INFLOW PERFORMANCE RELATIONSHIPS (*IPR*) FOR SOLUTION GAS DRIVE RESERVOIRS — A SEMI-ANALYTICAL APPROACH

A Thesis

by

MARÍA ALEJANDRA NASS

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

May 2010

Major Subject: Petroleum Engineering

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Approved by:

Co-Chairs of Committee,	Thomas A. Blasingame
	Maria A. Barrufet
Committee Member,	Robert Weiss
Head of Department,	Stephen A. Holditch

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ABSTRACT

Inflow Performance Relationships (IPR) for Solution Gas Drive Reservoirs —
a Semi-Analytical Approach. (May 2010)
María Alejandra Nass,
B.S., Universidad Metropolitana;
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This work provides a semi-analytical development of the pressure-mobility behavior of solution gas-drive reservoir systems producing below the bubble point pressure. Our primary result is the "characteristic" relation which relates normalized (or dimensionless) pressure and mobility functions — this result is:

$$\left[1-\frac{[k_o/(\mu_o B_o)]_{\bar{p}}-[k_o/(\mu_o B_o)]_{p_{abn}}}{[k_o/(\mu_o B_o)]_{p_i}-[k_o/(\mu_o B_o)]_{p_{abn}}}\right]=1-\zeta\left[\frac{\bar{p}-p_{abn}}{p_i-p_{abn}}\right]+(1-\zeta)\left[\frac{\bar{p}-p_{abn}}{p_i-p_{abn}}\right]^2-2(1-\zeta)\left[\frac{\bar{p}-p_{abn}}{p_i-p_{abn}}\right]^3$$

(where $\zeta \leq 1$)

This formulation is proven with an exhaustive numerical simulation study consisting of over 900 different cases. We considered 9 different pressure-volume-temperature (PVT) sets, and 13 different relative permeability cases in the simulation study. We also utilized the following 7 different depletion scenarios.

The secondary purpose of this work was to develop a correlation of the "characteristic parameter" (ζ) as a function of the following parameters:

$$\zeta = f(API_i,\ GOR_i,\ B_{oi},\ \mu_{oi},\ p_i,\ T_{Res},\ S_{oi},\ k_{ro,end},\ n_{Corey},\ \lambda_{oi})$$

We did successfully correlate the ζ-parameter as a function of these variables, which proves that we can uniquely represent the pressure-mobility path during depletion with specific reservoir and fluid property variables, taken as constant values for a particular case. The functional form of our correlation is:

$$\zeta = \mathrm{erf}\left[\alpha 1(GOR^{A1}\,API^{A2}\,T_{res}{}^{A3}\,S_{oi}{}^{A4}\,k_{rog}{}^{A5}\,p_i{}^{A6}\,B_{oi}{}^{A7}\,\mu_{oi}{}^{A8}\,\lambda_{oi}{}^{A9})\right.$$
$$\left.+\,n_w{}^{A10}+n_{ow}{}^{A11}+n_{og}{}^{A12}+n_g{}^{A13}\right]$$

The coefficients for this relation are obtained using regression on the results from the simulation study.

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DEDICATION

I dedicate this thesis to my husband Jose.

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CHAPTER I
INTRODUCTION

1.1. Research Problem

The concept of an Inflow Performance Relationship (IPR) has long been used to predict or estimate the relationship between pressure drop in the reservoir (drawdown) and well flowrates (production). Such relationships are used to monitor and optimize the producing life of a reservoir; and also for design calculations such as estimating tubing sizes, positions of gas lift mandrels, downhole pumps, etc. Engineers often make use of the IPR to understand the deliverability (or maximum productivity) of a reservoir, as well as to identify and resolve problems which may arise from the exploitation of a field. The IPR concept provides an engineer with the means to determine the performance of a given well by relating inflow (flowrate) to the pressure condition in the well and reservoir at a given time. The most common application of the IPR concept is to consider the effects of different operational conditions on the pressure and flowrate profiles for a given well at conditions other than the initial condition.

The development of the IPR approach was initially empirical (Rawlins and Schellhardt 1935), but the IPR can be *defined* using the simple "pseudosteady-state" flow relation which provides a direct relationship between wellbore pressure and flowrate in the reservoir. The underlying relationship between wellbore pressure and flowrate depends on the conditions — *e.g.*, for a "black oil" produced at pressures above the bubble-point, the pseudosteady-state flow relation provides a linear relationship between pressure and the oil flowrate. For the case of a dry gas produced at pressures *below* approximately 2000-3000 psia, there exists a linear relationship between gas flowrate and the pressure-squared (*i.e.*, p^2). The IPR concept is designed to relate three variables — flowrate, flowing bottomhole pressure, and the average reservoir pressure — where each of these variables is evaluated at the same condition (*i.e.*, time).

In this work we focus specifically on the development of IPR equations for *solution-gas-drive reservoir systems* (*i.e.*, cases where $p < p_b$); and we *assume* that the IPR for this case can be represented using some type of higher degree polynomial form. Such studies have been proposed by others (Vogel 1968, Richardson and Shaw 1982) — but in our work we focus on the *correlation of the oil mobility function,*

This thesis follows the style and format of the *SPE Journal*.

as we can demonstrate that this is the key performance variable for solution-gas-drive reservoirs.

In this work we use a black oil reservoir simulator (CMG 2008) to generate an exhaustive number of synthetic performance cases. Using these synthetic results, we have created a correlation for the dimensionless oil mobility ($\lambda_{D,IPR}$) as a function of a dimensionless pressure ($p_{D,IPR}$) and a unique characteristic parameter (ζ). We note that both $\lambda_{D,IPR}$ and $p_{D,IPR}$ are both defined using average reservoir pressure, abandonment pressure, and the flowing bottomhole pressure. The characteristic parameter (ζ) is then correlated with the following fluid and rock-fluid properties:

- (PVT) API_i = Initial Oil Gravity [Deg API]
- (PVT) GOR_i = Initial Gas-to-Oil Ratio [scf/STB]
- (PVT) B_{oi} = Initial Oil Formation Volume Factor [RB/STB]
- (PVT) μ_{oi} = Initial Oil Viscosity [cp]
- (Reservoir) p_i = Initial Reservoir Pressure [psia]
- (Reservoir) T_{Res} = Reservoir Temperature [Deg F]
- (Reservoir) S_{oi} = Initial (Average) Oil Saturation [fraction]
- (Reservoir) $k_{ro,end}$ = Endpoint Oil Relative Permeability [fraction]
- (Reservoir) n_{Corey} = Corey Relative Permeability Exponents [dimensionless]
- (Reservoir) λ_{oi} = Oil Mobility at Initial Reservoir Pressure [md/cp]

Chapter I of this thesis presents a review of the previous work and theory surrounding IPR formulations. Chapter II presents the methodology used to develop the all the output from reservoir simulation that was required to develop the ζ-parameter correlation. We present in this chapter all the data that was used as well as the polynomial curves that were obtained to describe the oil mobility function.

Chapter III presents the development and validation of the ζ-parameter correlation based on the results from Chapter II. The detailed methodology and procedure used to analyze the oil mobility calculations and results is also presented.

Chapter IV presents the summary, conclusions and recommendation for future work.

1.2. Review of Previous Work

1.2.1 IPR for Single-Phase Flow

The development of IPR for single-phase flow is reviewed as it provides the basis of the development of an IPR for two-phase flow (in this case, the solution gas-drive system). Beginning with the "pseudosteady-state" flow equation for a single-phase black oil system (Economides, *et al.* 1994), we have:

$$\overline{p} = p_{wf} + 141.2 \frac{B_o \mu_o}{k_o h} \left[\ln\left[\frac{r_e}{r_w}\right] - \frac{3}{4} + s \right] q_o \quad \text{(field units)} \quad \text{......(1.1)}$$

Consolidating terms in Eq. 1, we have:

$$\bar{p} = p_{wf} + b_{pss}\, q_o \quad \text{(1.2)}$$

A more common form of Eq. 2 is written in terms of the "productivity index," J_o, is given as:

$$\bar{p} = p_{wf} + \frac{1}{J_o} q_o \quad \text{(1.3)}$$

Where J_o is defined in terms of reservoir and production variables (for this case) as:

$$J_o = \frac{1}{b_{pss}} = \frac{1}{141.2 \dfrac{B_o \mu_o}{k_o h}\left[\ln\left[\dfrac{r_e}{r_w}\right] - \dfrac{3}{4} + s\right]} \quad \text{(1.4)}$$

And the definition of J_o in terms of the flowrate, the flowing bottomhole pressure at the well, and the average reservoir pressure is given by:

$$J_o = \frac{q_o}{(\bar{p} - p_{wf})} \quad \text{(1.5)}$$

Solving Eq. 5 for the case where p_{wf}=0; we define the maximum oil flowrate ($q_{o,\max}$) as:

$$q_{o,\max} = J_o\, \bar{p} \quad \text{(1.6)}$$

Solving Eq. 3 (or Eq. 5) for the oil flowrate (q_o) at any time, we have:

$$q_o = J_o\, (\bar{p} - p_{wf}) \quad \text{(1.7)}$$

We now define the Inflow Performance Relationship (or IPR) as $q_o/q_{o,\max}$ — substituting Eqs. 6 and 7 into this definition (*i.e.*, $q_o/q_{o,\max}$), we obtain:

$$\frac{q_o}{q_{o,\max}} = \frac{(\bar{p} - p_{wf})}{\bar{p}} = 1 - \frac{p_{wf}}{\bar{p}} \quad \text{(1.8)}$$

Solving Eq. 3 (or Eq. 5) for the flowing bottomhole pressure at the well yields:

$$p_{wf} = \bar{p} - \frac{1}{J_o} q_o \quad \text{(1.9)}$$

We note that the relationship implied by Eq. 9 for a given average reservoir pressure is that of a linear correlation between the flowing bottomhole pressure at the well (p_{wf}), the oil flowrate (q_o), and the average reservoir pressure ($\bar{p}$). This is the "liquid case" that Vogel (1968) considered as a limiting scenario for the 2-phase (oil-gas) IPR function (see **Fig. 1.1**).

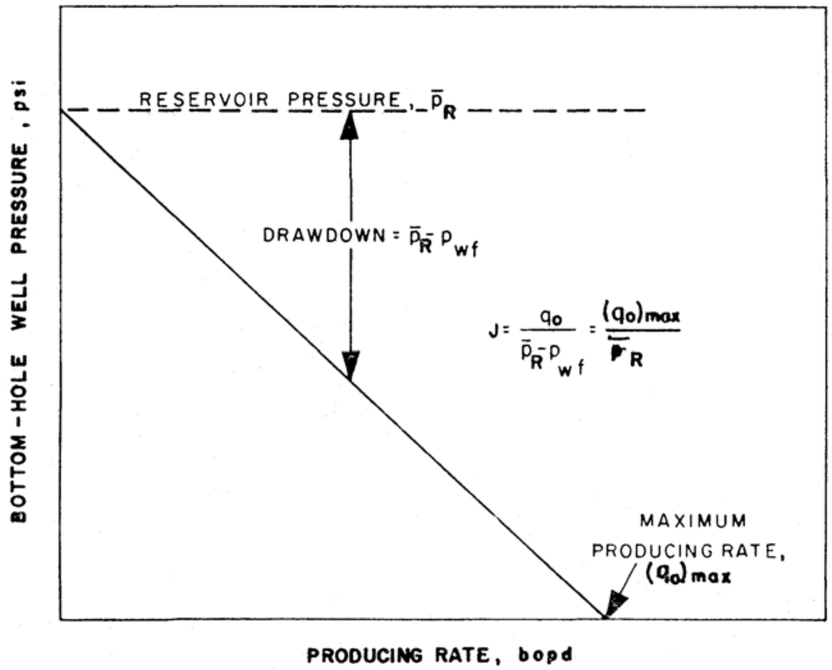

Figure 1.1 — Straight-line IPR for single phase, liquid flow (*i.e.*, the "black oil" case) (Vogel 1968).

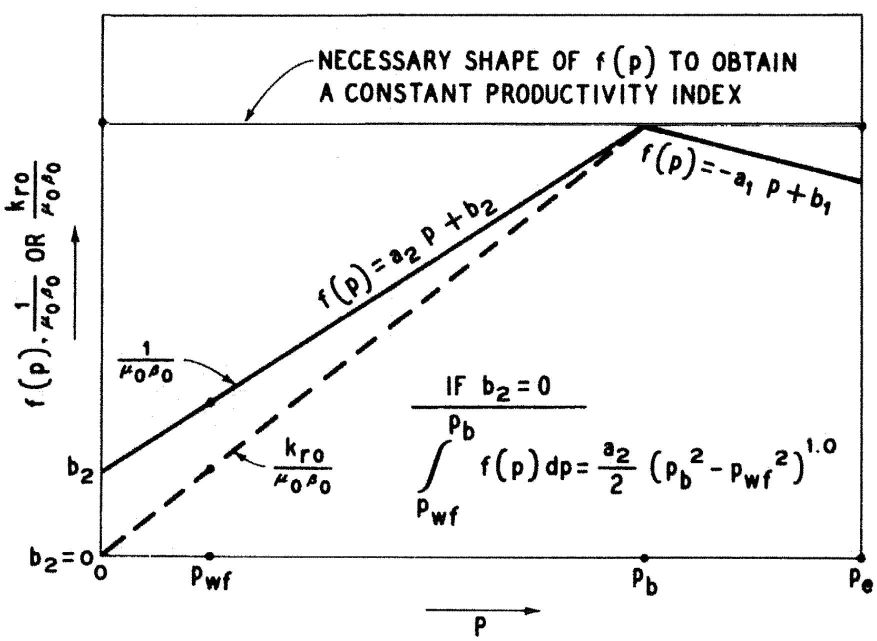

Figure 1.2 — Mobility vs. pressure behavior for a solution-gas-drive reservoir (Fetkovich 1973).

1.2.2 IPR for Two-Phase Flow

Del Castillo (2003) proposed the following relation as an *approximate* result for the case of oil flow in a solution-gas-drive reservoir system: (p_n is an arbitrary reference pressure)

$$q_o = J_o \left[\frac{1}{2\bar{p}} \frac{\left[\left[\frac{k_o}{\mu_o B_o} \right]_{\bar{p}} - \left[\frac{k_o}{\mu_o B_o} \right]_{\bar{p}=0} \right]}{\left[\frac{k_o}{\mu_o B_o} \right]_{p_n}} (\bar{p}^2 - p_{wf}^2) + \frac{\left[\frac{k_o}{\mu_o B_o} \right]_{\bar{p}=0}}{\left[\frac{k_o}{\mu_o B_o} \right]_{p_n}} (\bar{p} - p_{wf}) \right] \quad (1.10)$$

The underlying assumption for the result proposed by Del Castillo (2003) is the condition of a linear relationship between mobility and pressure (Fetkovich 1973) — where this condition is given in a mathematical form as:

$$\left[\frac{k_o}{\mu_o B_o} \right]_p = a + 2bp \quad (1.11)$$

The linear mobility versus pressure condition proposed in Eq. 11 is illustrated in **Fig. 1.2**. As a comment, it is interesting to observe that for the "single-phase" condition of a constant mobility (*i.e.*, $[k_o/(\mu_o B_o)]$ = constant), Eq. 10 reverts to Eq. 7.

The semi-empirical definition of the IPR for solution-gas-drive reservoir systems was given by Vogel (1968) as:

$$\frac{q_o}{q_{o,\max}} = 1 - 0.2 \left[\frac{p_{wf}}{\bar{p}} \right] - 0.8 \left[\frac{p_{wf}}{\bar{p}} \right]^2 \quad (1.12)$$

Richardson and Shaw (1982) proposed a single-parameter (v) formulation of the IPR correlation — this formulation is given by:

$$\frac{q_o}{q_{o,\max}} = 1 - v \left[\frac{p_{wf}}{\bar{p}} \right] - (1 - v) \left[\frac{p_{wf}}{\bar{p}} \right]^2 \quad (1.13)$$

It is also interesting to note that Eq. 13 can be derived from Eq. 10 (Del Castillo 2003), where we have

$$v = \frac{2 \left[\frac{k_o}{\mu_o B_o} \right]_{\bar{p}=0}}{\left[\left[\frac{k_o}{\mu_o B_o} \right]_{\bar{p}=0} + \left[\frac{k_o}{\mu_o B_o} \right]_{\bar{p}} \right]} \quad (1.14)$$

At this point we can conclude that there is some analytical (or at least semi-analytical) basis for the Vogel (quadratic) IPR concept (see **Fig. 1.3**).

Generalizing this pressure-dependent mobility concept further; Wiggins, *et al.* (1996) proposed a general polynomial form for the oil mobility function which in turn led to the following form for the IPR formulation:

$$\frac{q_o}{q_{o,\max}} = 1 + a_1 \left[\frac{p_{wf}}{\overline{p}}\right] + a_2 \left[\frac{p_{wf}}{\overline{p}}\right]^2 + a_3 \left[\frac{p_{wf}}{\overline{p}}\right]^3 + \ldots \quad (1.15)$$

Where the a_1, a_2, a_3, ... a_n coefficients are determined using the mobility function and its derivatives — all taken at the average reservoir pressure ($\overline{p}$). As comment, this approach is substantially limited by the requirement that the mobility function and its derivatives be known with respect to $\overline{p}$.

In addition to the various "polynomial" forms (*i.e.*, the relationship of mobility as a function or pressure), Fetkovich (1973) also provided the "pressured-squared" or "backpressure" form of the IPR; which is given in the following form:

$$\frac{q_o}{q_{o,\max}} = \left[1 - \frac{p_{wf}^2}{\overline{p}^2}\right]^n \quad (1.16)$$

Eq. 16, with n=1; is shown as the "gas flow" curve on **Fig. 1.3** (recall that the Vogel IPR (*i.e.*, Eq. 12) is shown as the "two-phase flow (reference curve)" in **Fig. 1.3**). The Fetkovich "backpressure" equation (Eq. 16) has found considerable service as an IPR, but the "Vogel" (quadratic polynomial) form is significantly more popular.

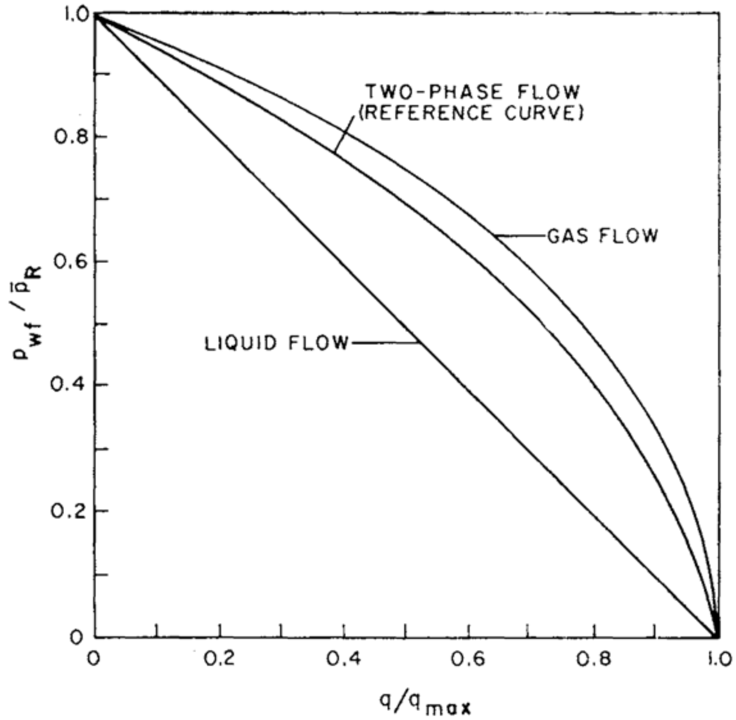

Figure 1.3 — Dimensionless IPR schematic plot (Vogel 1968).

1.3. Present Status of the Problem

Camacho and Raghavan (1989) presented numerical simulation results for various depletion scenarios for solution-gas-drive reservoirs — and one of the major contributions of their work was to identify the behavior of the mobility function as it relates to average reservoir pressure. Part of their motivation was to demonstrate that the (Fetkovich 1973) assumption of a linear relationship of mobility with pressure is incorrect (see **Fig. 1.4**).

Ilk, *et al.* (2007) proposed a "characteristic" formulation for the oil mobility profile based on the work by Camacho and Raghavan (1989). Recasting the results of Camacho and Raghavan, Ilk, *et al.* defined a "normalized" mobility function; where such a normalized mobility function would be 0 at t=0; and 1 at $t \rightarrow \infty$. This function is shown in **Fig. 1.5**. Ilk, *et al.* also provide a "correlating function" which is defined by a single "characteristic" parameter (ζ). **Fig. 1.5** also shows the resulting comparison, and we note that Ilk recast the Camacho and Raghavan formulation as 1 minus the normalized mobility function:

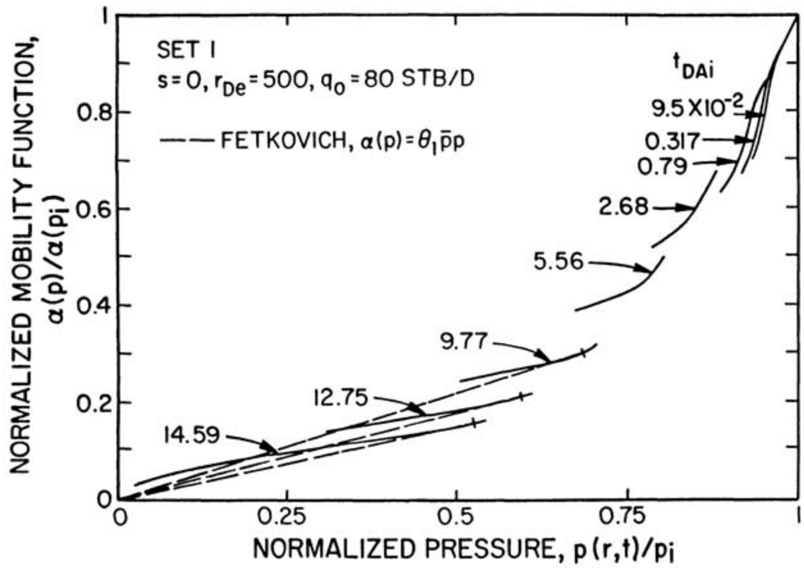

Figure 1.4 — Normalized mobility function profiles as functions of normalized pressure — note that a straight-line assumption is only valid for very late depletion stages (*i.e.*, late times) (Camacho and Raghavan 1989).

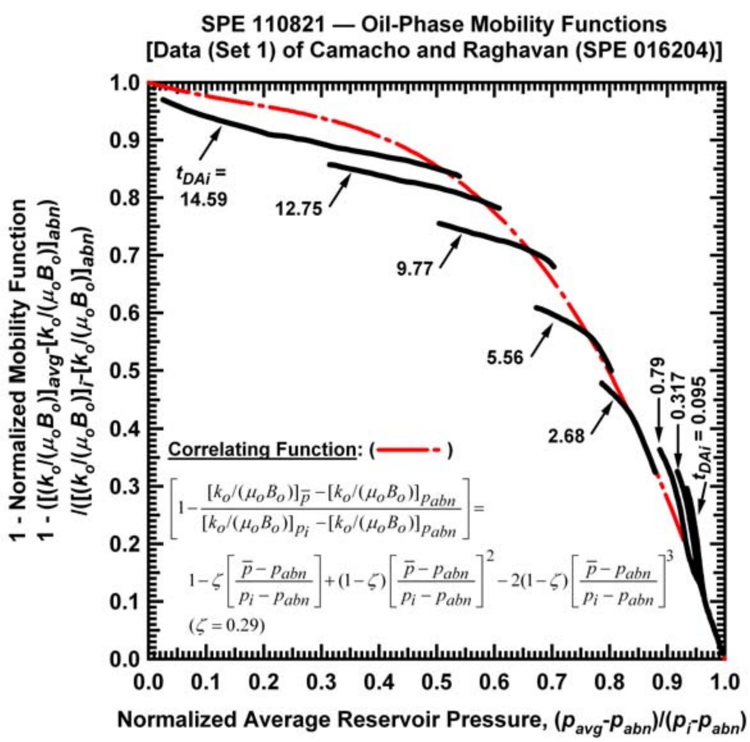

Figure 1.5 — Comparison between the Ilk, *et al.* (2007) characteristic mobility function and mobility results of Camacho and Raghavan (1989) (Ilk, *et al.* 2007).

The "characteristic" formulation proposed by Ilk, *et al.* (2007) is given as:

$$\left[1-\frac{[k_o/(\mu_o B_o)]_{\overline{p}}-[k_o/(\mu_o B_o)]_{p_{abn}}}{[k_o/(\mu_o B_o)]_{p_i}-[k_o/(\mu_o B_o)]_{p_{abn}}}\right]=1-\zeta\left[\frac{\overline{p}-p_{abn}}{p_i-p_{abn}}\right]+(1-\zeta)\left[\frac{\overline{p}-p_{abn}}{p_i-p_{abn}}\right]^2-2(1-\zeta)\left[\frac{\overline{p}-p_{abn}}{p_i-p_{abn}}\right]^3$$

(where $\zeta \leq 1$) ....(1.17)

From Eq. 1.17 it is apparent that the value of ζ will vary between 0 and 1 (*i.e.*, $0\leq\zeta\leq1$) — and perhaps not as obvious, the ζ-parameter will be correlated exclusively with reservoir and fluid properties. The ultimate application of the results from this work is the estimation of the "IPR" (or Inflow Performance Relationship) for various production scenarios. As an example, Ilk, *et al.* (2007) developed a quartic (4th order polynomial) IPR using the cubic (3rd order polynomial) "characteristic" formulation for the mobility function. This result is:

$$\frac{q_o}{q_{o,\max}}=1-\nu\left[\frac{p_{wf}}{\overline{p}}\right]-\nu\tau\,\overline{p}\left[\frac{p_{wf}^2}{\overline{p}^2}\right]-\nu\beta\,\overline{p}^2\left[\frac{p_{wf}^3}{\overline{p}^3}\right]-\nu\eta\,\overline{p}^3\left[\frac{p_{wf}^4}{\overline{p}^4}\right] \quad ....(1.18)$$

The ν, τ, β, and η variables are defined by the characteristic mobility function (details are given by Ilk, *et al.* (2007)).

Based on the work of Camacho and Raghavan (1989), Ilk, *et al.* developed a *concept-level* validation study using numerical simulation to establish the nature of the characteristic parameter (ζ). Depletion scenarios were created using constant rate, constant pressure and variable rate profiles. The Ilk, *et al.* work demonstrated that it is possible to describe the mobility function and subsequently, to establish an IPR for a solution-gas-drive reservoir directly from rock, fluid, and rock-fluid properties. The purpose of this thesis is to refine the Ilk, *et al.* (2007) concept and to *exhaustively* validate the concept of a dimensionless mobility-dimensionless pressure formulation that only requires a single correlation parameter (ζ).

1.4. Research Objectives

The overall objective of this work is to develop a *correlation* for the characteristic parameter, ζ, as defined by Eq. 1.17:

$$\left[1-\frac{[k_o/(\mu_o B_o)]_{\overline{p}}-[k_o/(\mu_o B_o)]_{p_{abn}}}{[k_o/(\mu_o B_o)]_{p_i}-[k_o/(\mu_o B_o)]_{p_{abn}}}\right]=1-\zeta\left[\frac{\overline{p}-p_{abn}}{p_i-p_{abn}}\right]+(1-\zeta)\left[\frac{\overline{p}-p_{abn}}{p_i-p_{abn}}\right]^2-2(1-\zeta)\left[\frac{\overline{p}-p_{abn}}{p_i-p_{abn}}\right]^3$$

(where $\zeta \leq 1$) ....(1.17)

The correlation will include the following rock-fluid and fluid thermodynamic properties:

$$\zeta = f(API_i,\ GOR_i,\ B_{oi},\ \mu_{oi},\ p_i,\ T_{Res},\ S_{oi},\ k_{ro,end},\ n_{Corey},\ \lambda_{oi})$$

As a point of reference, such a correlation would validate the quartic "Vogel-form" IPR proposed for solution-gas-drive reservoirs by Ilk, *et al.* (2007).

1.5. Thesis Outline

The thesis is outlined as follows:

- Chapter I — Introduction
  - Research Problem
  - Review of Previous Work
  - Present Status of the Problem
  - Research Objectives
  - Thesis Outline
- Chapter II — Model-Based Performance of Solution-Gas-Drive Reservoirs
  - Modeling Approach
  - Input Data Selection (Reservoir and Fluid Properties; Relative Permeability Curves)
  - Definition of the ζ-Parameter (Eq. 1.17)
- Chapter III — Correlation of the Characteristic Behavior of Solution-Gas-Drive Reservoirs
  - Correlation of the ζ-Parameter ($\zeta = f(API_i,\ GOR_i,\ B_{oi},\ \mu_{oi},\ p_i,\ T_{Res},\ S_{oi},\ k_{ro,end},\ n_{Corey},\ \lambda_{oi})$)
  - Validation of the ζ-Parameter Correlation
- Chapter IV — Summary, Conclusions and Recommendations
  - Summary
  - Conclusions
  - Recommendations for Future Research
- Nomenclature
- References
- Appendices

CHAPTER II

MODEL-BASED PERFORMANCE OF SOLUTION-GAS-DRIVE RESERVOIRS

2.1. Modeling Approach

In this work we continue with the Ilk, *et al.* methodology as we seek to understand the characteristic behavior of the solution-gas drive reservoir systems using reservoir simulation results at the wellbore and average reservoir pressures. We adopt the universal correlating relation for the mobility function (Eq. 1.17) from Ilk, *et al.* which is based on a single parameter (ζ).

Our procedure has the following steps:

Step 1: Establish the ζ-parameter (*i.e.*, the characteristic mobility parameter) for each case (*i.e.*, each reservoir simulation run). We use regression and hand refinements to establish the best practical (rather than statistical) fit of Eq. 1.17 for each case.

We also use the derivatives and integrals of the dimensionless mobility function as part of our analysis and visualization process (for completeness, the derivative and integral formulations are shown in Appendix C to N).

Step 2: Create a table of all cases where API_i, GOR_i, B_{oi}, μ_{oi}, p_i, T_{Res}, S_{oi}, $k_{ro,end}$, n_{Corey}, λ_{oi}, and ζ are tabulated for each case. Obviously, only one or two parameters will be varied for a particular case, but the table will be populated with all of the parameters for each individual case.

Step 3: Create a functional correlation for $\zeta = f(API_i, GOR_i, B_{oi}, \mu_{oi}, p_i, T_{Res}, S_{oi}, k_{ro,end}, n_{Corey}, \lambda_{oi})$.

Once established, the ζ correlation model can be used in conjunction with Eq. 1.18 (*i.e.*, the IPR model which results from Eq. 1.17) to estimate IPR (rate and pressure) behavior at any depletion condition.

To establish the ζ-parameter in Step 1, we utilize a commercial numerical reservoir simulator to generate the results (*i.e.*, pressures and flowrates) from which we estimate the ζ-parameter. In our work we use a solution-gas-drive (oil) model with radial coordinates (CMG 2008). We begin all simulation runs at a uniform initial reservoir pressure — where the initial reservoir pressure is equal to the bubble point pressure (*i.e.*, p_i=p_b). The simulation cases are run until maximum depletion is achieved (*i.e.*, until the simulator can no longer produce at a specified rate or pressure profile).

For each input data case we perform a simulation for 7 (seven) different production scenarios — where these production scenarios are:

- Constant bottomhole pressure
- Variable bottomhole pressure
- Stepwise bottomhole pressure
- Variable flowrate
- Constant flowrate
- Random flowrate
- Hyperbolic flowrate

Our procedure for Step 1 (*i.e.*, establishing the ζ-parameter), we use the following subtasks on each simulation:

- Calculate and tabulate the oil mobility as a function of average reservoir pressure, including at initial reservoir pressure, p_i.
- Estimate the "abandonment pressure" (p_{abn}) (*i.e.*, we define the "abandonment pressure" as the point where the simulator no longer produces fluids for a given rate or pressure at a particular depletion stage).
- Estimate the oil mobility at the abandonment pressure.
- Compute the dimensionless mobility and pressure functions as prescribed by Eq. 1.17.
- Use the formulation given by Eq. 1.17 to estimate the ζ-parameter for each simulation case using a combination of regression methods and hand refinements.
- Present the results of regression/hand refinement for each case on a suit of correlation plots.
  - — Plot 1: Base Function
  - — Plot 2: First Derivative Function
  - — Plot 3: Second Derivative Function
  - — Plot 4: Integral Function
  - — Plot 5: Integral-Difference Function

Examples of the proposed plotting functions are illustrated in **Figs. 2.6-2.10**.

For Step 2 (*i.e.*, establishing all the cases analyzed), we organize the input variables (*i.e.*, API_i, GOR_i, B_{oi}, μ_{oi}, p_i, T_{Res}, S_{oi}, $k_{ro,end}$, n_{Corey}, λ_{oi}) and the output results (*i.e.*, the estimated ζ and the calculated properties at p_{abn}) for each case in a table format, where one or two parameters will be varied for a particular case.

The table will be composed of permutations of the following:

- Input variables:
  - — PVT case, k_r case, simulation type, API_i, GOR_i, B_{oi}, μ_{oi}, p_i, T_{Res}, S_{oi}, $k_{ro,end}$, n_{Corey}, λ_{oi}
- Output variables (corresponding to each case):
  - — p_{abn}, $B_{o,abn}$, $\mu_{o,pabn}$, $k_{ro,pabn}$, $\lambda_{o,abn}$, $S_{o,abn}$, N_p/N, ζ

A table with the proposed simulation matrix is provided in **Appendix B**.

As noted, in Step 2 our primary goal is to estimate the ζ-parameter for each case. We estimate the ζ-parameter using Eq. 1.17 and *graphically* (not statistically) solve for the ζ-parameter by a hand-guided trial and error solution. This process is biased statistically, but in using this procedure we eliminate spurious matches that could be achieved using an "automated" statistical regression approach. As noted, the ζ-values estimated in this fashion are included in **Appendix B**.

Finally, for Step 3 (*i.e.*, creating a functional correlation for ζ), we attempt to define ζ as a function of all the input variables (*i.e.*, *only* the rock and fluid properties), we then:

- Propose a correlative relation for the ζ-parameter (*i.e.*, $\zeta = f(API_i, GOR_i, B_{oi}, \mu_{oi}, p_i, T_{Res}, S_{oi}, k_{ro,end}, n_{Corey}, \lambda_{oi})$) and we then calibrate this correlation using a regression procedure.

This research provides an exhaustive numerical simulation sensitivity study to assess the influence/impact of the following variables on the behavior of a solution-gas-drive reservoir system:

- Different PVT black-oil compositions/properties,
- Different relative permeability curves (and mobility ratios), and
- Different depletion scenarios (*i.e.*, prescribed rate or pressure profiles).

The purpose of this exhaustive study is to provide a very large sample size from which we can develop a viable correlation for the ζ-parameter for various mobility and pressure profiles. A summary of all cases generated in this work are provided in **Appendix B**, including the ζ-parameter values obtained from a "local" fit of Eq. 1.17 to each *individual* case.

2.2. Input Data Selection

2.2.1 Reservoir Fluid Properties

Reservoir fluid properties were calculated from Whitson and Brule's SPE Monograph 20. Pressure, volume and temperature (PVT) correlations were used for the calculation of all phase equilibrium and thermodynamic properties. In **Appendix P** we reproduce all the PVT correlations used on this study.

The use of black oil correlations carries the following assumptions:

a. When brought to surface there is not retrograde condensations of liquid.
b. The reservoir oil consists of two surface components, stock tank oil and total separator gas.
c. Properties of the stock tank oil and surface gas *do not change during depletion*, meaning that the composition of both phases remain fairly constant at reservoir conditions.

The literature shows different ranges of GOR that mark the end of black oil and the beginning of retrograde condensate gas behavior, for this study we use McCain (1991) suggestions that black oil fluids can be identified as those exhibiting an initial GOR < 2000 scf/STB and stock tank oil gravities < 45 API. Other authors provides with values of initial GOR < 750 or <1000 scf/STB.

By implementing a black-oil approach we do not foresee compositional changes having an impact in the modeling results for the GOR range studied.

2.1.2 Reservoir Model Characteristics and Assumptions

For this work a commercial reservoir simulator was used (CMG 2008). All cases were modeled with a solution-gas-drive (oil) model with radial coordinates. The following assumptions were made:

- The reservoir is cylindrical (radial system). The simulation grid is refined in the near-well region.
- The reservoir has a uniform thickness of 15 ft.
- The entire height of the reservoir is open for flow, there are no limited-entry effects.
- The reservoir is closed, and is homogeneous with a single vertical well located in the center.
- The reservoir rock is water wet.
- The reservoir is at the bubble point pressure at initial conditions (*i.e.*, single-phase oil initially).
- The reservoir produces at isothermal conditions.
- The water present in the reservoir is connate water — water does not flow in these cases.
- Gravity effects and capillarity pressures are not considered.
- "Black-oil" correlations are used for solution gas-oil-ratio, viscosity and the formation volume factors for both oil and gas. A review of all correlations used is given in **Appendix P**.
- The reservoir permeability is isotropic (*i.e.*, constant in all directions (*x, y, z*)).
- For all cases, the reservoir permeability is 10 md with a rock porosity of 10 percent.
- Non-Darcy effects (due to initial high gas (and or oil) flow) are not considered in this work.
- The effect of a reduced permeability zone around the wellbore (near-well "skin") is not considered.

2.3 Fluid Selection and PVT Properties

For this study all fluid properties were created from black oil correlations. Several fluids were considered for the development of all the numerical simulations that were analyzed. All fluids have a GOR, API and reservoir temperature such that black oil behavior can be expected. **Table 2.1** shows the initial values used to create each fluid's PVT properties. A total of 9 fluids were created, the PVT's were numbered from 1 to 9 *i.e*. PVT1, PVT2, etc:

Table 2.1 — Stock tank properties for selected black oil fluids.

PVT Case	GOR_i (scf/STB)	Reservoir Temperature (*ºF*)	Stock Tank Oil Density (*API*)	Gas Gravity (γ_g)
1	500	200	15	0.65
2	1000	200	25	0.65
3	1500	200	35	0.65
4	500	250	15	0.65
5	1000	250	25	0.65
6	1500	250	35	0.65
7	500	150	15	0.65
8	1000	150	25	0.65
9	1500	150	35	0.65

The stock tank properties shown on **Table 2.1** along with the reservoir temperature were used to generate several PVT tables that were subsequently fed into a reservoir simulator for all our calculations. Note that at this point in the study there has not been any benchmarking with real black oil PVT. It is estimated that the use of real PVT data should not affect the outcome of this study; although it is recommended that benchmarking and field validation be carried out. **Tables 2.2** to **Table 2.10** show all the PVT properties that were generated for each PVT case; a graphical representation of the PVT data is also shown on **Fig. 2.1** to **Fig. 2.9**:

Table 2.2 — Calculated fluid properties for PVT Case 1.

Pressure (psia)	*GOR* (scf/STB)	B_o (RB/STB)	$1/B_g$ (scf/rcf)	μ_o (cp)	μ_g (cp)
15	2	1.07	4	29.54	1.33
310	22	1.07	92	26.19	1.36
605	47	1.08	188	22.82	1.39
900	75	1.09	288	19.84	1.44
1195	105	1.10	391	17.28	1.50
1490	136	1.12	496	15.12	1.56
1785	169	1.13	603	13.29	1.64
2081	202	1.14	708	11.74	1.72
2376	237	1.16	811	10.42	1.81
2671	272	1.17	909	9.29	1.90
2966	309	1.19	1003	8.32	1.99
3261	346	1.20	1090	7.49	2.09
3556	383	1.22	1172	6.76	2.18
3851	422	1.23	1251	6.13	2.28
4146	461	1.25	1321	5.57	2.37
4441	500	1.27	1386	5.09	2.46

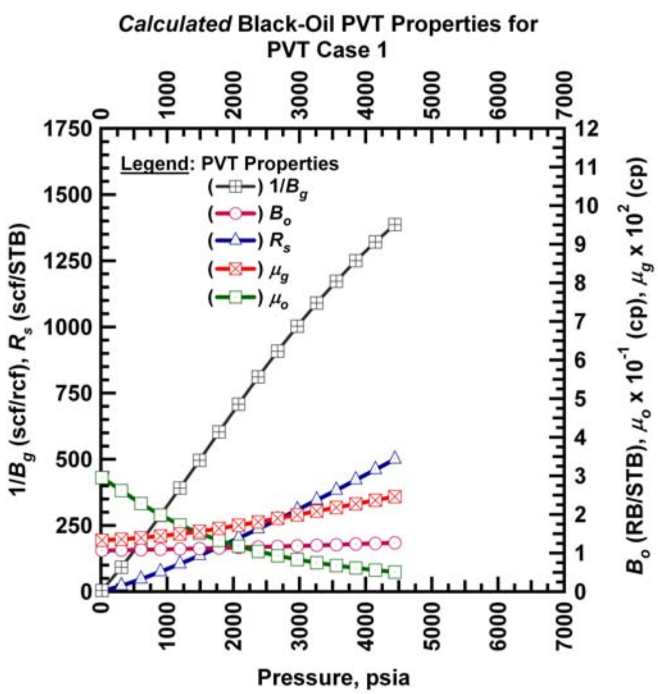

Figure 2.1 — Graphical representation of the calculated PVT properties for PVT Case 1.

