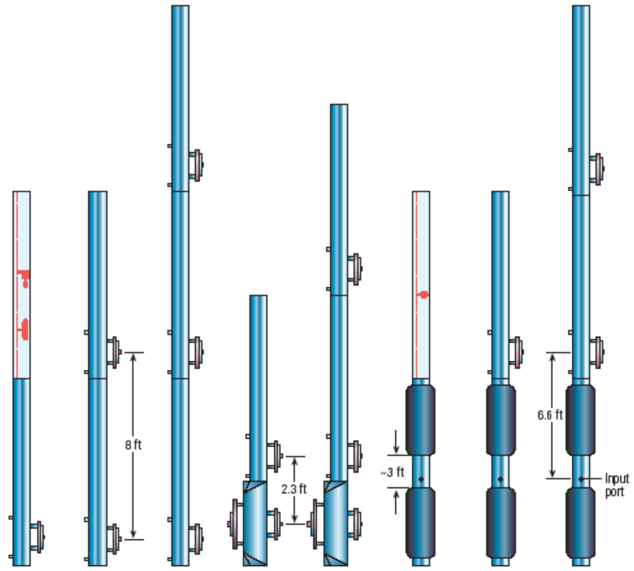

Figure 1: Variety of WFT configurations (Ayan et. al., 2001)

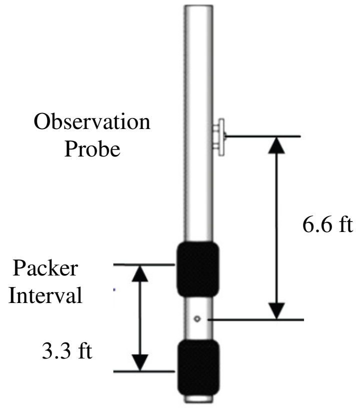

Figure 2: Mini-DST/Probe used for sensitivity simulation.

Conventional well test analyses are performed by matching wellbore storage coefficient, skin and horizontal permeability, while WFT (limited entry model) involves more three more: thickness of the open flow interval (usually 3.3 ft, Fig (2)), location of the mini-DST within the flow unit and the permeability anisotropy, K_v/K_h. In the case of an IPTT, one more information is added: vertical distance of the observation probe from dual packer.

The present paper aims to investigate and describe practical issues of the parameters that can be obtained from a Wireline Formation Test (mini-DST) response throughout a sensitivity analysis. Discussions based on simulated tests show that smaller scale tests often have advantages over full scale well tests (DST), which can be highlighted in terms of providing detailed layer flow behavior, vertical connectivity and flow potential. Additionally, interpretation's limitations from mini-DST data and IPTT interference data are discussed.

2. MATHEMATICAL MODEL

Perhaps one of the major analytical features which differs mini-DST from conventional DST formation test is the presence of spherical and hemispherical flow regimes (Moran and Finklea, 1962; Culham, 1974; Raghavan and Clark, 1975; Gerard and Horner, 1985; Good and Thambynayagam, 1992). In order to distinguish these flow regimes from others combined curves for measured pressure change and correspondent pressure derivatives (“log-log plots”) are used, as originally outlined by the work of Bourdet et. al. (1983). Spherical flow is identified by a -1/2 slope in the derivative curve, radial flow shows a zero slope line and wellbore storage period shows a slope of 1. If the mini-DST opening interval is much closer from one bed boundary than from other, spherical flow regime is altered and it may become hemispherical. The hemispherical flow shows the same slope presented by spherical flow on the log-log plot, however, specialized plot (pressure vs. inverse square root of time) shows doubled slope, which can take to an underestimated permeability value.

Here will be presented a brief review of the interpretation techniques for the pressure transient data obtained during a WFT operation. This is not an exhaustive summary but rather a means to show most of the assumptions needed for these solutions, which in large part have been derived from the well test literature. The radial flow solution (line-source solution) is not shown here. As a general reference, we refer the reader to the publications by Bourdet (2002), Lee et al (2003) and Larsen (2006), from which some parts have been adapted to describe the analytical equations given here.

2.1. **Spherical flow (point-source solution)**

The simplest analytical solution used to analyze pressure transient data from wireline tools are based on spherical flow models considering a sphere (sphere radius $r_s > 0$) or a point ($r_s = 0$) (Larsen, 2006). Having the spherical flow solution, the point-source solution is obtained by setting $r_s = 0$.

Let r denote the radial distance from the center of open interval, then the single-phase spherical diffusivity equation is as follows (in consistent units):

$$\frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial p}{\partial r}\right) = \frac{\phi\mu c_t}{k_s}\frac{\partial p}{\partial t} \quad (1)$$

where p is the reservoir pressure, ϕ is the formation porosity, μ is the oil viscosity, c_t is the total reservoir compressibility, k_s is the spherical permeability and t is the elapse time.