Table 2.3 — Calculated fluid properties for PVT Case 2.

Pressure (psia)	*GOR* (scf/STB)	B_o (RB/STB)	$1/B_g$ (scf/rcf)	μ_o (cp)	μ_g (cp)
15	2	1.07	4	4.62	1.33
409	43	1.08	124	4.01	1.37
804	93	1.10	256	3.43	1.42
1198	149	1.12	393	2.93	1.50
1592	208	1.15	534	2.52	1.59
1987	271	1.17	675	2.18	1.69
2381	336	1.20	810	1.90	1.80
2775	403	1.23	944	1.67	1.93
3170	472	1.26	1065	1.47	2.06
3564	543	1.29	1176	1.31	2.18
3958	616	1.33	1278	1.17	2.31
4352	690	1.36	1369	1.05	2.43
4747	766	1.40	1453	0.96	2.55
5141	843	1.43	1528	0.87	2.67
5535	921	1.47	1597	0.80	2.78
5930	1000	1.51	1660	0.74	2.89

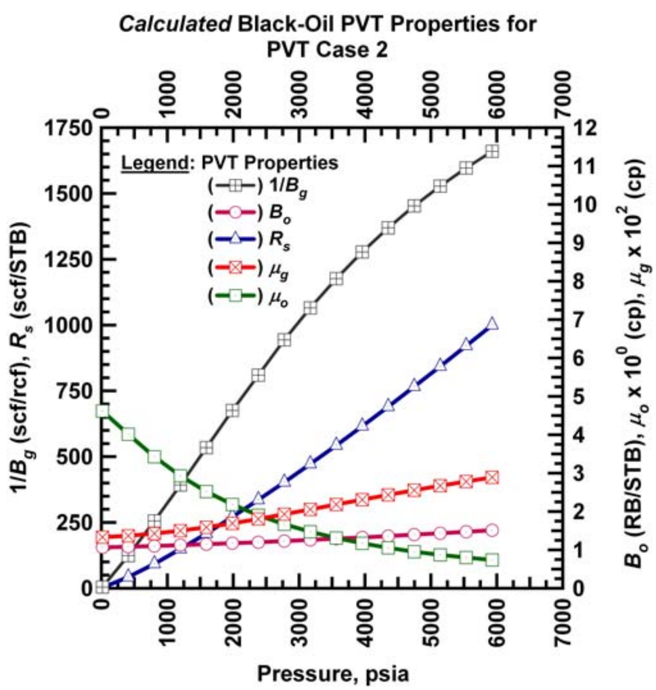

Figure 2.2 — Graphical representation of the calculated PVT properties for PVT Case 2.

Table 2.4 — Calculated fluid properties for PVT Case 3.

Pressure (psia)	*GOR* (scf/STB)	B_o (RB/STB)	$1/B_g$ (scf/rcf)	μ_o (cp)	μ_g (cp)
15	3	1.07	4	1.30	1.33
429	64	1.09	131	1.15	1.37
843	139	1.12	269	1.01	1.43
1258	222	1.16	413	0.87	1.51
1672	312	1.20	562	0.76	1.61
2086	405	1.24	711	0.66	1.72
2500	503	1.28	853	0.58	1.84
2914	604	1.33	988	0.51	1.97
3328	708	1.38	1111	0.46	2.11
3742	815	1.43	1223	0.41	2.24
4156	924	1.49	1325	0.37	2.37
4570	1035	1.54	1416	0.34	2.50
4985	1149	1.60	1499	0.32	2.62
5399	1264	1.66	1574	0.30	2.74
5813	1381	1.73	1642	0.29	2.86
6227	1500	1.79	1704	0.28	2.97

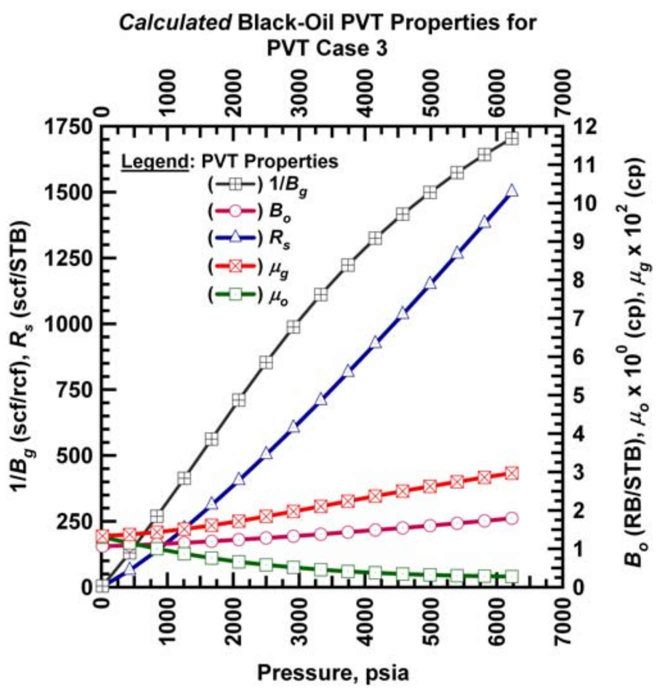

Figure 2.3 — Graphical representation of the calculated PVT properties for PVT Case 3.

Table 2.5 — Calculated fluid properties for PVT Case 4.

Pressure (psia)	*GOR* (scf/STB)	B_o (RB/STB)	$1/B_g$ (scf/rcf)	μ_o (cp)	μ_g (cp)
15	2	1.09	4	9.58	1.43
343	22	1.10	95	8.74	1.45
671	47	1.11	193	7.86	1.49
999	75	1.12	293	7.05	1.54
1327	104	1.13	396	6.33	1.59
1655	136	1.15	499	5.70	1.66
1983	168	1.16	603	5.14	1.73
2311	202	1.17	704	4.65	1.81
2639	236	1.19	803	4.22	1.89
2967	272	1.20	895	3.84	1.97
3295	308	1.22	986	3.51	2.06
3623	345	1.23	1070	3.22	2.15
3951	383	1.25	1149	2.95	2.24
4279	421	1.27	1223	2.72	2.33
4607	460	1.28	1292	2.51	2.42
4935	500	1.30	1356	2.33	2.50

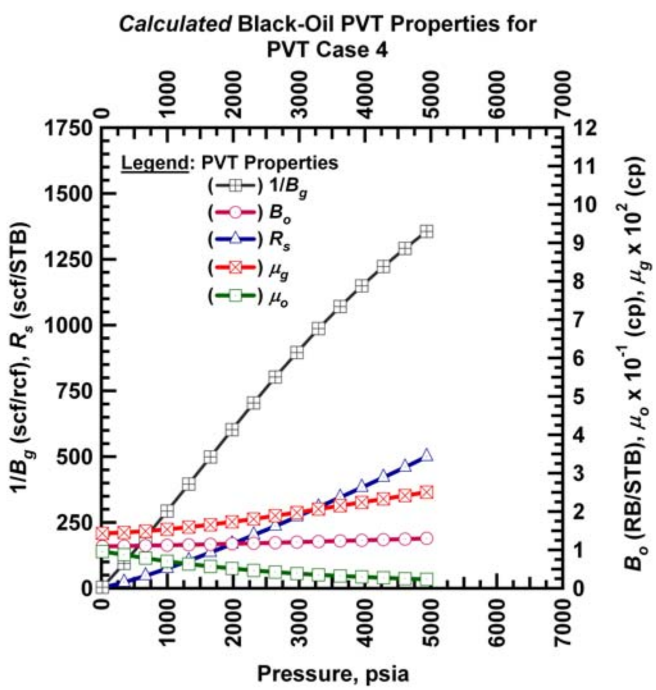

Figure 2.4 — Graphical representation of the calculated PVT properties for PVT Case 4.

Table 2.6 — Calculated fluid properties for PVT Case 5.

Pressure (psia)	*GOR* (scf/STB)	B_o (RB/STB)	$1/B_g$ (scf/rcf)	μ_o (cp)	μ_g (cp)
15	2	1.10	4	2.35	1.43
453	42	1.11	128	2.11	1.46
891	92	1.13	259	1.86	1.52
1330	148	1.15	397	1.64	1.59
1768	208	1.18	535	1.45	1.68
2206	270	1.20	672	1.29	1.78
2644	335	1.23	804	1.14	1.89
3082	403	1.26	926	1.02	2.00
3520	472	1.29	1044	0.92	2.12
3958	543	1.33	1151	0.83	2.24
4397	616	1.36	1248	0.75	2.36
4835	690	1.40	1337	0.68	2.48
5273	766	1.43	1417	0.63	2.59
5711	843	1.47	1492	0.58	2.70
6149	921	1.51	1561	0.53	2.81
6587	1000	1.55	1624	0.50	2.91

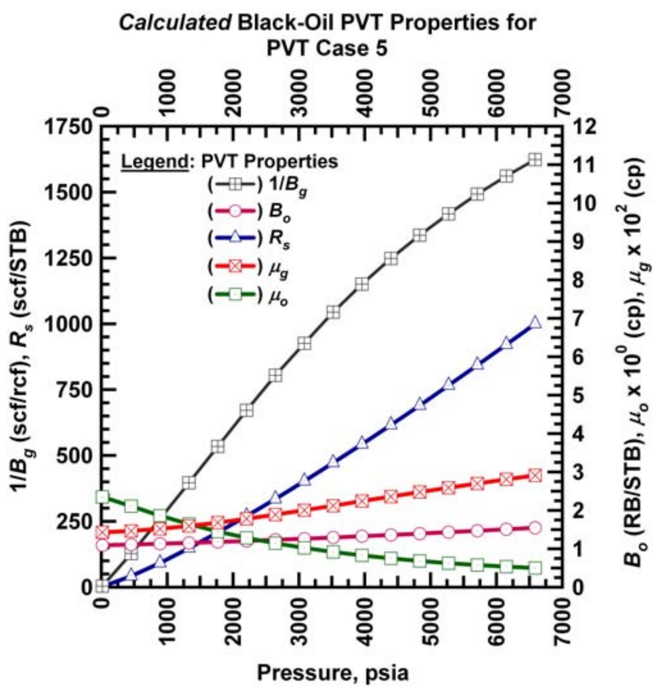

Figure 2.5 — Graphical representation of the calculated PVT properties for PVT Case 5.

Table 2.7 — Calculated fluid properties for PVT Case 6.

Pressure (psia)	*GOR* (scf/STB)	B_o (RB/STB)	$1/B_g$ (scf/rcf)	μ_o (cp)	μ_g (cp)
15	3	1.10	4	0.76	1.43
475	63	1.12	134	0.70	1.47
935	138	1.15	273	0.63	1.53
1396	222	1.19	418	0.56	1.61
1856	311	1.23	562	0.50	1.70
2316	405	1.27	705	0.45	1.81
2776	503	1.32	843	0.40	1.92
3236	604	1.36	971	0.36	2.05
3696	708	1.41	1088	0.32	2.17
4157	814	1.47	1196	0.30	2.30
4617	924	1.52	1294	0.27	2.42
5077	1035	1.58	1382	0.25	2.54
5537	1148	1.64	1463	0.24	2.66
5997	1264	1.70	1537	0.22	2.77
6457	1381	1.77	1605	0.22	2.88
6917	1500	1.83	1668	0.21	2.99

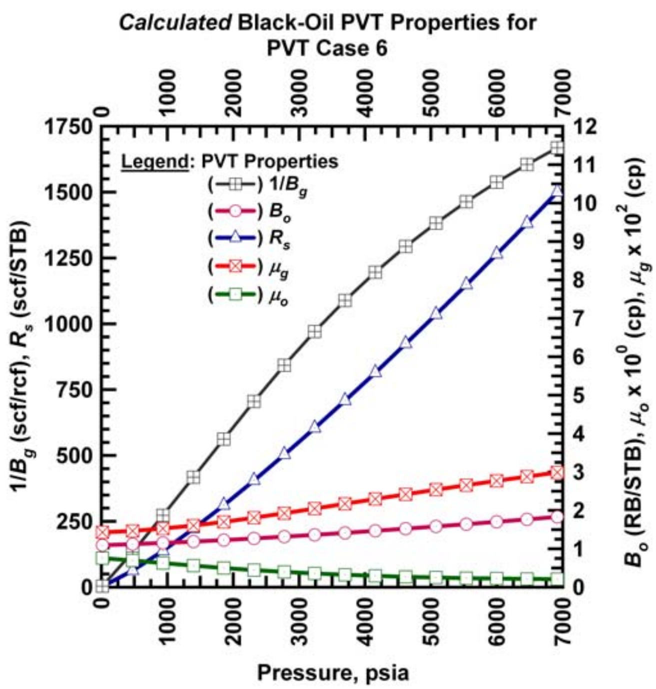

Figure 2.6 — Graphical representation of the calculated PVT properties for PVT Case 6.

Table 2.8 — Calculated fluid properties for PVT Case 7.

Pressure (psia)	*GOR* (scf/STB)	B_o (RB/STB)	$1/B_g$ (scf/rcf)	μ_o (cp)	μ_g (cp)
15	2	1.04	5	105.81	1.23
281	22	1.05	91	90.77	1.26
546	48	1.06	187	76.29	1.30
812	75	1.07	287	64.02	1.35
1077	105	1.08	392	53.93	1.41
1343	136	1.09	501	45.72	1.47
1608	169	1.10	613	39.02	1.55
1874	202	1.11	722	33.54	1.64
2139	237	1.13	834	29.02	1.74
2405	272	1.14	940	25.28	1.84
2670	309	1.15	1041	22.15	1.94
2936	346	1.17	1135	19.51	2.05
3201	383	1.18	1223	17.28	2.16
3467	422	1.20	1303	15.38	2.26
3732	461	1.22	1378	13.75	2.36
3998	500	1.23	1447	12.35	2.46

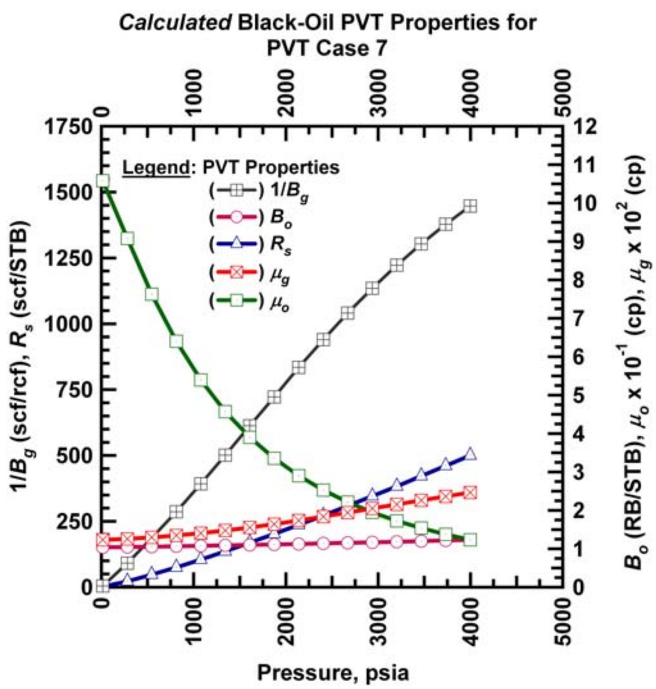

Figure 2. 7 — Graphical representation of the calculated PVT properties for PVT Case 7.

Table 2.9 — Calculated fluid properties for PVT Case 8.

Pressure (psia)	*GOR* (scf/STB)	B_o (RB/STB)	$1/B_g$ (scf/rcf)	μ_o (cp)	μ_g (cp)
15	3	1.04	5	9.91	1.23
370	43	1.06	123	8.29	1.27
725	93	1.07	254	6.82	1.33
1080	149	1.09	394	5.65	1.41
1434	208	1.12	540	4.71	1.50
1789	271	1.14	690	3.98	1.61
2144	336	1.17	836	3.39	1.74
2499	403	1.20	976	2.91	1.88
2854	473	1.23	1107	2.52	2.02
3208	544	1.26	1225	2.21	2.16
3563	616	1.29	1332	1.94	2.30
3918	690	1.33	1427	1.72	2.44
4273	766	1.36	1512	1.54	2.57
4628	843	1.40	1589	1.39	2.69
4983	921	1.44	1658	1.26	2.81
5337	1000	1.47	1721	1.16	2.93

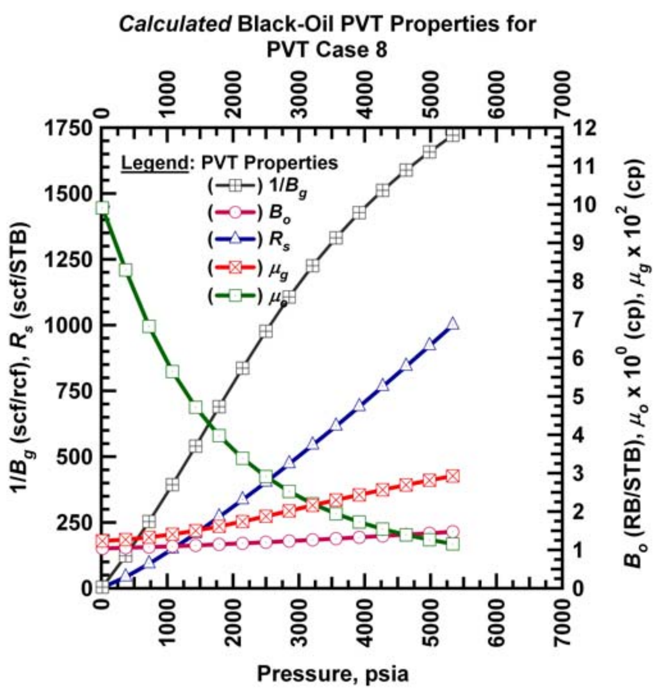

Figure 2.8 — Graphical representation of the calculated PVT properties for PVT Case 8.

Table 2.10 — Calculated fluid properties for PVT Case 9.

Pressure (psia)	*GOR* (scf/STB)	B_o (RB/STB)	$1/B_g$ (scf/rcf)	μ_o (cp)	μ_g (cp)
15	4	1.04	5	2.40	1.23
388	64	1.06	129	2.04	1.27
761	140	1.09	267	1.71	1.34
1133	223	1.13	415	1.43	1.42
1506	312	1.16	570	1.21	1.52
1878	406	1.21	722	1.03	1.64
2251	504	1.25	880	0.89	1.78
2624	605	1.30	1024	0.77	1.92
2996	709	1.35	1156	0.68	2.07
3369	815	1.40	1275	0.60	2.22
3742	924	1.45	1381	0.54	2.37
4114	1036	1.51	1476	0.49	2.51
4487	1149	1.57	1559	0.45	2.64
4860	1264	1.63	1635	0.42	2.77
5232	1381	1.69	1702	0.40	2.89
5605	1500	1.75	1764	0.38	3.01

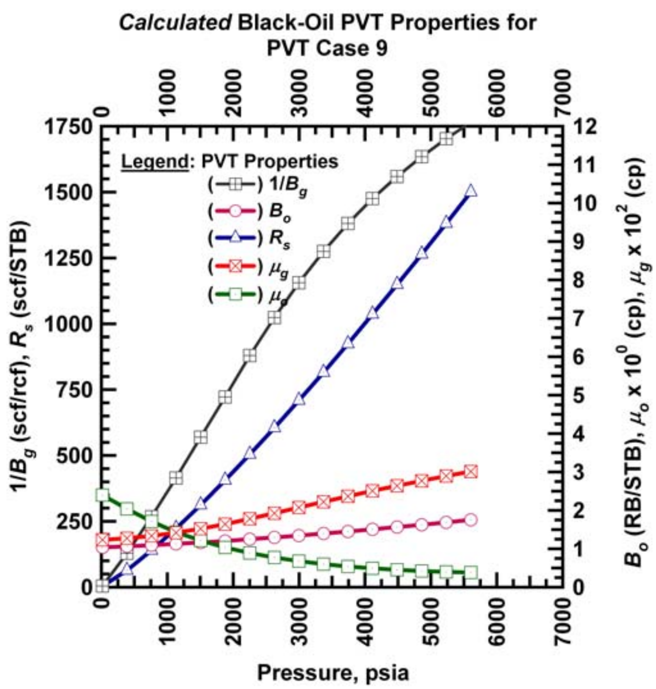

Figure 2.9 — Graphical representation of the calculated PVT properties for PVT Case 9.

2.4 Relative Permeability Curves

The Corey-Brookes [CMG (software)] model for relative permeability curves was used to generate 13 sets of relative permeability curves. The variables to generate these curves included the initial water saturation (S_{wi}), the Corey exponent (n_{Corey}) for all phases and; the end points. For all relative permeability curves it is assumed that the gas critical saturation is zero ($S_{gc} = 0$).

The Corey-Brookes model is given by[10]:

$$k_{rw} = k_{rwiro}\left[\frac{S_w - S_{wcrit}}{1 - S_{wcrit} - S_{oirw}}\right]^{n_w} \quad \text{.......... (2.1)}$$

$$k_{row} = k_{rocw}\left[\frac{S_o - S_{orw}}{1 - S_{wcon} - S_{orw}}\right]^{n_{ow}} \quad \text{.......... (2.2)}$$

$$k_{rog} = k_{roqcg}\left[\frac{S_l - S_{org}}{1 - S_{gcon} - S_{org}}\right]^{n_{og}} \quad \text{.......... (2.3)}$$

$$k_{rog} = k_{roqcl}\left[\frac{S_g - S_{gcrit}}{1 - S_{gcrit} - S_{oirg}}\right]^{n_g} \quad \text{.......... (2.4)}$$

A total of 13 sets of relative permeability curves were generated using these formulas. For the purposes of identification they are numbered 1 to 13 i.e. k_r1, k_r2, etc. The main group corresponds to k_r1, k_r2 and k_r3 and; from these 3 sets all of the others were generated by varying either the Corey exponents or the end points.

- k_r1, k_r2 and k_r3 correspond to the base case, the Corey exponent for all phases is equal to 3.
- k_r4 and k_r5 are equivalent to $kr1$ and $kr3$ with a Corey **oil** exponent of 4 and all the remaining exponents equal to 3.
- k_r6 to k_r8 reproduce k_r1, k_r2 and k_r3 with a Corey exponent of 2 for all phases.
- k_r9 to k_r11 reproduce k_r1, k_r2 and k_r3 with a Corey oil exponent of 4 for all phases.
- k_r12 and k_r13 have the same Corey exponents as k_r1, k_r2 and k_r3 but with either different end points or initial saturations.

Table 2.11 to **Table 2.13** shows a summary of the parameters employed to create each set of relative permeability curves, sets are numbered 1 to 13 (i.e. k_r1, k_r2, etc):

Table 2.11 — Parameters used to for relative permeability curves calculation (k_r1 to k_r5).

Parameter	k_r1	k_r2	k_r3	k_r4	k_r5
S_{wcon}	0	0.2	0.4	0	0.4
S_{wcrit}	0	0.2	0.4	0	0.4
S_{oirw}	0	0.15	0.25	0	0.25
S_{orw}	0	0.15	0.25	0	0.25
S_{oirg}	0	0.1	0.15	0	0.15
S_{org}	0	0.1	0.15	0	0.15
S_{gcon}	0	0	0	0	0
S_{gcrit}	0	0	0	0	0
k_{rocw}	1	0.9	0.8	1	0.8
k_{rwiro}	1	0.9	0.8	1	0.8
k_{rgcl}	1	0.9	0.8	1	0.8
k_{rogcg}	1	0.9	0.8	1	0.8
n_w	3	3	3	3	3
n_{ow}	3	3	3	3	3
n_{og}	3	3	3	4	4
n_g	3	3	3	3	3

Table 2.12 — Parameters used to for relative permeability curves calculation (k_r6 to k_r10).

Parameter	k_r6	k_r7	k_r8	k_r9	k_r10
S_{wcon}	0	0.2	0.4	0	0.2
S_{wcrit}	0	0.2	0.4	0	0.2
S_{oirw}	0	0.15	0.25	0	0.15
S_{orw}	0	0.15	0.25	0	0.15
S_{oirg}	0	0.1	0.15	0	0.1
S_{org}	0	0.1	0.15	0	0.1
S_{gcon}	0	0	0	0	0
S_{gcrit}	0	0	0	0	0
k_{rocw}	1	0.9	0.8	1	0.9
k_{rwiro}	1	0.9	0.8	1	0.9
k_{rgcl}	1	0.9	0.8	1	0.9
k_{rogcg}	1	0.9	0.8	1	0.9
n_w	2	2	2	4	4
n_{ow}	2	2	2	4	4
n_{og}	2	2	2	4	4
n_g	2	2	2	4	4

Table 2.13 — Parameters used to for relative permeability curves calculation (k_r11 to k_r13).

Parameter	k_r11	k_r12	k_r13
S_{wcon}	0.4	0.1	0.2
S_{wcrit}	0.4	0.1	0.2
S_{oirw}	0.25	0	0.15
S_{orw}	0.25	0	0.15
S_{oirg}	0.15	0	0.1
S_{org}	0.15	0	0.1
S_{gcon}	0	0	0
S_{gcrit}	0	0	0
k_{rocw}	0.8	0.9	0.7
k_{rwiro}	0.8	0.9	0.7
k_{rgcl}	0.8	0.9	0.7
k_{rogcg}	0.8	0.9	0.7
n_w	4	3	3
n_{ow}	4	3	3
n_{og}	4	3	3
n_g	4	3	3

Fig. 2.10 to **Fig. 2.16** show the graphical representation of each relative permeability set alongside with the modify sets, the reduction on relative permeability due to the change of end point, Corey exponent, etc, can be observed:

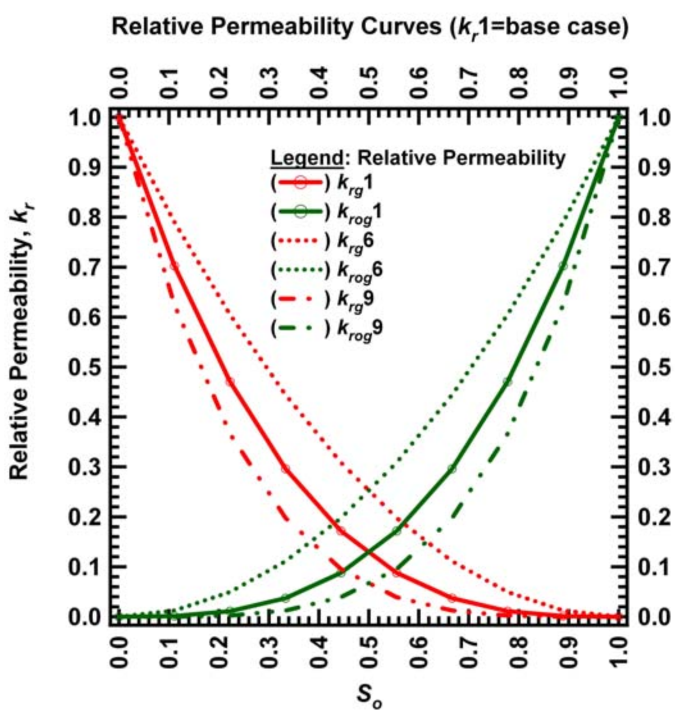

Figure 2.10— Relative permeability curves for k_r1, k_r6 and k_r9 sets (k_r1 = base case).

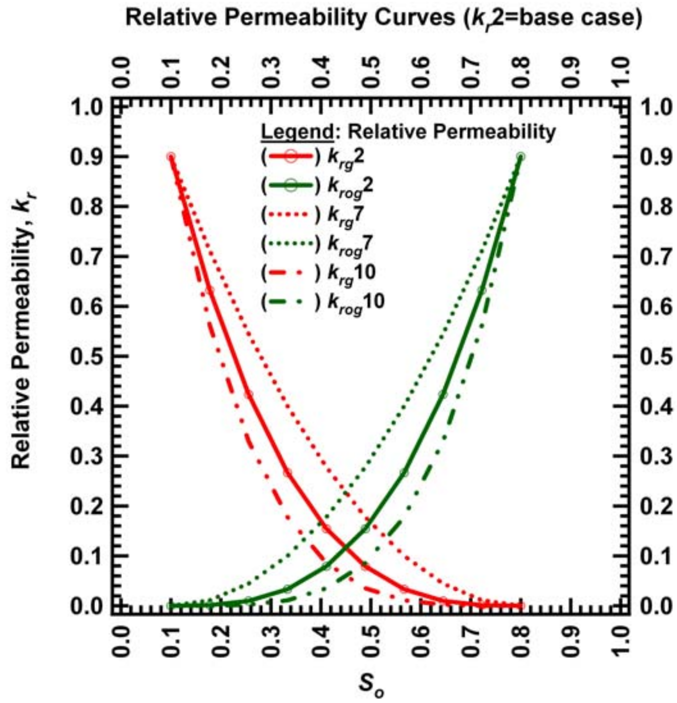

Figure 2.11 — Relative permeability curves for k_r2, k_r7 and k_r10 sets (k_r2 = base case).

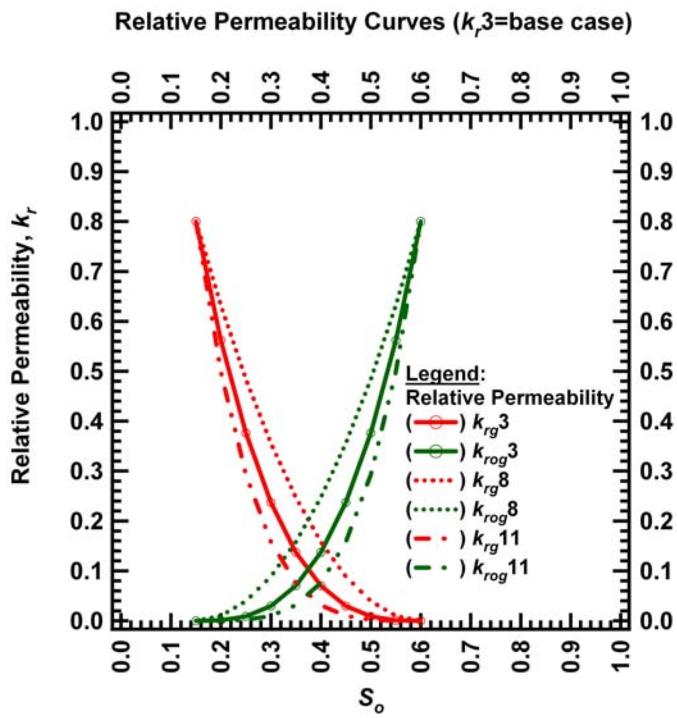

Figure 2.12 — Relative permeability curves for k_r3, k_r8 and k_r11 sets (k_r3 = base case).

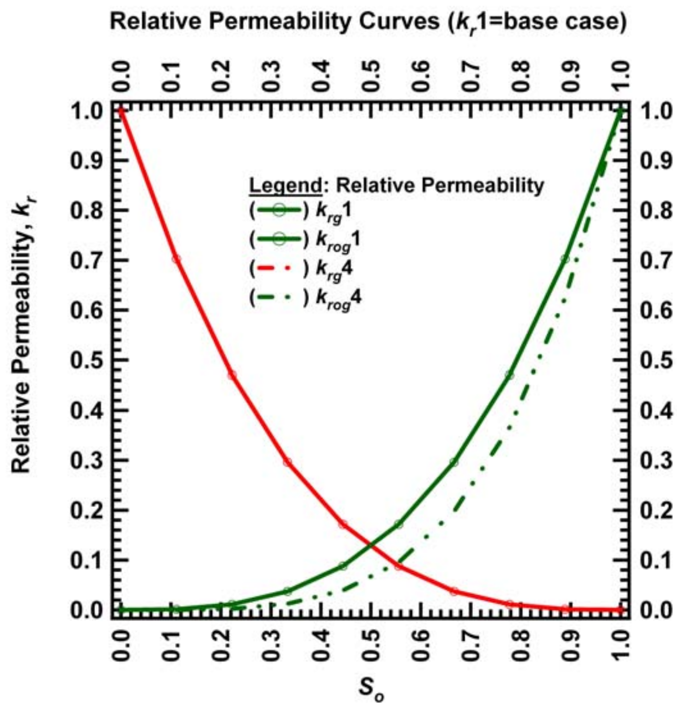

Figure 2.13 — Relative permeability curves for k_r1 and k_r4 sets (k_r1 = base case).

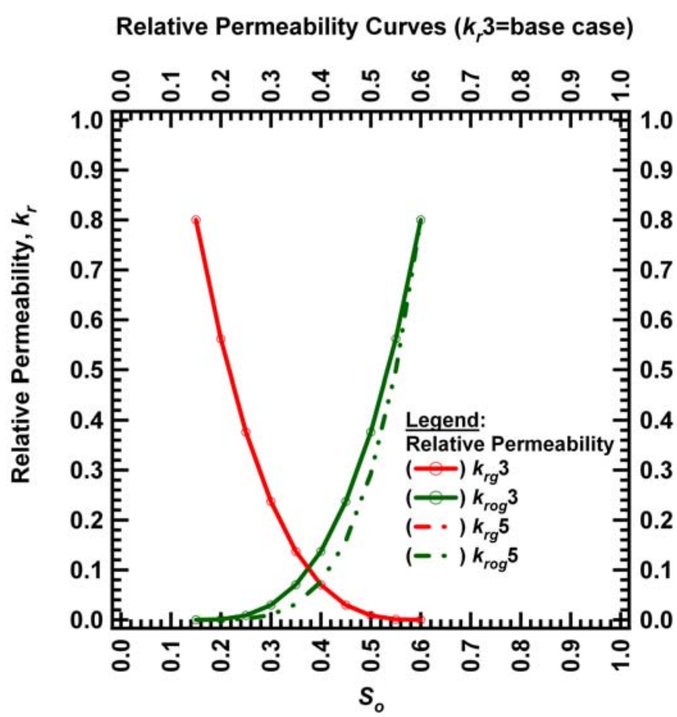

Figure 2.14 — Relative permeability curves for k_r3 and k_r5 sets (k_r3 = base case).

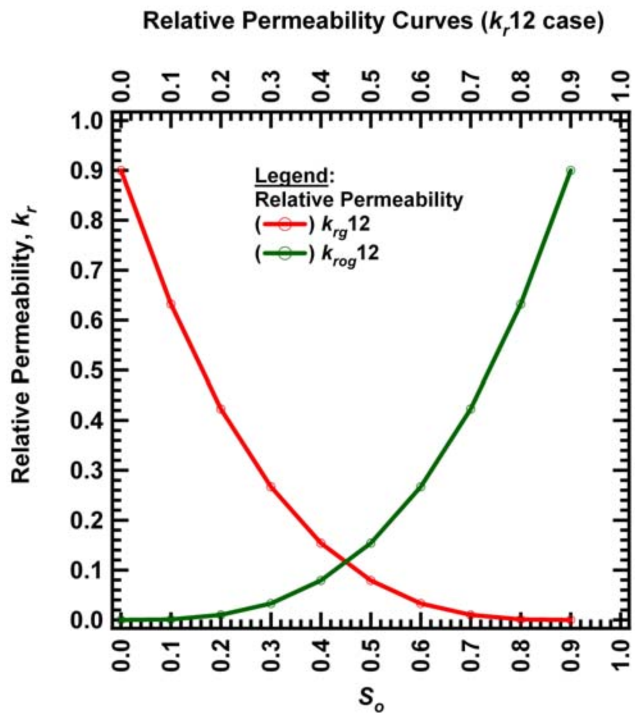

Figure 2.15 — Relative permeability curves for k_r12 set.

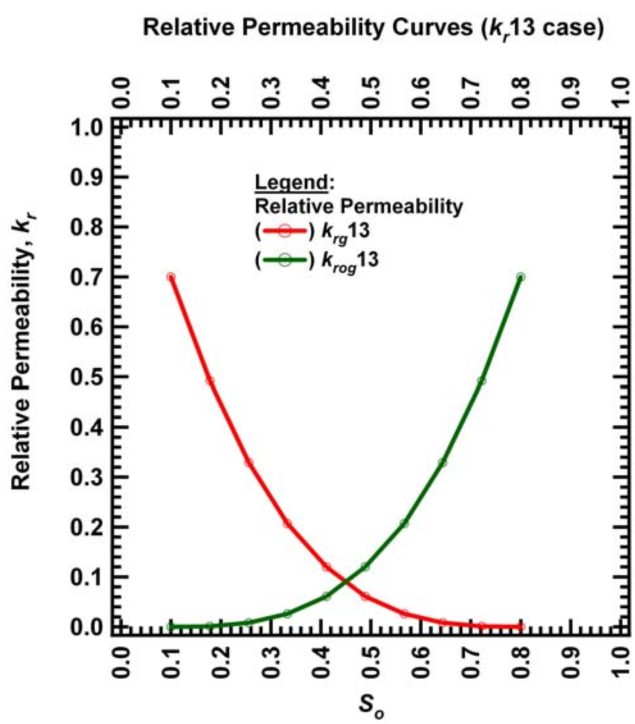

Figure 2.16 — Relative permeability curves for k_r13 set.

CHAPTER III
CORRELATION OF THE CHARACTERISTIC BEHAVIOR OF SOLUTION-GAS-DRIVE RESERVOIRS

3.1. Correlation of the ζ-parameter

Our correlation for the ζ-parameter relation is "erf-based" and is given as:

$$\zeta = \mathrm{erf}\left[\alpha_1 (GOR^{A1} API^{A2} T_{res}^{A3} S_{oi}^{A4} k_{rog}^{A5} p_i^{A6} B_{oi}^{A7} \mu_{oi}^{A8} \lambda_{oi}^{A9}) + n_w^{A10} + n_{ow}^{A11} + n_{og}^{A12} + n_g^{A13}\right] \quad (3.1)$$

The coefficients for Eq. 3.1 are calibrated using a regression procedure and, are given in **Table 3.1**.

Table 3.1 — Constants for Eq. 3.1.

Coefficients	Value	Coefficients	Value
α_1	4.9734	A_7	4.0536
A_1	2.0369	A_8	-0.0442
A_2	-4.7583	A_9	-0.1305
A_3	-0.3713	A_{10}	-0.0378
A_4	0.3970	A_{11}	-0.0006
A_5	0.0922	A_{12}	-0.1077
A_6	-0.0053	A_{13}	-0.0003

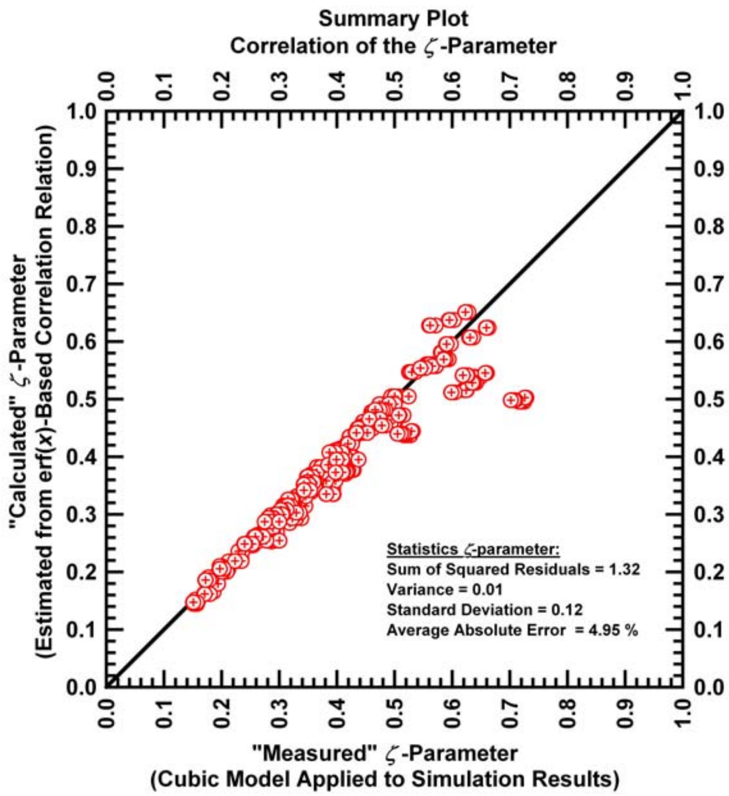

Figure 3.1 — Computed ζ-parameter versus measured ζ-parameter (all data).

In **Fig. 3.1** we present the "summary" correlation plot where the ζ-parameter computed using the global correlation is plotted versus the "base" or "measured" values of the ζ-parameter as prescribed in Step 2. The comparison shown in **Fig. 3.1** suggests that we have achieved a fairly strong correlation of the ζ-parameter, with deviation from the perfect trend worsening as values of the ζ-parameter increase.

3.2. Validation of the ζ-parameter Correlation

A suit of correlation plots is proposed for the validation of the ζ-parameter correlation. The proposed plotting functions are illustrated for "Case 1" in **Figs. 3.2-3.6**. **Fig. 3.2** is cast using the variables "1-Normalized Mobility Function" and "Normalized Pressure Function" which are given in Eq. 1.17. The use of these variable permits a "non-dimensional" view of the data and model functions. In **Fig. 3.2** we note the "local" best fit in red, and the global correlation fit in green — for this particular case the model matches are in very close agreement; suggesting that the "global" correlation represents this particular case (i.e., combination of variables) quite well. Obviously, this case was selected for the clarity it provides, but it can also be considered to be a "typical" case in this work.

In **Fig. 3.3** we present the derivative of the "1-Normalized Mobility Function" with respect to "Normalized Pressure Function" — this plot would yield a constant trend for a linear mobility function; a linear trend for a quadratic mobility function; and a quadratic trend for a cubic mobility function. The data function in Fig. 8 suggests that a portion of the behavior is linear (hence, a quadratic mobility function) and a portion is quadratic (hence, a linear mobility function) — the model functions are clearly quadratic (as the base mode is a cubic, this is expected). While the extreme ends of the data function are not matched well, the overall trend is matched very well by the 2 (cubic) mobility models, and as noted for the mobility model comparisons in **Fig. 3.2**, in **Fig. 3.3** we note that the derivatives of the mobility model comparison are also very consistent.

The "second derivative" of the mobility function with respect to normalized pressure is shown in **Fig. 3.4**, and while there is a "mis-match" of sorts between the data and model functions, a somewhat linear trend is evident (which would be the result of a cubic mobility function). In short, **Fig. 3.4** validates our concept that the mobility function (and its derivatives) can be represented by a cubic function. It is worth noting that most of the cases in this work would have a similar overall comparison as to the one shown in **Fig. 3.4**.

In **Fig. 3.5** we present the "integral function" for this case — the "integral function" is the integral of the "1-Normalized Mobility Function" taken with respect to the "Normalized Pressure Function," then normalized by the "Normalized Pressure Function." This formulation gives a very smooth trend; and, in the case of a polynomial model, this formulation yields the same functional form as the original model (the "integral function" of a cubic relation is a cubic relation). In **Fig. 3.5** we not the smoothness of the data function (as predicted) and we note that the "local" fit (in red) and the correlation fit (in green) agree very well with the data trend, with only a slight mis-match for the lowest values of the "Normalized Pressure Function."

A final comparison, this time using the "integral-difference" function (which is analogous to the derivative) is shown for this case in **Fig. 3.6**. The most distinctive aspect of **Fig. 3.6** is that the match of the data function and the models appears to be at least as good as that for the "integral function" shown in **Fig. 3.6**. This suggests a unique match of the data and model for this particular data set.

In our opinion, our "Case 1" example has not only validated our procedure, but also validated the concept that a cubic relationship exists between normalized mobility and normalized pressure (or more directly, mobility and pressure). This is perhaps the most important observation in this work, as this observation leads gives credence to our hypothesis that a universal correlation of mobility and pressure can be achieved for the solution-gas-drive reservoir system — and that such a correlation can be made using only reservoir and fluid properties.

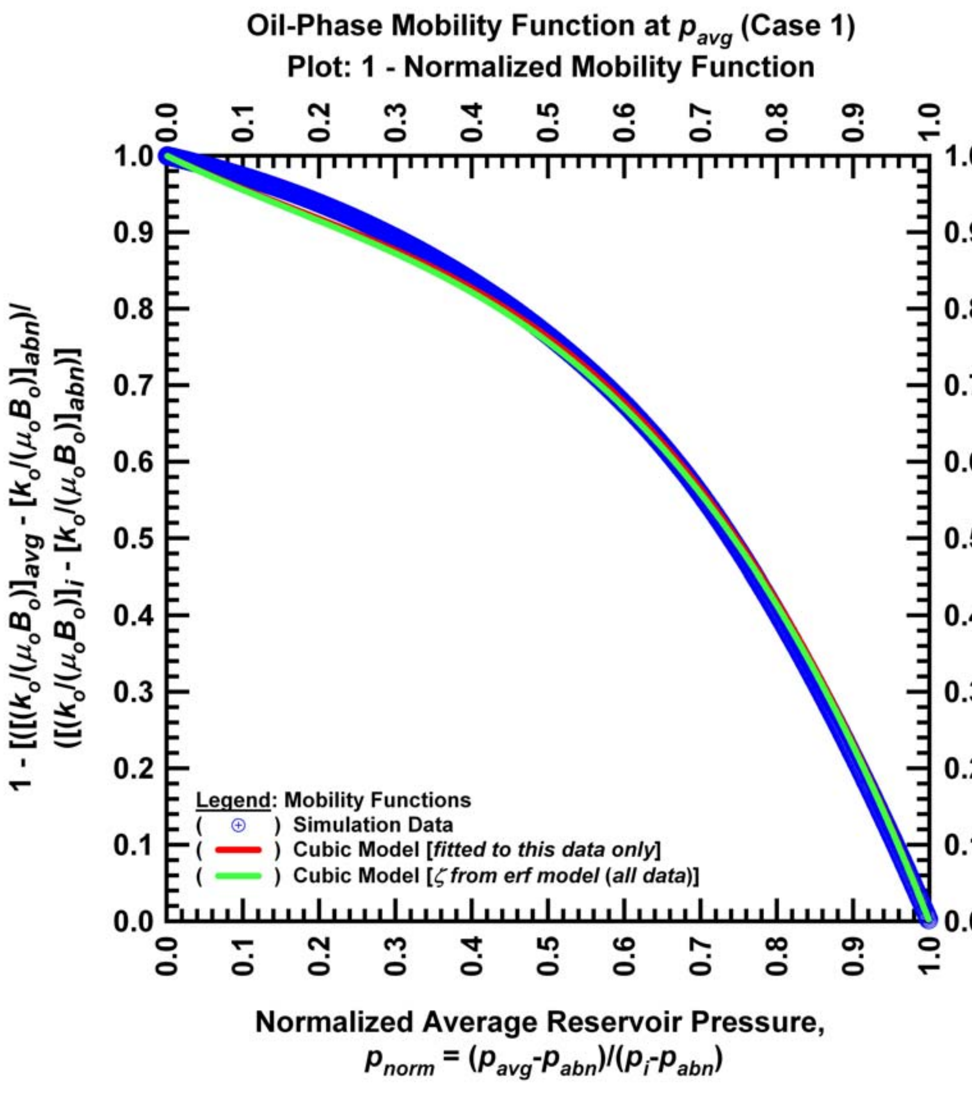

Figure 3.2 — Normalized oil-phase mobility function plotted versus the normalized average reservoir pressure function (Case 1).

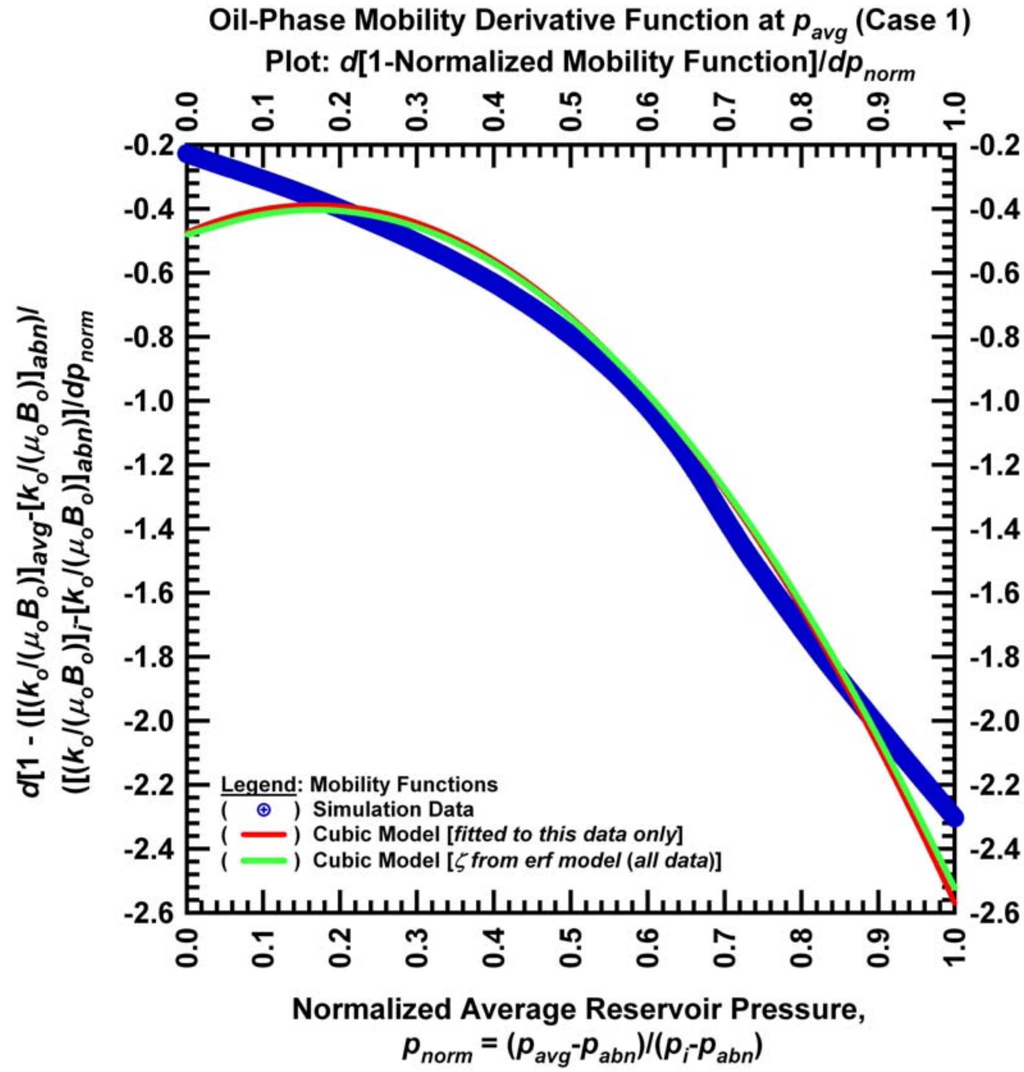

Figure 3.3 — Derivative of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 1).

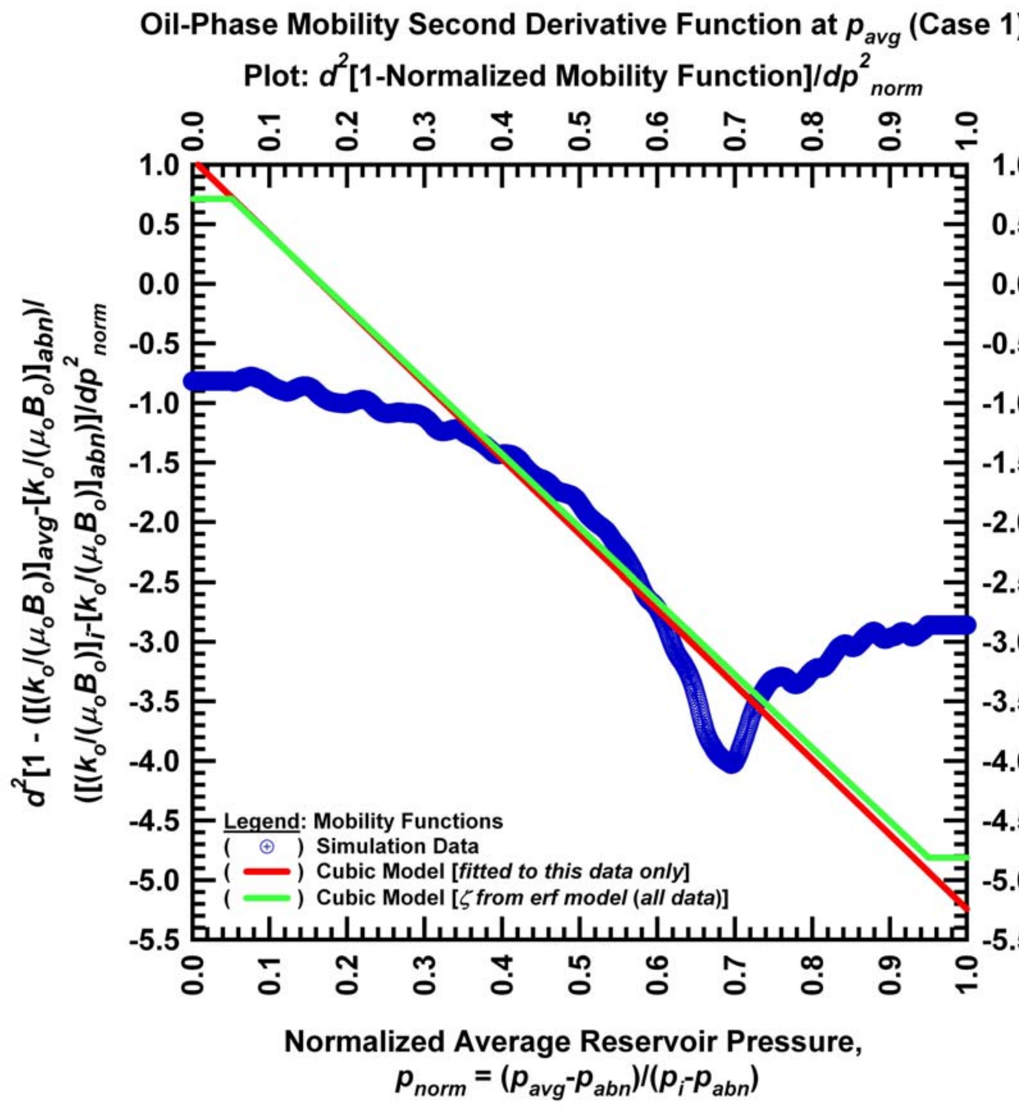

Figure 3.4 — Second derivative of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 1).

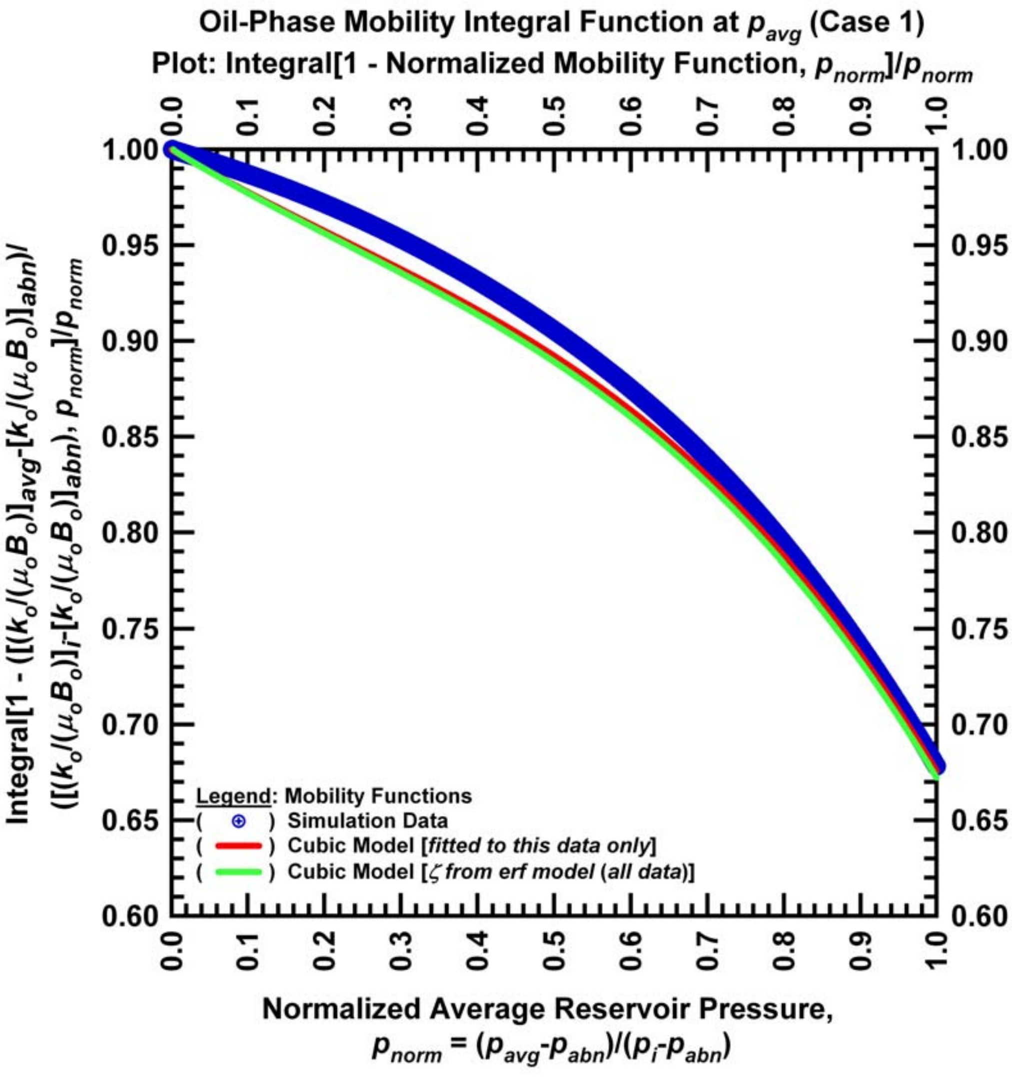

Figure 3.5 — Integral of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 1).

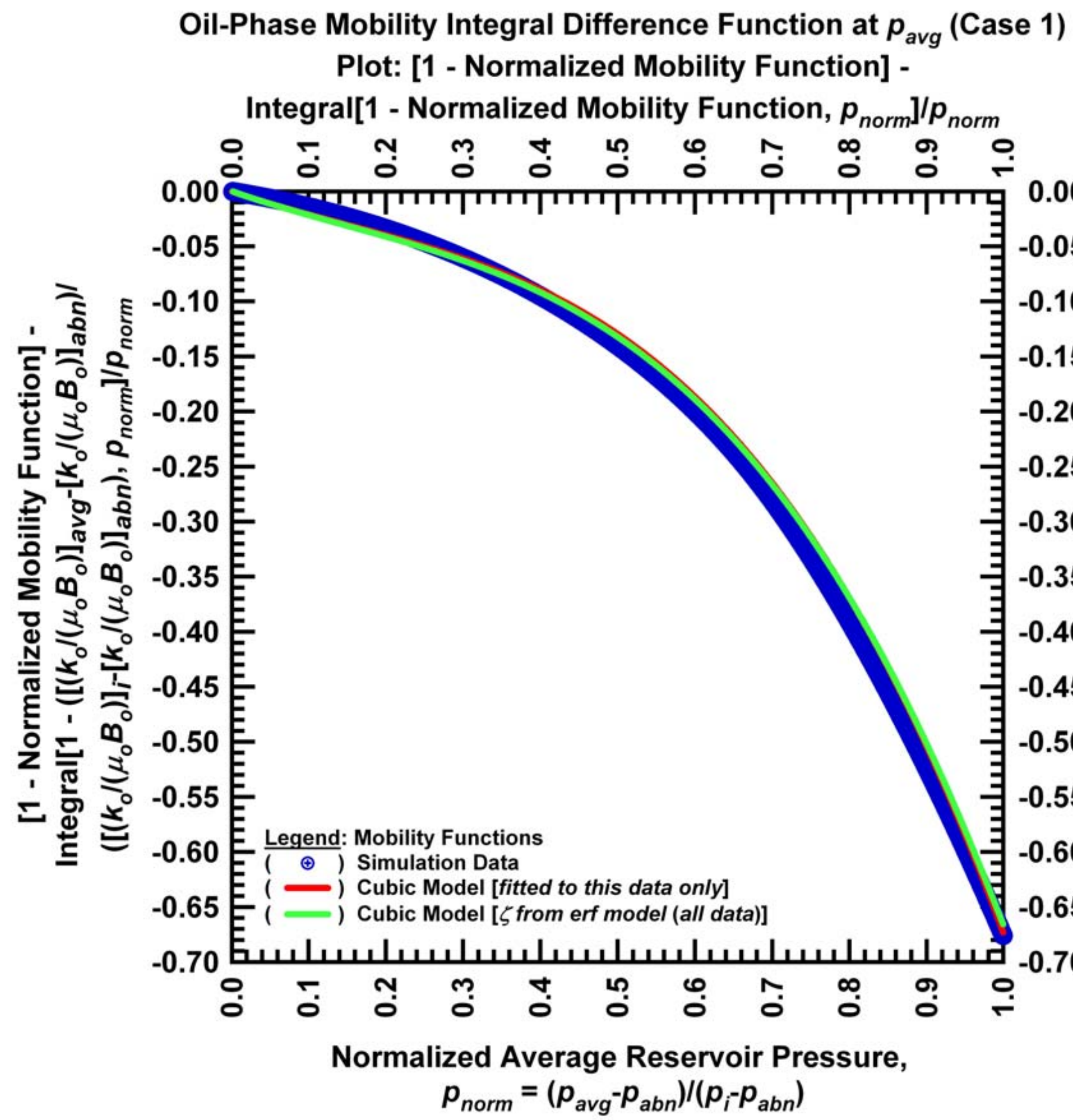

Figure 3.6 — Integral difference of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 1).

3.3. Effect of Input Variables on the ζ-parameter Correlation

A set of plots was developed to graphically assess the effect of the input variables on the ζ-parameter calculations. **Figures 3.7 to 3.11** present the correlated ζ-parameter computed using the global correlation versus the "base" or "measured" values of the ζ-parameter as a function of a particular input variable (*e.g.*, *GOR, API*, T_{Res}, λ_{oi}, n_w, n_g, and n_{Corey}).

In **Fig. 3.7** we present the variation of the ζ-parameter as a function of specified ranges of the *GOR* and *API* variables — and we note that there is a slight increase in deviation from the perfect trend for the ζ-parameter, for $\zeta > 0.6$. This behavior could be attributed to a relatively smaller sample of data for these ranges of the *GOR* and *API* variables, this is the most likely scenario.

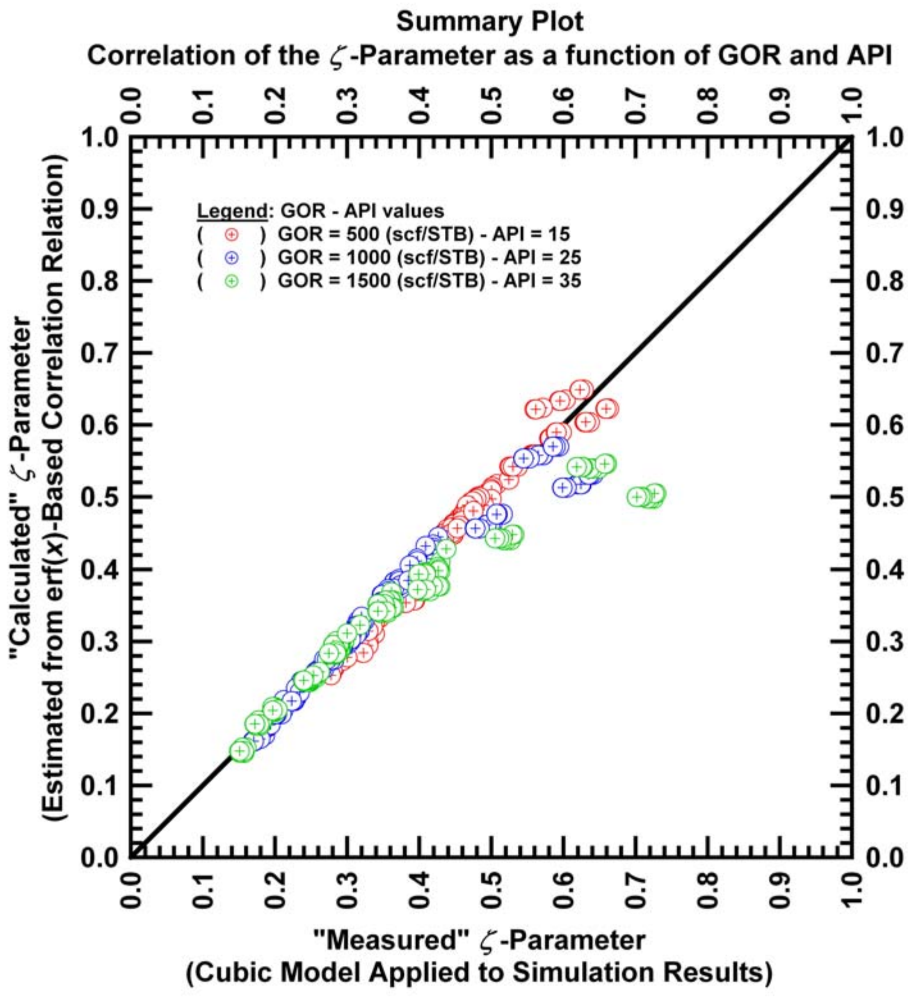

Figure 3.7 — Effect of the GOR and API on the computed ζ-parameter.

In **Fig. 3.8** we present the variation of the ζ-parameter as a function of reservoir temperature (T_{Res}) — and, as with the case of the *GOR* and *API* variables, we again note deviation from the perfect trend for the ζ-parameter, for $\zeta > 0.6$. We note that this deviation is somewhat independent of the reservoir temperature, which again suggests that the deviation is probably due to a relatively smaller sample of data.

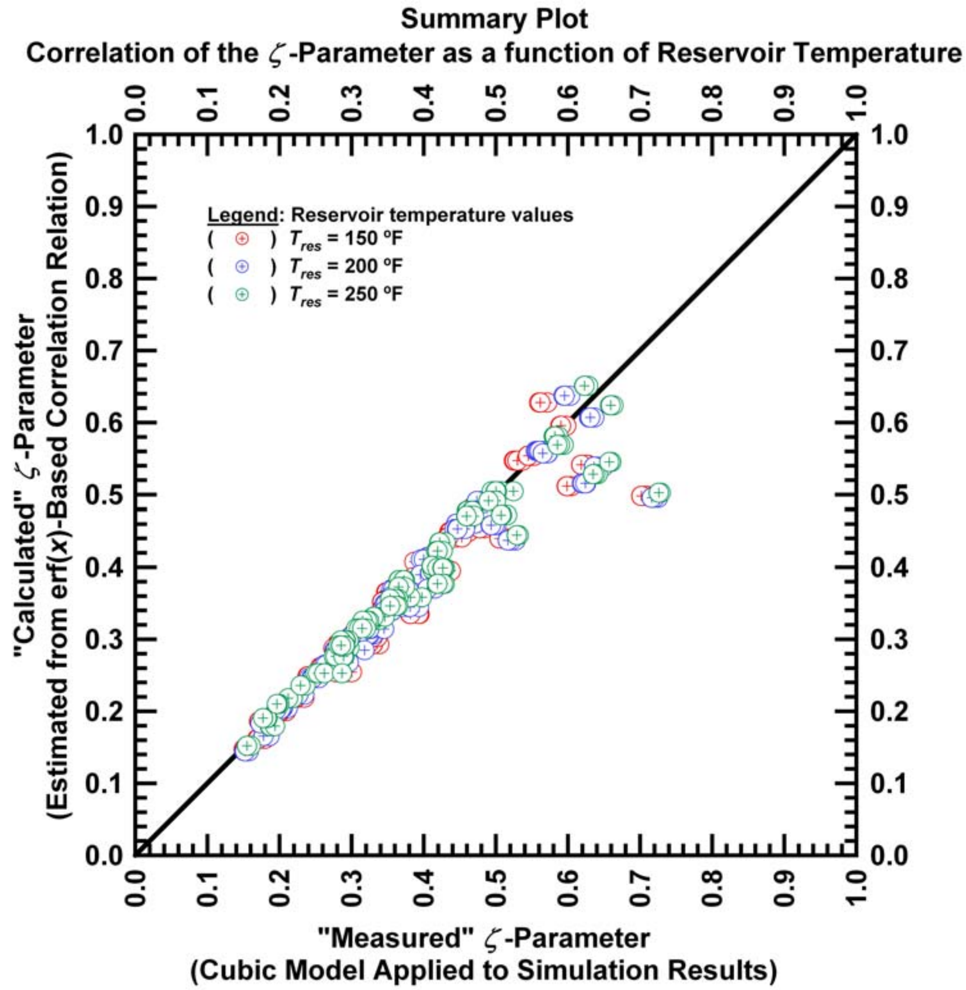

Figure 3.8 — Effect of the reservoir temperature (T_{Res}) on the computed ζ-parameter.

In **Fig. 3.9** we present the variation of the ζ-parameter as a function of initial oil mobility (λ_{oi}). The influence of λ_{oi} is very similar to that for T_{Res} — *i.e.*, the outliers include data from each range of the λ_{oi}-parameter. This behavior (again) suggests that the deviation may be due to sample size.

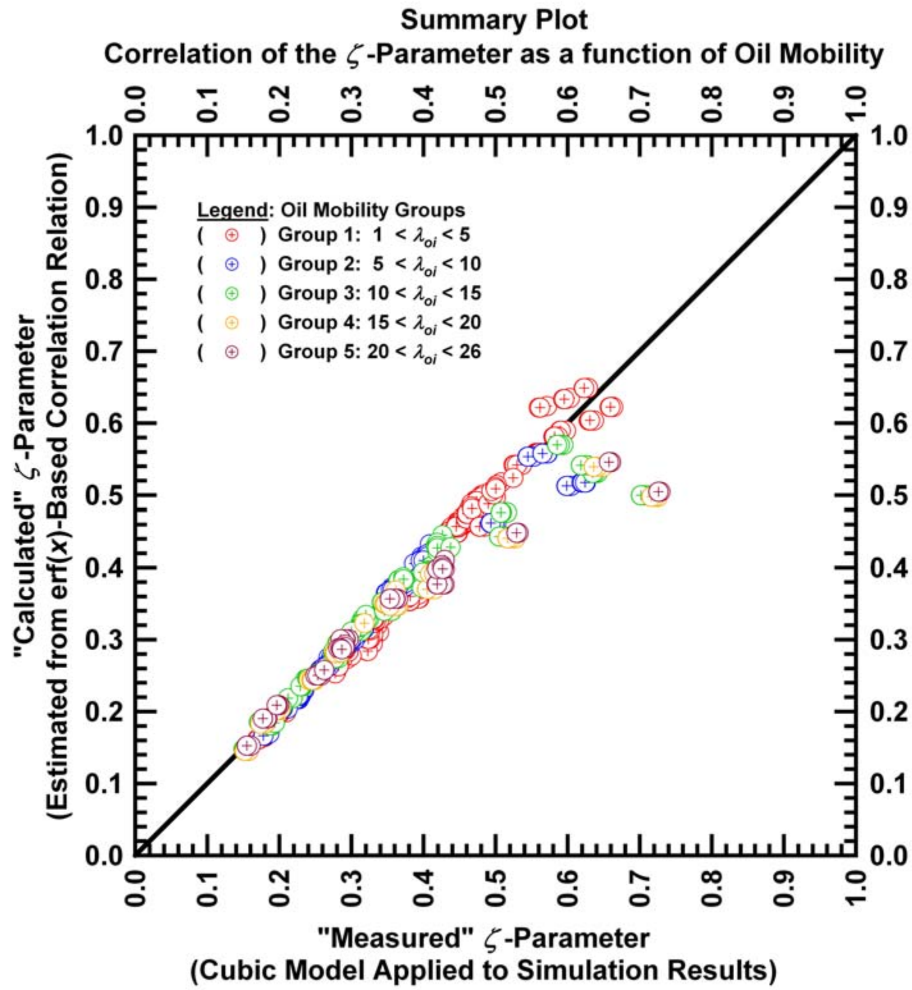

Figure 3.9 — Effect of the initial oil mobility (λ_{oi}) on the computed ζ-parameter.

In **Fig. 3.10** we present the variation of the ζ-parameter as a function of Corey exponents for the water and gas relative permeabilities (n_w and n_g). The influence of n_w and n_g does not cause significant deviation from the perfect trend, except for the case of n_w=n_g=2. For the case of n_w=n_g=2, there is systematic deviation in the computed versus measured ζ-parameter values. It is our contention that this case (n_w=n_g=2) is not necessarily unique, but most likely this deviation is caused by a low sample size for the n_w=n_g=2 case.

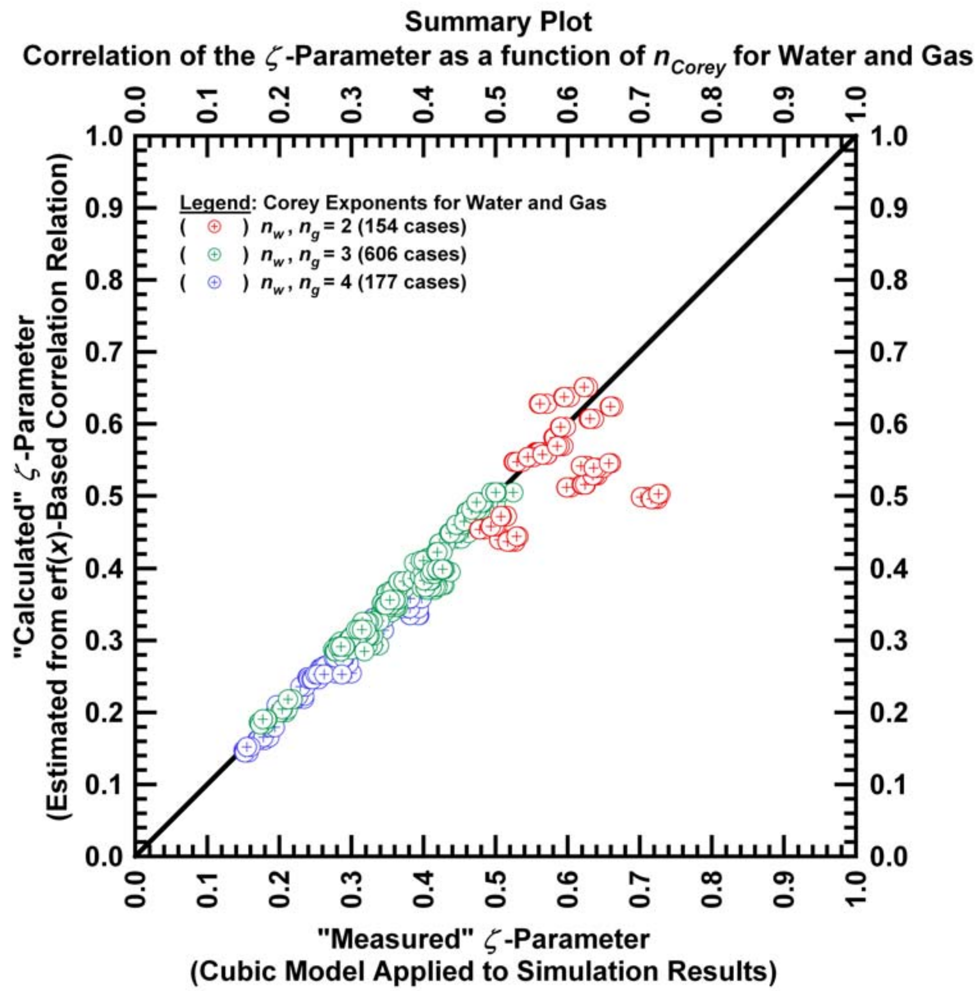

Figure 3.10 — Effect of the Corey exponents for the water and gas relative permeabilities (n_w and n_g) on the computed ζ-parameter.

In **Fig. 3.11** we present the final sensitivity case, where the variation of the ζ-parameter is considered as a function of the Corey exponents for the oil relative permeability held constant (n_{og}=n_{ow}). The influence of n_{og} and n_{ow} does not cause significant deviation from the perfect trend, similar to the cases where n_w=n_g. Similar to the cases where n_w=n_g=2, for n_{ow}=n_{og}=2 there is (again) a systematic deviation in the computed versus measured ζ-parameter values. Similar to the n_w=n_g=2 cases, we also believe that the influence exhibited by the n_{ow}=n_{og}=2 cases is due to the relatively small sample size.

The phenomena exhibited by the n_w=n_g=n_{ow}=n_{og}=2 cases is a point for future investigation.

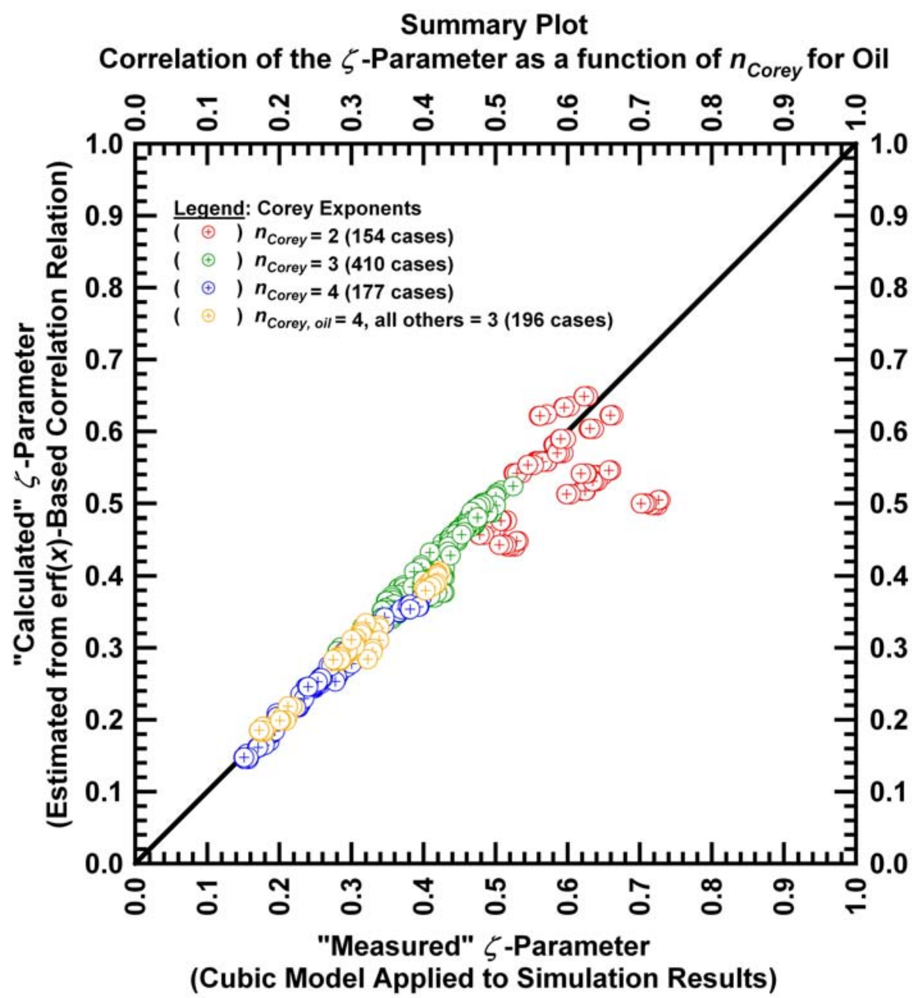

Figure 3.11 — Effect of the Corey exponents for the oil relative permeabilities (n_{og} and n_{ow}) on the computed ζ-parameter.

CHAPTER IV
CONCLUSIONS AND RECOMMENDATIONS

4.1. Conclusions

- The oil mobility profile can be uniquely approximated as a function of the correlating "ζ-parameter," where the ζ-parameter is a function of rock-fluid properties for $p < p_b$.
- The simulation results confirm that the mobility profile is independent of the depletion mechanism for a given set of rock-fluid conditions.
- The evaluation of the ζ-parameter indicates a strong dependency on the Corey exponent (relative permeability model).
- The development of validation plots confirm the concept that a cubic relationship exists between normalized mobility and normalized pressure (or more directly, mobility and pressure).
- The established relationship between mobility and pressure indicate that a universal correlation of mobility and pressure can be achieved for the solution-gas-drive reservoir system — and that such a correlation can be made using only reservoir and fluid properties.
- The cubic polynomial based on the ζ-parameter works well for all Corey exponent cases, except n_{Corey}=2.

4.2. Recommendations for Future Research

- The cubic ζ-parameter model should be tested to validate the quartic "Vogel-form" IPR proposed by Ilk *et al.* (2007) (these 2 relations are interrelated).
- The behavior of the ζ-parameter with respect to the case of $n_{Corey} = 2$ should be investigated further.
- The behavior of the ζ-parameter was NOT evaluated against the following factors:

  — skin effect
  — partial penetration
  — slanted/horizontal well
  — permeability anisotropy

  A more extensive validation of the ζ-parameter should be performed against these factors.

NOMENCLATURE

Variables

a = Constant established from the presumed behavior of the mobility profile.

API = API density of the oil

b = Constant established from the presumed behavior of the mobility profile.

b_{pss} = Pseudosteady-state flow constant.