Using constant flow rate qB as inner boundary condition at the sphere radius r_s, then

$$\frac{qB}{4\pi r_p^2} = \frac{k_s}{\mu}\left(\frac{\partial p}{\partial r}\right)_{r=r_s} \quad (2)$$

where q is the flow rate and B the formation volume factor.

Equation (1) can also be rewritten in terms of dimensionless variables:

$$\frac{1}{r_D^2}\frac{\partial}{\partial r_D}\left(r_D^2\frac{\partial p_D}{\partial r_D}\right) = \frac{\partial p_D}{\partial t_D} \quad (3.a)$$

where r_D is the dimensionless radius ($r_D=r/r_w$), r_w is the wellbore radius, p_D is the dimensionless pressure, and t_D the dimensionless time, also expressed as

$$t_D = \frac{k_s t}{\phi\mu c_t r_w^2} \quad (3.b)$$

$$p_D = \frac{2\pi k_s h}{qB\mu}\left[p_i - p(r,t)\right] \quad (3.c)$$

where h is the reservoir thickness.

For the point-source model, the following solution can be derived:

$$p_D(r_D,t_D) = \frac{h_D}{2r_D}\, erfc\left[\frac{r_D}{2\sqrt{t_D}}\right] \quad (4)$$

where $h_D = h/r_w$.

Similarly to several other models, the above solution is derived by using Laplace transforms and further combining with Stehfest algorithm to generate values of $p_D(t_D)$ for any t_D (Lee, 2003). If t_D/r_D^2 is sufficiently large, the complementary error function can then be approximated by

$$p_D(r_D,t_D) = \frac{h_D}{2}\left[\frac{1}{r_D} - \frac{1}{\sqrt{\pi t_D}}\right] \quad (5)$$

Equations to be used in analysis of pressure transient drawdown and buildup data can be based on the Eq. (5). In practical SI units, the drawdown equation for spherical flow is:

$$p_{wf}(t)=p_i-\frac{18.6647qB\mu}{k_s r_s}+\frac{279.3347qB\mu\sqrt{\phi\mu c_t}}{k_s^{\frac{3}{2}}}\frac{1}{\sqrt{t}} \tag{6}$$

p_{wf} is the pressure at the well and p_i is the initial reservoir pressure.

The drawdown pressure derivative can be calculated as follows:

$$p'(t)=\frac{dp}{dlnt}\equiv t\frac{dp}{dt}=-\frac{139.667qB\mu\sqrt{\phi\mu c_t}}{k_s^{\frac{3}{2}}}\frac{1}{\sqrt{t}} \tag{7}$$

which confirms that if one plots pressure and time in logarithmic scale (log-log plots), the resulting derivative curve should exhibits a -1/2 slope. For buildup, the equation becomes

$$p_{ws}(\Delta t)=p_i-\frac{279.3347qB\mu\sqrt{\phi\mu c_t}}{k_s^{\frac{3}{2}}}\left(\frac{1}{\sqrt{\Delta t}}-\frac{1}{\sqrt{t_p+\Delta t}}\right) \tag{8}$$

where p_{ws} is the pressure increase in buildup and t_p is the production time or the time of buildup start.

Once flow regimes (spherical and radial) are identified, it is straightforward to fit a line in a given portion of the pressure data (plotted against a suitable time variable) and derive from there the corresponding permeability value. Assuming a homogeneous reservoir with horizontal permeability k_h and vertical permeability k_v, spherical permeability k_s is given by:

$$k_s=\sqrt[3]{k_h^2 k_v} \tag{9}$$

If both spherical and radial flow regimes occur during the formation test, it is possible to estimate vertical and horizontal permeability.

There are several others equations that can describe the different flow regimes in a formation tester but are not shown here because this would go beyond the purpose of this paper. For instance, it was not consider the solutions for multi-probe formation testing and packer-probe models, available for horizontal (Kuchuk, 1998) and deviated wells (Onur et. al., 2004 and Onur et. al, 2009). The reader is encouraged to refer to the suggested literature for the cases not considered explicitly in this work.

3. PRESSURE TRANSIENT SENSITIVITY SIMULATION

The objectives of the sensitivity simulation in this paper are to confirm and to expand the knowledge concerning pressure curve derivative behavior due to possible spherical and radial flow in both mini-DST and observation probe. Especial focus will be given to reservoir's parameters estimations. Several simulations were run in order to investigate the distortions on the pressure responses due to flow unit (thickness), location of the mini-DST interval, permeability anisotropy ratio, K_v/K_h, and fluid mobility. The understanding of pressure responses characteristics from a mini-DST is the key to assess its reliability.

The first simulation refers to a WFT configuration showed in the Fig. (2). Considered features were stated as a 3.3 ft open interval, that was set at the middle of a 20 ft reservoir thickness. Others input parameter are: horizontal permeability (30 *mD)*, porosity (0.2), viscosity (1 *cp)*, formation volume factor (1 *RB/STB)*, compressibility (1e-5 psi^{-1}), skin (5) and wellbore storage (2e-5 *bbl/psi*). The production history shows 1.5 hour buildup after 1 hour drawdown at 20 *STB/d*.

For practical problems of interest, such as the one considered in this paper, the analysis of early-time radial flow regime is limited because skin and storage effects usually mask this entire flow regime. Thus, it will not be considered in this sensitivity studies.

For most application of mini-DST, usually the flowing interval is much less than the real thickness of the whole formation tested. Therefore, a spherical flow period usually occurs at early times during transient periods. As stated for Onur et al (2004) and in overall agreement with the sensitivity studies presented here, the duration and existence of these spherical flow regimes depend on many factors such as wellbore storage, formation thickness, location of the mini-DST interval and anisotropy ratio. Further, assuming the pressure transient advances to meet the upper and lower boundaries of the formation, late-time radial flow develops and analysis of the transient pressure will give the formation horizontal permeability.

The generated figures illustrate the main features of each studied case and how that features can influence the observed flow regimes in a mini-DST test. The figures show results for variation of one parameter at time letting all others fixed. The sensitivity analysis of mini-DST measurements to variations of formation properties considers tree separate cases: variation of formation anisotropy (see Figs 3 and 4), mobility (see Figs 5 and 6) and formation thickness (see Fig 9 and 10). It is also presented a sensitivity analysis to the tool positioning on the flow unit interval (see Fig 7 and 8).

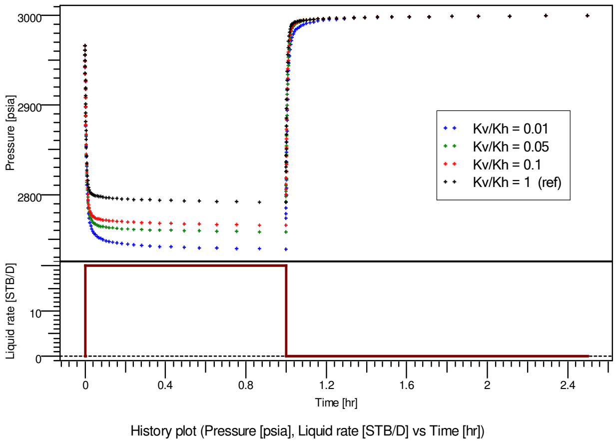

Figure 3: Pressure change sensitivity of mini-DST to variation on K_v/K_h ratio

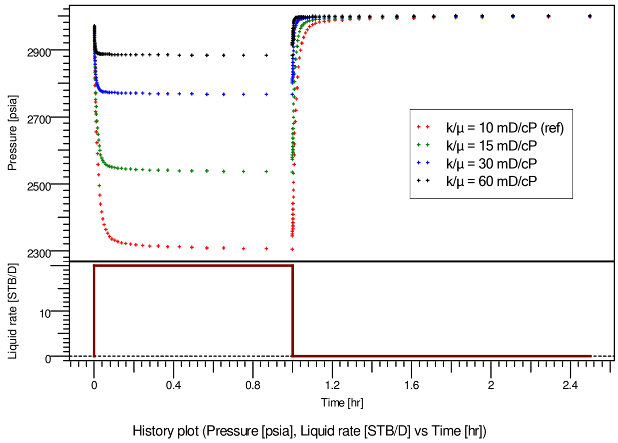

Figure 5: Pressure change sensitivity of mini-DST to to Mobility

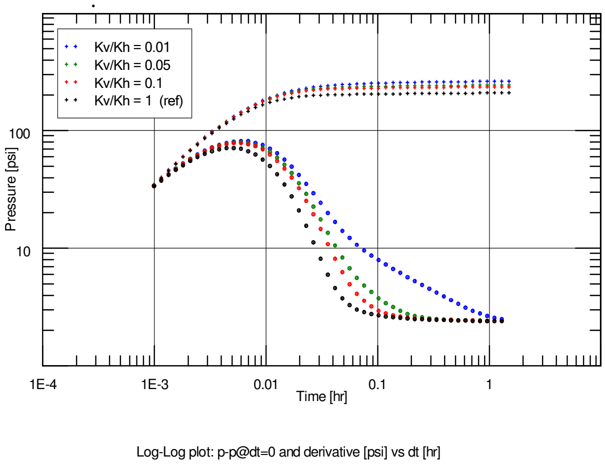

Figure 4: Pressure change and derivative sensitivity of mini-DST to variation on K_v/K_h ratio