B_g = Gas formation volume factor, RB/SCF

B_o = Oil formation volume factor, RB/STB

B_{oi} = Initial Oil formation volume factor, RB/STB

$°F$ = Temperature, degree Fahrenheit

GOR_i = Initial Gas to Oil ratio, SCF/STB

h = Pay thickness, ft

J_o = Productivity index, STB/D/PSI

k = Absolute permeability, md

k_{rocw} = k_{ro} at connate S_w (S_{wcon})

k_{rwiro} = k_{rw} at irreducible S_o (S_{oirw})

k_{rgcl} = k_{rg} at connate S_l

k_{rogcg} = k_{rog} at connate S_g (S_{gcon})

N = Original oil-in-place, MMSTB

N_p = Cumulative oil production, STB

N_p/N = Recovery, oil depletion ratio, fraction

n_{Corey} = Corey exponent for relative permeability curves, dimensionless

n_w = Exponent for calculating k_{rw} from k_{rwiro}, dimensionless

n_{ow} = Exponent for calculating k_{row} from k_{rocw}, dimensionless

n_{og} = Exponent for calculating k_{rog} from k_{rogcg}, dimensionless

n_g = Exponent for calculating k_{rg} from k_{rgcl}, dimensionless

$\bar{p}$ = Average reservoir pressure, psia

p_{abn} = Abandonment pressure, psia

p_{base} = Base pressure, psia

$p_{D,IPR}$ = Dimensionless pressure

p_n = Reference pressure, psia

p_i = Initial reservoir pressure, psia

p_{po} = Oil pseudopressure, psia

p_{wf} = Flowing bottomhole pressure, psia

q_o = Oil flowrate, STB/D

q_{oi} = Initial Oil flowrate, STB/D

$q_{o,\max}$ = Maximum Oil flowrate, STB/D

R_{so} = Solution gas-oil ratio, SCF/STB

r_e = Outer reservoir radius, ft

r_w = Wellbore radius, ft

s = Skin factor, dimensionless

S_g = Gas saturation, dimensionless

S_o = Oil saturation, dimensionless

S_{wcon} = Endpoint Saturation: Connate Water

$S_{wcri}t$ = Endpoint Saturation: Critical Water

S_{oirw} = Endpoint Saturation: Irreducible Oil (w/water)

S_{orw} = Endpoint Saturation: Residual Oil (w/water)

S_{oirg} = Endpoint Saturation: Irreducible Oil (w/gas)

S_{org} = Endpoint Saturation: Residual Oil (w/gas)

S_{gcon} = Endpoint Saturation: Connate Gas

S_{gcrit} = Endpoint Saturation: Critical Gas

T_{Res} = Reservoir temperature, Deg F

Greek Symbols

ϕ = Porosity, fraction

β = General *IPR* "lump" parameter, dimensionless

χ = Linear *IPR* "lump" parameter, dimensionless

η = General *IPR* "lump" parameter, dimensionless

λ = Mobility function, md/(cp-RB/STB)

$\lambda_{D,IPR}$ = Dimensionless oil mobility, dimensionless

μ_g = Gas viscosity, cp

μ_o = Oil viscosity, cp

ν = General *IPR* "lump" parameter, dimensionless

τ = General *IPR* "lump" parameter, dimensionless

ζ = Characteristic mobility parameter, dimensionless

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APPENDIX A

DEFINITION OF THE ζ-CHARACTERISTIC FUNCTION (CUBIC MODEL)

In this Appendix we present an inventory of the relations for the "characteristic" (ζ-parameter) formulation proposed by Ilk, *et al* [2007] is given as:

$$\left[1-\frac{[k_o/(\mu_o B_o)]_{\overline{p}}-[k_o/(\mu_o B_o)]_{p_{abn}}}{[k_o/(\mu_o B_o)]_{p_i}-[k_o/(\mu_o B_o)]_{p_{abn}}}\right]=1-\zeta\left[\frac{\overline{p}-p_{abn}}{p_i-p_{abn}}\right]+(1-\zeta)\left[\frac{\overline{p}-p_{abn}}{p_i-p_{abn}}\right]^2-2(1-\zeta)\left[\frac{\overline{p}-p_{abn}}{p_i-p_{abn}}\right]^3$$

(where $\zeta \leq 1$) ....(A-1)

Plotting Function (PF_1): (*base function*)

$$\left[1-\frac{[k_o/(\mu_o B_o)]_{\overline{p}}-[k_o/(\mu_o B_o)]_{p_{abn}}}{[k_o/(\mu_o B_o)]_{p_i}-[k_o/(\mu_o B_o)]_{p_{abn}}}\right] \text{ versus } \left[\frac{\overline{p}-p_{abn}}{p_i-p_{abn}}\right] \quad \text{....................(A-2)}$$

Plotting Function (PF_2): (*first derivative function*)

$$d\left[1-\frac{[k_o/(\mu_o B_o)]_{\overline{p}}-[k_o/(\mu_o B_o)]_{p_{abn}}}{[k_o/(\mu_o B_o)]_{p_i}-[k_o/(\mu_o B_o)]_{p_{abn}}}\right]/d\left[\frac{\overline{p}-p_{abn}}{p_i-p_{abn}}\right] \text{ versus } \left[\frac{\overline{p}-p_{abn}}{p_i-p_{abn}}\right] \quad \text{....................(A-3)}$$

Plotting Function (PF_3): (*second derivative function*)

$$d^2\left[1-\frac{[k_o/(\mu_o B_o)]_{\overline{p}}-[k_o/(\mu_o B_o)]_{p_{abn}}}{[k_o/(\mu_o B_o)]_{p_i}-[k_o/(\mu_o B_o)]_{p_{abn}}}\right]/d\left[\frac{\overline{p}-p_{abn}}{p_i-p_{abn}}\right]^2 \text{ versus } \left[\frac{\overline{p}-p_{abn}}{p_i-p_{abn}}\right] \quad \text{....................(A-4)}$$

Plotting Function (PF_4): (*integral function*)

$$\frac{1}{p_{norm}}\int_0^{p_{norm}}\left[1-\frac{[k_o/(\mu_o B_o)]_{\overline{p}}-[k_o/(\mu_o B_o)]_{p_{abn}}}{[k_o/(\mu_o B_o)]_{p_i}-[k_o/(\mu_o B_o)]_{p_{abn}}}\right] \text{ versus } \left[\frac{\overline{p}-p_{abn}}{p_i-p_{abn}}\right] \quad \text{....................(A-5)}$$

Plotting Function (PF_5): (*integral-difference function*)

$$\left[1-\frac{[k_o/(\mu_o B_o)]_{\overline{p}}-[k_o/(\mu_o B_o)]_{p_{abn}}}{[k_o/(\mu_o B_o)]_{p_i}-[k_o/(\mu_o B_o)]_{p_{abn}}}\right] - \frac{1}{p_{norm}}\int_0^{p_{norm}}\left[1-\frac{[k_o/(\mu_o B_o)]_{\overline{p}}-[k_o/(\mu_o B_o)]_{p_{abn}}}{[k_o/(\mu_o B_o)]_{p_i}-[k_o/(\mu_o B_o)]_{p_{abn}}}\right] \text{ versus } \left[\frac{\overline{p}-p_{abn}}{p_i-p_{abn}}\right] \quad \text{....................(A-6)}$$

APPENDIX B

NUMERICAL SIMULATION RESULTS USED TO CALIBRATE THE ζ-PARAMETER CORRELATION

In this Appendix we provide a summary of the numerical simulation results used to calibrate the ζ-parameter correlation. The input data parameters for this work are given in **Table B-1** and the results of this simulation study are provided in **Table B-2**. Our defining (or "local") model in a cubic form for the ζ-parameter is given as:

$$\left[1-\frac{[k_o/(\mu_o B_o)]_{\bar{p}}-[k_o/(\mu_o B_o)]_{p_{abn}}}{[k_o/(\mu_o B_o)]_{p_i}-[k_o/(\mu_o B_o)]_{p_{abn}}}\right]=1-\zeta\left[\frac{\bar{p}-p_{abn}}{p_i-p_{abn}}\right]+(1-\zeta)\left[\frac{\bar{p}-p_{abn}}{p_i-p_{abn}}\right]^2-2(1-\zeta)\left[\frac{\bar{p}-p_{abn}}{p_i-p_{abn}}\right]^3$$

(where $\zeta \leq 1$) ....(B-1)

We also develop an empirical correlation of for the ζ-parameter, the form of this correlation is given by:

$$\zeta=\mathrm{erf}\left[\begin{array}{l}\alpha 1(GOR^{A1}\,API^{A2}\,T_{res}^{A3}\,S_{oi}^{A4}\,k_{rog}^{A5}\,p_i^{A6}\,B_{oi}^{A7}\,\mu_{oi}^{A8}\,\lambda_{oi}^{A9})^{\beta 1}\\+n_w^{A10}+n_{ow}^{A11}+n_{og}^{A12}+n_g^{A13}\end{array}\right] \qquad \text{(B-2)}$$

The coefficients in Eq. B-2 are derived using the values given in the results table provided later in this Appendix.

Table B-1 — Input Parameters for the Numerical Simulation Study

GOR_i (scf/STB)	API_i (Deg API)	T_{Res} (Deg F)	S_{wi} (fraction)	S_{oi} (fraction)	$k_{r,\ end}$ (dimensionless)	n_{Corey} (dimensionless)
500	15	150	0	1	0.7	2
1000	25	200	0.1	0.9	0.8	3
1500	35	250	0.2	0.8	0.9	4
-	-	-	0.4	0.6	1	

Table B-2 — Numerical Simulation Results used to Calibrate the ζ-Parameter Correlation

Case	PVT Set	k_r Set	Simulation Type	q_{oi} (STBD)	GOR_i (scf/STB)	API_i (API)	T_{Res} (°F)	S_{wi} (frac.)	S_{oi} (frac.)	$k_{ro,end}$ (frac.)	p_i (psi)	B_{oi} (RB/STB)	μ_{oi} (cp)	λ_{oi} (md/cp)	n_w	n_w	n_g	n_g	(Eq. B-1) ζ
1	1	1	CONBHP	15	500	15	200	0	1	1	4441	1.3	5.1	1.6	3	3	3	3	0.475
2	1	1	CRATE	4	500	15	200	0	1	1	4441	1.3	5.1	1.6	3	3	3	3	0.481
3	1	1	HYPRATE	10	500	15	200	0	1	1	4441	1.3	5.1	1.6	3	3	3	3	0.473
4	1	1	HYPRATE	12	500	15	200	0	1	1	4441	1.3	5.1	1.6	3	3	3	3	0.474
5	1	1	HYPRATE	36	500	15	200	0	1	1	4441	1.3	5.1	1.6	3	3	3	3	0.475
6	1	1	RANDRATE	15	500	15	200	0	1	1	4441	1.3	5.1	1.6	3	3	3	3	0.475
7	1	1	RANDRATE	30	500	15	200	0	1	1	4441	1.3	5.1	1.6	3	3	3	3	0.475
8	1	1	RANDRATE	8	500	15	200	0	1	1	4441	1.3	5.1	1.6	3	3	3	3	0.479
9	1	1	STEPBHP	-	500	15	200	0	1	1	4441	1.3	5.1	1.6	3	3	3	3	0.484
10	1	1	VARBHP	-	500	15	200	0	1	1	4441	1.3	5.1	1.6	3	3	3	3	0.482
11	1	1	VARRATE	12	500	15	200	0	1	1	4441	1.3	5.1	1.6	3	3	3	3	0.474
12	1	2	CONBHP	15	500	15	200	0.2	0.8	0.9	4441	1.3	5.1	1.4	3	3	3	3	0.449
13	1	2	CRATE	2	500	15	200	0.2	0.8	0.9	4441	1.3	5.1	1.4	3	3	3	3	0.471
14	1	2	CRATE	4	500	15	200	0.2	0.8	0.9	4441	1.3	5.1	1.4	3	3	3	3	0.446
15	1	2	HYPRATE	10	500	15	200	0.2	0.8	0.9	4441	1.3	5.1	1.4	3	3	3	3	0.447
16	1	2	HYPRATE	12	500	15	200	0.2	0.8	0.9	4441	1.3	5.1	1.4	3	3	3	3	0.445
17	1	2	HYPRATE	36	500	15	200	0.2	0.8	0.9	4441	1.3	5.1	1.4	3	3	3	3	0.449
18	1	2	RANDRATE	15	500	15	200	0.2	0.8	0.9	4441	1.3	5.1	1.4	3	3	3	3	0.445
19	1	2	RANDRATE	30	500	15	200	0.2	0.8	0.9	4441	1.3	5.1	1.4	3	3	3	3	0.448
20	1	2	RANDRATE	8	500	15	200	0.2	0.8	0.9	4441	1.3	5.1	1.4	3	3	3	3	0.445
21	1	2	STEPBHP	-	500	15	200	0.2	0.8	0.9	4441	1.3	5.1	1.4	3	3	3	3	0.454
22	1	2	VARBHP	-	500	15	200	0.2	0.8	0.9	4441	1.3	5.1	1.4	3	3	3	3	0.454
23	1	2	VARRATE	12	500	15	200	0.2	0.8	0.9	4441	1.3	5.1	1.4	3	3	3	3	0.447
24	1	2	VARRATE	8	500	15	200	0.2	0.8	0.9	4441	1.3	5.1	1.4	3	3	3	3	0.445
25	1	3	CONBHP	15	500	15	200	0.4	0.6	0.8	4441	1.3	5.1	1.2	3	3	3	3	0.412
26	1	3	CRATE	2	500	15	200	0.4	0.6	0.8	4441	1.3	5.1	1.2	3	3	3	3	0.408

Case	PVT Set	k_r Set	Simulation Type	q_{oi} (STBD)	GOR_i (scf/STB)	API_i (API)	T_{Res} (ºF)	S_{wi} (frac.)	S_{oi} (frac.)	$k_{ro,end}$ (frac.)	p_i (psi)	B_{oi} (RB/STB)	μ_{oi} (cp)	λ_{oi} (md/cp)	n_w	n_w	n_g	n_g	(Eq. B-1) ζ
27	1	3	CRATE	4	500	15	200	0.4	0.6	0.8	4441	1.3	5.1	1.2	3	3	3	3	0.405
28	1	3	HYPRATE	10	500	15	200	0.4	0.6	0.8	4441	1.3	5.1	1.2	3	3	3	3	0.409
29	1	3	HYPRATE	12	500	15	200	0.4	0.6	0.8	4441	1.3	5.1	1.2	3	3	3	3	0.408
30	1	3	HYPRATE	36	500	15	200	0.4	0.6	0.8	4441	1.3	5.1	1.2	3	3	3	3	0.412
31	1	3	RANDRATE	15	500	15	200	0.4	0.6	0.8	4441	1.3	5.1	1.2	3	3	3	3	0.407
32	1	3	RANDRATE	30	500	15	200	0.4	0.6	0.8	4441	1.3	5.1	1.2	3	3	3	3	0.410
33	1	3	RANDRATE	8	500	15	200	0.4	0.6	0.8	4441	1.3	5.1	1.2	3	3	3	3	0.405
34	1	3	STEPBHP	-	500	15	200	0.4	0.6	0.8	4441	1.3	5.1	1.2	3	3	3	3	0.415
35	1	3	VARBHP	-	500	15	200	0.4	0.6	0.8	4441	1.3	5.1	1.2	3	3	3	3	0.417
36	1	3	VARRATE	12	500	15	200	0.4	0.6	0.8	4441	1.3	5.1	1.2	3	3	3	3	0.409
37	1	3	VARRATE	8	500	15	200	0.4	0.6	0.8	4441	1.3	5.1	1.2	3	3	3	3	0.407
38	1	4	CONBHP	15	500	15	200	0	1	1	4441	1.3	5.1	1.6	3	3	4	3	0.403
39	1	4	CRATE	4	500	15	200	0	1	1	4441	1.3	5.1	1.6	3	3	4	3	0.408
40	1	4	HYPRATE	10	500	15	200	0	1	1	4441	1.3	5.1	1.6	3	3	4	3	0.401
41	1	4	HYPRATE	12	500	15	200	0	1	1	4441	1.3	5.1	1.6	3	3	4	3	0.401
42	1	4	HYPRATE	36	500	15	200	0	1	1	4441	1.3	5.1	1.6	3	3	4	3	0.403
43	1	4	RANDRATE	15	500	15	200	0	1	1	4441	1.3	5.1	1.6	3	3	4	3	0.402
44	1	4	RANDRATE	30	500	15	200	0	1	1	4441	1.3	5.1	1.6	3	3	4	3	0.402
45	1	4	RANDRATE	8	500	15	200	0	1	1	4441	1.3	5.1	1.6	3	3	4	3	0.406
46	1	4	STEPBHP	-	500	15	200	0	1	1	4441	1.3	5.1	1.6	3	3	4	3	0.411
47	1	4	VARBHP	-	500	15	200	0	1	1	4441	1.3	5.1	1.6	3	3	4	3	0.409
48	1	4	VARRATE	12	500	15	200	0	1	1	4441	1.3	5.1	1.6	3	3	4	3	0.400
49	1	5	CONBHP	15	500	15	200	0.4	0.6	0.8	4441	1.3	5.1	1.2	3	3	4	3	0.326
50	1	5	CRATE	2	500	15	200	0.4	0.6	0.8	4441	1.3	5.1	1.2	3	3	4	3	0.323
51	1	5	CRATE	4	500	15	200	0.4	0.6	0.8	4441	1.3	5.1	1.2	3	3	4	3	0.322
52	1	5	HYPRATE	10	500	15	200	0.4	0.6	0.8	4441	1.3	5.1	1.2	3	3	4	3	0.326
53	1	5	HYPRATE	12	500	15	200	0.4	0.6	0.8	4441	1.3	5.1	1.2	3	3	4	3	0.324
54	1	5	HYPRATE	36	500	15	200	0.4	0.6	0.8	4441	1.3	5.1	1.2	3	3	4	3	0.326
55	1	5	RANDRATE	15	500	15	200	0.4	0.6	0.8	4441	1.3	5.1	1.2	3	3	4	3	0.324
56	1	5	RANDRATE	30	500	15	200	0.4	0.6	0.8	4441	1.3	5.1	1.2	3	3	4	3	0.325

Case	PVT Set	k_r Set	Simulation Type	q_{oi} (STBD)	GOR_i (scf/STB)	API_i (API)	T_{Res} (ºF)	S_{wi} (frac.)	S_{oi} (frac.)	$k_{ro,end}$ (frac.)	p_i (psi)	B_{oi} (RB/STB)	μ_{oi} (cp)	λ_{oi} (md/cp)	n_w	n_w	n_g	n_g	(Eq. B-1) ζ
57	1	5	RANDRATE	8	500	15	200	0.4	0.6	0.8	4441	1.3	5.1	1.2	3	3	4	3	0.322
58	1	5	STEPBHP	-	500	15	200	0.4	0.6	0.8	4441	1.3	5.1	1.2	3	3	4	3	0.330
59	1	5	VARBHP	-	500	15	200	0.4	0.6	0.8	4441	1.3	5.1	1.2	3	3	4	3	0.330
60	1	5	VARRATE	12	500	15	200	0.4	0.6	0.8	4441	1.3	5.1	1.2	3	3	4	3	0.325
61	1	5	VARRATE	8	500	15	200	0.4	0.6	0.8	4441	1.3	5.1	1.2	3	3	4	3	0.323
62	1	6	CONBHP	15	500	15	200	0	1	1	4441	1.3	5.1	1.6	2	2	2	2	0.597
63	1	6	CRATE	4	500	15	200	0	1	1	4441	1.3	5.1	1.6	2	2	2	2	0.594
64	1	6	RANDRATE	8	500	15	200	0	1	1	4441	1.3	5.1	1.6	2	2	2	2	0.595
65	1	6	STEPBHP	-	500	15	200	0	1	1	4441	1.3	5.1	1.6	2	2	2	2	0.595
66	1	6	VARBHP	-	500	15	200	0	1	1	4441	1.3	5.1	1.6	2	2	2	2	0.603
67	1	6	VARRATE	12	500	15	200	0	1	1	4441	1.3	5.1	1.6	2	2	2	2	0.595
68	1	7	CONBHP	15	500	15	200	0.2	0.8	0.9	4441	1.3	5.1	1.4	2	2	2	2	0.632
69	1	7	CRATE	4	500	15	200	0.2	0.8	0.9	4441	1.3	5.1	1.4	2	2	2	2	0.629
70	1	7	STEPBHP	-	500	15	200	0.2	0.8	0.9	4441	1.3	5.1	1.4	2	2	2	2	0.630
71	1	7	VARBHP	-	500	15	200	0.2	0.8	0.9	4441	1.3	5.1	1.4	2	2	2	2	0.636
72	1	7	VARRATE	12	500	15	200	0.2	0.8	0.9	4441	1.3	5.1	1.4	2	2	2	2	0.631
73	1	8	CONBHP	15	500	15	200	0.4	0.6	0.8	4441	1.3	5.1	1.2	2	2	2	2	0.562
74	1	8	CRATE	4	500	15	200	0.4	0.6	0.8	4441	1.3	5.1	1.2	2	2	2	2	0.555
75	1	8	HYPRATE	13	500	15	200	0.4	0.6	0.8	4441	1.3	5.1	1.2	2	2	2	2	0.561
76	1	8	RANDRATE	10	500	15	200	0.4	0.6	0.8	4441	1.3	5.1	1.2	2	2	2	2	0.557
77	1	8	STEPBHP	-	500	15	200	0.4	0.6	0.8	4441	1.3	5.1	1.2	2	2	2	2	0.559
78	1	8	VARBHP	-	500	15	200	0.4	0.6	0.8	4441	1.3	5.1	1.2	2	2	2	2	0.565
79	1	8	VARRATE	12	500	15	200	0.4	0.6	0.8	4441	1.3	5.1	1.2	2	2	2	2	0.561
80	1	9	CONBHP	15	500	15	200	0	1	1	4441	1.3	5.1	1.6	4	4	4	4	0.366
81	1	9	CRATE	4	500	15	200	0	1	1	4441	1.3	5.1	1.6	4	4	4	4	0.378
82	1	9	HYPRATE	17	500	15	200	0	1	1	4441	1.3	5.1	1.6	4	4	4	4	0.366
83	1	9	STEPBHP	-	500	15	200	0	1	1	4441	1.3	5.1	1.6	4	4	4	4	0.369
84	1	9	VARBHP	-	500	15	200	0	1	1	4441	1.3	5.1	1.6	4	4	4	4	0.393
85	1	9	VARRATE	12	500	15	200	0	1	1	4441	1.3	5.1	1.6	4	4	4	4	0.381
86	1	10	CONBHP	15	500	15	200	0.2	0.8	0.9	4441	1.3	5.1	1.4	4	4	4	4	0.326

Case	PVT Set	k_r Set	Simulation Type	q_{oi} (STBD)	GOR_i (scf/STB)	API_i (API)	T_{Res} (°F)	S_{wi} (frac.)	S_{oi} (frac.)	$k_{ro,end}$ (frac.)	p_i (psi)	B_{oi} (RB/STB)	μ_{oi} (cp)	λ_{oi} (md/cp)	n_w	n_w	n_g	n_g	(Eq. B-1) ζ
87	1	10	CRATE	4	500	15	200	0.2	0.8	0.9	4441	1.3	5.1	1.4	4	4	4	4	0.327
88	1	10	HYPRATE	17	500	15	200	0.2	0.8	0.9	4441	1.3	5.1	1.4	4	4	4	4	0.327
89	1	10	RANDRATE	10	500	15	200	0.2	0.8	0.9	4441	1.3	5.1	1.4	4	4	4	4	0.344
90	1	10	STEPBHP	-	500	15	200	0.2	0.8	0.9	4441	1.3	5.1	1.4	4	4	4	4	0.327
91	1	10	VARBHP	-	500	15	200	0.2	0.8	0.9	4441	1.3	5.1	1.4	4	4	4	4	0.345
92	1	10	VARRATE	12	500	15	200	0.2	0.8	0.9	4441	1.3	5.1	1.4	4	4	4	4	0.325
93	1	11	CONBHP	15	500	15	200	0.4	0.6	0.8	4441	1.3	5.1	1.2	4	4	4	4	0.283
94	1	11	CRATE	4	500	15	200	0.4	0.6	0.8	4441	1.3	5.1	1.2	4	4	4	4	0.281
95	1	11	HYPRATE	17	500	15	200	0.4	0.6	0.8	4441	1.3	5.1	1.2	4	4	4	4	0.283
96	1	11	RANDRATE	10	500	15	200	0.4	0.6	0.8	4441	1.3	5.1	1.2	4	4	4	4	0.289
97	1	11	STEPBHP	-	500	15	200	0.4	0.6	0.8	4441	1.3	5.1	1.2	4	4	4	4	0.283
98	1	11	VARBHP	-	500	15	200	0.4	0.6	0.8	4441	1.3	5.1	1.2	4	4	4	4	0.296
99	1	11	VARRATE	12	500	15	200	0.4	0.6	0.8	4441	1.3	5.1	1.2	4	4	4	4	0.282
100	1	12	CONBHP	15	500	15	200	0.1	0.9	0.9	4441	1.3	5.1	1.4	3	3	3	3	0.471
101	1	12	CRATE	4	500	15	200	0.1	0.9	0.9	4441	1.3	5.1	1.4	3	3	3	3	0.469
102	1	12	HYPRATE	13	500	15	200	0.1	0.9	0.9	4441	1.3	5.1	1.4	3	3	3	3	0.469
103	1	12	RANDRATE	10	500	15	200	0.1	0.9	0.9	4441	1.3	5.1	1.4	3	3	3	3	0.476
104	1	12	STEPBHP	-	500	15	200	0.1	0.9	0.9	4441	1.3	5.1	1.4	3	3	3	3	0.471
105	1	12	VARBHP	-	500	15	200	0.1	0.9	0.9	4441	1.3	5.1	1.4	3	3	3	3	0.482
106	1	12	VARRATE	12	500	15	200	0.1	0.9	0.9	4441	1.3	5.1	1.4	3	3	3	3	0.468
107	1	13	CONBHP	15	500	15	200	0.2	0.8	0.7	4441	1.3	5.1	1.1	3	3	3	3	0.448
108	1	13	CRATE	4	500	15	200	0.2	0.8	0.7	4441	1.3	5.1	1.1	3	3	3	3	0.443
109	1	13	HYPRATE	13	500	15	200	0.2	0.8	0.7	4441	1.3	5.1	1.1	3	3	3	3	0.446
110	1	13	RANDRATE	10	500	15	200	0.2	0.8	0.7	4441	1.3	5.1	1.1	3	3	3	3	0.449
111	1	13	STEPBHP	-	500	15	200	0.2	0.8	0.7	4441	1.3	5.1	1.1	3	3	3	3	0.446
112	1	13	VARBHP	-	500	15	200	0.2	0.8	0.7	4441	1.3	5.1	1.1	3	3	3	3	0.457
113	1	13	VARRATE	12	500	15	200	0.2	0.8	0.7	4441	1.3	5.1	1.1	3	3	3	3	0.447
114	2	1	CONBHP	15	1000	25	200	0	1	1	5930	1.5	0.7	9.0	3	3	3	3	0.403
115	2	1	CRATE	4	1000	25	200	0	1	1	5930	1.5	0.7	9.0	3	3	3	3	0.402
116	2	1	HYPRATE	10	1000	25	200	0	1	1	5930	1.5	0.7	9.0	3	3	3	3	0.397

Case	PVT Set	k_r Set	Simulation Type	q_{oi} (STBD)	GOR_i (scf/STB)	API_i (API)	T_{Res} (ºF)	S_{wi} (frac.)	S_{oi} (frac.)	$k_{ro,end}$ (frac.)	p_i (psi)	B_{oi} (RB/STB)	μ_{oi} (cp)	λ_{oi} (md/cp)	n_w	n_w	n_g	n_g	(Eq. B-1) ζ
117	2	1	HYPRATE	12	1000	25	200	0	1	1	5930	1.5	0.7	9.0	3	3	3	3	0.400
118	2	1	HYPRATE	23	1000	25	200	0	1	1	5930	1.5	0.7	9.0	3	3	3	3	0.396
119	2	1	RANDRATE	15	1000	25	200	0	1	1	5930	1.5	0.7	9.0	3	3	3	3	0.396
120	2	1	RANDRATE	20	1000	25	200	0	1	1	5930	1.5	0.7	9.0	3	3	3	3	0.396
121	2	1	RANDRATE	8	1000	25	200	0	1	1	5930	1.5	0.7	9.0	3	3	3	3	0.400
122	2	1	STEPBHP	-	1000	25	200	0	1	1	5930	1.5	0.7	9.0	3	3	3	3	0.406
123	2	1	VARBHP	-	1000	25	200	0	1	1	5930	1.5	0.7	9.0	3	3	3	3	0.406
124	2	1	VARRATE	12	1000	25	200	0	1	1	5930	1.5	0.7	9.0	3	3	3	3	0.400
125	2	2	CONBHP	15	1000	25	200	0.2	0.8	0.9	5930	1.5	0.7	8.1	3	3	3	3	0.362
126	2	2	CRATE	4	1000	25	200	0.2	0.8	0.9	5930	1.5	0.7	8.1	3	3	3	3	0.356
127	2	2	HYPRATE	10	1000	25	200	0.2	0.8	0.9	5930	1.5	0.7	8.1	3	3	3	3	0.355
128	2	2	HYPRATE	12	1000	25	200	0.2	0.8	0.9	5930	1.5	0.7	8.1	3	3	3	3	0.355
129	2	2	HYPRATE	23	1000	25	200	0.2	0.8	0.9	5930	1.5	0.7	8.1	3	3	3	3	0.355
130	2	2	RANDRATE	15	1000	25	200	0.2	0.8	0.9	5930	1.5	0.7	8.1	3	3	3	3	0.355
131	2	2	RANDRATE	20	1000	25	200	0.2	0.8	0.9	5930	1.5	0.7	8.1	3	3	3	3	0.355
132	2	2	RANDRATE	8	1000	25	200	0.2	0.8	0.9	5930	1.5	0.7	8.1	3	3	3	3	0.355
133	2	2	STEPBHP	-	1000	25	200	0.2	0.8	0.9	5930	1.5	0.7	8.1	3	3	3	3	0.363
134	2	2	VARBHP	-	1000	25	200	0.2	0.8	0.9	5930	1.5	0.7	8.1	3	3	3	3	0.364
135	2	2	VARRATE	12	1000	25	200	0.2	0.8	0.9	5930	1.5	0.7	8.1	3	3	3	3	0.355
136	2	2	VARRATE	8	1000	25	200	0.2	0.8	0.9	5930	1.5	0.7	8.1	3	3	3	3	0.357
137	2	3	CONBHP	15	1000	25	200	0.4	0.6	0.8	5930	1.5	0.7	7.2	3	3	3	3	0.317
138	2	3	CRATE	2	1000	25	200	0.4	0.6	0.8	5930	1.5	0.7	7.2	3	3	3	3	0.310
139	2	3	CRATE	4	1000	25	200	0.4	0.6	0.8	5930	1.5	0.7	7.2	3	3	3	3	0.309
140	2	3	HYPRATE	10	1000	25	200	0.4	0.6	0.8	5930	1.5	0.7	7.2	3	3	3	3	0.309
141	2	3	HYPRATE	12	1000	25	200	0.4	0.6	0.8	5930	1.5	0.7	7.2	3	3	3	3	0.309
142	2	3	HYPRATE	23	1000	25	200	0.4	0.6	0.8	5930	1.5	0.7	7.2	3	3	3	3	0.310
143	2	3	RANDRATE	15	1000	25	200	0.4	0.6	0.8	5930	1.5	0.7	7.2	3	3	3	3	0.309
144	2	3	RANDRATE	20	1000	25	200	0.4	0.6	0.8	5930	1.5	0.7	7.2	3	3	3	3	0.310
145	2	3	STEPBHP	-	1000	25	200	0.4	0.6	0.8	5930	1.5	0.7	7.2	3	3	3	3	0.316
146	2	3	VARBHP	-	1000	25	200	0.4	0.6	0.8	5930	1.5	0.7	7.2	3	3	3	3	0.317

Case	PVT Set	k_r Set	Simulation Type	q_{oi} (STBD)	GOR_i (scf/STB)	API_i (API)	T_{Res} (°F)	S_{wi} (frac.)	S_{oi} (frac.)	$k_{ro,end}$ (frac.)	p_i (psi)	B_{oi} (RB/STB)	μ_{oi} (cp)	λ_{oi} (md/cp)	n_w	n_w	n_g	n_g	(Eq. B-1) ζ
147	2	3	VARRATE	12	1000	25	200	0.4	0.6	0.8	5930	1.5	0.7	7.2	3	3	3	3	0.309
148	2	3	VARRATE	8	1000	25	200	0.4	0.6	0.8	5930	1.5	0.7	7.2	3	3	3	3	0.309
149	2	4	CONBHP	15	1000	25	200	0	1	1	5930	1.5	0.7	9.0	3	3	4	3	0.305
150	2	4	CRATE	4	1000	25	200	0	1	1	5930	1.5	0.7	9.0	3	3	4	3	0.302
151	2	4	HYPRATE	10	1000	25	200	0	1	1	5930	1.5	0.7	9.0	3	3	4	3	0.298
152	2	4	HYPRATE	12	1000	25	200	0	1	1	5930	1.5	0.7	9.0	3	3	4	3	0.299
153	2	4	HYPRATE	23	1000	25	200	0	1	1	5930	1.5	0.7	9.0	3	3	4	3	0.298
154	2	4	RANDRATE	15	1000	25	200	0	1	1	5930	1.5	0.7	9.0	3	3	4	3	0.298
155	2	4	RANDRATE	20	1000	25	200	0	1	1	5930	1.5	0.7	9.0	3	3	4	3	0.298
156	2	4	RANDRATE	8	1000	25	200	0	1	1	5930	1.5	0.7	9.0	3	3	4	3	0.301
157	2	4	STEPBHP	-	1000	25	200	0	1	1	5930	1.5	0.7	9.0	3	3	4	3	0.307
158	2	4	VARBHP	-	1000	25	200	0	1	1	5930	1.5	0.7	9.0	3	3	4	3	0.308
159	2	4	VARRATE	12	1000	25	200	0	1	1	5930	1.5	0.7	9.0	3	3	4	3	0.299
160	2	5	CONBHP	15	1000	25	200	0.4	0.6	0.8	5930	1.5	0.7	7.2	3	3	4	3	0.210
161	2	5	CRATE	2	1000	25	200	0.4	0.6	0.8	5930	1.5	0.7	7.2	3	3	4	3	0.205
162	2	5	CRATE	4	1000	25	200	0.4	0.6	0.8	5930	1.5	0.7	7.2	3	3	4	3	0.204
163	2	5	HYPRATE	10	1000	25	200	0.4	0.6	0.8	5930	1.5	0.7	7.2	3	3	4	3	0.205
164	2	5	HYPRATE	12	1000	25	200	0.4	0.6	0.8	5930	1.5	0.7	7.2	3	3	4	3	0.204
165	2	5	HYPRATE	23	1000	25	200	0.4	0.6	0.8	5930	1.5	0.7	7.2	3	3	4	3	0.205
166	2	5	RANDRATE	15	1000	25	200	0.4	0.6	0.8	5930	1.5	0.7	7.2	3	3	4	3	0.204
167	2	5	RANDRATE	20	1000	25	200	0.4	0.6	0.8	5930	1.5	0.7	7.2	3	3	4	3	0.205
168	2	5	RANDRATE	8	1000	25	200	0.4	0.6	0.8	5930	1.5	0.7	7.2	3	3	4	3	0.204
169	2	5	STEPBHP	-	1000	25	200	0.4	0.6	0.8	5930	1.5	0.7	7.2	3	3	4	3	0.211
170	2	5	VARBHP	-	1000	25	200	0.4	0.6	0.8	5930	1.5	0.7	7.2	3	3	4	3	0.211
171	2	5	VARRATE	12	1000	25	200	0.4	0.6	0.8	5930	1.5	0.7	7.2	3	3	4	3	0.205
172	2	5	VARRATE	8	1000	25	200	0.4	0.6	0.8	5930	1.5	0.7	7.2	3	3	4	3	0.204
173	2	6	CONBHP	15	1000	25	200	0	1	1	5930	1.5	0.7	9.0	2	2	2	2	0.572
174	2	6	CRATE	4	1000	25	200	0	1	1	5930	1.5	0.7	9.0	2	2	2	2	0.565
175	2	6	RANDRATE	8	1000	25	200	0	1	1	5930	1.5	0.7	9.0	2	2	2	2	0.565
176	2	6	STEPBHP	-	1000	25	200	0	1	1	5930	1.5	0.7	9.0	2	2	2	2	0.567

Case	PVT Set	k_r Set	Simulation Type	q_{oi} (STBD)	GOR_i (scf/STB)	API_i (API)	T_{Res} (°F)	S_{wi} (frac.)	S_{oi} (frac.)	$k_{ro,end}$ (frac.)	p_i (psi)	B_{oi} (RB/STB)	μ_{oi} (cp)	λ_{oi} (md/cp)	n_w	n_w	n_g	n_g	(Eq. B-1) ζ
177	2	6	VARBHP	-	1000	25	200	0	1	1	5930	1.5	0.7	9.0	2	2	2	2	0.572
178	2	6	VARRATE	12	1000	25	200	0	1	1	5930	1.5	0.7	9.0	2	2	2	2	0.565
179	2	7	CONBHP	15	1000	25	200	0.2	0.8	0.9	5930	1.5	0.7	8.1	2	2	2	2	0.625
180	2	7	CRATE	4	1000	25	200	0.2	0.8	0.9	5930	1.5	0.7	8.1	2	2	2	2	0.619
181	2	7	STEPBHP	-	1000	25	200	0.2	0.8	0.9	5930	1.5	0.7	8.1	2	2	2	2	0.621
182	2	7	VARBHP	-	1000	25	200	0.2	0.8	0.9	5930	1.5	0.7	8.1	2	2	2	2	0.624
183	2	8	CONBHP	15	1000	25	200	0.4	0.6	0.8	5930	1.5	0.7	7.2	2	2	2	2	0.501
184	2	8	CRATE	4	1000	25	200	0.4	0.6	0.8	5930	1.5	0.7	7.2	2	2	2	2	0.493
185	2	8	HYPRATE	13	1000	25	200	0.4	0.6	0.8	5930	1.5	0.7	7.2	2	2	2	2	0.494
186	2	8	RANDRATE	10	1000	25	200	0.4	0.6	0.8	5930	1.5	0.7	7.2	2	2	2	2	0.493
187	2	8	STEPBHP	-	1000	25	200	0.4	0.6	0.8	5930	1.5	0.7	7.2	2	2	2	2	0.495
188	2	8	VARBHP	-	1000	25	200	0.4	0.6	0.8	5930	1.5	0.7	7.2	2	2	2	2	0.498
189	2	8	VARRATE	12	1000	25	200	0.4	0.6	0.8	5930	1.5	0.7	7.2	2	2	2	2	0.493
190	2	9	CONBHP	15	1000	25	200	0	1	1	5930	1.5	0.7	9.0	4	4	4	4	0.268
191	2	9	CRATE	4	1000	25	200	0	1	1	5930	1.5	0.7	9.0	4	4	4	4	0.266
192	2	9	HYPRATE	17	1000	25	200	0	1	1	5930	1.5	0.7	9.0	4	4	4	4	0.262
193	2	9	RANDRATE	8	1000	25	200	0	1	1	5930	1.5	0.7	9.0	4	4	4	4	0.276
194	2	9	STEPBHP	-	1000	25	200	0	1	1	5930	1.5	0.7	9.0	4	4	4	4	0.265
195	2	9	VARBHP	-	1000	25	200	0	1	1	5930	1.5	0.7	9.0	4	4	4	4	0.277
196	2	9	VARRATE	12	1000	25	200	0	1	1	5930	1.5	0.7	9.0	4	4	4	4	0.277
197	2	10	CONBHP	15	1000	25	200	0.2	0.8	0.9	5930	1.5	0.7	8.1	4	4	4	4	0.230
198	2	10	CRATE	4	1000	25	200	0.2	0.8	0.9	5930	1.5	0.7	8.1	4	4	4	4	0.226
199	2	10	HYPRATE	17	1000	25	200	0.2	0.8	0.9	5930	1.5	0.7	8.1	4	4	4	4	0.226
200	2	10	RANDRATE	10	1000	25	200	0.2	0.8	0.9	5930	1.5	0.7	8.1	4	4	4	4	0.229
201	2	10	STEPBHP	-	1000	25	200	0.2	0.8	0.9	5930	1.5	0.7	8.1	4	4	4	4	0.228
202	2	10	VARBHP	-	1000	25	200	0.2	0.8	0.9	5930	1.5	0.7	8.1	4	4	4	4	0.234
203	2	10	VARRATE	12	1000	25	200	0.2	0.8	0.9	5930	1.5	0.7	8.1	4	4	4	4	0.226
204	2	11	CONBHP	15	1000	25	200	0.4	0.6	0.8	5930	1.5	0.7	7.2	4	4	4	4	0.180
205	2	11	CRATE	4	1000	25	200	0.4	0.6	0.8	5930	1.5	0.7	7.2	4	4	4	4	0.177
206	2	11	HYPRATE	17	1000	25	200	0.4	0.6	0.8	5930	1.5	0.7	7.2	4	4	4	4	0.178