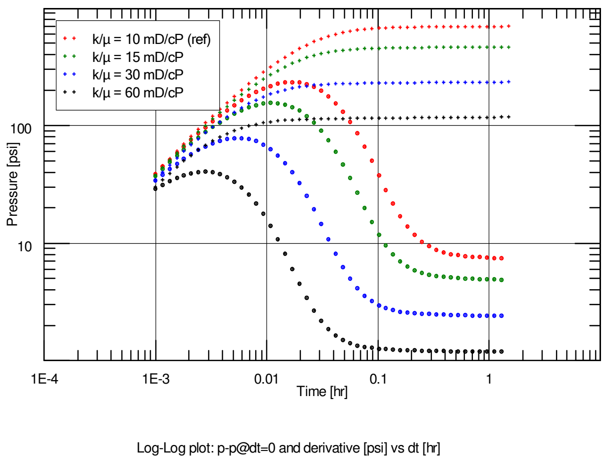

Figure 6: Pressure Derivative Sensitivity of mini-DST to Mobility.

From the pressure change due to variation on K_v/K_h ratio (Fig 3) can be inferred that as lower is the ratio higher is the pressure drop. This observation is meaningful for flow unit characterized by low vertical connectivity. It represents a difficult scenario for interpretation because the radial flow regime may not be developed during test registration period for mini-DST. This consequence can be clearly observed in the pressure curve derivative for the lowest K_v/K_h ratio of 0.01 in Fig (4). It was also observed a relative small discrepancy among pressure changes based on K_v/K_h ratio values increased in order of 10 times.

As stated early before, in Fig (4) it's very clear that with a low K_v/K_h ratio of 0.01 the pressure curve derivative reaches the end of the 1.5 hours buildup with a -1/2 slope well established, not reaching the late-time radial flow period. This analysis is quite obvious because with a low K_v the transient pressure would take more time to reach the upper and lower boundaries of the formation layer. In this case, anisotropy is disadvantageous to interpretation. However, for the lowest K_v/K_h ratio, the negative half slope it is better established than that for higher K_v/K_h ratio. Following the analysis, the K_v/K_h ratio of 0.05 reaches the radial flow regime by 0.3 hours and with a K_v/K_h ratio of 1 the derivative response reaches the late-radial flow at 0.1 hours. As previously stated by Elshahawi *et al.* (2008), K_v/K_h ratio equal to 1 shows that the mini-DST derivative result is not much different from a full DST well test case, but showing results with a high skin and discrepancies on wellbore storage. This is because the type curve match for the full DST model interprets the flow to the mini-DST partial completion model as a high damaged zone.

Although the reservoir transmissibility (product of mobility by thickness) has together a direct impact on the log-log plot, here the variables are analyzed separately. For this paper were simulated several sensitivity pressure measurements for permeability and viscosity for a fixed anisotropy ratio. Although the graphics are not shown here, it is known that the log-log plots have the same behavior but with permeability and viscosity been inversely proportional to pressure. Moreover sensitivity to viscosity change is better observed in the pressure curve derivative. Therefore although several publications talks about permeability, a pressure transient analysis actually estimates horizontal and vertical mobility. Thus here it is presented a sensitivity analysis to the formation mobility (k/μ) with a 0.1 of anisotropy ratio and 20 ft of flow unit being fixed.

Figure (6) shows that the lower mobility of 10 *mD/cP* develops a radial flow regime at 0.7 hours. With higher mobility values for a given set of formation thickness, the radial flow regime will be reached sooner. Figure (5) shows the simulated pressure change for mini-DST due to variation in formation mobility. It can be inferred from this figure that the pressure measurements are highly affected by changes of mobility. The higher the mobility lower will be the pressure change. This observation applies for only the pressure drawdown data. Visually it can be inferred that pressure data exhibits a very low sensitivity to the variation during the buildup.

An important observation is that the discrepancies between the values of pressure data will decrease for increasing values of mobility. The simulated case for *k/μ* of 10 *mD/cP* shows the larger pressure decrease whereas for the case with 30 and 60 *mD/cP* exhibits smaller pressure differential. Also important to note that the pressure measurements simulated starts with a low value of pressure for a low value of mobility but they reach the same steady-state pressure for the buildup test.

It is well know that reaching the late-time radial flow is the more important parameter for predicting the reservoir performance. Although, it is important to emphasize that it is not mandatory that radial flow be observed in all mini-DST applications. This may occur when reservoir heterogeneities affects for low diffusivity in the porous medium, such as low vertical permeability, damaged zone, drawdown and buildup insufficient test duration, etc.