Case	PVT Set	k_r Set	Simulation Type	q_{oi} (STBD)	GOR_i (scf/STB)	API_i (API)	T_{Res} (ºF)	S_{wi} (frac.)	S_{oi} (frac.)	$k_{ro,end}$ (frac.)	p_i (psi)	B_{oi} (RB/STB)	μ_{oi} (cp)	λ_{oi} (md/cp)	n_w	n_w	n_g	n_g	(Eq. B-1) ζ
207	2	11	RANDRATE	10	1000	25	200	0.4	0.6	0.8	5930	1.5	0.7	7.2	4	4	4	4	0.179
208	2	11	STEPBHP	-	1000	25	200	0.4	0.6	0.8	5930	1.5	0.7	7.2	4	4	4	4	0.179
209	2	11	VARBHP	-	1000	25	200	0.4	0.6	0.8	5930	1.5	0.7	7.2	4	4	4	4	0.186
210	2	11	VARRATE	12	1000	25	200	0.4	0.6	0.8	5930	1.5	0.7	7.2	4	4	4	4	0.178
211	2	12	CONBHP	15	1000	25	200	0.1	0.9	0.9	5930	1.5	0.7	8.1	3	3	3	3	0.403
212	2	12	CRATE	4	1000	25	200	0.1	0.9	0.9	5930	1.5	0.7	8.1	3	3	3	3	0.395
213	2	12	HYPRATE	13	1000	25	200	0.1	0.9	0.9	5930	1.5	0.7	8.1	3	3	3	3	0.395
214	2	12	RANDRATE	10	1000	25	200	0.1	0.9	0.9	5930	1.5	0.7	8.1	3	3	3	3	0.397
215	2	12	STEPBHP	-	1000	25	200	0.1	0.9	0.9	5930	1.5	0.7	8.1	3	3	3	3	0.398
216	2	12	VARBHP	-	1000	25	200	0.1	0.9	0.9	5930	1.5	0.7	8.1	3	3	3	3	0.406
217	2	12	VARRATE	12	1000	25	200	0.1	0.9	0.9	5930	1.5	0.7	8.1	3	3	3	3	0.395
218	2	13	CONBHP	15	1000	25	200	0.2	0.8	0.7	5930	1.5	0.7	6.3	3	3	3	3	0.362
219	2	13	CRATE	4	1000	25	200	0.2	0.8	0.7	5930	1.5	0.7	6.3	3	3	3	3	0.354
220	2	13	HYPRATE	13	1000	25	200	0.2	0.8	0.7	5930	1.5	0.7	6.3	3	3	3	3	0.355
221	2	13	RANDRATE	10	1000	25	200	0.2	0.8	0.7	5930	1.5	0.7	6.3	3	3	3	3	0.356
222	2	13	STEPBHP	-	1000	25	200	0.2	0.8	0.7	5930	1.5	0.7	6.3	3	3	3	3	0.357
223	2	13	VARBHP	-	1000	25	200	0.2	0.8	0.7	5930	1.5	0.7	6.3	3	3	3	3	0.365
224	2	13	VARRATE	12	1000	25	200	0.2	0.8	0.7	5930	1.5	0.7	6.3	3	3	3	3	0.355
225	3	1	CONBHP	15	1500	35	200	0	1	1	6227	1.8	0.3	20.0	3	3	3	3	0.416
226	3	1	CRATE	4	1500	35	200	0	1	1	6227	1.8	0.3	20.0	3	3	3	3	0.412
227	3	1	HYPRATE	12	1500	35	200	0	1	1	6227	1.8	0.3	20.0	3	3	3	3	0.413
228	3	1	RANDRATE	8	1500	35	200	0	1	1	6227	1.8	0.3	20.0	3	3	3	3	0.409
229	3	1	STEPBHP	-	1500	35	200	0	1	1	6227	1.8	0.3	20.0	3	3	3	3	0.416
230	3	1	VARBHP	-	1500	35	200	0	1	1	6227	1.8	0.3	20.0	3	3	3	3	0.415
231	3	2	CONBHP	15	1500	35	200	0.2	0.8	0.9	6227	1.8	0.3	18.0	3	3	3	3	0.356
232	3	2	CRATE	4	1500	35	200	0.2	0.8	0.9	6227	1.8	0.3	18.0	3	3	3	3	0.346
233	3	2	HYPRATE	12	1500	35	200	0.2	0.8	0.9	6227	1.8	0.3	18.0	3	3	3	3	0.345
234	3	2	HYPRATE	8	1500	35	200	0.2	0.8	0.9	6227	1.8	0.3	18.0	3	3	3	3	0.346
235	3	2	RANDRATE	4	1500	35	200	0.2	0.8	0.9	6227	1.8	0.3	18.0	3	3	3	3	0.362
236	3	2	RANDRATE	8	1500	35	200	0.2	0.8	0.9	6227	1.8	0.3	18.0	3	3	3	3	0.346

Case	PVT Set	k_r Set	Simulation Type	q_{oi} (STBD)	GOR_i (scf/STB)	API_i (API)	T_{Res} (ºF)	S_{wi} (frac.)	S_{oi} (frac.)	$k_{ro,end}$ (frac.)	p_i (psi)	B_{oi} (RB/STB)	μ_{oi} (cp)	λ_{oi} (md/cp)	n_w	n_w	n_g	n_g	(Eq. B-1) ζ
237	3	2	STEPBHP	-	1500	35	200	0.2	0.8	0.9	6227	1.8	0.3	18.0	3	3	3	3	0.354
238	3	2	VARBHP	-	1500	35	200	0.2	0.8	0.9	6227	1.8	0.3	18.0	3	3	3	3	0.354
239	3	2	VARRATE	8	1500	35	200	0.2	0.8	0.9	6227	1.8	0.3	18.0	3	3	3	3	0.348
240	3	3	CONBHP	15	1500	35	200	0.4	0.6	0.8	6227	1.8	0.3	16.0	3	3	3	3	0.292
241	3	3	CRATE	2	1500	35	200	0.4	0.6	0.8	6227	1.8	0.3	16.0	3	3	3	3	0.282
242	3	3	CRATE	4	1500	35	200	0.4	0.6	0.8	6227	1.8	0.3	16.0	3	3	3	3	0.281
243	3	3	HYPRATE	12	1500	35	200	0.4	0.6	0.8	6227	1.8	0.3	16.0	3	3	3	3	0.282
244	3	3	HYPRATE	8	1500	35	200	0.4	0.6	0.8	6227	1.8	0.3	16.0	3	3	3	3	0.281
245	3	3	RANDRATE	4	1500	35	200	0.4	0.6	0.8	6227	1.8	0.3	16.0	3	3	3	3	0.282
246	3	3	RANDRATE	8	1500	35	200	0.4	0.6	0.8	6227	1.8	0.3	16.0	3	3	3	3	0.281
247	3	3	STEPBHP	-	1500	35	200	0.4	0.6	0.8	6227	1.8	0.3	16.0	3	3	3	3	0.289
248	3	3	VARBHP	-	1500	35	200	0.4	0.6	0.8	6227	1.8	0.3	16.0	3	3	3	3	0.289
249	3	3	VARRATE	8	1500	35	200	0.4	0.6	0.8	6227	1.8	0.3	16.0	3	3	3	3	0.281
250	3	4	CONBHP	15	1500	35	200	0	1	1	6227	1.8	0.3	20.0	3	3	4	3	0.285
251	3	4	CRATE	4	1500	35	200	0	1	1	6227	1.8	0.3	20.0	3	3	4	3	0.279
252	3	4	HYPRATE	12	1500	35	200	0	1	1	6227	1.8	0.3	20.0	3	3	4	3	0.277
253	3	4	HYPRATE	8	1500	35	200	0	1	1	6227	1.8	0.3	20.0	3	3	4	3	0.318
254	3	4	RANDRATE	8	1500	35	200	0	1	1	6227	1.8	0.3	20.0	3	3	4	3	0.278
255	3	4	STEPBHP	-	1500	35	200	0	1	1	6227	1.8	0.3	20.0	3	3	4	3	0.286
256	3	4	VARBHP	-	1500	35	200	0	1	1	6227	1.8	0.3	20.0	3	3	4	3	0.285
257	3	5	CONBHP	15	1500	35	200	0.4	0.6	0.8	6227	1.8	0.3	16.0	3	3	4	3	0.180
258	3	5	CRATE	2	1500	35	200	0.4	0.6	0.8	6227	1.8	0.3	16.0	3	3	4	3	0.174
259	3	5	CRATE	4	1500	35	200	0.4	0.6	0.8	6227	1.8	0.3	16.0	3	3	4	3	0.173
260	3	5	HYPRATE	12	1500	35	200	0.4	0.6	0.8	6227	1.8	0.3	16.0	3	3	4	3	0.174
261	3	5	HYPRATE	8	1500	35	200	0.4	0.6	0.8	6227	1.8	0.3	16.0	3	3	4	3	0.173
262	3	5	RANDRATE	4	1500	35	200	0.4	0.6	0.8	6227	1.8	0.3	16.0	3	3	4	3	0.173
263	3	5	RANDRATE	8	1500	35	200	0.4	0.6	0.8	6227	1.8	0.3	16.0	3	3	4	3	0.173
264	3	5	STEPBHP	-	1500	35	200	0.4	0.6	0.8	6227	1.8	0.3	16.0	3	3	4	3	0.179
265	3	5	VARBHP	-	1500	35	200	0.4	0.6	0.8	6227	1.8	0.3	16.0	3	3	4	3	0.179
266	3	5	VARRATE	4	1500	35	200	0.4	0.6	0.8	6227	1.8	0.3	16.0	3	3	4	3	0.174

Case	PVT Set	k_r Set	Simulation Type	q_{oi} (STBD)	GOR_i (scf/STB)	API_i (API)	T_{Res} (°F)	S_{wi} (frac.)	S_{oi} (frac.)	$k_{ro,end}$ (frac.)	p_i (psi)	B_{oi} (RB/STB)	μ_{oi} (cp)	λ_{oi} (md/cp)	n_w	n_w	n_g	n_g	(Eq. B-1) ζ
267	3	5	VARRATE	8	1500	35	200	0.4	0.6	0.8	6227	1.8	0.3	16.0	3	3	4	3	0.173
268	3	6	CONBHP	15	1500	35	200	0	1	1	6227	1.8	0.3	20.0	2	2	2	2	0.649
269	3	6	CRATE	4	1500	35	200	0	1	1	6227	1.8	0.3	20.0	2	2	2	2	0.636
270	3	6	RANDRATE	8	1500	35	200	0	1	1	6227	1.8	0.3	20.0	2	2	2	2	0.636
271	3	6	STEPBHP	-	1500	35	200	0	1	1	6227	1.8	0.3	20.0	2	2	2	2	0.638
272	3	6	VARBHP	-	1500	35	200	0	1	1	6227	1.8	0.3	20.0	2	2	2	2	0.641
273	3	6	VARRATE	12	1500	35	200	0	1	1	6227	1.8	0.3	20.0	2	2	2	2	0.636
274	3	7	CONBHP	15	1500	35	200	0.2	0.8	0.9	6227	1.8	0.3	18.0	2	2	2	2	0.725
275	3	7	CRATE	4	1500	35	200	0.2	0.8	0.9	6227	1.8	0.3	18.0	2	2	2	2	0.716
276	3	7	STEPBHP	-	1500	35	200	0.2	0.8	0.9	6227	1.8	0.3	18.0	2	2	2	2	0.718
277	3	7	VARBHP	-	1500	35	200	0.2	0.8	0.9	6227	1.8	0.3	18.0	2	2	2	2	0.720
278	3	7	VARRATE	12	1500	35	200	0.2	0.8	0.9	6227	1.8	0.3	18.0	2	2	2	2	0.716
279	3	8	CONBHP	15	1500	35	200	0.4	0.6	0.8	6227	1.8	0.3	16.0	2	2	2	2	0.527
280	3	8	CRATE	4	1500	35	200	0.4	0.6	0.8	6227	1.8	0.3	16.0	2	2	2	2	0.516
281	3	8	HYPRATE	13	1500	35	200	0.4	0.6	0.8	6227	1.8	0.3	16.0	2	2	2	2	0.517
282	3	8	RANDRATE	10	1500	35	200	0.4	0.6	0.8	6227	1.8	0.3	16.0	2	2	2	2	0.516
283	3	8	STEPBHP	-	1500	35	200	0.4	0.6	0.8	6227	1.8	0.3	16.0	2	2	2	2	0.519
284	3	8	VARBHP	-	1500	35	200	0.4	0.6	0.8	6227	1.8	0.3	16.0	2	2	2	2	0.521
285	3	8	VARRATE	12	1500	35	200	0.4	0.6	0.8	6227	1.8	0.3	16.0	2	2	2	2	0.517
286	3	9	CONBHP	15	1500	35	200	0	1	1	6227	1.8	0.3	20.0	4	4	4	4	0.249
287	3	9	CRATE	4	1500	35	200	0	1	1	6227	1.8	0.3	20.0	4	4	4	4	0.243
288	3	9	HYPRATE	17	1500	35	200	0	1	1	6227	1.8	0.3	20.0	4	4	4	4	0.241
289	3	9	RANDRATE	8	1500	35	200	0	1	1	6227	1.8	0.3	20.0	4	4	4	4	0.248
290	3	9	STEPBHP	-	1500	35	200	0	1	1	6227	1.8	0.3	20.0	4	4	4	4	0.244
291	3	9	VARBHP	-	1500	35	200	0	1	1	6227	1.8	0.3	20.0	4	4	4	4	0.255
292	3	9	VARRATE	12	1500	35	200	0	1	1	6227	1.8	0.3	20.0	4	4	4	4	0.246
293	3	10	CONBHP	15	1500	35	200	0.2	0.8	0.9	6227	1.8	0.3	18.0	4	4	4	4	0.200
294	3	10	CRATE	4	1500	35	200	0.2	0.8	0.9	6227	1.8	0.3	18.0	4	4	4	4	0.196
295	3	10	HYPRATE	17	1500	35	200	0.2	0.8	0.9	6227	1.8	0.3	18.0	4	4	4	4	0.196
296	3	10	RANDRATE	10	1500	35	200	0.2	0.8	0.9	6227	1.8	0.3	18.0	4	4	4	4	0.197

Case	PVT Set	k_r Set	Simulation Type	q_{oi} (STBD)	GOR_i (scf/STB)	API_i (API)	T_{Res} (°F)	S_{wi} (frac.)	S_{oi} (frac.)	$k_{ro,end}$ (frac.)	p_i (psi)	B_{oi} (RB/STB)	μ_{oi} (cp)	λ_{oi} (md/cp)	n_w	n_w	n_g	n_g	(Eq. B-1) ζ
297	3	10	STEPBHP	-	1500	35	200	0.2	0.8	0.9	6227	1.8	0.3	18.0	4	4	4	4	0.197
298	3	10	VARBHP	-	1500	35	200	0.2	0.8	0.9	6227	1.8	0.3	18.0	4	4	4	4	0.202
299	3	10	VARRATE	12	1500	35	200	0.2	0.8	0.9	6227	1.8	0.3	18.0	4	4	4	4	0.196
300	3	11	CONBHP	15	1500	35	200	0.4	0.6	0.8	6227	1.8	0.3	16.0	4	4	4	4	0.155
301	3	11	CRATE	4	1500	35	200	0.4	0.6	0.8	6227	1.8	0.3	16.0	4	4	4	4	0.151
302	3	11	HYPRATE	17	1500	35	200	0.4	0.6	0.8	6227	1.8	0.3	16.0	4	4	4	4	0.152
303	3	11	RANDRATE	10	1500	35	200	0.4	0.6	0.8	6227	1.8	0.3	16.0	4	4	4	4	0.152
304	3	11	STEPBHP	-	1500	35	200	0.4	0.6	0.8	6227	1.8	0.3	16.0	4	4	4	4	0.152
305	3	11	VARBHP	-	1500	35	200	0.4	0.6	0.8	6227	1.8	0.3	16.0	4	4	4	4	0.157
306	3	11	VARRATE	12	1500	35	200	0.4	0.6	0.8	6227	1.8	0.3	16.0	4	4	4	4	0.152
307	3	12	CONBHP	15	1500	35	200	0.1	0.9	0.9	6227	1.8	0.3	18.0	3	3	3	3	0.415
308	3	12	CRATE	4	1500	35	200	0.1	0.9	0.9	6227	1.8	0.3	18.0	3	3	3	3	0.405
309	3	12	HYPRATE	13	1500	35	200	0.1	0.9	0.9	6227	1.8	0.3	18.0	3	3	3	3	0.405
310	3	12	RANDRATE	10	1500	35	200	0.1	0.9	0.9	6227	1.8	0.3	18.0	3	3	3	3	0.407
311	3	12	STEPBHP	-	1500	35	200	0.1	0.9	0.9	6227	1.8	0.3	18.0	3	3	3	3	0.408
312	3	12	VARBHP	-	1500	35	200	0.1	0.9	0.9	6227	1.8	0.3	18.0	3	3	3	3	0.415
313	3	12	VARRATE	12	1500	35	200	0.1	0.9	0.9	6227	1.8	0.3	18.0	3	3	3	3	0.405
314	3	13	CONBHP	15	1500	35	200	0.2	0.8	0.7	6227	1.8	0.3	14.0	3	3	3	3	0.356
315	3	13	CRATE	4	1500	35	200	0.2	0.8	0.7	6227	1.8	0.3	14.0	3	3	3	3	0.345
316	3	13	HYPRATE	13	1500	35	200	0.2	0.8	0.7	6227	1.8	0.3	14.0	3	3	3	3	0.345
317	3	13	RANDRATE	10	1500	35	200	0.2	0.8	0.7	6227	1.8	0.3	14.0	3	3	3	3	0.346
318	3	13	STEPBHP	-	1500	35	200	0.2	0.8	0.7	6227	1.8	0.3	14.0	3	3	3	3	0.349
319	3	13	VARBHP	-	1500	35	200	0.2	0.8	0.7	6227	1.8	0.3	14.0	3	3	3	3	0.356
320	3	13	VARRATE	12	1500	35	200	0.2	0.8	0.7	6227	1.8	0.3	14.0	3	3	3	3	0.346
321	4	1	CONBHP	15	500	15	250	0	1	1	4935	1.3	2.3	3.3	3	3	3	3	0.497
322	4	1	CRATE	4	500	15	250	0	1	1	4935	1.3	2.3	3.3	3	3	3	3	0.508
323	4	1	HYPRATE	12	500	15	250	0	1	1	4935	1.3	2.3	3.3	3	3	3	3	0.525
324	4	1	HYPRATE	16	500	15	250	0	1	1	4935	1.3	2.3	3.3	3	3	3	3	0.494
325	4	1	RANDRATE	8	500	15	250	0	1	1	4935	1.3	2.3	3.3	3	3	3	3	0.502
326	4	1	STEPBHP	-	500	15	250	0	1	1	4935	1.3	2.3	3.3	3	3	3	3	0.500

Case	PVT Set	k_r Set	Simulation Type	q_{oi} (STBD)	GOR_i (scf/STB)	API_i (API)	T_{Res} (°F)	S_{wi} (frac.)	S_{oi} (frac.)	$k_{ro,end}$ (frac.)	p_i (psi)	B_{oi} (RB/STB)	μ_{oi} (cp)	λ_{oi} (md/cp)	n_w	n_w	n_g	n_g	(Eq. B-1) ζ
327	4	1	VARBHP	-	500	15	250	0	1	1	4935	1.3	2.3	3.3	3	3	3	3	0.500
328	4	2	CONBHP	15	500	15	250	0.2	0.8	0.9	4935	1.3	2.3	3.0	3	3	3	3	0.466
329	4	2	CRATE	4	500	15	250	0.2	0.8	0.9	4935	1.3	2.3	3.0	3	3	3	3	0.461
330	4	2	HYPRATE	12	500	15	250	0.2	0.8	0.9	4935	1.3	2.3	3.0	3	3	3	3	0.460
331	4	2	HYPRATE	16	500	15	250	0.2	0.8	0.9	4935	1.3	2.3	3.0	3	3	3	3	0.460
332	4	2	HYPRATE	8	500	15	250	0.2	0.8	0.9	4935	1.3	2.3	3.0	3	3	3	3	0.463
333	4	2	RANDRATE	8	500	15	250	0.2	0.8	0.9	4935	1.3	2.3	3.0	3	3	3	3	0.461
334	4	2	STEPBHP	-	500	15	250	0.2	0.8	0.9	4935	1.3	2.3	3.0	3	3	3	3	0.467
335	4	2	VARBHP	-	500	15	250	0.2	0.8	0.9	4935	1.3	2.3	3.0	3	3	3	3	0.468
336	4	3	CONBHP	15	500	15	250	0.4	0.6	0.8	4935	1.3	2.3	2.6	3	3	3	3	0.430
337	4	3	CRATE	2	500	15	250	0.4	0.6	0.8	4935	1.3	2.3	2.6	3	3	3	3	0.427
338	4	3	CRATE	4	500	15	250	0.4	0.6	0.8	4935	1.3	2.3	2.6	3	3	3	3	0.422
339	4	3	HYPRATE	12	500	15	250	0.4	0.6	0.8	4935	1.3	2.3	2.6	3	3	3	3	0.423
340	4	3	HYPRATE	16	500	15	250	0.4	0.6	0.8	4935	1.3	2.3	2.6	3	3	3	3	0.424
341	4	3	HYPRATE	8	500	15	250	0.4	0.6	0.8	4935	1.3	2.3	2.6	3	3	3	3	0.422
342	4	3	RANDRATE	4	500	15	250	0.4	0.6	0.8	4935	1.3	2.3	2.6	3	3	3	3	0.425
343	4	3	RANDRATE	8	500	15	250	0.4	0.6	0.8	4935	1.3	2.3	2.6	3	3	3	3	0.422
344	4	3	STEPBHP	-	500	15	250	0.4	0.6	0.8	4935	1.3	2.3	2.6	3	3	3	3	0.429
345	4	3	VARBHP	-	500	15	250	0.4	0.6	0.8	4935	1.3	2.3	2.6	3	3	3	3	0.430
346	4	3	VARRATE	8	500	15	250	0.4	0.6	0.8	4935	1.3	2.3	2.6	3	3	3	3	0.422
347	4	4	CONBHP	15	500	15	250	0	1	1	4935	1.3	2.3	3.3	3	3	4	3	0.416
348	4	4	CRATE	4	500	15	250	0	1	1	4935	1.3	2.3	3.3	3	3	4	3	0.423
349	4	4	HYPRATE	12	500	15	250	0	1	1	4935	1.3	2.3	3.3	3	3	4	3	0.419
350	4	4	HYPRATE	16	500	15	250	0	1	1	4935	1.3	2.3	3.3	3	3	4	3	0.412
351	4	4	RANDRATE	8	500	15	250	0	1	1	4935	1.3	2.3	3.3	3	3	4	3	0.419
352	4	4	STEPBHP	-	500	15	250	0	1	1	4935	1.3	2.3	3.3	3	3	4	3	0.419
353	4	4	VARBHP	-	500	15	250	0	1	1	4935	1.3	2.3	3.3	3	3	4	3	0.420
354	4	5	CRATE	2	500	15	250	0.4	0.6	0.8	4935	1.3	2.3	2.6	3	3	4	3	0.334
355	4	5	CRATE	4	500	15	250	0.4	0.6	0.8	4935	1.3	2.3	2.6	3	3	4	3	0.330
356	4	5	HYPRATE	12	500	15	250	0.4	0.6	0.8	4935	1.3	2.3	2.6	3	3	4	3	0.331

Case	PVT Set	k_r Set	Simulation Type	q_{oi} (STBD)	GOR_i (scf/STB)	API_i (API)	T_{Res} (ºF)	S_{wi} (frac.)	S_{oi} (frac.)	$k_{ro,end}$ (frac.)	p_i (psi)	B_{oi} (RB/STB)	μ_{oi} (cp)	λ_{oi} (md/cp)	n_w	n_w	n_g	n_g	(Eq. B-1) ζ
357	4	5	HYPRATE	16	500	15	250	0.4	0.6	0.8	4935	1.3	2.3	2.6	3	3	4	3	0.332
358	4	5	HYPRATE	8	500	15	250	0.4	0.6	0.8	4935	1.3	2.3	2.6	3	3	4	3	0.330
359	4	5	RANDRATE	4	500	15	250	0.4	0.6	0.8	4935	1.3	2.3	2.6	3	3	4	3	0.333
360	4	5	RANDRATE	8	500	15	250	0.4	0.6	0.8	4935	1.3	2.3	2.6	3	3	4	3	0.330
361	4	5	STEPBHP	-	500	15	250	0.4	0.6	0.8	4935	1.3	2.3	2.6	3	3	4	3	0.338
362	4	5	VARBHP	-	500	15	250	0.4	0.6	0.8	4935	1.3	2.3	2.6	3	3	4	3	0.339
363	4	5	VARRATE	8	500	15	250	0.4	0.6	0.8	4935	1.3	2.3	2.6	3	3	4	3	0.330
364	4	6	CONBHP	15	500	15	250	0	1	1	4935	1.3	2.3	3.3	2	2	2	2	0.628
365	4	6	CRATE	4	500	15	250	0	1	1	4935	1.3	2.3	3.3	2	2	2	2	0.622
366	4	6	RANDRATE	8	500	15	250	0	1	1	4935	1.3	2.3	3.3	2	2	2	2	0.623
367	4	6	STEPBHP	-	500	15	250	0	1	1	4935	1.3	2.3	3.3	2	2	2	2	0.624
368	4	6	VARBHP	-	500	15	250	0	1	1	4935	1.3	2.3	3.3	2	2	2	2	0.628
369	4	6	VARRATE	12	500	15	250	0	1	1	4935	1.3	2.3	3.3	2	2	2	2	0.623
370	4	7	CONBHP	15	500	15	250	0.2	0.8	0.9	4935	1.3	2.3	3.0	2	2	2	2	0.663
371	4	7	CRATE	4	500	15	250	0.2	0.8	0.9	4935	1.3	2.3	3.0	2	2	2	2	0.658
372	4	7	STEPBHP	-	500	15	250	0.2	0.8	0.9	4935	1.3	2.3	3.0	2	2	2	2	0.659
373	4	7	VARBHP	-	500	15	250	0.2	0.8	0.9	4935	1.3	2.3	3.0	2	2	2	2	0.663
374	4	7	VARRATE	12	500	15	250	0.2	0.8	0.9	4935	1.3	2.3	3.0	2	2	2	2	0.659
375	4	8	CONBHP	15	500	15	250	0.4	0.6	0.8	4935	1.3	2.3	2.6	2	2	2	2	0.587
376	4	8	CRATE	4	500	15	250	0.4	0.6	0.8	4935	1.3	2.3	2.6	2	2	2	2	0.580
377	4	8	HYPRATE	13	500	15	250	0.4	0.6	0.8	4935	1.3	2.3	2.6	2	2	2	2	0.582
378	4	8	RANDRATE	10	500	15	250	0.4	0.6	0.8	4935	1.3	2.3	2.6	2	2	2	2	0.581
379	4	8	STEPBHP	-	500	15	250	0.4	0.6	0.8	4935	1.3	2.3	2.6	2	2	2	2	0.581
380	4	8	VARRATE	12	500	15	250	0.4	0.6	0.8	4935	1.3	2.3	2.6	2	2	2	2	0.582
381	4	9	CONBHP	15	500	15	250	0	1	1	4935	1.3	2.3	3.3	4	4	4	4	0.381
382	4	9	CRATE	4	500	15	250	0	1	1	4935	1.3	2.3	3.3	4	4	4	4	0.397
383	4	9	HYPRATE	17	500	15	250	0	1	1	4935	1.3	2.3	3.3	4	4	4	4	0.378
384	4	9	STEPBHP		500	15	250	0	1	1	4935	1.3	2.3	3.3	4	4	4	4	0.381
385	4	10	CONBHP	15	500	15	250	0.2	0.8	0.9	4935	1.3	2.3	3.0	4	4	4	4	0.334
386	4	10	CRATE	4	500	15	250	0.2	0.8	0.9	4935	1.3	2.3	3.0	4	4	4	4	0.332

Case	PVT Set	k_r Set	Simulation Type	q_{oi} (STBD)	GOR_i (scf/STB)	API_i (API)	T_{Res} (°F)	S_{wi} (frac.)	S_{oi} (frac.)	$k_{ro,end}$ (frac.)	p_i (psi)	B_{oi} (RB/STB)	μ_{oi} (cp)	λ_{oi} (md/cp)	n_w	n_w	n_g	n_g	(Eq. B-1) ζ
387	4	10	HYPRATE	17	500	15	250	0.2	0.8	0.9	4935	1.3	2.3	3.0	4	4	4	4	0.330
388	4	10	STEPBHP	-	500	15	250	0.2	0.8	0.9	4935	1.3	2.3	3.0	4	4	4	4	0.332
389	4	10	VARBHP	-	500	15	250	0.2	0.8	0.9	4935	1.3	2.3	3.0	4	4	4	4	0.346
390	4	10	VARRATE	12	500	15	250	0.2	0.8	0.9	4935	1.3	2.3	3.0	4	4	4	4	0.331
391	4	11	CONBHP	15	500	15	250	0.4	0.6	0.8	4935	1.3	2.3	2.6	4	4	4	4	0.292
392	4	11	CRATE	4	500	15	250	0.4	0.6	0.8	4935	1.3	2.3	2.6	4	4	4	4	0.287
393	4	11	HYPRATE	17	500	15	250	0.4	0.6	0.8	4935	1.3	2.3	2.6	4	4	4	4	0.290
394	4	11	RANDRATE	10	500	15	250	0.4	0.6	0.8	4935	1.3	2.3	2.6	4	4	4	4	0.291
395	4	11	STEPBHP	-	500	15	250	0.4	0.6	0.8	4935	1.3	2.3	2.6	4	4	4	4	0.289
396	4	11	VARBHP	-	500	15	250	0.4	0.6	0.8	4935	1.3	2.3	2.6	4	4	4	4	0.297
397	4	11	VARRATE	12	500	15	250	0.4	0.6	0.8	4935	1.3	2.3	2.6	4	4	4	4	0.288
398	4	12	CONBHP	15	500	15	250	0.1	0.9	0.9	4935	1.3	2.3	3.0	3	3	3	3	0.496
399	4	12	CRATE	4	500	15	250	0.1	0.9	0.9	4935	1.3	2.3	3.0	3	3	3	3	0.490
400	4	12	HYPRATE	13	500	15	250	0.1	0.9	0.9	4935	1.3	2.3	3.0	3	3	3	3	0.490
401	4	12	RANDRATE	10	500	15	250	0.1	0.9	0.9	4935	1.3	2.3	3.0	3	3	3	3	0.494
402	4	12	STEPBHP	-	500	15	250	0.1	0.9	0.9	4935	1.3	2.3	3.0	3	3	3	3	0.491
403	4	12	VARBHP	-	500	15	250	0.1	0.9	0.9	4935	1.3	2.3	3.0	3	3	3	3	0.500
404	4	12	VARRATE	12	500	15	250	0.1	0.9	0.9	4935	1.3	2.3	3.0	3	3	3	3	0.490
405	4	13	CONBHP	15	500	15	250	0.2	0.8	0.7	4935	1.3	2.3	2.3	3	3	3	3	0.465
406	4	13	CRATE	4	500	15	250	0.2	0.8	0.7	4935	1.3	2.3	2.3	3	3	3	3	0.459
407	4	13	HYPRATE	13	500	15	250	0.2	0.8	0.7	4935	1.3	2.3	2.3	3	3	3	3	0.460
408	4	13	RANDRATE	10	500	15	250	0.2	0.8	0.7	4935	1.3	2.3	2.3	3	3	3	3	0.462
409	4	13	STEPBHP	-	500	15	250	0.2	0.8	0.7	4935	1.3	2.3	2.3	3	3	3	3	0.461
410	4	13	VARBHP	-	500	15	250	0.2	0.8	0.7	4935	1.3	2.3	2.3	3	3	3	3	0.470
411	4	13	VARRATE	12	500	15	250	0.2	0.8	0.7	4935	1.3	2.3	2.3	3	3	3	3	0.459
412	5	1	CONBHP	15	1000	25	250	0	1	1	6587	1.5	0.5	13.0	3	3	3	3	0.419
413	5	1	CRATE	4	1000	25	250	0	1	1	6587	1.5	0.5	13.0	3	3	3	3	0.426
414	5	1	HYPRATE	16	1000	25	250	0	1	1	6587	1.5	0.5	13.0	3	3	3	3	0.417
415	5	1	RANDRATE	8	1000	25	250	0	1	1	6587	1.5	0.5	13.0	3	3	3	3	0.419
416	5	1	STEPBHP	-	1000	25	250	0	1	1	6587	1.5	0.5	13.0	3	3	3	3	0.419

Case	PVT Set	k_r Set	Simulation Type	q_{oi} (STBD)	GOR_i (scf/STB)	API_i (API)	T_{Res} (°F)	S_{wi} (frac.)	S_{oi} (frac.)	$k_{ro,end}$ (frac.)	p_i (psi)	B_{oi} (RB/STB)	μ_{oi} (cp)	λ_{oi} (md/cp)	n_w	n_w	n_g	n_g	(Eq. B-1) ζ
417	5	1	VARBHP	-	1000	25	250	0	1	1	6587	1.5	0.5	13.0	3	3	3	3	0.419
418	5	2	CONBHP	15	1000	25	250	0.2	0.8	0.9	6587	1.5	0.5	11.7	3	3	3	3	0.374
419	5	2	CRATE	4	1000	25	250	0.2	0.8	0.9	6587	1.5	0.5	11.7	3	3	3	3	0.366
420	5	2	HYPRATE	12	1000	25	250	0.2	0.8	0.9	6587	1.5	0.5	11.7	3	3	3	3	0.365
421	5	2	HYPRATE	16	1000	25	250	0.2	0.8	0.9	6587	1.5	0.5	11.7	3	3	3	3	0.365
422	5	2	HYPRATE	8	1000	25	250	0.2	0.8	0.9	6587	1.5	0.5	11.7	3	3	3	3	0.368
423	5	2	RANDRATE	8	1000	25	250	0.2	0.8	0.9	6587	1.5	0.5	11.7	3	3	3	3	0.366
424	5	2	STEPBHP	-	1000	25	250	0.2	0.8	0.9	6587	1.5	0.5	11.7	3	3	3	3	0.372
425	5	2	VARBHP	-	1000	25	250	0.2	0.8	0.9	6587	1.5	0.5	11.7	3	3	3	3	0.372
426	5	3	CONBHP	15	1000	25	250	0.4	0.6	0.8	6587	1.5	0.5	10.4	3	3	3	3	0.324
427	5	3	CRATE	2	1000	25	250	0.4	0.6	0.8	6587	1.5	0.5	10.4	3	3	3	3	0.317
428	5	3	CRATE	4	1000	25	250	0.4	0.6	0.8	6587	1.5	0.5	10.4	3	3	3	3	0.315
429	5	3	HYPRATE	12	1000	25	250	0.4	0.6	0.8	6587	1.5	0.5	10.4	3	3	3	3	0.315
430	5	3	HYPRATE	16	1000	25	250	0.4	0.6	0.8	6587	1.5	0.5	10.4	3	3	3	3	0.315
431	5	3	HYPRATE	8	1000	25	250	0.4	0.6	0.8	6587	1.5	0.5	10.4	3	3	3	3	0.315
432	5	3	RANDRATE	4	1000	25	250	0.4	0.6	0.8	6587	1.5	0.5	10.4	3	3	3	3	0.316
433	5	3	RANDRATE	8	1000	25	250	0.4	0.6	0.8	6587	1.5	0.5	10.4	3	3	3	3	0.315
434	5	3	STEPBHP	-	1000	25	250	0.4	0.6	0.8	6587	1.5	0.5	10.4	3	3	3	3	0.321
435	5	3	VARBHP	-	1000	25	250	0.4	0.6	0.8	6587	1.5	0.5	10.4	3	3	3	3	0.322
436	5	3	VARRATE	8	1000	25	250	0.4	0.6	0.8	6587	1.5	0.5	10.4	3	3	3	3	0.315
437	5	4	CONBHP	15	1000	25	250	0	1	1	6587	1.5	0.5	13.0	3	3	4	3	0.314
438	5	4	CRATE	4	1000	25	250	0	1	1	6587	1.5	0.5	13.0	3	3	4	3	0.313
439	5	4	HYPRATE	12	1000	25	250	0	1	1	6587	1.5	0.5	13.0	3	3	4	3	0.320
440	5	4	HYPRATE	16	1000	25	250	0	1	1	6587	1.5	0.5	13.0	3	3	4	3	0.306
441	5	4	RANDRATE	8	1000	25	250	0	1	1	6587	1.5	0.5	13.0	3	3	4	3	0.310
442	5	4	STEPBHP	-	1000	25	250	0	1	1	6587	1.5	0.5	13.0	3	3	4	3	0.315
443	5	4	VARBHP	-	1000	25	250	0	1	1	6587	1.5	0.5	13.0	3	3	4	3	0.315
444	5	5	CONBHP	15	1000	25	250	0.4	0.6	0.8	6587	1.5	0.5	10.4	3	3	4	3	0.218
445	5	5	CRATE	2	1000	25	250	0.4	0.6	0.8	6587	1.5	0.5	10.4	3	3	4	3	0.214
446	5	5	CRATE	4	1000	25	250	0.4	0.6	0.8	6587	1.5	0.5	10.4	3	3	4	3	0.212

Case	PVT Set	k_r Set	Simulation Type	q_{oi} (STBD)	GOR_i (scf/STB)	API_i (API)	T_{Res} (°F)	S_{wi} (frac.)	S_{oi} (frac.)	$k_{ro,end}$ (frac.)	p_i (psi)	B_{oi} (RB/STB)	μ_{oi} (cp)	λ_{oi} (md/cp)	n_w	n_w	n_g	n_g	(Eq. B-1) ζ
447	5	5	HYPRATE	12	1000	25	250	0.4	0.6	0.8	6587	1.5	0.5	10.4	3	3	4	3	0.212
448	5	5	HYPRATE	16	1000	25	250	0.4	0.6	0.8	6587	1.5	0.5	10.4	3	3	4	3	0.212
449	5	5	HYPRATE	8	1000	25	250	0.4	0.6	0.8	6587	1.5	0.5	10.4	3	3	4	3	0.212
450	5	5	RANDRATE	4	1000	25	250	0.4	0.6	0.8	6587	1.5	0.5	10.4	3	3	4	3	0.213
451	5	5	RANDRATE	8	1000	25	250	0.4	0.6	0.8	6587	1.5	0.5	10.4	3	3	4	3	0.212
452	5	5	STEPBHP	-	1000	25	250	0.4	0.6	0.8	6587	1.5	0.5	10.4	3	3	4	3	0.219
453	5	5	VARBHP	-	1000	25	250	0.4	0.6	0.8	6587	1.5	0.5	10.4	3	3	4	3	0.218
454	5	5	VARRATE	8	1000	25	250	0.4	0.6	0.8	6587	1.5	0.5	10.4	3	3	4	3	0.212
455	5	6	CONBHP	15	1000	25	250	0	1	1	6587	1.5	0.5	13.0	2	2	2	2	0.594
456	5	6	CRATE	4	1000	25	250	0	1	1	6587	1.5	0.5	13.0	2	2	2	2	0.585
457	5	6	RANDRATE	8	1000	25	250	0	1	1	6587	1.5	0.5	13.0	2	2	2	2	0.585
458	5	6	STEPBHP	-	1000	25	250	0	1	1	6587	1.5	0.5	13.0	2	2	2	2	0.587
459	5	6	VARBHP	-	1000	25	250	0	1	1	6587	1.5	0.5	13.0	2	2	2	2	0.589
460	5	6	VARRATE	12	1000	25	250	0	1	1	6587	1.5	0.5	13.0	2	2	2	2	0.586
461	5	7	CONBHP	15	1000	25	250	0.2	0.8	0.9	6587	1.5	0.5	11.7	2	2	2	2	0.641
462	5	7	CRATE	4	1000	25	250	0.2	0.8	0.9	6587	1.5	0.5	11.7	2	2	2	2	0.635
463	5	7	STEPBHP	-	1000	25	250	0.2	0.8	0.9	6587	1.5	0.5	11.7	2	2	2	2	0.636
464	5	7	VARBHP	-	1000	25	250	0.2	0.8	0.9	6587	1.5	0.5	11.7	2	2	2	2	0.638
465	5	7	VARRATE	12	1000	25	250	0.2	0.8	0.9	6587	1.5	0.5	11.7	2	2	2	2	0.635
466	5	8	CONBHP	15	1000	25	250	0.4	0.6	0.8	6587	1.5	0.5	10.4	2	2	2	2	0.516
467	5	8	CRATE	4	1000	25	250	0.4	0.6	0.8	6587	1.5	0.5	10.4	2	2	2	2	0.507
468	5	8	HYPRATE	13	1000	25	250	0.4	0.6	0.8	6587	1.5	0.5	10.4	2	2	2	2	0.507
469	5	8	RANDRATE	10	1000	25	250	0.4	0.6	0.8	6587	1.5	0.5	10.4	2	2	2	2	0.507
470	5	8	STEPBHP	-	1000	25	250	0.4	0.6	0.8	6587	1.5	0.5	10.4	2	2	2	2	0.509
471	5	8	VARRATE	12	1000	25	250	0.4	0.6	0.8	6587	1.5	0.5	10.4	2	2	2	2	0.507
472	5	9	CONBHP	15	1000	25	250	0	1	1	6587	1.5	0.5	13.0	4	4	4	4	0.282
473	5	9	CRATE	4	1000	25	250	0	1	1	6587	1.5	0.5	13.0	4	4	4	4	0.280
474	5	9	HYPRATE	17	1000	25	250	0	1	1	6587	1.5	0.5	13.0	4	4	4	4	0.275
475	5	9	RANDRATE	8	1000	25	250	0	1	1	6587	1.5	0.5	13.0	4	4	4	4	0.290
476	5	9	STEPBHP	-	1000	25	250	0	1	1	6587	1.5	0.5	13.0	4	4	4	4	0.278

Case	PVT Set	k_r Set	Simulation Type	q_{oi} (STBD)	GOR_i (scf/STB)	API_i (API)	T_{Res} (°F)	S_{wi} (frac.)	S_{oi} (frac.)	$k_{ro,end}$ (frac.)	p_i (psi)	B_{oi} (RB/STB)	μ_{oi} (cp)	λ_{oi} (md/cp)	n_w	n_w	n_g	n_g	(Eq. B-1) ζ
477	5	9	VARBHP	-	1000	25	250	0	1	1	6587	1.5	0.5	13.0	4	4	4	4	0.289
478	5	10	CONBHP	15	1000	25	250	0.2	0.8	0.9	6587	1.5	0.5	11.7	4	4	4	4	0.233
479	5	10	CRATE	4	1000	25	250	0.2	0.8	0.9	6587	1.5	0.5	11.7	4	4	4	4	0.229
480	5	10	HYPRATE	17	1000	25	250	0.2	0.8	0.9	6587	1.5	0.5	11.7	4	4	4	4	0.230
481	5	10	RANDRATE	10	1000	25	250	0.2	0.8	0.9	6587	1.5	0.5	11.7	4	4	4	4	0.231
482	5	10	STEPBHP	-	1000	25	250	0.2	0.8	0.9	6587	1.5	0.5	11.7	4	4	4	4	0.231
483	5	10	VARBHP	-	1000	25	250	0.2	0.8	0.9	6587	1.5	0.5	11.7	4	4	4	4	0.236
484	5	10	VARRATE	12	1000	25	250	0.2	0.8	0.9	6587	1.5	0.5	11.7	4	4	4	4	0.229
485	5	11	CONBHP	15	1000	25	250	0.4	0.6	0.8	6587	1.5	0.5	10.4	4	4	4	4	0.190
486	5	11	CRATE	4	1000	25	250	0.4	0.6	0.8	6587	1.5	0.5	10.4	4	4	4	4	0.186
487	5	11	HYPRATE	17	1000	25	250	0.4	0.6	0.8	6587	1.5	0.5	10.4	4	4	4	4	0.187
488	5	11	RANDRATE	10	1000	25	250	0.4	0.6	0.8	6587	1.5	0.5	10.4	4	4	4	4	0.187
489	5	11	STEPBHP	-	1000	25	250	0.4	0.6	0.8	6587	1.5	0.5	10.4	4	4	4	4	0.187
490	5	11	VARBHP	-	1000	25	250	0.4	0.6	0.8	6587	1.5	0.5	10.4	4	4	4	4	0.194
491	5	12	CONBHP	15	1000	25	250	0.1	0.9	0.9	6587	1.5	0.5	11.7	3	3	3	3	0.419
492	5	12	CRATE	4	1000	25	250	0.1	0.9	0.9	6587	1.5	0.5	11.7	3	3	3	3	0.411
493	5	12	HYPRATE	13	1000	25	250	0.1	0.9	0.9	6587	1.5	0.5	11.7	3	3	3	3	0.411
494	5	12	RANDRATE	10	1000	25	250	0.1	0.9	0.9	6587	1.5	0.5	11.7	3	3	3	3	0.412
495	5	12	STEPBHP	-	1000	25	250	0.1	0.9	0.9	6587	1.5	0.5	11.7	3	3	3	3	0.413
496	5	12	VARBHP	-	1000	25	250	0.1	0.9	0.9	6587	1.5	0.5	11.7	3	3	3	3	0.419
497	5	12	VARRATE	12	1000	25	250	0.1	0.9	0.9	6587	1.5	0.5	11.7	3	3	3	3	0.411
498	5	13	CONBHP	15	1000	25	250	0.2	0.8	0.7	6587	1.5	0.5	9.1	3	3	3	3	0.374
499	5	13	CRATE	4	1000	25	250	0.2	0.8	0.7	6587	1.5	0.5	9.1	3	3	3	3	0.365
500	5	13	HYPRATE	13	1000	25	250	0.2	0.8	0.7	6587	1.5	0.5	9.1	3	3	3	3	0.365
501	5	13	RANDRATE	10	1000	25	250	0.2	0.8	0.7	6587	1.5	0.5	9.1	3	3	3	3	0.366
502	5	13	STEPBHP	-	1000	25	250	0.2	0.8	0.7	6587	1.5	0.5	9.1	3	3	3	3	0.367
503	5	13	VARBHP	-	1000	25	250	0.2	0.8	0.7	6587	1.5	0.5	9.1	3	3	3	3	0.374
504	5	13	VARRATE	12	1000	25	250	0.2	0.8	0.7	6587	1.5	0.5	9.1	3	3	3	3	0.365
505	6	1	CONBHP	15	1500	35	250	0	1	1	6917	1.8	0.2	25.9	3	3	3	3	0.429
506	6	1	CRATE	6	1500	35	250	0	1	1	6917	1.8	0.2	25.9	3	3	3	3	0.420

Case	PVT Set	k_r Set	Simulation Type	q_{oi} (STBD)	GOR_i (scf/STB)	API_i (API)	T_{Res} (°F)	S_{wi} (frac.)	S_{oi} (frac.)	$k_{ro,end}$ (frac.)	p_i (psi)	B_{oi} (RB/STB)	μ_{oi} (cp)	λ_{oi} (md/cp)	n_w	n_w	n_g	n_g	(Eq. B-1) ζ
507	6	1	HYPRATE	10	1500	35	250	0	1	1	6917	1.8	0.2	25.9	3	3	3	3	0.429
508	6	1	HYPRATE	23	1500	35	250	0	1	1	6917	1.8	0.2	25.9	3	3	3	3	0.419
509	6	1	RANDRATE	10	1500	35	250	0	1	1	6917	1.8	0.2	25.9	3	3	3	3	0.420
510	6	1	RANDRATE	15	1500	35	250	0	1	1	6917	1.8	0.2	25.9	3	3	3	3	0.419
511	6	1	RANDRATE	8	1500	35	250	0	1	1	6917	1.8	0.2	25.9	3	3	3	3	0.426
512	6	1	STEPBHP	-	1500	35	250	0	1	1	6917	1.8	0.2	25.9	3	3	3	3	0.427
513	6	1	VARBHP	-	1500	35	250	0	1	1	6917	1.8	0.2	25.9	3	3	3	3	0.427
514	6	2	CONBHP	15	1500	35	250	0.2	0.8	0.9	6917	1.8	0.2	23.3	3	3	3	3	0.365
515	6	2	CRATE	3	1500	35	250	0.2	0.8	0.9	6917	1.8	0.2	23.3	3	3	3	3	0.356
516	6	2	CRATE	6	1500	35	250	0.2	0.8	0.9	6917	1.8	0.2	23.3	3	3	3	3	0.353
517	6	2	HYPRATE	10	1500	35	250	0.2	0.8	0.9	6917	1.8	0.2	23.3	3	3	3	3	0.353
518	6	2	HYPRATE	12	1500	35	250	0.2	0.8	0.9	6917	1.8	0.2	23.3	3	3	3	3	0.353
519	6	2	HYPRATE	23	1500	35	250	0.2	0.8	0.9	6917	1.8	0.2	23.3	3	3	3	3	0.353
520	6	2	RANDRATE	10	1500	35	250	0.2	0.8	0.9	6917	1.8	0.2	23.3	3	3	3	3	0.353
521	6	2	RANDRATE	15	1500	35	250	0.2	0.8	0.9	6917	1.8	0.2	23.3	3	3	3	3	0.353
522	6	2	RANDRATE	8	1500	35	250	0.2	0.8	0.9	6917	1.8	0.2	23.3	3	3	3	3	0.354
523	6	2	STEPBHP	-	1500	35	250	0.2	0.8	0.9	6917	1.8	0.2	23.3	3	3	3	3	0.361
524	6	2	VARBHP	-	1500	35	250	0.2	0.8	0.9	6917	1.8	0.2	23.3	3	3	3	3	0.361
525	6	2	VARRATE	12	1500	35	250	0.2	0.8	0.9	6917	1.8	0.2	23.3	3	3	3	3	0.353
526	6	3	CONBHP	15	1500	35	250	0.4	0.6	0.8	6917	1.8	0.2	20.7	3	3	3	3	0.296
527	6	3	CRATE	3	1500	35	250	0.4	0.6	0.8	6917	1.8	0.2	20.7	3	3	3	3	0.285
528	6	3	CRATE	6	1500	35	250	0.4	0.6	0.8	6917	1.8	0.2	20.7	3	3	3	3	0.285
529	6	3	HYPRATE	10	1500	35	250	0.4	0.6	0.8	6917	1.8	0.2	20.7	3	3	3	3	0.285
530	6	3	HYPRATE	12	1500	35	250	0.4	0.6	0.8	6917	1.8	0.2	20.7	3	3	3	3	0.285
531	6	3	HYPRATE	23	1500	35	250	0.4	0.6	0.8	6917	1.8	0.2	20.7	3	3	3	3	0.285
532	6	3	RANDRATE	10	1500	35	250	0.4	0.6	0.8	6917	1.8	0.2	20.7	3	3	3	3	0.285
533	6	3	RANDRATE	15	1500	35	250	0.4	0.6	0.8	6917	1.8	0.2	20.7	3	3	3	3	0.285
534	6	3	RANDRATE	8	1500	35	250	0.4	0.6	0.8	6917	1.8	0.2	20.7	3	3	3	3	0.285
535	6	3	STEPBHP	-	1500	35	250	0.4	0.6	0.8	6917	1.8	0.2	20.7	3	3	3	3	0.292
536	6	3	VARBHP	-	1500	35	250	0.4	0.6	0.8	6917	1.8	0.2	20.7	3	3	3	3	0.291

Case	PVT Set	k_r Set	Simulation Type	q_{oi} (STBD)	GOR_i (scf/STB)	API_i (API)	T_{Res} (°F)	S_{wi} (frac.)	S_{oi} (frac.)	$k_{ro,end}$ (frac.)	p_i (psi)	B_{oi} (RB/STB)	μ_{oi} (cp)	λ_{oi} (md/cp)	n_w	n_w	n_g	n_g	(Eq. B-1) ζ
537	6	3	VARRATE	12	1500	35	250	0.4	0.6	0.8	6917	1.8	0.2	20.7	3	3	3	3	0.285
538	6	3	VARRATE	8	1500	35	250	0.4	0.6	0.8	6917	1.8	0.2	20.7	3	3	3	3	0.285
539	6	4	CONBHP	15	1500	35	250	0	1	1	6917	1.8	0.2	25.9	3	3	4	3	0.292
540	6	4	CRATE	6	1500	35	250	0	1	1	6917	1.8	0.2	25.9	3	3	4	3	0.282
541	6	4	HYPRATE	10	1500	35	250	0	1	1	6917	1.8	0.2	25.9	3	3	4	3	0.282
542	6	4	HYPRATE	12	1500	35	250	0	1	1	6917	1.8	0.2	25.9	3	3	4	3	0.285
543	6	4	HYPRATE	23	1500	35	250	0	1	1	6917	1.8	0.2	25.9	3	3	4	3	0.282
544	6	4	RANDRATE	10	1500	35	250	0	1	1	6917	1.8	0.2	25.9	3	3	4	3	0.283
545	6	4	RANDRATE	15	1500	35	250	0	1	1	6917	1.8	0.2	25.9	3	3	4	3	0.282
546	6	4	RANDRATE	8	1500	35	250	0	1	1	6917	1.8	0.2	25.9	3	3	4	3	0.285
547	6	4	STEPBHP	-	1500	35	250	0	1	1	6917	1.8	0.2	25.9	3	3	4	3	0.291
548	6	4	VARBHP	-	1500	35	250	0	1	1	6917	1.8	0.2	25.9	3	3	4	3	0.291
549	6	4	VARRATE	12	1500	35	250	0	1	1	6917	1.8	0.2	25.9	3	3	4	3	0.285
550	6	5	CONBHP	15	1500	35	250	0.4	0.6	0.8	6917	1.8	0.2	20.7	3	3	4	3	0.183
551	6	5	CRATE	3	1500	35	250	0.4	0.6	0.8	6917	1.8	0.2	20.7	3	3	4	3	0.177
552	6	5	CRATE	6	1500	35	250	0.4	0.6	0.8	6917	1.8	0.2	20.7	3	3	4	3	0.177
553	6	5	HYPRATE	10	1500	35	250	0.4	0.6	0.8	6917	1.8	0.2	20.7	3	3	4	3	0.177
554	6	5	HYPRATE	12	1500	35	250	0.4	0.6	0.8	6917	1.8	0.2	20.7	3	3	4	3	0.177
555	6	5	HYPRATE	23	1500	35	250	0.4	0.6	0.8	6917	1.8	0.2	20.7	3	3	4	3	0.178
556	6	5	RANDRATE	10	1500	35	250	0.4	0.6	0.8	6917	1.8	0.2	20.7	3	3	4	3	0.177
557	6	5	RANDRATE	15	1500	35	250	0.4	0.6	0.8	6917	1.8	0.2	20.7	3	3	4	3	0.177
558	6	5	RANDRATE	8	1500	35	250	0.4	0.6	0.8	6917	1.8	0.2	20.7	3	3	4	3	0.177
559	6	5	STEPBHP	-	1500	35	250	0.4	0.6	0.8	6917	1.8	0.2	20.7	3	3	4	3	0.182
560	6	5	VARBHP	-	1500	35	250	0.4	0.6	0.8	6917	1.8	0.2	20.7	3	3	4	3	0.182
561	6	5	VARRATE	12	1500	35	250	0.4	0.6	0.8	6917	1.8	0.2	20.7	3	3	4	3	0.177
562	6	5	VARRATE	8	1500	35	250	0.4	0.6	0.8	6917	1.8	0.2	20.7	3	3	4	3	0.177
563	6	6	CRATE	4	1500	35	250	0	1	1	6917	1.8	0.2	25.9	2	2	2	2	0.658
564	6	6	STEPBHP	-	1500	35	250	0	1	1	6917	1.8	0.2	25.9	2	2	2	2	0.660
565	6	6	VARBHP	-	1500	35	250	0	1	1	6917	1.8	0.2	25.9	2	2	2	2	0.660
566	6	6	VARRATE	12	1500	35	250	0	1	1	6917	1.8	0.2	25.9	2	2	2	2	0.657

Case	PVT Set	k_r Set	Simulation Type	q_{oi} (STBD)	GOR_i (scf/STB)	API_i (API)	T_{Res} (°F)	S_{wi} (frac.)	S_{oi} (frac.)	$k_{ro,end}$ (frac.)	p_i (psi)	B_{oi} (RB/STB)	μ_{oi} (cp)	λ_{oi} (md/cp)	n_w	n_w	n_g	n_g	(Eq. B-1) ζ
567	6	7	CRATE	4	1500	35	250	0.2	0.8	0.9	6917	1.8	0.2	23.3	2	2	2	2	0.726
568	6	7	STEPBHP	-	1500	35	250	0.2	0.8	0.9	6917	1.8	0.2	23.3	2	2	2	2	0.728
569	6	7	VARBHP	-	1500	35	250	0.2	0.8	0.9	6917	1.8	0.2	23.3	2	2	2	2	0.729
570	6	7	VARRATE	12	1500	35	250	0.2	0.8	0.9	6917	1.8	0.2	23.3	2	2	2	2	0.726
571	6	8	CRATE	4	1500	35	250	0.4	0.6	0.8	6917	1.8	0.2	20.7	2	2	2	2	0.529
572	6	8	HYPRATE	13	1500	35	250	0.4	0.6	0.8	6917	1.8	0.2	20.7	2	2	2	2	0.529
573	6	8	STEPBHP	-	1500	35	250	0.4	0.6	0.8	6917	1.8	0.2	20.7	2	2	2	2	0.531
574	6	8	VARBHP	-	1500	35	250	0.4	0.6	0.8	6917	1.8	0.2	20.7	2	2	2	2	0.532
575	6	8	VARRATE	12	1500	35	250	0.4	0.6	0.8	6917	1.8	0.2	20.7	2	2	2	2	0.529
576	6	9	CONBHP	15	1500	35	250	0	1	1	6917	1.8	0.2	25.9	4	4	4	4	0.258
577	6	9	CRATE	4	1500	35	250	0	1	1	6917	1.8	0.2	25.9	4	4	4	4	0.253
578	6	9	HYPRATE	17	1500	35	250	0	1	1	6917	1.8	0.2	25.9	4	4	4	4	0.250
579	6	9	RANDRATE	8	1500	35	250	0	1	1	6917	1.8	0.2	25.9	4	4	4	4	0.257
580	6	9	STEPBHP	-	1500	35	250	0	1	1	6917	1.8	0.2	25.9	4	4	4	4	0.253
581	6	9	VARBHP	-	1500	35	250	0	1	1	6917	1.8	0.2	25.9	4	4	4	4	0.262
582	6	9	VARRATE	12	1500	35	250	0	1	1	6917	1.8	0.2	25.9	4	4	4	4	0.287
583	6	10	CONBHP	15	1500	35	250	0.2	0.8	0.9	6917	1.8	0.2	23.3	4	4	4	4	0.200
584	6	10	CRATE	4	1500	35	250	0.2	0.8	0.9	6917	1.8	0.2	23.3	4	4	4	4	0.197
585	6	10	HYPRATE	17	1500	35	250	0.2	0.8	0.9	6917	1.8	0.2	23.3	4	4	4	4	0.197
586	6	10	RANDRATE	10	1500	35	250	0.2	0.8	0.9	6917	1.8	0.2	23.3	4	4	4	4	0.197
587	6	10	STEPBHP	-	1500	35	250	0.2	0.8	0.9	6917	1.8	0.2	23.3	4	4	4	4	0.198
588	6	10	VARRATE	12	1500	35	250	0.2	0.8	0.9	6917	1.8	0.2	23.3	4	4	4	4	0.196
589	6	11	CONBHP	15	1500	35	250	0.4	0.6	0.8	6917	1.8	0.2	20.7	4	4	4	4	0.159
590	6	11	CRATE	4	1500	35	250	0.4	0.6	0.8	6917	1.8	0.2	20.7	4	4	4	4	0.155
591	6	11	HYPRATE	17	1500	35	250	0.4	0.6	0.8	6917	1.8	0.2	20.7	4	4	4	4	0.155
592	6	11	RANDRATE	10	1500	35	250	0.4	0.6	0.8	6917	1.8	0.2	20.7	4	4	4	4	0.155
593	6	11	STEPBHP	-	1500	35	250	0.4	0.6	0.8	6917	1.8	0.2	20.7	4	4	4	4	0.156
594	6	11	VARBHP	-	1500	35	250	0.4	0.6	0.8	6917	1.8	0.2	20.7	4	4	4	4	0.160
595	6	11	VARRATE	12	1500	35	250	0.4	0.6	0.8	6917	1.8	0.2	20.7	4	4	4	4	0.155
596	6	12	CONBHP	15	1500	35	250	0.1	0.9	0.9	6917	1.8	0.2	23.3	3	3	3	3	0.429

Case	PVT Set	k_r Set	Simulation Type	q_{oi} (STBD)	GOR_i (scf/STB)	API_i (API)	T_{Res} (°F)	S_{wi} (frac.)	S_{oi} (frac.)	$k_{ro,end}$ (frac.)	p_i (psi)	B_{oi} (RB/STB)	μ_{oi} (cp)	λ_{oi} (md/cp)	n_w	n_w	n_g	n_g	(Eq. B-1) ζ
597	6	12	CRATE	4	1500	35	250	0.1	0.9	0.9	6917	1.8	0.2	23.3	3	3	3	3	0.418
598	6	12	HYPRATE	13	1500	35	250	0.1	0.9	0.9	6917	1.8	0.2	23.3	3	3	3	3	0.418
599	6	12	RANDRATE	10	1500	35	250	0.1	0.9	0.9	6917	1.8	0.2	23.3	3	3	3	3	0.420
600	6	12	STEPBHP	-	1500	35	250	0.1	0.9	0.9	6917	1.8	0.2	23.3	3	3	3	3	0.421
601	6	12	VARBHP	-	1500	35	250	0.1	0.9	0.9	6917	1.8	0.2	23.3	3	3	3	3	0.427
602	6	12	VARRATE	12	1500	35	250	0.1	0.9	0.9	6917	1.8	0.2	23.3	3	3	3	3	0.419
603	6	13	CONBHP	15	1500	35	250	0.2	0.8	0.7	6917	1.8	0.2	18.1	3	3	3	3	0.365
604	6	13	CRATE	4	1500	35	250	0.2	0.8	0.7	6917	1.8	0.2	18.1	3	3	3	3	0.353
605	6	13	HYPRATE	13	1500	35	250	0.2	0.8	0.7	6917	1.8	0.2	18.1	3	3	3	3	0.353
606	6	13	RANDRATE	10	1500	35	250	0.2	0.8	0.7	6917	1.8	0.2	18.1	3	3	3	3	0.354
607	6	13	STEPBHP	-	1500	35	250	0.2	0.8	0.7	6917	1.8	0.2	18.1	3	3	3	3	0.356
608	6	13	VARBHP	-	1500	35	250	0.2	0.8	0.7	6917	1.8	0.2	18.1	3	3	3	3	0.362
609	6	13	VARRATE	12	1500	35	250	0.2	0.8	0.7	6917	1.8	0.2	18.1	3	3	3	3	0.353
610	7	1	CONBHP	15	500	15	150	0	1	1	3998	1.2	12.4	0.7	3	3	3	3	0.466
611	7	1	HYPRATE	10	500	15	150	0	1	1	3998	1.2	12.4	0.7	3	3	3	3	0.466
612	7	1	HYPRATE	5	500	15	150	0	1	1	3998	1.2	12.4	0.7	3	3	3	3	0.479
613	7	1	RANDRATE	5	500	15	150	0	1	1	3998	1.2	12.4	0.7	3	3	3	3	0.484
614	7	1	RANDRATE	8	500	15	150	0	1	1	3998	1.2	12.4	0.7	3	3	3	3	0.472
615	7	1	STEPBHP	-	500	15	150	0	1	1	3998	1.2	12.4	0.7	3	3	3	3	0.479
616	7	1	VARBHP	-	500	15	150	0	1	1	3998	1.2	12.4	0.7	3	3	3	3	0.475
617	7	1	VARRATE	12	500	15	150	0	1	1	3998	1.2	12.4	0.7	3	3	3	3	0.466
618	7	2	CONBHP	15	500	15	150	0.2	0.8	0.9	3998	1.2	12.4	0.6	3	3	3	3	0.437
619	7	2	CRATE	2	500	15	150	0.2	0.8	0.9	3998	1.2	12.4	0.6	3	3	3	3	0.447
620	7	2	HYPRATE	10	500	15	150	0.2	0.8	0.9	3998	1.2	12.4	0.6	3	3	3	3	0.437
621	7	2	HYPRATE	5	500	15	150	0.2	0.8	0.9	3998	1.2	12.4	0.6	3	3	3	3	0.436
622	7	2	RANDRATE	3	500	15	150	0.2	0.8	0.9	3998	1.2	12.4	0.6	3	3	3	3	0.462
623	7	2	RANDRATE	5	500	15	150	0.2	0.8	0.9	3998	1.2	12.4	0.6	3	3	3	3	0.439
624	7	2	RANDRATE	8	500	15	150	0.2	0.8	0.9	3998	1.2	12.4	0.6	3	3	3	3	0.436
625	7	2	STEPBHP	-	500	15	150	0.2	0.8	0.9	3998	1.2	12.4	0.6	3	3	3	3	0.448
626	7	2	VARBHP	-	500	15	150	0.2	0.8	0.9	3998	1.2	12.4	0.6	3	3	3	3	0.445

Case	PVT Set	k_r Set	Simulation Type	q_{oi} (STBD)	GOR_i (scf/STB)	API_i (API)	T_{Res} (ºF)	S_{wi} (frac.)	S_{oi} (frac.)	$k_{ro,end}$ (frac.)	p_i (psi)	B_{oi} (RB/STB)	μ_{oi} (cp)	λ_{oi} (md/cp)	n_w	n_w	n_g	n_g	(Eq. B-1) ζ
627	7	2	VARRATE	12	500	15	150	0.2	0.8	0.9	3998	1.2	12.4	0.6	3	3	3	3	0.437
628	7	3	CONBHP	15	500	15	150	0.4	0.6	0.8	3998	1.2	12.4	0.5	3	3	3	3	0.395
629	7	3	CRATE	1	500	15	150	0.4	0.6	0.8	3998	1.2	12.4	0.5	3	3	3	3	0.414
630	7	3	CRATE	2	500	15	150	0.4	0.6	0.8	3998	1.2	12.4	0.5	3	3	3	3	0.393
631	7	3	HYPRATE	10	500	15	150	0.4	0.6	0.8	3998	1.2	12.4	0.5	3	3	3	3	0.395
632	7	3	HYPRATE	2	500	15	150	0.4	0.6	0.8	3998	1.2	12.4	0.5	3	3	3	3	0.401
633	7	3	HYPRATE	5	500	15	150	0.4	0.6	0.8	3998	1.2	12.4	0.5	3	3	3	3	0.392
634	7	3	RANDRATE	3	500	15	150	0.4	0.6	0.8	3998	1.2	12.4	0.5	3	3	3	3	0.394
635	7	3	RANDRATE	5	500	15	150	0.4	0.6	0.8	3998	1.2	12.4	0.5	3	3	3	3	0.392
636	7	3	RANDRATE	8	500	15	150	0.4	0.6	0.8	3998	1.2	12.4	0.5	3	3	3	3	0.392
637	7	3	STEPBHP	-	500	15	150	0.4	0.6	0.8	3998	1.2	12.4	0.5	3	3	3	3	0.402
638	7	3	VARBHP	-	500	15	150	0.4	0.6	0.8	3998	1.2	12.4	0.5	3	3	3	3	0.402
639	7	3	VARRATE	12	500	15	150	0.4	0.6	0.8	3998	1.2	12.4	0.5	3	3	3	3	0.395
640	7	4	CONBHP	15	500	15	150	0	1	1	3998	1.2	12.4	0.7	3	3	4	3	0.403
641	7	4	HYPRATE	10	500	15	150	0	1	1	3998	1.2	12.4	0.7	3	3	4	3	0.403
642	7	4	HYPRATE	5	500	15	150	0	1	1	3998	1.2	12.4	0.7	3	3	4	3	0.412
643	7	4	RANDRATE	5	500	15	150	0	1	1	3998	1.2	12.4	0.7	3	3	4	3	0.419
644	7	4	RANDRATE	8	500	15	150	0	1	1	3998	1.2	12.4	0.7	3	3	4	3	0.406
645	7	4	STEPBHP	-	500	15	150	0	1	1	3998	1.2	12.4	0.7	3	3	4	3	0.416
646	7	4	VARBHP	-	500	15	150	0	1	1	3998	1.2	12.4	0.7	3	3	4	3	0.411
647	7	4	VARRATE	12	500	15	150	0	1	1	3998	1.2	12.4	0.7	3	3	4	3	0.403
648	7	5	CONBHP	15	500	15	150	0.4	0.6	0.8	3998	1.2	12.4	0.5	3	3	4	3	0.323
649	7	5	CRATE	1	500	15	150	0.4	0.6	0.8	3998	1.2	12.4	0.5	3	3	4	3	0.338
650	7	5	CRATE	2	500	15	150	0.4	0.6	0.8	3998	1.2	12.4	0.5	3	3	4	3	0.322
651	7	5	HYPRATE	10	500	15	150	0.4	0.6	0.8	3998	1.2	12.4	0.5	3	3	4	3	0.323
652	7	5	HYPRATE	2	500	15	150	0.4	0.6	0.8	3998	1.2	12.4	0.5	3	3	4	3	0.328
653	7	5	HYPRATE	5	500	15	150	0.4	0.6	0.8	3998	1.2	12.4	0.5	3	3	4	3	0.322
654	7	5	RANDRATE	3	500	15	150	0.4	0.6	0.8	3998	1.2	12.4	0.5	3	3	4	3	0.324
655	7	5	RANDRATE	5	500	15	150	0.4	0.6	0.8	3998	1.2	12.4	0.5	3	3	4	3	0.322
656	7	5	RANDRATE	8	500	15	150	0.4	0.6	0.8	3998	1.2	12.4	0.5	3	3	4	3	0.322

Case	PVT Set	k_r Set	Simulation Type	q_{oi} (STBD)	GOR_i (scf/STB)	API_i (API)	T_{Res} (°F)	S_{wi} (frac.)	S_{oi} (frac.)	$k_{ro,end}$ (frac.)	p_i (psi)	B_{oi} (RB/STB)	μ_{oi} (cp)	λ_{oi} (md/cp)	n_w	n_w	n_g	n_g	(Eq. B-1) ζ
657	7	5	STEPBHP	-	500	15	150	0.4	0.6	0.8	3998	1.2	12.4	0.5	3	3	4	3	0.330
658	7	5	VARBHP	-	500	15	150	0.4	0.6	0.8	3998	1.2	12.4	0.5	3	3	4	3	0.329
659	7	5	VARRATE	12	500	15	150	0.4	0.6	0.8	3998	1.2	12.4	0.5	3	3	4	3	0.323
660	7	6	CONBHP	15	500	15	150	0	1	1	3998	1.2	12.4	0.7	2	2	2	2	0.562
661	7	6	CRATE	4	500	15	150	0	1	1	3998	1.2	12.4	0.7	2	2	2	2	0.560
662	7	6	RANDRATE	8	500	15	150	0	1	1	3998	1.2	12.4	0.7	2	2	2	2	0.562
663	7	6	STEPBHP	-	500	15	150	0	1	1	3998	1.2	12.4	0.7	2	2	2	2	0.562
664	7	6	VARBHP	-	500	15	150	0	1	1	3998	1.2	12.4	0.7	2	2	2	2	0.571
665	7	6	VARRATE	12	500	15	150	0	1	1	3998	1.2	12.4	0.7	2	2	2	2	0.562
666	7	7	CONBHP	15	500	15	150	0.2	0.8	0.9	3998	1.2	12.4	0.6	2	2	2	2	0.590
667	7	7	CRATE	4	500	15	150	0.2	0.8	0.9	3998	1.2	12.4	0.6	2	2	2	2	0.589
668	7	7	STEPBHP	-	500	15	150	0.2	0.8	0.9	3998	1.2	12.4	0.6	2	2	2	2	0.590
669	7	7	VARBHP	-	500	15	150	0.2	0.8	0.9	3998	1.2	12.4	0.6	2	2	2	2	0.598
670	7	7	VARRATE	12	500	15	150	0.2	0.8	0.9	3998	1.2	12.4	0.6	2	2	2	2	0.590
671	7	8	CONBHP	15	500	15	150	0.4	0.6	0.8	3998	1.2	12.4	0.5	2	2	2	2	0.530
672	7	8	CRATE	4	500	15	150	0.4	0.6	0.8	3998	1.2	12.4	0.5	2	2	2	2	0.525
673	7	8	HYPRATE	13	500	15	150	0.4	0.6	0.8	3998	1.2	12.4	0.5	2	2	2	2	0.530
674	7	8	RANDRATE	10	500	15	150	0.4	0.6	0.8	3998	1.2	12.4	0.5	2	2	2	2	0.528
675	7	8	STEPBHP	-	500	15	150	0.4	0.6	0.8	3998	1.2	12.4	0.5	2	2	2	2	0.527
676	7	8	VARBHP	-	500	15	150	0.4	0.6	0.8	3998	1.2	12.4	0.5	2	2	2	2	0.537
677	7	8	VARRATE	12	500	15	150	0.4	0.6	0.8	3998	1.2	12.4	0.5	2	2	2	2	0.530
678	7	9	CONBHP	15	500	15	150	0	1	1	3998	1.2	12.4	0.7	4	4	4	4	0.381
679	7	9	CRATE	4	500	15	150	0	1	1	3998	1.2	12.4	0.7	4	4	4	4	0.394
680	7	9	HYPRATE	17	500	15	150	0	1	1	3998	1.2	12.4	0.7	4	4	4	4	0.381
681	7	9	STEPBHP	-	500	15	150	0	1	1	3998	1.2	12.4	0.7	4	4	4	4	0.393
682	7	9	VARRATE	12	500	15	150	0	1	1	3998	1.2	12.4	0.7	4	4	4	4	0.382
683	7	10	CONBHP	15	500	15	150	0.2	0.8	0.9	3998	1.2	12.4	0.6	4	4	4	4	0.329
684	7	10	CRATE	4	500	15	150	0.2	0.8	0.9	3998	1.2	12.4	0.6	4	4	4	4	0.333
685	7	10	HYPRATE	17	500	15	150	0.2	0.8	0.9	3998	1.2	12.4	0.6	4	4	4	4	0.329
686	7	10	STEPBHP	-	500	15	150	0.2	0.8	0.9	3998	1.2	12.4	0.6	4	4	4	4	0.336

Case	PVT Set	k_r Set	Simulation Type	q_{oi} (STBD)	GOR_i (scf/STB)	API_i (API)	T_{Res} (°F)	S_{wi} (frac.)	S_{oi} (frac.)	$k_{ro,end}$ (frac.)	p_i (psi)	B_{oi} (RB/STB)	μ_{oi} (cp)	λ_{oi} (md/cp)	n_w	n_w	n_g	n_g	(Eq. B-1) ζ
687	7	10	VARRATE	12	500	15	150	0.2	0.8	0.9	3998	1.2	12.4	0.6	4	4	4	4	0.329
688	7	11	CONBHP	15	500	15	150	0.4	0.6	0.8	3998	1.2	12.4	0.5	4	4	4	4	0.278
689	7	11	CRATE	4	500	15	150	0.4	0.6	0.8	3998	1.2	12.4	0.5	4	4	4	4	0.279
690	7	11	HYPRATE	17	500	15	150	0.4	0.6	0.8	3998	1.2	12.4	0.5	4	4	4	4	0.278
691	7	11	RANDRATE	10	500	15	150	0.4	0.6	0.8	3998	1.2	12.4	0.5	4	4	4	4	0.294
692	7	11	STEPBHP	-	500	15	150	0.4	0.6	0.8	3998	1.2	12.4	0.5	4	4	4	4	0.280
693	7	11	VARBHP	-	500	15	150	0.4	0.6	0.8	3998	1.2	12.4	0.5	4	4	4	4	0.300
694	7	11	VARRATE	12	500	15	150	0.4	0.6	0.8	3998	1.2	12.4	0.5	4	4	4	4	0.278
695	7	12	CONBHP	15	500	15	150	0.1	0.9	0.9	3998	1.2	12.4	0.6	3	3	3	3	0.456
696	7	12	CRATE	4	500	15	150	0.1	0.9	0.9	3998	1.2	12.4	0.6	3	3	3	3	0.458
697	7	12	HYPRATE	13	500	15	150	0.1	0.9	0.9	3998	1.2	12.4	0.6	3	3	3	3	0.456
698	7	12	RANDRATE	10	500	15	150	0.1	0.9	0.9	3998	1.2	12.4	0.6	3	3	3	3	0.469
699	7	12	STEPBHP	-	500	15	150	0.1	0.9	0.9	3998	1.2	12.4	0.6	3	3	3	3	0.459
700	7	12	VARBHP	-	500	15	150	0.1	0.9	0.9	3998	1.2	12.4	0.6	3	3	3	3	0.475
701	7	12	VARRATE	12	500	15	150	0.1	0.9	0.9	3998	1.2	12.4	0.6	3	3	3	3	0.456
702	7	13	CONBHP	15	500	15	150	0.2	0.8	0.7	3998	1.2	12.4	0.5	3	3	3	3	0.434
703	7	13	CRATE	4	500	15	150	0.2	0.8	0.7	3998	1.2	12.4	0.5	3	3	3	3	0.432
704	7	13	HYPRATE	13	500	15	150	0.2	0.8	0.7	3998	1.2	12.4	0.5	3	3	3	3	0.434
705	7	13	RANDRATE	10	500	15	150	0.2	0.8	0.7	3998	1.2	12.4	0.5	3	3	3	3	0.445
706	7	13	STEPBHP	-	500	15	150	0.2	0.8	0.7	3998	1.2	12.4	0.5	3	3	3	3	0.434
707	7	13	VARBHP	-	500	15	150	0.2	0.8	0.7	3998	1.2	12.4	0.5	3	3	3	3	0.453
708	7	13	VARRATE	12	500	15	150	0.2	0.8	0.7	3998	1.2	12.4	0.5	3	3	3	3	0.434
709	8	1	CONBHP	15	1000	25	150	0	1	1	5337	1.5	1.2	5.9	3	3	3	3	0.392
710	8	1	CRATE	4	1000	25	150	0	1	1	5337	1.5	1.2	5.9	3	3	3	3	0.390
711	8	1	HYPRATE	10	1000	25	150	0	1	1	5337	1.5	1.2	5.9	3	3	3	3	0.388
712	8	1	RANDRATE	10	1000	25	150	0	1	1	5337	1.5	1.2	5.9	3	3	3	3	0.387
713	8	1	RANDRATE	5	1000	25	150	0	1	1	5337	1.5	1.2	5.9	3	3	3	3	0.409
714	8	1	RANDRATE	8	1000	25	150	0	1	1	5337	1.5	1.2	5.9	3	3	3	3	0.389
715	8	1	STEPBHP	-	1000	25	150	0	1	1	5337	1.5	1.2	5.9	3	3	3	3	0.397
716	8	1	VARBHP	-	1000	25	150	0	1	1	5337	1.5	1.2	5.9	3	3	3	3	0.397

Case	PVT Set	k_r Set	Simulation Type	q_{oi} (STBD)	GOR_i (scf/STB)	API_i (API)	T_{Res} (°F)	S_{wi} (frac.)	S_{oi} (frac.)	$k_{ro,end}$ (frac.)	p_i (psi)	B_{oi} (RB/STB)	μ_{oi} (cp)	λ_{oi} (md/cp)	n_w	n_w	n_g	n_g	(Eq. B-1) ζ
717	8	1	VARRATE	12	1000	25	150	0	1	1	5337	1.5	1.2	5.9	3	3	3	3	0.387
718	8	2	CONBHP	15	1000	25	150	0.2	0.8	0.9	5337	1.5	1.2	5.3	3	3	3	3	0.354
719	8	2	CRATE	2	1000	25	150	0.2	0.8	0.9	5337	1.5	1.2	5.3	3	3	3	3	0.356
720	8	2	CRATE	4	1000	25	150	0.2	0.8	0.9	5337	1.5	1.2	5.3	3	3	3	3	0.348
721	8	2	HYPRATE	10	1000	25	150	0.2	0.8	0.9	5337	1.5	1.2	5.3	3	3	3	3	0.348
722	8	2	HYPRATE	5	1000	25	150	0.2	0.8	0.9	5337	1.5	1.2	5.3	3	3	3	3	0.350
723	8	2	RANDRATE	10	1000	25	150	0.2	0.8	0.9	5337	1.5	1.2	5.3	3	3	3	3	0.348
724	8	2	RANDRATE	5	1000	25	150	0.2	0.8	0.9	5337	1.5	1.2	5.3	3	3	3	3	0.350
725	8	2	RANDRATE	8	1000	25	150	0.2	0.8	0.9	5337	1.5	1.2	5.3	3	3	3	3	0.348
726	8	2	STEPBHP	-	1000	25	150	0.2	0.8	0.9	5337	1.5	1.2	5.3	3	3	3	3	0.357
727	8	2	VARBHP	-	1000	25	150	0.2	0.8	0.9	5337	1.5	1.2	5.3	3	3	3	3	0.358
728	8	2	VARRATE	12	1000	25	150	0.2	0.8	0.9	5337	1.5	1.2	5.3	3	3	3	3	0.349
729	8	3	CONBHP	15	1000	25	150	0.4	0.6	0.8	5337	1.5	1.2	4.7	3	3	3	3	0.311
730	8	3	CRATE	2	1000	25	150	0.4	0.6	0.8	5337	1.5	1.2	4.7	3	3	3	3	0.303
731	8	3	CRATE	4	1000	25	150	0.4	0.6	0.8	5337	1.5	1.2	4.7	3	3	3	3	0.302
732	8	3	HYPRATE	10	1000	25	150	0.4	0.6	0.8	5337	1.5	1.2	4.7	3	3	3	3	0.303
733	8	3	HYPRATE	5	1000	25	150	0.4	0.6	0.8	5337	1.5	1.2	4.7	3	3	3	3	0.302
734	8	3	RANDRATE	10	1000	25	150	0.4	0.6	0.8	5337	1.5	1.2	4.7	3	3	3	3	0.303
735	8	3	RANDRATE	5	1000	25	150	0.4	0.6	0.8	5337	1.5	1.2	4.7	3	3	3	3	0.302
736	8	3	RANDRATE	8	1000	25	150	0.4	0.6	0.8	5337	1.5	1.2	4.7	3	3	3	3	0.302
737	8	3	STEPBHP	-	1000	25	150	0.4	0.6	0.8	5337	1.5	1.2	4.7	3	3	3	3	0.311
738	8	3	VARBHP	-	1000	25	150	0.4	0.6	0.8	5337	1.5	1.2	4.7	3	3	3	3	0.313
739	8	3	VARRATE	12	1000	25	150	0.4	0.6	0.8	5337	1.5	1.2	4.7	3	3	3	3	0.304
740	8	3	VARRATE	5	1000	25	150	0.4	0.6	0.8	5337	1.5	1.2	4.7	3	3	3	3	0.303
741	8	4	CONBHP	15	1000	25	150	0	1	1	5337	1.5	1.2	5.9	3	3	4	3	0.300
742	8	4	CRATE	4	1000	25	150	0	1	1	5337	1.5	1.2	5.9	3	3	4	3	0.297
743	8	4	HYPRATE	10	1000	25	150	0	1	1	5337	1.5	1.2	5.9	3	3	4	3	0.295
744	8	4	RANDRATE	10	1000	25	150	0	1	1	5337	1.5	1.2	5.9	3	3	4	3	0.296
745	8	4	RANDRATE	5	1000	25	150	0	1	1	5337	1.5	1.2	5.9	3	3	4	3	0.307
746	8	4	RANDRATE	8	1000	25	150	0	1	1	5337	1.5	1.2	5.9	3	3	4	3	0.297