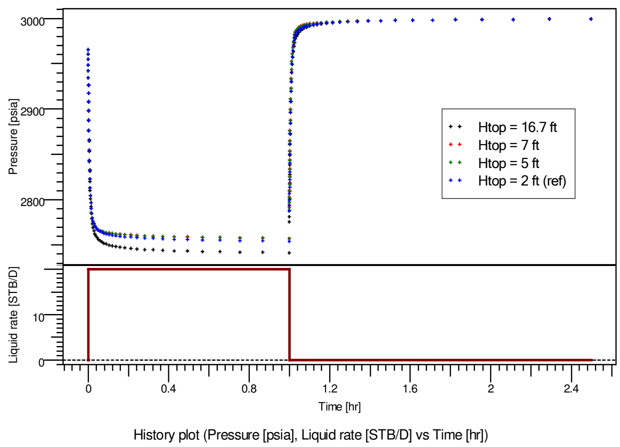

Figure 7: Pressure change of mini-DST to variation on H_{top}.

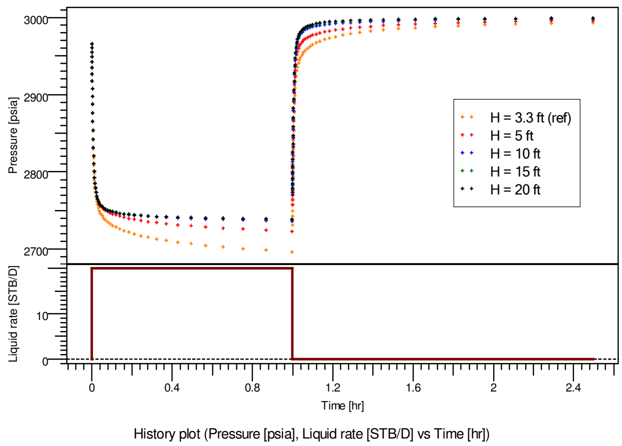

Figure 9: Pressure change of mini-DST to thickness.

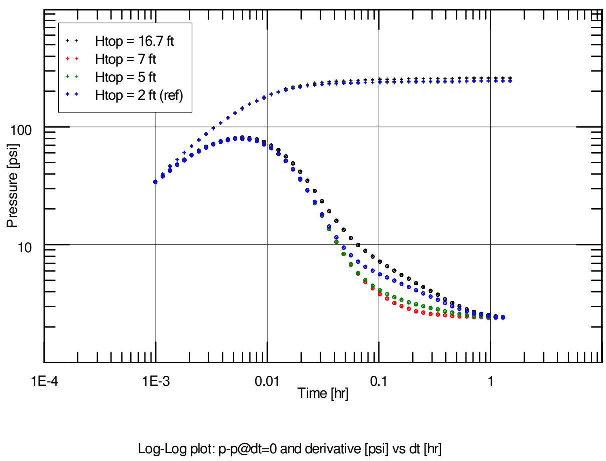

Figure 8: Sensitivity of mini-DST to variation on H_{top}.

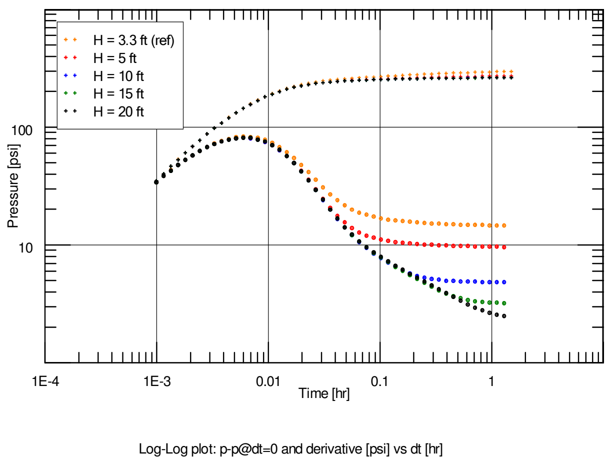

Figure 10: Sensitivity of mini-DST to thickness.

The sensitivity to mini-DST positioning is summarized in Figs (7) and (8). It was observed that the pressure change is more sensitive to the mini-DST location at the bottom (or top) of the flow unit. Despite the positioning of the tool at the bottom (or top) on the formation flow unit shown a higher the pressure change, it's derivative only reaches the radial flow by the end of the test. It is worth to note that although its derivative shown a -1/2 slope, an erroneous interpretation could be made, since with the tool at this location a hemispherical flow regime can be developed. It can be inferred that the derivative reaches the radial flow regime sooner with the mini-DST located at closer as possible to the middle of the flow unit.

Figures (9) and (10) show the pressure behavior due to formation thickness for the tool located at middle of the flow unit. In the Fig (9) could be concluded that increasing values of thickness tends to show the same pressure change behavior, with decrease pressure curve derivative shown in Fig (10). It can be seen that with higher flow unit the time to reach radial flow regime increase greatly. This can be easily explained with the fact that with higher flow unit the geometrical skin, due to transition period (spherical flow), increase proportionately. This observation implies that for thicker flow unit intervals it may take long time to reach radial flow regime. Important to note that with a 3.3 ft formation thick (exactly the mini-DST open interval) it can be expected that the radial flow regime be developed immediately. Although, the lateness development saw in Fig (10) is due to the wellbore storage effect in early time.

It's well known that heterogeneous and layered reservoirs, such as carbonates, often shows as a challenge for pressure transient analysis especially because of uncertainties such as flow unit and formation fluid properties (Kuchuk *et al.*, 2000; Ayan *et al.*, 2001; Kuchuk and Onur, 2003; Xian *et al.*, 2004). Especial attention has been given to mini-DST due to the possibility to test multiple intervals in the total reservoir thickness. This often shown to be an advantage because upscaling those multiple interval data, of a multi-layered reservoir, can provide more accurate average permeability value (Whittle *et al.* 2003; Xian *et al.*, 2004; Elshahawi *et al.* 2008; Ramaswami *et al.* 2010).

As mentioned before, with an observation probe settled 6.6 ft above the mini-DST interval it's possible to perform an IPTT. Next it's presented a sensitivity study on pressure change and derivative for this type of WFT module. The sensitivity simulations were generated to highlight the importance of including an observation probe and integrating its transient data to evaluate accurate horizontal and vertical permeability from a mini-DST test, improving the uniqueness and reliability of data measurements.

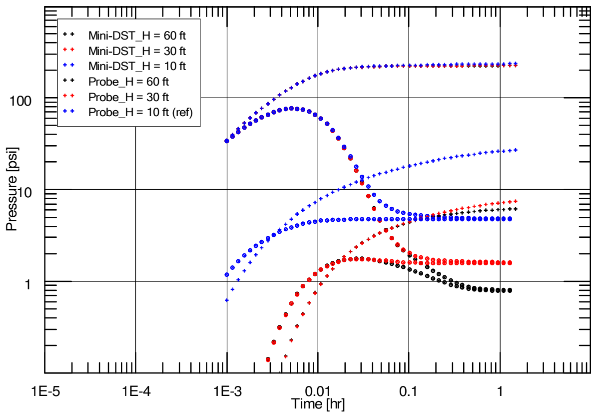

Figure 11: Sensitivity of mini-DST/Probe to *H* variation.

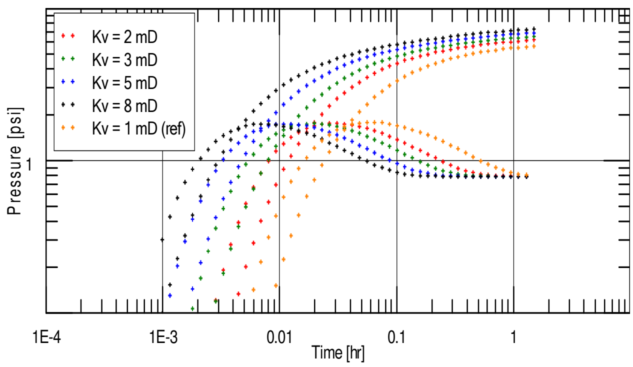

Figure 12: Probe Sensitivity to K_v.

Important consideration about transient pressure data from an observation probe is that with an early-time spherical flow near the mini-DST and radial flow at a distance, the pressure response at the probe will be dominated by linear interference at first and gradually reaching the transition (spherical flow) to late-time radial flow (Fig 11). The simulated curves response illustrated in Fig (11) shown usual data sets with the probes derivatives merging to a common consistent value within mini-DST derivatives when radial flow is reached.

This tool configuration feature is very important to eventual permeability estimative, especially when are uncertainty about mini-DST data. The interpretation of an IPTT test together with a mini-DST can provide a better match for horizontal and vertical permeability, reducing uncertainty on parameters estimation.

As stated before, the observation probe characterizes interference data response, in general dominated by vertical permeability. Figure (12) shown that small variations on K_v values are sufficient to generate great affect on the derivative curves. It was observed that for lower K_v values higher will be the discrepancies between the pressure curve derivatives. A low vertical permeability value can represent a difficult scenario for interpretation because the radial flow regime may not be developed during test duration on observation probe.

It is very important to obtain quality data during a mini-DST in order to perform a reliable interpretation, and hence estimate reservoir parameters (Ramaswami et. al., 2010). The simulations response displayed in this paper are the exact values of the analytical model with very high precision. But, in reality, all pressure gauges have limitations, drift, noise and accuracy. Figure (13) and (14) illustrate how the pressure resolution and accuracy could change by different gauges, both for mini-DST and observation probe. The Fig (13) indicates a pressure resolution of 0.01 for quartz gauge mode and 0.1 for strain gauge mode.