Case	PVT Set	k_r Set	Simulation Type	q_{oi} (STBD)	GOR_i (scf/STB)	API_i (API)	T_{Res} (°F)	S_{wi} (frac.)	S_{oi} (frac.)	$k_{ro,end}$ (frac.)	p_i (psi)	B_{oi} (RB/STB)	μ_{oi} (cp)	λ_{oi} (md/cp)	n_w	n_w	n_g	n_g	(Eq. B-1) ζ
747	8	4	STEPBHP	-	1000	25	150	0	1	1	5337	1.5	1.2	5.9	3	3	4	3	0.305
748	8	4	VARBHP	-	1000	25	150	0	1	1	5337	1.5	1.2	5.9	3	3	4	3	0.305
749	8	4	VARRATE	10	1000	25	150	0	1	1	5337	1.5	1.2	5.9	3	3	4	3	0.295
750	8	4	VARRATE	12	1000	25	150	0	1	1	5337	1.5	1.2	5.9	3	3	4	3	0.295
751	8	5	CONBHP	15	1000	25	150	0.4	0.6	0.8	5337	1.5	1.2	4.7	3	3	4	3	0.207
752	8	5	CRATE	2	1000	25	150	0.4	0.6	0.8	5337	1.5	1.2	4.7	3	3	4	3	0.201
753	8	5	CRATE	4	1000	25	150	0.4	0.6	0.8	5337	1.5	1.2	4.7	3	3	4	3	0.201
754	8	5	HYPRATE	10	1000	25	150	0.4	0.6	0.8	5337	1.5	1.2	4.7	3	3	4	3	0.202
755	8	5	HYPRATE	5	1000	25	150	0.4	0.6	0.8	5337	1.5	1.2	4.7	3	3	4	3	0.201
756	8	5	RANDRATE	10	1000	25	150	0.4	0.6	0.8	5337	1.5	1.2	4.7	3	3	4	3	0.202
757	8	5	RANDRATE	5	1000	25	150	0.4	0.6	0.8	5337	1.5	1.2	4.7	3	3	4	3	0.201
758	8	5	RANDRATE	6	1000	25	150	0.4	0.6	0.8	5337	1.5	1.2	4.7	3	3	4	3	0.201
759	8	5	RANDRATE	8	1000	25	150	0.4	0.6	0.8	5337	1.5	1.2	4.7	3	3	4	3	0.201
760	8	5	STEPBHP	-	1000	25	150	0.4	0.6	0.8	5337	1.5	1.2	4.7	3	3	4	3	0.209
761	8	5	VARBHP	-	1000	25	150	0.4	0.6	0.8	5337	1.5	1.2	4.7	3	3	4	3	0.209
762	8	5	VARRATE	10	1000	25	150	0.4	0.6	0.8	5337	1.5	1.2	4.7	3	3	4	3	0.203
763	8	5	VARRATE	12	1000	25	150	0.4	0.6	0.8	5337	1.5	1.2	4.7	3	3	4	3	0.203
764	8	5	VARRATE	5	1000	25	150	0.4	0.6	0.8	5337	1.5	1.2	4.7	3	3	4	3	0.201
765	8	6	CONBHP	15	1000	25	150	0	1	1	5337	1.5	1.2	5.9	2	2	2	2	0.550
766	8	6	CRATE	4	1000	25	150	0	1	1	5337	1.5	1.2	5.9	2	2	2	2	0.544
767	8	6	RANDRATE	8	1000	25	150	0	1	1	5337	1.5	1.2	5.9	2	2	2	2	0.545
768	8	6	STEPBHP	-	1000	25	150	0	1	1	5337	1.5	1.2	5.9	2	2	2	2	0.547
769	8	6	VARBHP	-	1000	25	150	0	1	1	5337	1.5	1.2	5.9	2	2	2	2	0.553
770	8	6	VARRATE	12	1000	25	150	0	1	1	5337	1.5	1.2	5.9	2	2	2	2	0.545
771	8	7	CONBHP	15	1000	25	150	0.2	0.8	0.9	5337	1.5	1.2	5.3	2	2	2	2	0.603
772	8	7	CRATE	4	1000	25	150	0.2	0.8	0.9	5337	1.5	1.2	5.3	2	2	2	2	0.598
773	8	7	STEPBHP	-	1000	25	150	0.2	0.8	0.9	5337	1.5	1.2	5.3	2	2	2	2	0.599
774	8	7	VARBHP	-	1000	25	150	0.2	0.8	0.9	5337	1.5	1.2	5.3	2	2	2	2	0.604
775	8	7	VARRATE	12	1000	25	150	0.2	0.8	0.9	5337	1.5	1.2	5.3	2	2	2	2	0.599
776	8	8	CONBHP	15	1000	25	150	0.4	0.6	0.8	5337	1.5	1.2	4.7	2	2	2	2	0.484

Case	PVT Set	k_r Set	Simulation Type	q_{oi} (STBD)	GOR_i (scf/STB)	API_i (API)	T_{Res} (°F)	S_{wi} (frac.)	S_{oi} (frac.)	$k_{ro,end}$ (frac.)	p_i (psi)	B_{oi} (RB/STB)	μ_{oi} (cp)	λ_{oi} (md/cp)	n_w	n_w	n_g	n_g	(Eq. B-1) ζ
777	8	8	CRATE	4	1000	25	150	0.4	0.6	0.8	5337	1.5	1.2	4.7	2	2	2	2	0.477
778	8	8	HYPRATE	13	1000	25	150	0.4	0.6	0.8	5337	1.5	1.2	4.7	2	2	2	2	0.478
779	8	8	RANDRATE	10	1000	25	150	0.4	0.6	0.8	5337	1.5	1.2	4.7	2	2	2	2	0.477
780	8	8	STEPBHP	-	1000	25	150	0.4	0.6	0.8	5337	1.5	1.2	4.7	2	2	2	2	0.479
781	8	8	VARBHP	-	1000	25	150	0.4	0.6	0.8	5337	1.5	1.2	4.7	2	2	2	2	0.484
782	8	8	VARRATE	12	1000	25	150	0.4	0.6	0.8	5337	1.5	1.2	4.7	2	2	2	2	0.478
783	8	9	CONBHP	15	1000	25	150	0	1	1	5337	1.5	1.2	5.9	4	4	4	4	0.261
784	8	9	CRATE	4	1000	25	150	0	1	1	5337	1.5	1.2	5.9	4	4	4	4	0.259
785	8	9	HYPRATE	17	1000	25	150	0	1	1	5337	1.5	1.2	5.9	4	4	4	4	0.256
786	8	9	RANDRATE	8	1000	25	150	0	1	1	5337	1.5	1.2	5.9	4	4	4	4	0.268
787	8	9	STEPBHP	-	1000	25	150	0	1	1	5337	1.5	1.2	5.9	4	4	4	4	0.259
788	8	9	VARBHP	-	1000	25	150	0	1	1	5337	1.5	1.2	5.9	4	4	4	4	0.272
789	8	9	VARRATE	12	1000	25	150	0	1	1	5337	1.5	1.2	5.9	4	4	4	4	0.258
790	8	10	CONBHP	15	1000	25	150	0.2	0.8	0.9	5337	1.5	1.2	5.3	4	4	4	4	0.226
791	8	10	CRATE	4	1000	25	150	0.2	0.8	0.9	5337	1.5	1.2	5.3	4	4	4	4	0.224
792	8	10	HYPRATE	17	1000	25	150	0.2	0.8	0.9	5337	1.5	1.2	5.3	4	4	4	4	0.224
793	8	10	RANDRATE	10	1000	25	150	0.2	0.8	0.9	5337	1.5	1.2	5.3	4	4	4	4	0.227
794	8	10	STEPBHP	-	1000	25	150	0.2	0.8	0.9	5337	1.5	1.2	5.3	4	4	4	4	0.225
795	8	10	VARBHP	-	1000	25	150	0.2	0.8	0.9	5337	1.5	1.2	5.3	4	4	4	4	0.234
796	8	10	VARRATE	12	1000	25	150	0.2	0.8	0.9	5337	1.5	1.2	5.3	4	4	4	4	0.223
797	8	11	CONBHP	15	1000	25	150	0.4	0.6	0.8	5337	1.5	1.2	4.7	4	4	4	4	0.172
798	8	11	CRATE	4	1000	25	150	0.4	0.6	0.8	5337	1.5	1.2	4.7	4	4	4	4	0.169
799	8	11	HYPRATE	17	1000	25	150	0.4	0.6	0.8	5337	1.5	1.2	4.7	4	4	4	4	0.171
800	8	11	RANDRATE	10	1000	25	150	0.4	0.6	0.8	5337	1.5	1.2	4.7	4	4	4	4	0.171
801	8	11	STEPBHP	-	1000	25	150	0.4	0.6	0.8	5337	1.5	1.2	4.7	4	4	4	4	0.171
802	8	11	VARBHP	-	1000	25	150	0.4	0.6	0.8	5337	1.5	1.2	4.7	4	4	4	4	0.180
803	8	11	VARRATE	12	1000	25	150	0.4	0.6	0.8	5337	1.5	1.2	4.7	4	4	4	4	0.171
804	8	12	CONBHP	15	1000	25	150	0.1	0.9	0.9	5337	1.5	1.2	5.3	3	3	3	3	0.391
805	8	12	CRATE	4	1000	25	150	0.1	0.9	0.9	5337	1.5	1.2	5.3	3	3	3	3	0.385
806	8	12	HYPRATE	13	1000	25	150	0.1	0.9	0.9	5337	1.5	1.2	5.3	3	3	3	3	0.385

Case	PVT Set	k_r Set	Simulation Type	q_{oi} (STBD)	GOR_i (scf/STB)	API_i (API)	T_{Res} (ºF)	S_{wi} (frac.)	S_{oi} (frac.)	$k_{ro,end}$ (frac.)	p_i (psi)	B_{oi} (RB/STB)	μ_{oi} (cp)	λ_{oi} (md/cp)	n_w	n_w	n_g	n_g	(Eq. B-1) ζ
807	8	12	RANDRATE	10	1000	25	150	0.1	0.9	0.9	5337	1.5	1.2	5.3	3	3	3	3	0.387
808	8	12	STEPBHP	-	1000	25	150	0.1	0.9	0.9	5337	1.5	1.2	5.3	3	3	3	3	0.388
809	8	12	VARBHP	-	1000	25	150	0.1	0.9	0.9	5337	1.5	1.2	5.3	3	3	3	3	0.398
810	8	12	VARRATE	12	1000	25	150	0.1	0.9	0.9	5337	1.5	1.2	5.3	3	3	3	3	0.385
811	8	13	CONBHP	15	1000	25	150	0.2	0.8	0.7	5337	1.5	1.2	4.1	3	3	3	3	0.354
812	8	13	CRATE	4	1000	25	150	0.2	0.8	0.7	5337	1.5	1.2	4.1	3	3	3	3	0.347
813	8	13	HYPRATE	13	1000	25	150	0.2	0.8	0.7	5337	1.5	1.2	4.1	3	3	3	3	0.348
814	8	13	RANDRATE	10	1000	25	150	0.2	0.8	0.7	5337	1.5	1.2	4.1	3	3	3	3	0.350
815	8	13	STEPBHP	-	1000	25	150	0.2	0.8	0.7	5337	1.5	1.2	4.1	3	3	3	3	0.350
816	8	13	VARBHP	-	1000	25	150	0.2	0.8	0.7	5337	1.5	1.2	4.1	3	3	3	3	0.360
817	8	13	VARRATE	12	1000	25	150	0.2	0.8	0.7	5337	1.5	1.2	4.1	3	3	3	3	0.349
818	9	1	CONBHP	15	1500	35	150	0	1	1	5605	1.8	0.4	14.9	3	3	3	3	0.408
819	9	1	CRATE	4	1500	35	150	0	1	1	5605	1.8	0.4	14.9	3	3	3	3	0.402
820	9	1	HYPRATE	10	1500	35	150	0	1	1	5605	1.8	0.4	14.9	3	3	3	3	0.401
821	9	1	HYPRATE	12	1500	35	150	0	1	1	5605	1.8	0.4	14.9	3	3	3	3	0.400
822	9	1	HYPRATE	8	1500	35	150	0	1	1	5605	1.8	0.4	14.9	3	3	3	3	0.437
823	9	1	RANDRATE	6	1500	35	150	0	1	1	5605	1.8	0.4	14.9	3	3	3	3	0.407
824	9	1	RANDRATE	8	1500	35	150	0	1	1	5605	1.8	0.4	14.9	3	3	3	3	0.401
825	9	1	STEPBHP	-	1500	35	150	0	1	1	5605	1.8	0.4	14.9	3	3	3	3	0.409
826	9	1	VARBHP	-	1500	35	150	0	1	1	5605	1.8	0.4	14.9	3	3	3	3	0.409
827	9	1	VARRATE	10	1500	35	150	0	1	1	5605	1.8	0.4	14.9	3	3	3	3	0.399
828	9	1	VARRATE	12	1500	35	150	0	1	1	5605	1.8	0.4	14.9	3	3	3	3	0.399
829	9	2	CONBHP	15	1500	35	150	0.2	0.8	0.9	5605	1.8	0.4	13.4	3	3	3	3	0.352
830	9	2	CRATE	2	1500	35	150	0.2	0.8	0.9	5605	1.8	0.4	13.4	3	3	3	3	0.350
831	9	2	CRATE	4	1500	35	150	0.2	0.8	0.9	5605	1.8	0.4	13.4	3	3	3	3	0.343
832	9	2	HYPRATE	10	1500	35	150	0.2	0.8	0.9	5605	1.8	0.4	13.4	3	3	3	3	0.342
833	9	2	HYPRATE	12	1500	35	150	0.2	0.8	0.9	5605	1.8	0.4	13.4	3	3	3	3	0.342
834	9	2	HYPRATE	8	1500	35	150	0.2	0.8	0.9	5605	1.8	0.4	13.4	3	3	3	3	0.342
835	9	2	RANDRATE	4	1500	35	150	0.2	0.8	0.9	5605	1.8	0.4	13.4	3	3	3	3	0.347
836	9	2	RANDRATE	6	1500	35	150	0.2	0.8	0.9	5605	1.8	0.4	13.4	3	3	3	3	0.343

Case	PVT Set	k_r Set	Simulation Type	q_{oi} (STBD)	GOR_i (scf/STB)	API_i (API)	T_{Res} (°F)	S_{wi} (frac.)	S_{oi} (frac.)	$k_{ro,end}$ (frac.)	p_i (psi)	B_{oi} (RB/STB)	μ_{oi} (cp)	λ_{oi} (md/cp)	n_w	n_w	n_g	n_g	(Eq. B-1) ζ
837	9	2	RANDRATE	8	1500	35	150	0.2	0.8	0.9	5605	1.8	0.4	13.4	3	3	3	3	0.343
838	9	2	STEPBHP	-	1500	35	150	0.2	0.8	0.9	5605	1.8	0.4	13.4	3	3	3	3	0.352
839	9	2	VARBHP	-	1500	35	150	0.2	0.8	0.9	5605	1.8	0.4	13.4	3	3	3	3	0.352
840	9	2	VARRATE	10	1500	35	150	0.2	0.8	0.9	5605	1.8	0.4	13.4	3	3	3	3	0.343
841	9	2	VARRATE	12	1500	35	150	0.2	0.8	0.9	5605	1.8	0.4	13.4	3	3	3	3	0.343
842	9	2	VARRATE	8	1500	35	150	0.2	0.8	0.9	5605	1.8	0.4	13.4	3	3	3	3	0.343
843	9	3	CONBHP	15	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	3	3	3	3	0.290
844	9	3	CRATE	2	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	3	3	3	3	0.281
845	9	3	CRATE	4	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	3	3	3	3	0.281
846	9	3	HYPRATE	10	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	3	3	3	3	0.281
847	9	3	HYPRATE	12	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	3	3	3	3	0.281
848	9	3	HYPRATE	8	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	3	3	3	3	0.281
849	9	3	RANDRATE	4	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	3	3	3	3	0.281
850	9	3	RANDRATE	6	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	3	3	3	3	0.281
851	9	3	RANDRATE	8	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	3	3	3	3	0.281
852	9	3	STEPBHP	-	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	3	3	3	3	0.288
853	9	3	VARBHP	-	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	3	3	3	3	0.288
854	9	3	VARRATE	10	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	3	3	3	3	0.281
855	9	3	VARRATE	12	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	3	3	3	3	0.281
856	9	3	VARRATE	5	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	3	3	3	3	0.281
857	9	3	VARRATE	8	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	3	3	3	3	0.281
858	9	4	CONBHP	15	1500	35	150	0	1	1	5605	1.8	0.4	14.9	3	3	4	3	0.283
859	9	4	CRATE	4	1500	35	150	0	1	1	5605	1.8	0.4	14.9	3	3	4	3	0.276
860	9	4	HYPRATE	10	1500	35	150	0	1	1	5605	1.8	0.4	14.9	3	3	4	3	0.275
861	9	4	HYPRATE	12	1500	35	150	0	1	1	5605	1.8	0.4	14.9	3	3	4	3	0.275
862	9	4	HYPRATE	8	1500	35	150	0	1	1	5605	1.8	0.4	14.9	3	3	4	3	0.277
863	9	4	RANDRATE	6	1500	35	150	0	1	1	5605	1.8	0.4	14.9	3	3	4	3	0.279
864	9	4	RANDRATE	8	1500	35	150	0	1	1	5605	1.8	0.4	14.9	3	3	4	3	0.276
865	9	4	STEPBHP	-	1500	35	150	0	1	1	5605	1.8	0.4	14.9	3	3	4	3	0.285
866	9	4	VARBHP	-	1500	35	150	0	1	1	5605	1.8	0.4	14.9	3	3	4	3	0.285

Case	PVT Set	k_r Set	Simulation Type	q_{oi} (STBD)	GOR_i (scf/STB)	API_i (API)	T_{Res} (ºF)	S_{wi} (frac.)	S_{oi} (frac.)	$k_{ro,end}$ (frac.)	p_i (psi)	B_{oi} (RB/STB)	μ_{oi} (cp)	λ_{oi} (md/cp)	n_w	n_w	n_g	n_g	(Eq. B-1) ζ
867	9	4	VARRATE	10	1500	35	150	0	1	1	5605	1.8	0.4	14.9	3	3	4	3	0.275
868	9	4	VARRATE	12	1500	35	150	0	1	1	5605	1.8	0.4	14.9	3	3	4	3	0.275
869	9	4	VARRATE	8	1500	35	150	0	1	1	5605	1.8	0.4	14.9	3	3	4	3	0.300
870	9	5	CONBHP	15	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	3	3	4	3	0.178
871	9	5	CRATE	2	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	3	3	4	3	0.172
872	9	5	CRATE	4	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	3	3	4	3	0.172
873	9	5	HYPRATE	10	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	3	3	4	3	0.172
874	9	5	HYPRATE	12	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	3	3	4	3	0.172
875	9	5	HYPRATE	8	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	3	3	4	3	0.172
876	9	5	RANDRATE	4	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	3	3	4	3	0.172
877	9	5	RANDRATE	6	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	3	3	4	3	0.172
878	9	5	RANDRATE	8	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	3	3	4	3	0.172
879	9	5	STEPBHP	-	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	3	3	4	3	0.178
880	9	5	VARBHP	-	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	3	3	4	3	0.178
881	9	5	VARRATE	10	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	3	3	4	3	0.172
882	9	5	VARRATE	12	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	3	3	4	3	0.172
883	9	5	VARRATE	5	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	3	3	4	3	0.172
884	9	5	VARRATE	8	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	3	3	4	3	0.172
885	9	6	CONBHP	15	1500	35	150	0	1	1	5605	1.8	0.4	14.9	2	2	2	2	0.627
886	9	6	CRATE	4	1500	35	150	0	1	1	5605	1.8	0.4	14.9	2	2	2	2	0.618
887	9	6	RANDRATE	8	1500	35	150	0	1	1	5605	1.8	0.4	14.9	2	2	2	2	0.619
888	9	6	STEPBHP	-	1500	35	150	0	1	1	5605	1.8	0.4	14.9	2	2	2	2	0.621
889	9	6	VARBHP	-	1500	35	150	0	1	1	5605	1.8	0.4	14.9	2	2	2	2	0.626
890	9	6	VARRATE	12	1500	35	150	0	1	1	5605	1.8	0.4	14.9	2	2	2	2	0.618
891	9	7	CONBHP	15	1500	35	150	0.2	0.8	0.9	5605	1.8	0.4	13.4	2	2	2	2	0.710
892	9	7	CRATE	4	1500	35	150	0.2	0.8	0.9	5605	1.8	0.4	13.4	2	2	2	2	0.702
893	9	7	STEPBHP	-	1500	35	150	0.2	0.8	0.9	5605	1.8	0.4	13.4	2	2	2	2	0.704
894	9	7	VARBHP	-	1500	35	150	0.2	0.8	0.9	5605	1.8	0.4	13.4	2	2	2	2	0.707
895	9	7	VARRATE	12	1500	35	150	0.2	0.8	0.9	5605	1.8	0.4	13.4	2	2	2	2	0.702
896	9	8	CONBHP	15	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	2	2	2	2	0.515

Case	PVT Set	k_r Set	Simulation Type	q_{oi} (STBD)	GOR_i (scf/STB)	API_i (API)	T_{Res} (°F)	S_{wi} (frac.)	S_{oi} (frac.)	$k_{ro,end}$ (frac.)	p_i (psi)	B_{oi} (RB/STB)	μ_{oi} (cp)	λ_{oi} (md/cp)	n_w	n_w	n_g	n_g	(Eq. B-1) ζ
897	9	8	CRATE	4	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	2	2	2	2	0.505
898	9	8	HYPRATE	13	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	2	2	2	2	0.506
899	9	8	RANDRATE	10	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	2	2	2	2	0.505
900	9	8	STEPBHP	-	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	2	2	2	2	0.507
901	9	8	VARBHP	-	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	2	2	2	2	0.511
902	9	8	VARRATE	12	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	2	2	2	2	0.505
903	9	9	CONBHP	15	1500	35	150	0	1	1	5605	1.8	0.4	14.9	4	4	4	4	0.246
904	9	9	CRATE	4	1500	35	150	0	1	1	5605	1.8	0.4	14.9	4	4	4	4	0.240
905	9	9	HYPRATE	17	1500	35	150	0	1	1	5605	1.8	0.4	14.9	4	4	4	4	0.239
906	9	9	RANDRATE	8	1500	35	150	0	1	1	5605	1.8	0.4	14.9	4	4	4	4	0.244
907	9	9	STEPBHP	-	1500	35	150	0	1	1	5605	1.8	0.4	14.9	4	4	4	4	0.242
908	9	9	VARBHP	-	1500	35	150	0	1	1	5605	1.8	0.4	14.9	4	4	4	4	0.253
909	9	9	VARRATE	12	1500	35	150	0	1	1	5605	1.8	0.4	14.9	4	4	4	4	0.240
910	9	10	CONBHP	15	1500	35	150	0.2	0.8	0.9	5605	1.8	0.4	13.4	4	4	4	4	0.201
911	9	10	CRATE	4	1500	35	150	0.2	0.8	0.9	5605	1.8	0.4	13.4	4	4	4	4	0.197
912	9	10	HYPRATE	17	1500	35	150	0.2	0.8	0.9	5605	1.8	0.4	13.4	4	4	4	4	0.197
913	9	10	RANDRATE	10	1500	35	150	0.2	0.8	0.9	5605	1.8	0.4	13.4	4	4	4	4	0.198
914	9	10	STEPBHP	-	1500	35	150	0.2	0.8	0.9	5605	1.8	0.4	13.4	4	4	4	4	0.198
915	9	10	VARBHP	-	1500	35	150	0.2	0.8	0.9	5605	1.8	0.4	13.4	4	4	4	4	0.204
916	9	10	VARRATE	12	1500	35	150	0.2	0.8	0.9	5605	1.8	0.4	13.4	4	4	4	4	0.197
917	9	11	CONBHP	15	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	4	4	4	4	0.154
918	9	11	CRATE	4	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	4	4	4	4	0.150
919	9	11	HYPRATE	17	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	4	4	4	4	0.151
920	9	11	RANDRATE	10	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	4	4	4	4	0.151
921	9	11	STEPBHP	-	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	4	4	4	4	0.151
922	9	11	VARBHP	-	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	4	4	4	4	0.157
923	9	11	VARRATE	12	1500	35	150	0.4	0.6	0.8	5605	1.8	0.4	11.9	4	4	4	4	0.151
924	9	12	CONBHP	15	1500	35	150	0.1	0.9	0.9	5605	1.8	0.4	13.4	3	3	3	3	0.407
925	9	12	CRATE	4	1500	35	150	0.1	0.9	0.9	5605	1.8	0.4	13.4	3	3	3	3	0.398
926	9	12	HYPRATE	13	1500	35	150	0.1	0.9	0.9	5605	1.8	0.4	13.4	3	3	3	3	0.398

Case	PVT Set	k_r Set	Simulation Type	q_{oi} (STBD)	GOR_i (scf/STB)	API_i (API)	T_{Res} (ºF)	S_{wi} (frac.)	S_{oi} (frac.)	$k_{ro,end}$ (frac.)	p_i (psi)	B_{oi} (RB/STB)	μ_{oi} (cp)	λ_{oi} (md/cp)	n_w	n_w	n_g	n_g	(Eq. B-1) ζ
927	9	12	RANDRATE	10	1500	35	150	0.1	0.9	0.9	5605	1.8	0.4	13.4	3	3	3	3	0.399
928	9	12	STEPBHP	-	1500	35	150	0.1	0.9	0.9	5605	1.8	0.4	13.4	3	3	3	3	0.401
929	9	12	VARBHP	-	1500	35	150	0.1	0.9	0.9	5605	1.8	0.4	13.4	3	3	3	3	0.409
930	9	12	VARRATE	12	1500	35	150	0.1	0.9	0.9	5605	1.8	0.4	13.4	3	3	3	3	0.398
931	9	13	CONBHP	15	1500	35	150	0.2	0.8	0.7	5605	1.8	0.4	10.4	3	3	3	3	0.352
932	9	13	CRATE	4	1500	35	150	0.2	0.8	0.7	5605	1.8	0.4	10.4	3	3	3	3	0.342
933	9	13	HYPRATE	13	1500	35	150	0.2	0.8	0.7	5605	1.8	0.4	10.4	3	3	3	3	0.342
934	9	13	RANDRATE	10	1500	35	150	0.2	0.8	0.7	5605	1.8	0.4	10.4	3	3	3	3	0.343
935	9	13	STEPBHP	-	1500	35	150	0.2	0.8	0.7	5605	1.8	0.4	10.4	3	3	3	3	0.346
936	9	13	VARBHP	-	1500	35	150	0.2	0.8	0.7	5605	1.8	0.4	10.4	3	3	3	3	0.354
937	9	13	VARRATE	12	1500	35	150	0.2	0.8	0.7	5605	1.8	0.4	10.4	3	3	3	3	0.343

APPENDIX C
CORRELATION PLOTS FOR THE CUBIC MODEL (CASE 1)

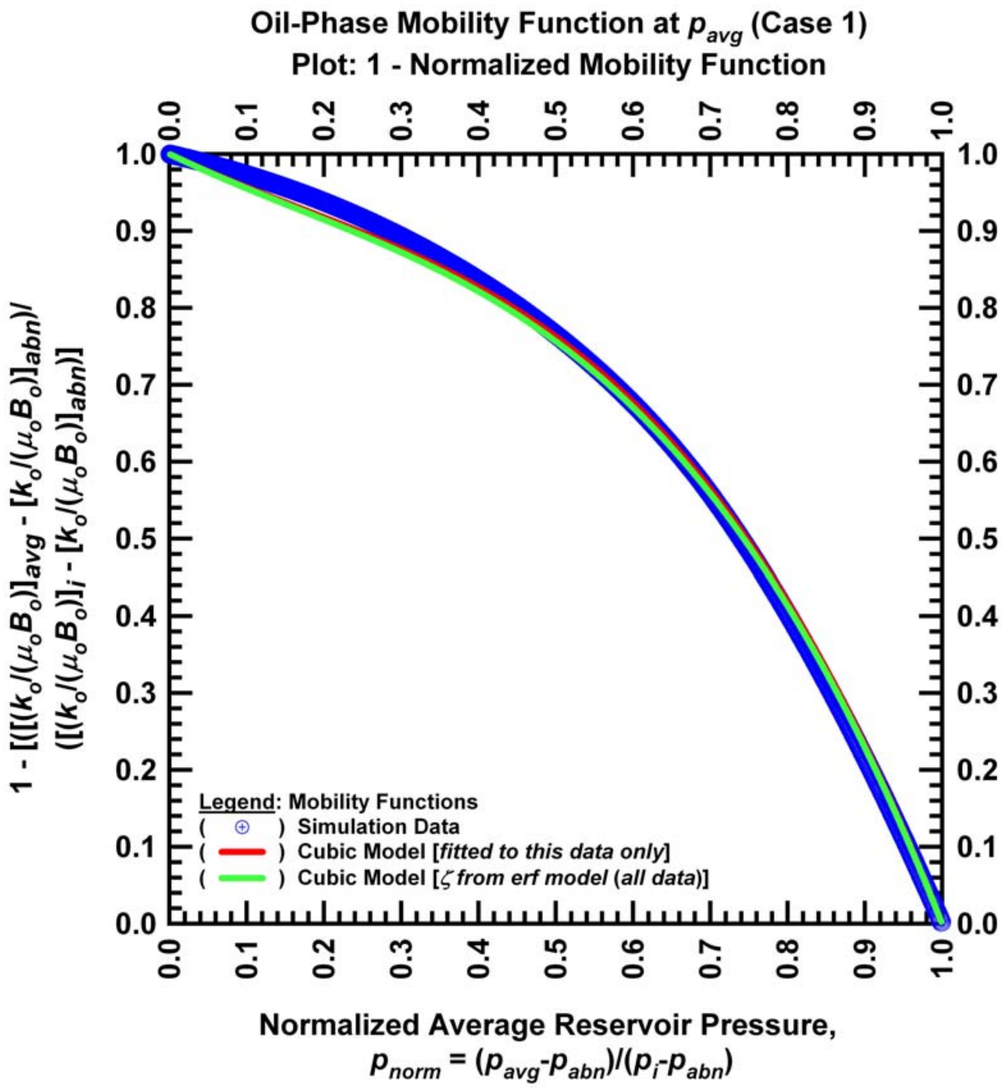

Figure C.1 — Normalized oil-phase mobility function plotted versus the normalized average reservoir pressure function (Case 1).

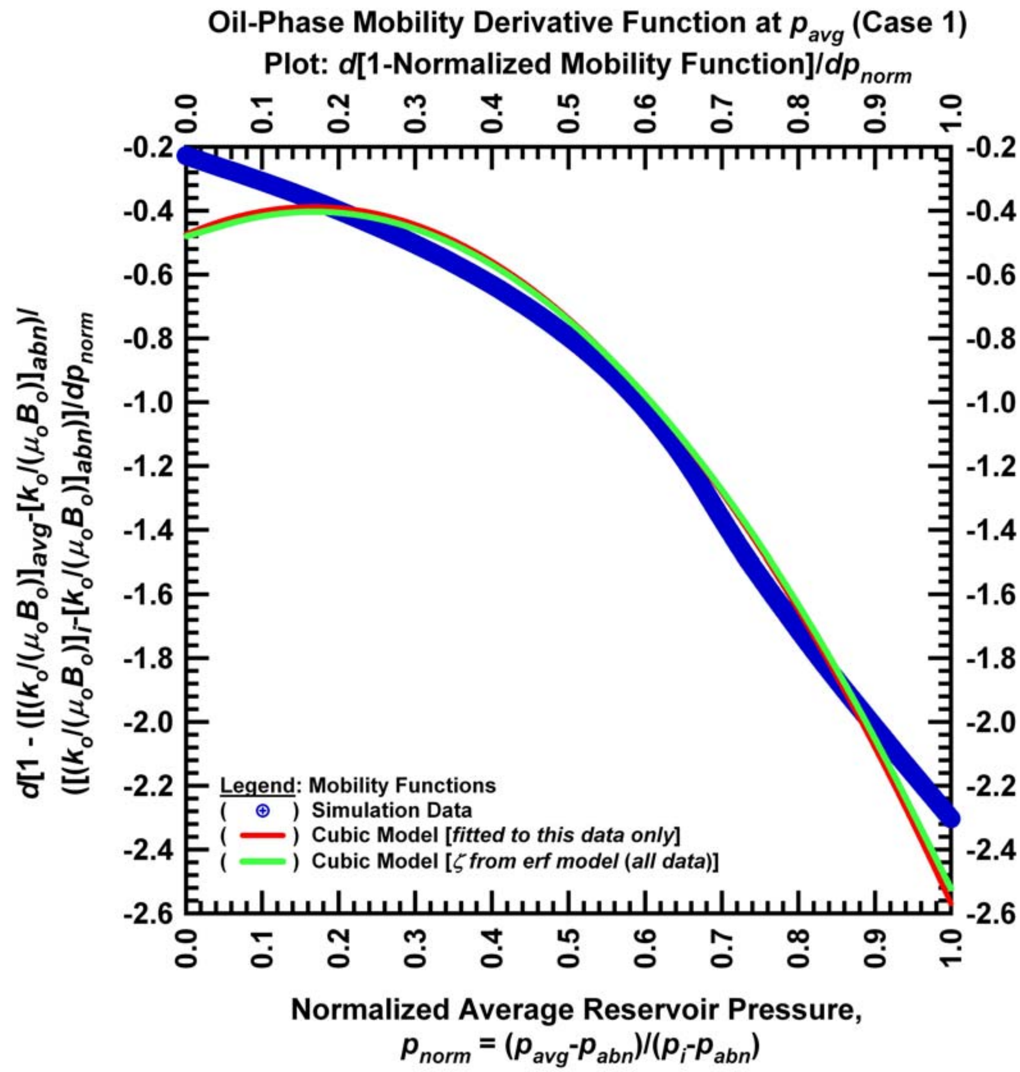

Figure C.2 — Derivative of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 1).

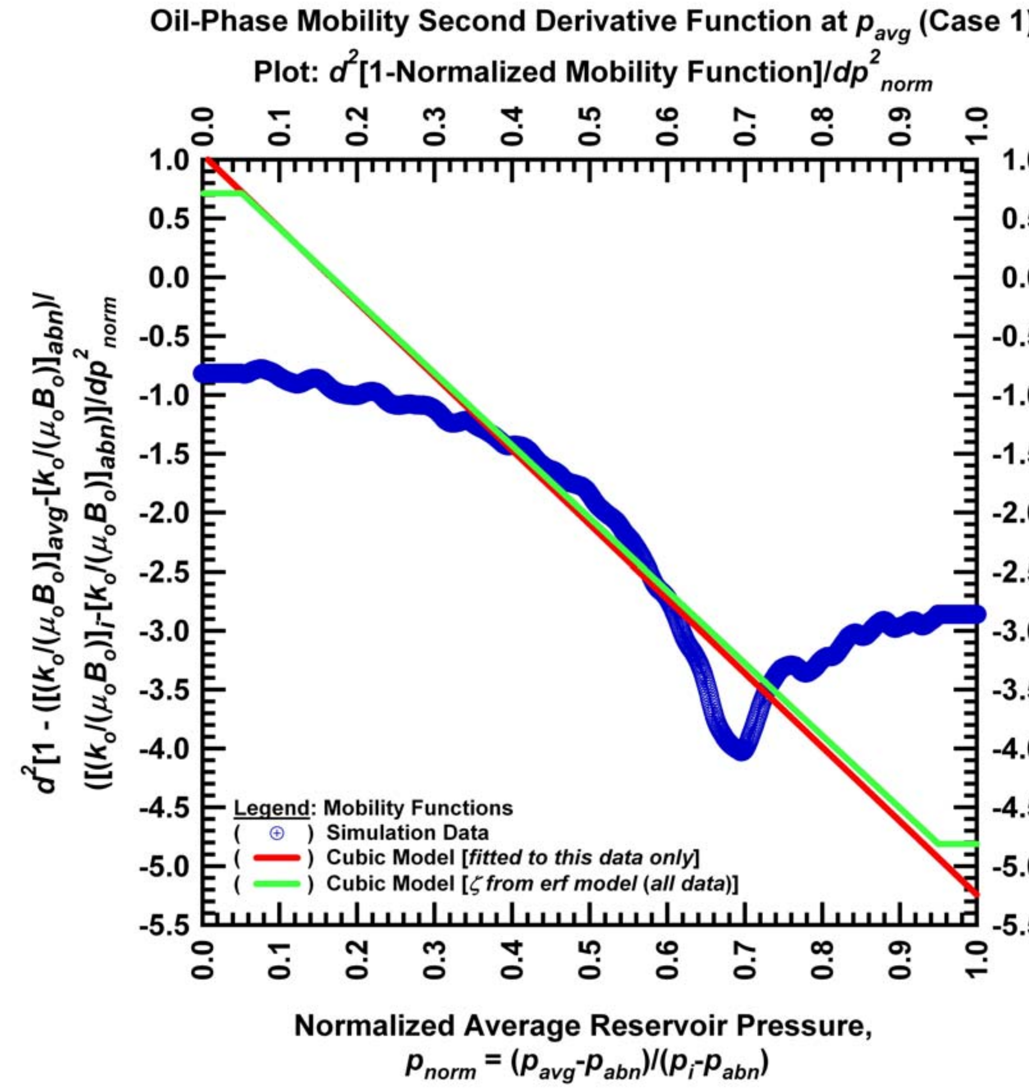

Figure C.3 — Second derivative of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 1).