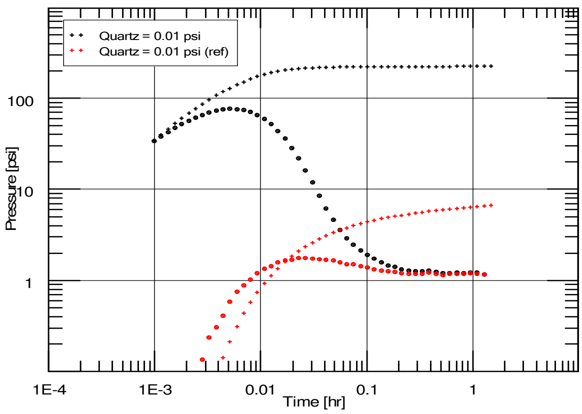

Figure 13: Mini-DST/Probe derivative with quartz gauge.

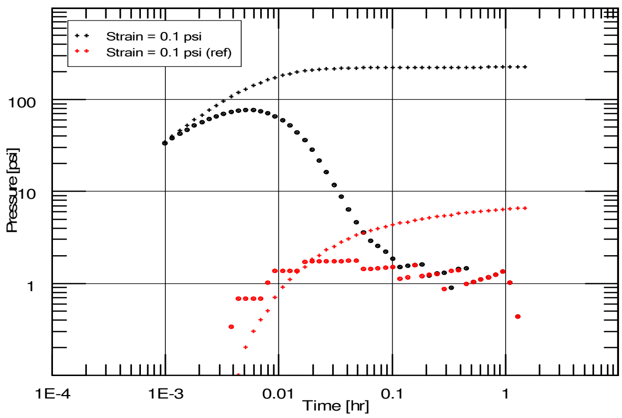

Figure 14: Mini-DST/Probe derivative with strain gauge.

Obviously strain gauge behavior is a lot worse and it is apparent that the slope of the radial flow, and thus the permeability estimation, will be in error from this plot analysis. Previews work by Stewart and Wittmann (1979) discusses the influence of pressure gauge resolution related to limitations in obtaining good pressure buildup data for analysis. Simulations include specified gauge resolutions for sensitivity analyses.

An erratic measured pressure profiles can indicate that vertical communication is poor in the formation. Poor quality data can be worse than no data at all. So, it is very important to ensure data quantity and quality when planning a WFT application. The quartz gauge enables a better pressure data derivative, thus enabling analytical methods to be applied successfully to derive both the horizontal and vertical permeability values.

4. CONCLUSION

Clear objectives and careful considerations of the conditions under which tests are to be conducted are necessary for an appropriate selection of the Well Test tools and procedures to ensure a successful operation.

Mini-DST is a short duration test, thus presenting less radius of investigation compared to a full DST test. Nevertheless this paper has shown that this is not quite a disadvantage, i.e., while a conventional full DST test averages the permeability across the tested interval, mini-DST enables to evaluate each zone separately and to identify variation on permeability across those zones.

More accurate values of vertical and horizontal permeability can be determined by the use of an observation probe in a mini-DST module. Also, the use of mini-DST, together with an IPTT, allows acquiring essential information related to uncertainties arising from heterogeneous and layered reservoirs, such as carbonates. As stated before, it is very important to obtain good quality data from mini-DST to guarantee a feasible interpretation and parameters estimation.

3. ACKNOWLEDGEMENTS

The authors acknowledge support by CNPq, Petrobras and KAPPA for the Ecrin v4.12 academic license.

4. REFERENCES

Ayan, C., Hafez, H., Hurst, S., Kuchuk, F., O'Callaghan, A., Peffer, J., and Zeybek, M., 2001, "Characterizing Permeability with Formation Testers". Published in Schlumberger Oilfield Review Magazine (autumn).

Bertolini, C., Tripaldi, G., Manassero, E., Beretta, E., Viberti, D., Verga, F., 2009, "A Cost Effective and User Frindly Approach for Mini-DST Design". SPE 122886 presented at the SPE EUROPEC/EAGE Annual Conference and Exhibition, Amsterdam.

Bourdet, D., Ayoub, J.A., and Pirad, Y.M., 1989, "Use of Pressure Derivative in Well-Test Interpretation" SPE 12777. SPE Formation Evaluation, Vol 4 nº 2, 293-302.

Bourdet, D., 2002 "Well Test Analysis: The Use of Advanced Interpretation Models", Handbook of Petroleum Exploration and Production, 3, Elsevier, Vol 1.

Coelho, A.C.D., Camargo, C., Kato, E.T. and Legrand, V.M.Q.F., 2005, "Utilizing Mini-DST for Formation Evaluation". SPE 94963 presented at the SP Latin American and Caribbean Petroleum Engineering Conference, Rio de Janeiro, Brazil.

Culham, W., 1974, "Pressure Buildup Equations for Spherical Flow Regime Problems". SPE Journal, Vol4 nº 6, 545-555.

Daungkaew, S., Harfoushian, J. H., Cheong, B., Akinsanmi, O., Yeo, J., and Toulekima, S., 2007, "Mini-DST Applications for Shell Deepwater Malaysia". SPE 109279 presented at SPE Asia Pacific Oil and Gas Conference and Exhibition, Jakarta, Indonesia.

Elshahawi, H., Hite, R. and Hows M., 2008, "The State of Optimum Value Testing – The Vision and the Reality". IPTC 12075 presented at the International Petroleum Technology Conference held in Kuala Lumpur, Malaysia.

Gerard, M. and Horner, R., 1985, "Effects of External Boundaries on the Recognition of Reservoir Pinchout Boundaries by Pressure Transient Analysis". SPE Journal, Vol 25 nº 3, 427-436.

Good, P. and Thambynayagam, R., 1992, "Permeability Determination with a Multiprobe Formation Tester". SPE Formation Evaluation, Vol 7 nº 4, 297-303.

Kuchuk, F., 1994, "Pressure Behavior of MDT Packer Module and DST in Crossflow-multilayer Reservoirs". Journal of Petroleum Science and Engineering, Vol 11 nº 2, 123-135.

Kuchuk, F. J., 1998, "Interval Pressure Transient Testing with MDT Packer-Probe Module in Horizontal Wells". SPE 39523 presented at the SPE India Oil and Gas Conference and Exhibition, New Delhi, India.

Kuchuk, F.J., Halford, F., Hafez, H., and Zeybek, M., 2000, "The Use of Vertical Interference Testing to Improve Reservoir Characterization". SPE 87236 presented at the 9th Abu Dhabi International Petroleum Exhibition and Conference, Abu Dhabi.

Kuchuk, F. J. and Onur, M., 2003, "Estimating Permeability Distribuition From 3D Interval Pressure Transient Tests". Jornal of Petroleum Science and Engineering, Vol 39, 5-27.

Kumar, V., Dunlap, J., Klimentos, T., Khan, Z.A., and Farooqui, M.Y., 2010, "The Use of Wireline Formation Tester for Optimization of Conventional Well Design and Interpretation". SPE 129031 presented at the SPE Oil and Gas India Conference and Exhibition, Mumbai.

Larsen, L., 2006. "Modeling and Analyzing Source and Interference Data From Packer-Probe and Multiprobe Testes". SPE 102698 presented at SPE Annual Techinical Conference and Exhibition, San Antonio, Texas.

Lee, J., Rollins, J.B., Spivey, J.P., 2003, "Pressure Transient Testing", SPE Textbook Series Vol. 9.

Moran, J. and Finklea, E., 1962, "Theoretical Analysis of Pressure Phenomena Associated with the Wireline Formation Tester". Journal of Petroleum Technology, Vol 14 nº 8, 899-908.

Onur, M., Hegeman, P. S., and Kuchuk, F. J., 2004, "Pressure Transient Analysis of Dual Packer-Probe Wireline Formation Testers in Slanted Wells". SPE 90250 presented at the SPE Annual Technical Conference and Exhibition, Houston.

Onur, M., Hegeman, P. S., Gok, I.M. and Kuchuk, F. J., 2009, "A Novel Analysis Procedure for Estimating Thickness-Independent Horizontal and Vertical Permeability from Pressure Data at an Observation Probe Acquired by Packer-Probe Wireline Formation Testers". IPTC 13912 presented at the International Technology Conference, Doha, Qatar.

Raghavan, R. and Clark, K., 1975, "Vertical Permeability from Limited Entry Flow Tests in Thick Formations". SPE Journal, Vol 15 nº 1, 65-73.

Ramaswami, S., Elshahawi, H., El Battawy, A., 2010, "Integration of Wireline Formation Testing and Well Testing Evaluation – An Example from the Caspian". SPE 139837 presented at the Caspian Carbonates Technology Conference, Atyrau, Kazakhstan.

Stewart, G. and Wittmann, M., 1979, "Interpretation of the Pressure Response of the Repeated Formation Tester". SPE 8362 presented at the 54th Annual Fall Tachnical Conference and Exhibition, Las Vegas.

Whittle, T.M., Lee, J., and Gringarten, A.C., 2003, "Will Wireline Formation Tests Replace Well Tests?". SPE 84086 presented at SPE Annual Technical Conference and Exhibition, Dever, CO.

Xian, C., Carnegie, C., Al Raisi, M. R., Petricola, M., Chen, J., 2004, "Na Integrated Efficient Approach To Perform IPTT Interpretation". SPE 88561 presented at the SPE Asia Pacific Oil and Gas Conference and Exhibition held in Perth, Australia.