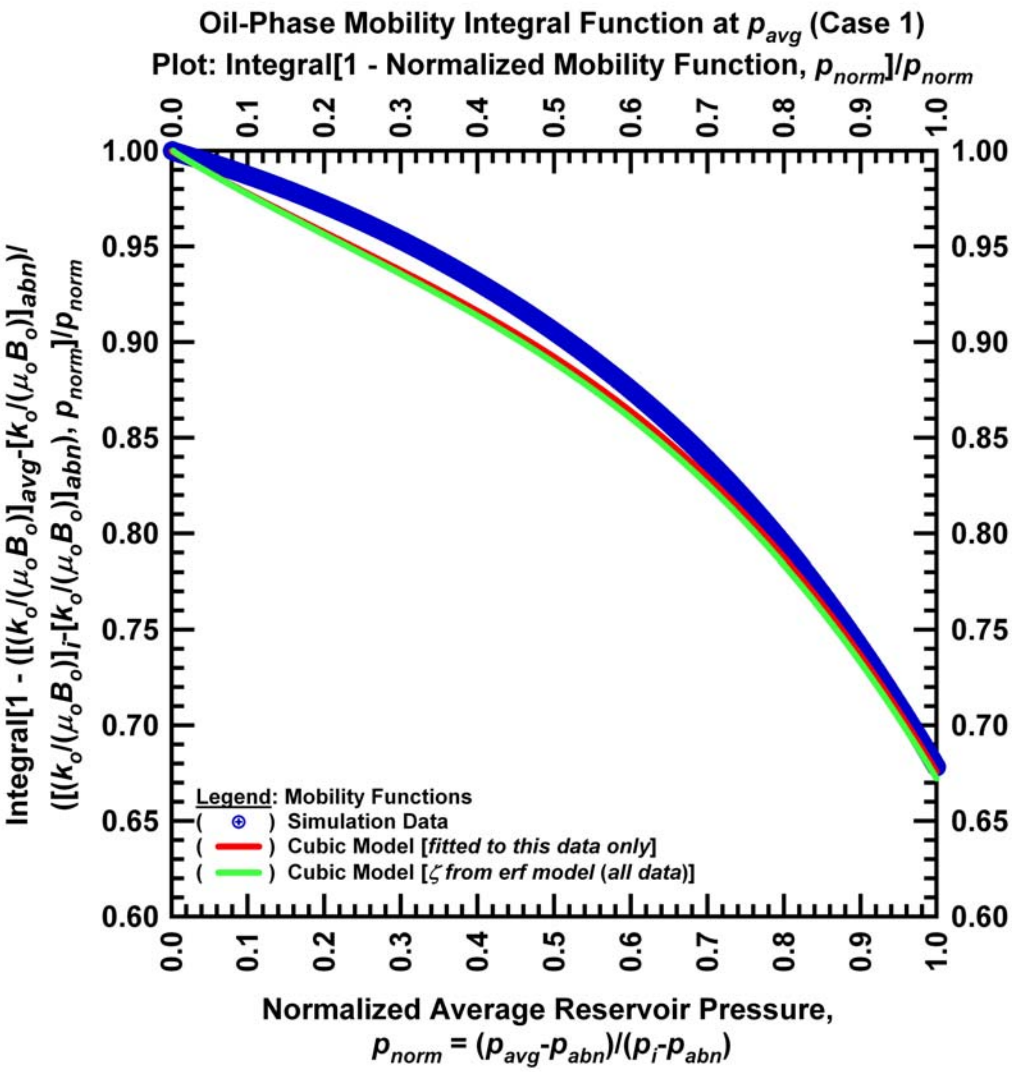

Figure C.4 — Integral of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 1).

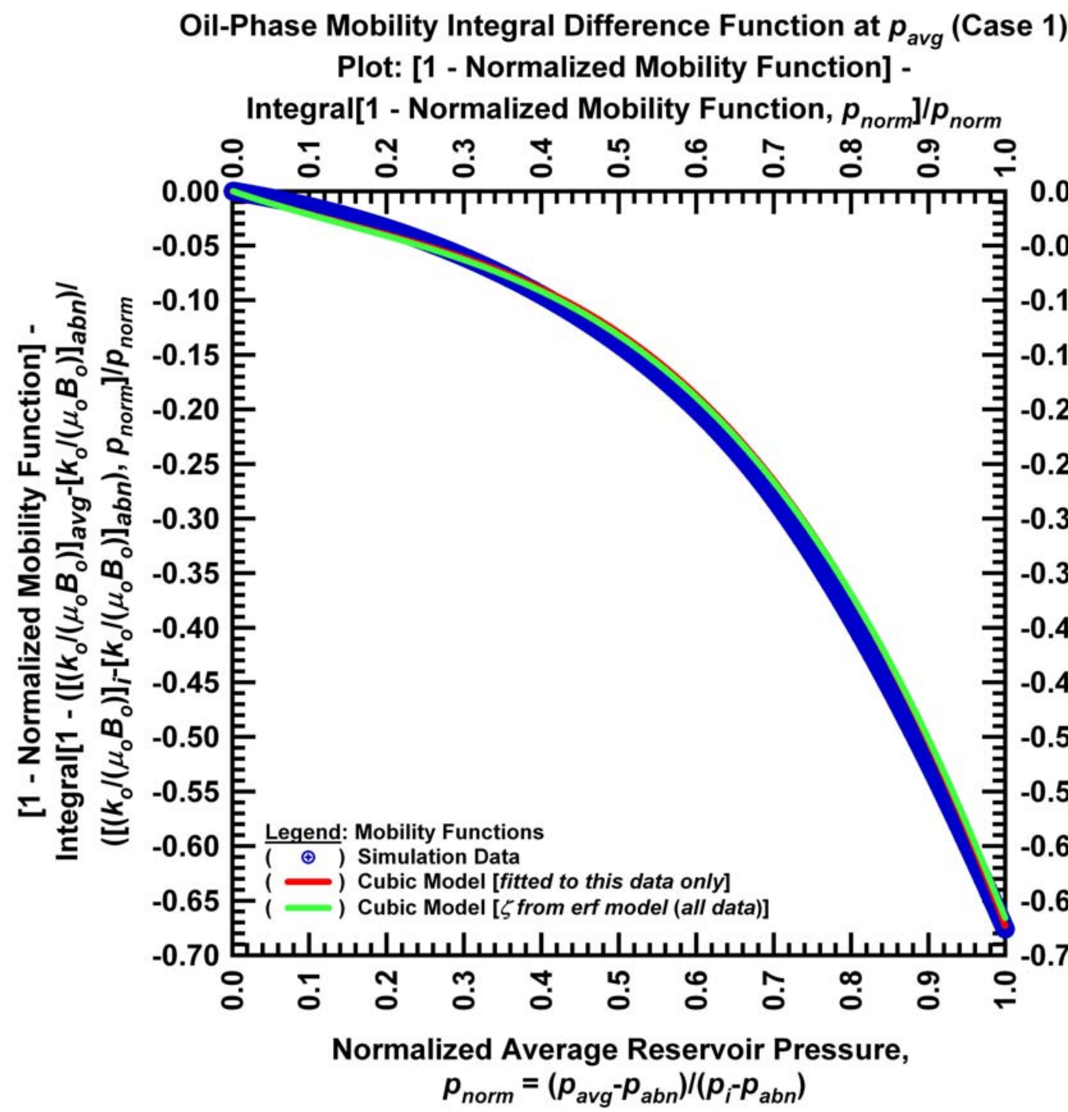

Figure C.5 — Integral difference of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 1).

APPENDIX D
CORRELATION PLOTS FOR THE CUBIC MODEL (CASE 62)

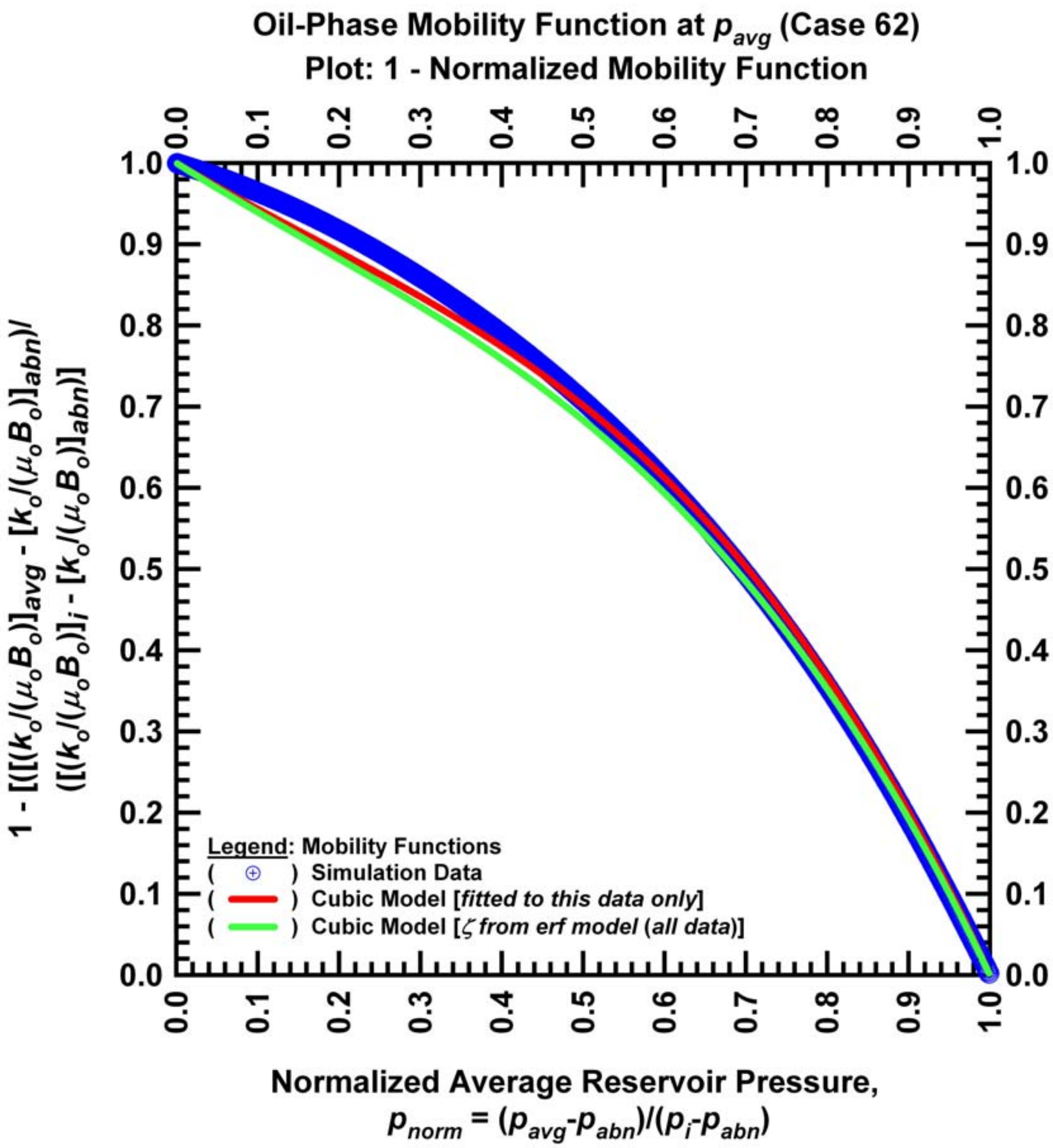

Figure D.1 — Normalized oil-phase mobility function plotted versus the normalized average reservoir pressure function (Case 62).

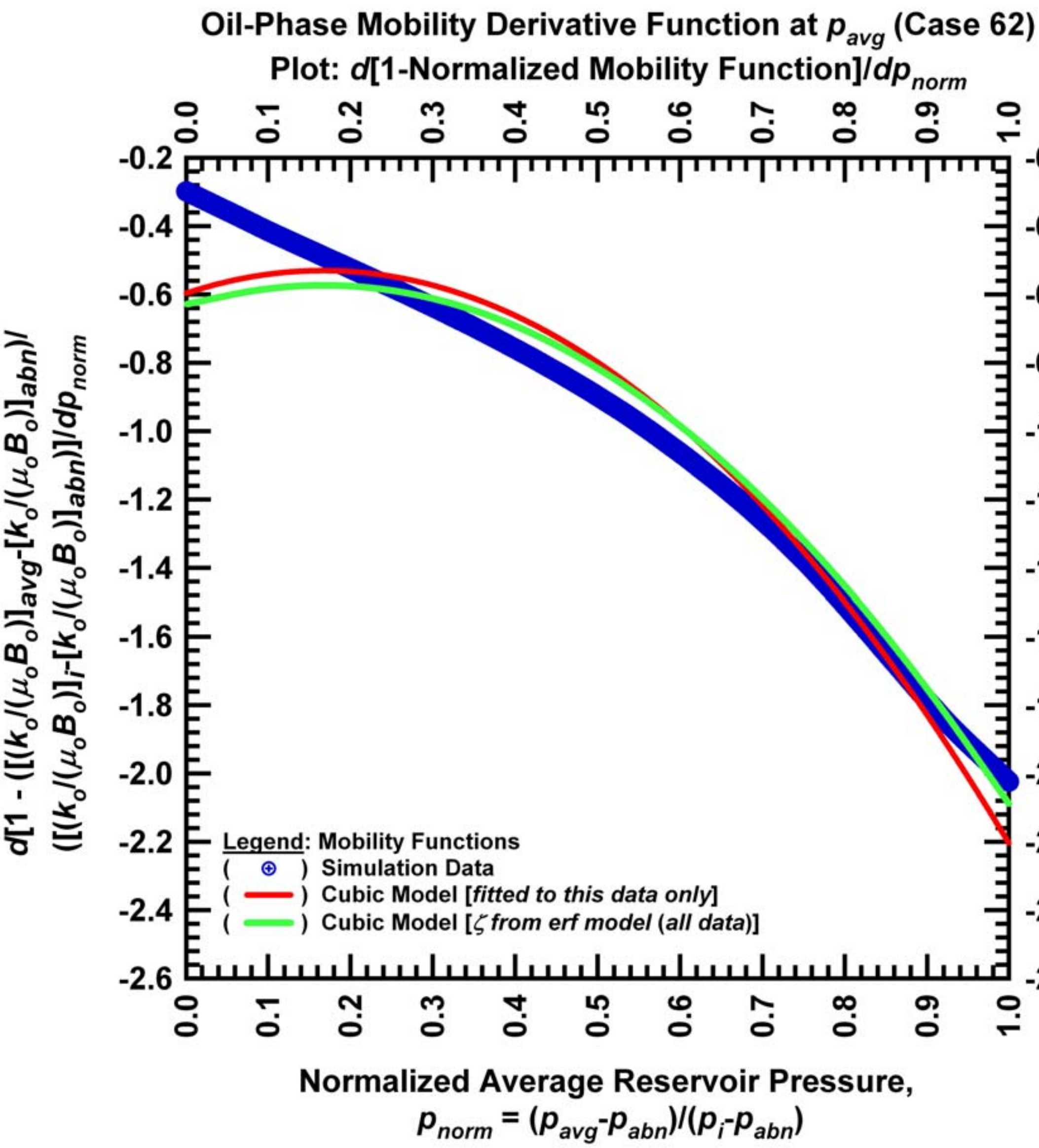

Figure D.2 — Derivative of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 62).

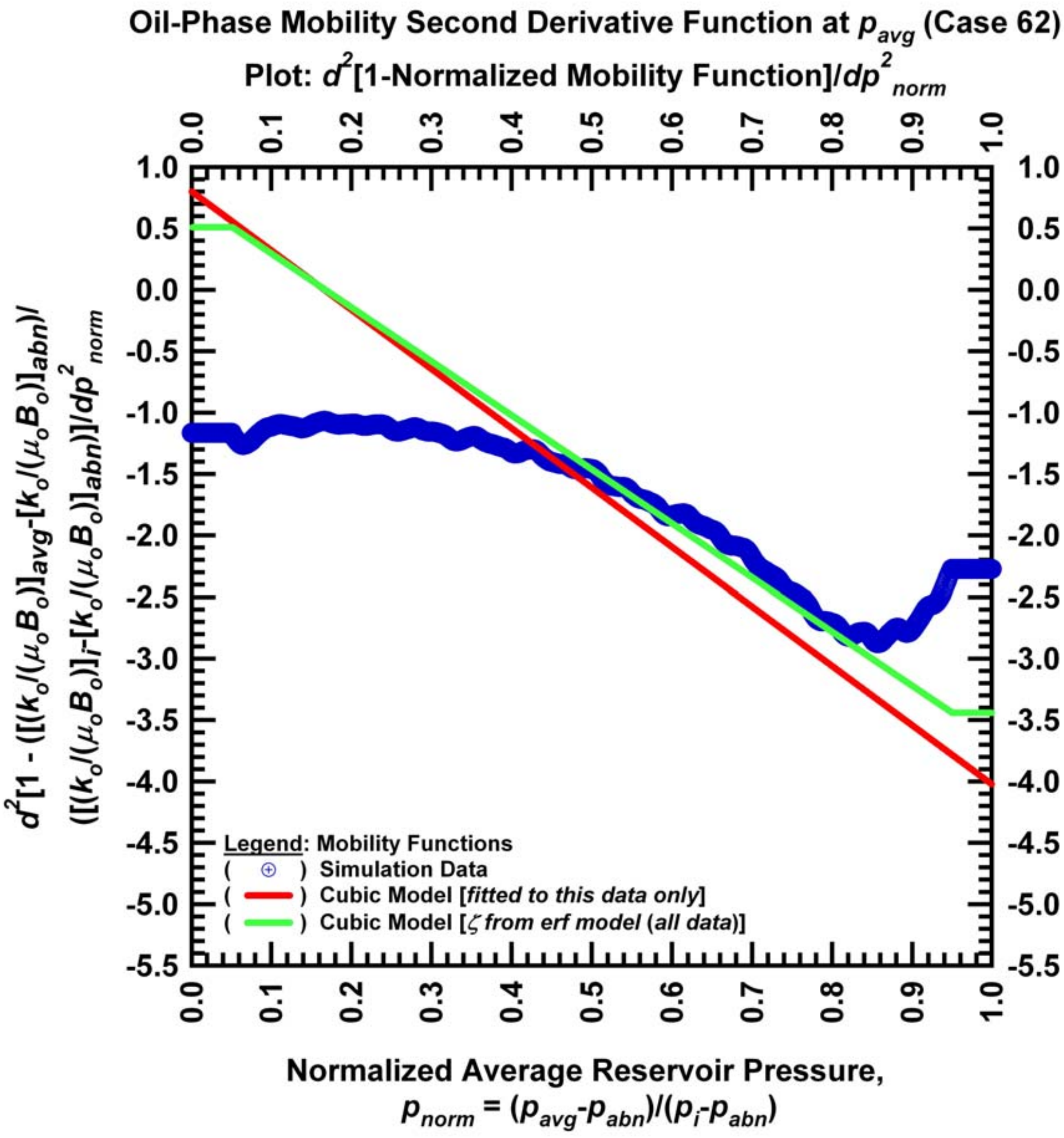

Figure D.3 — Second derivative of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 62).

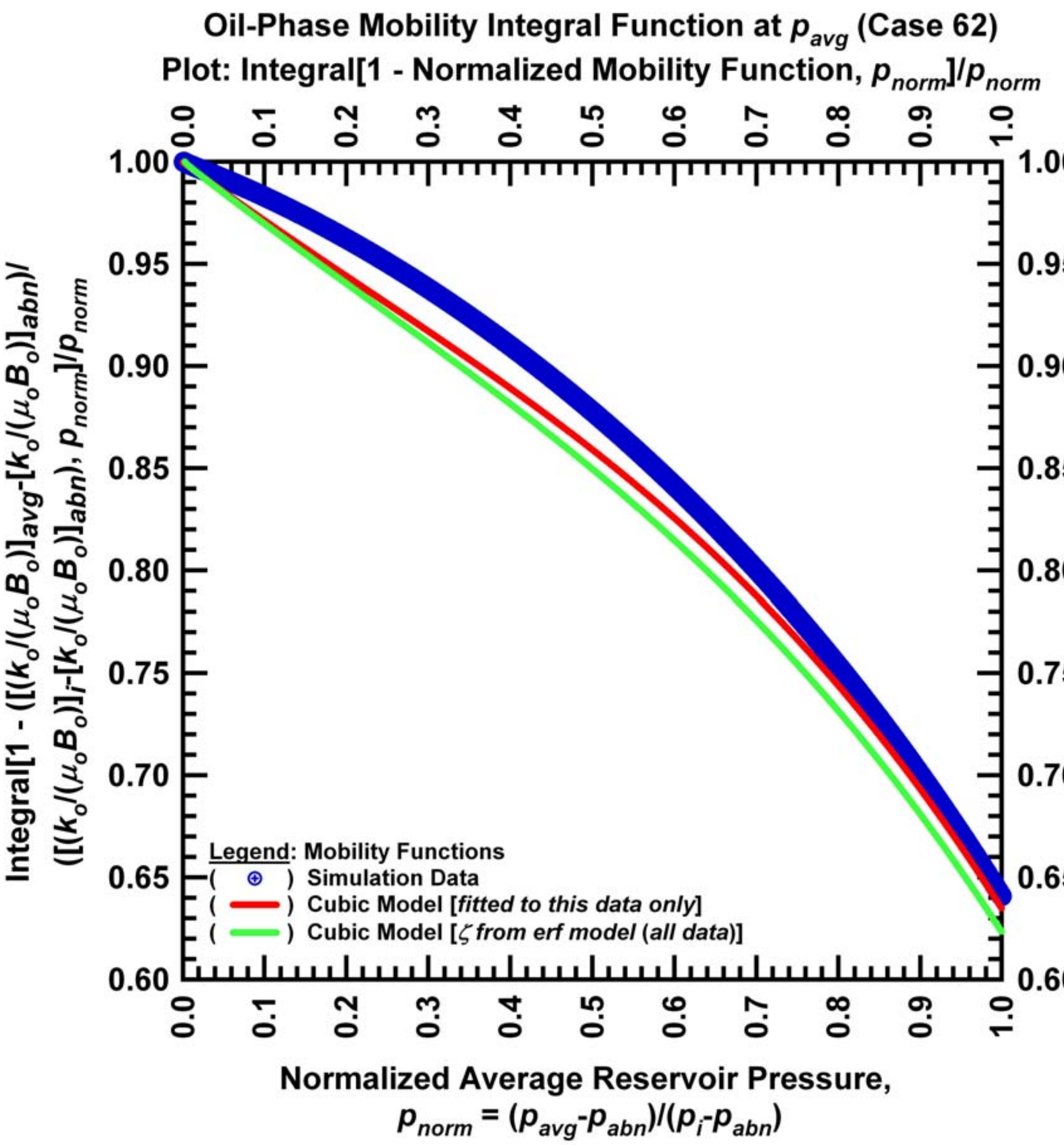

Figure D.4 — Integral of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 62).

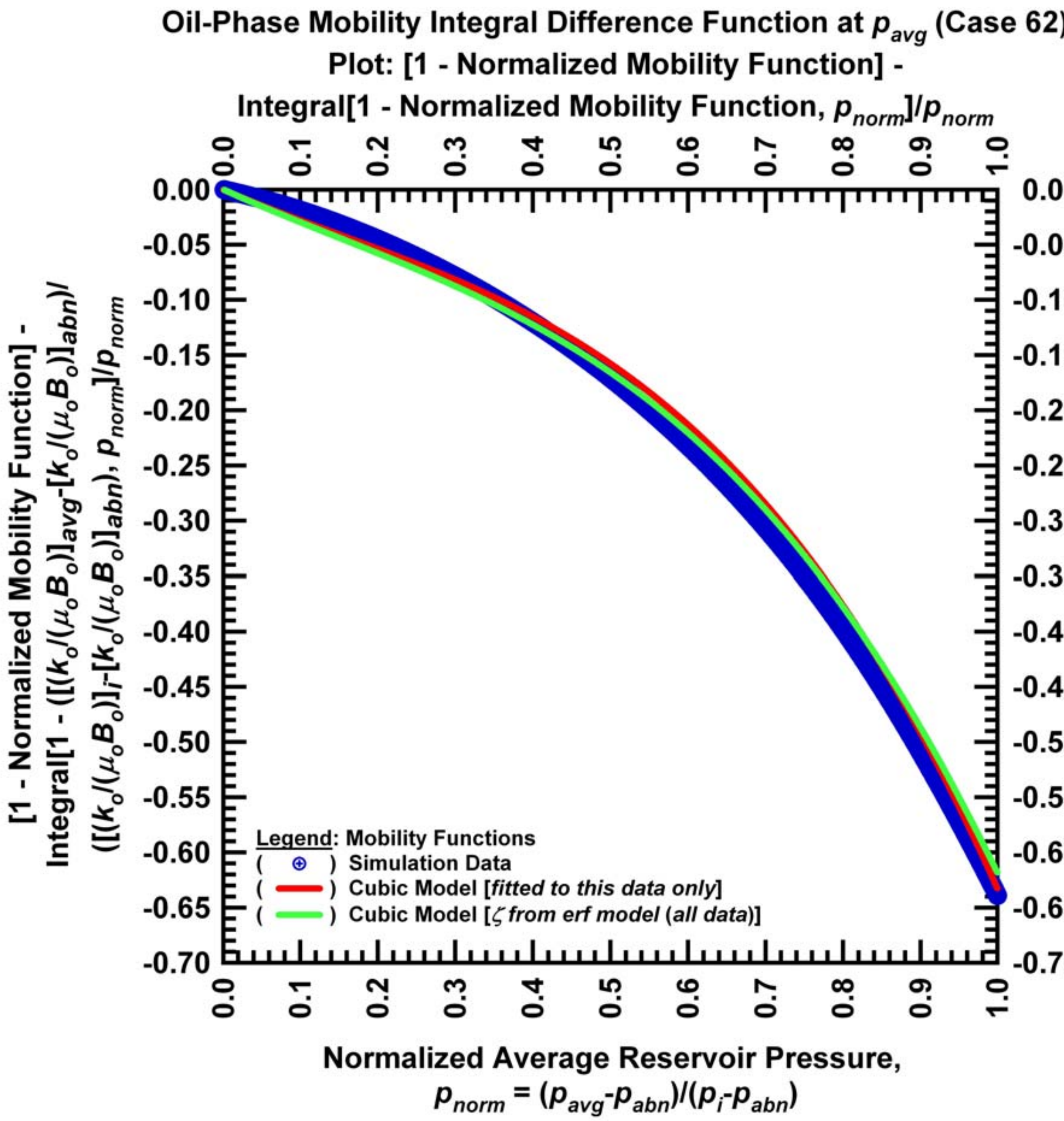

Figure D.5 — Integral difference of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 62).

APPENDIX E
CORRELATION PLOTS FOR THE CUBIC MODEL (CASE 80)

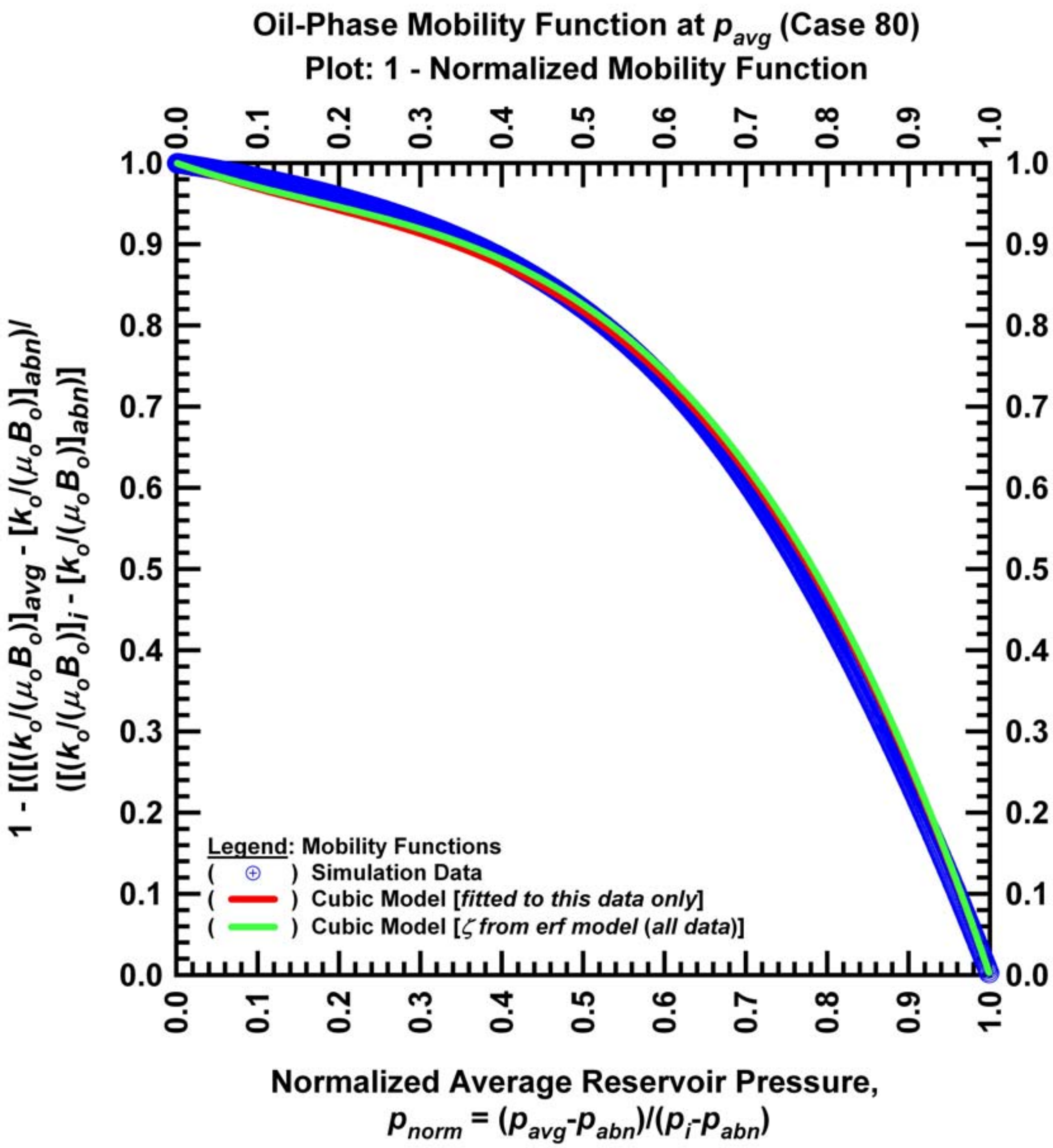

Figure E.1 — Normalized oil-phase mobility function plotted versus the normalized average reservoir pressure function (Case 80).

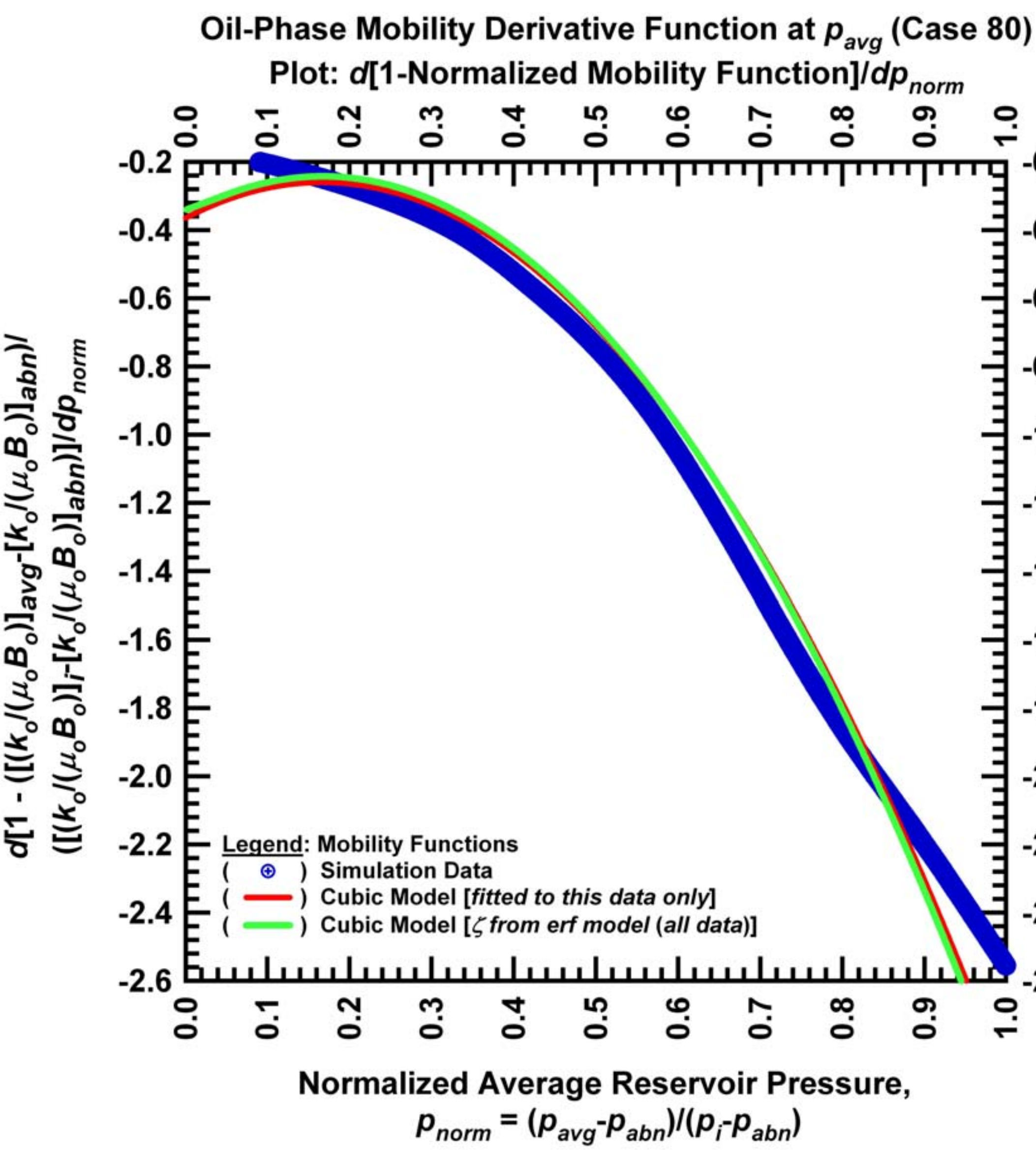

Figure E.2 — Derivative of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 80).

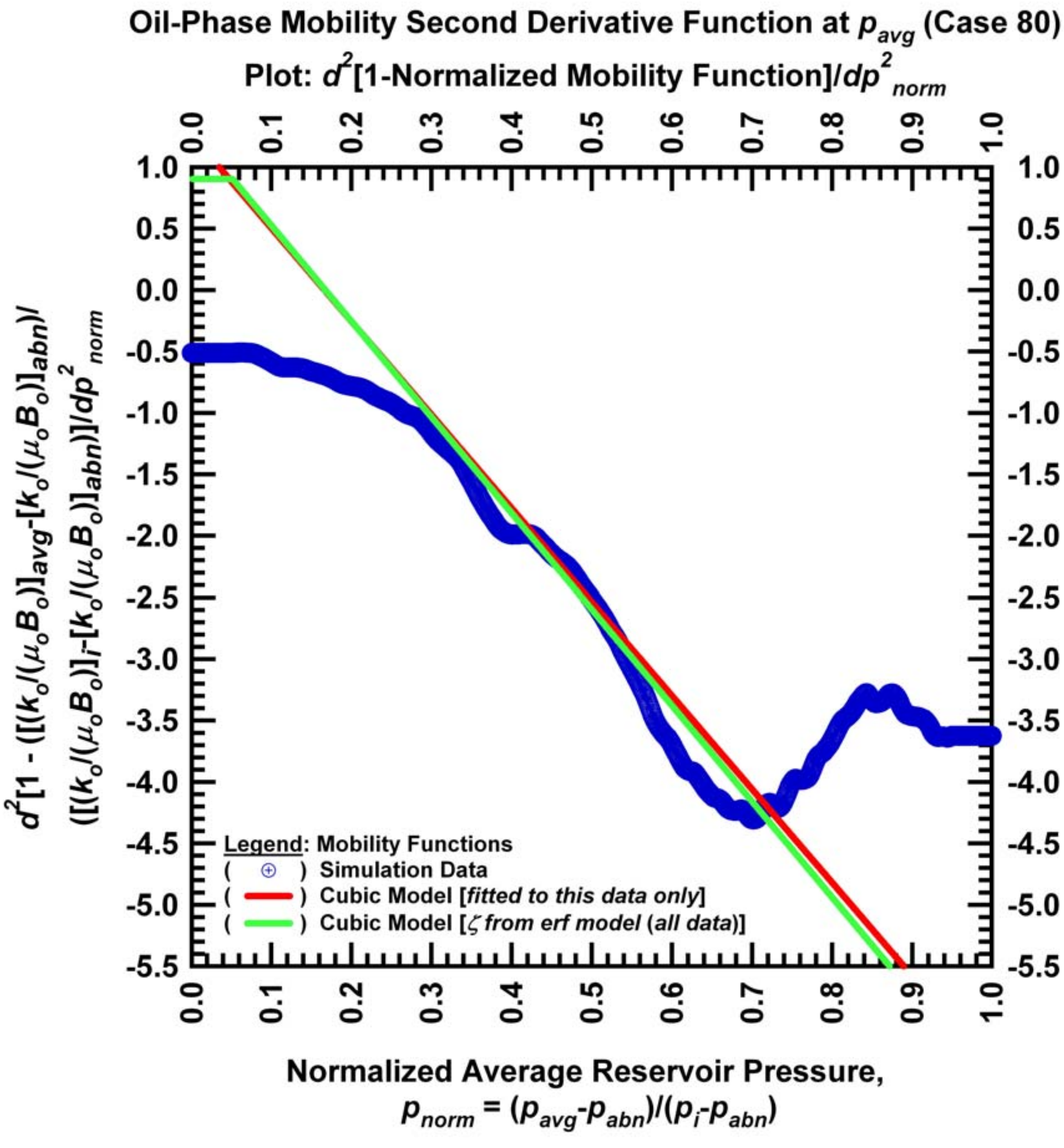

Figure E.3 — Second derivative of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 80).

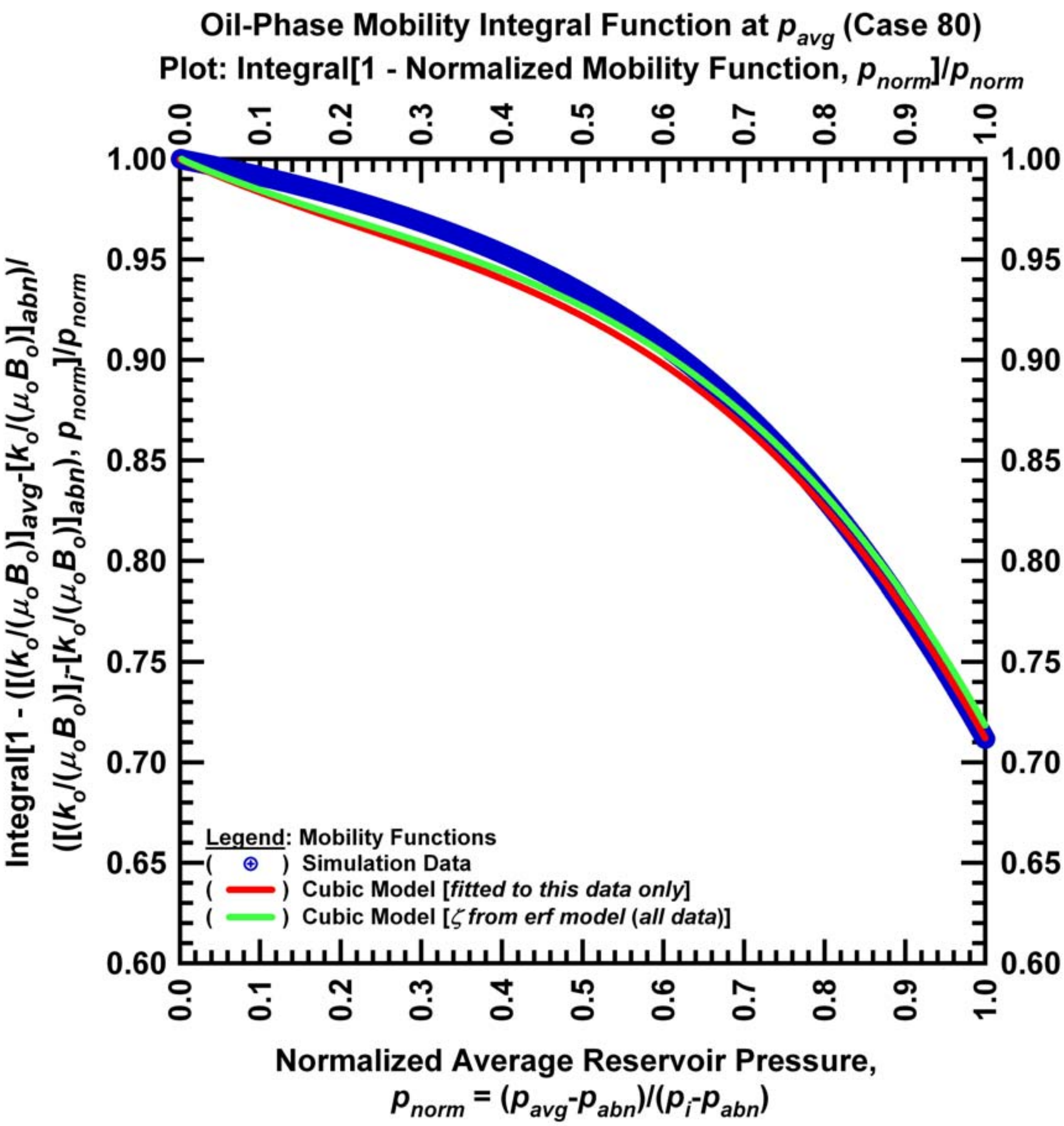

Figure E.4 — Integral of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 80).

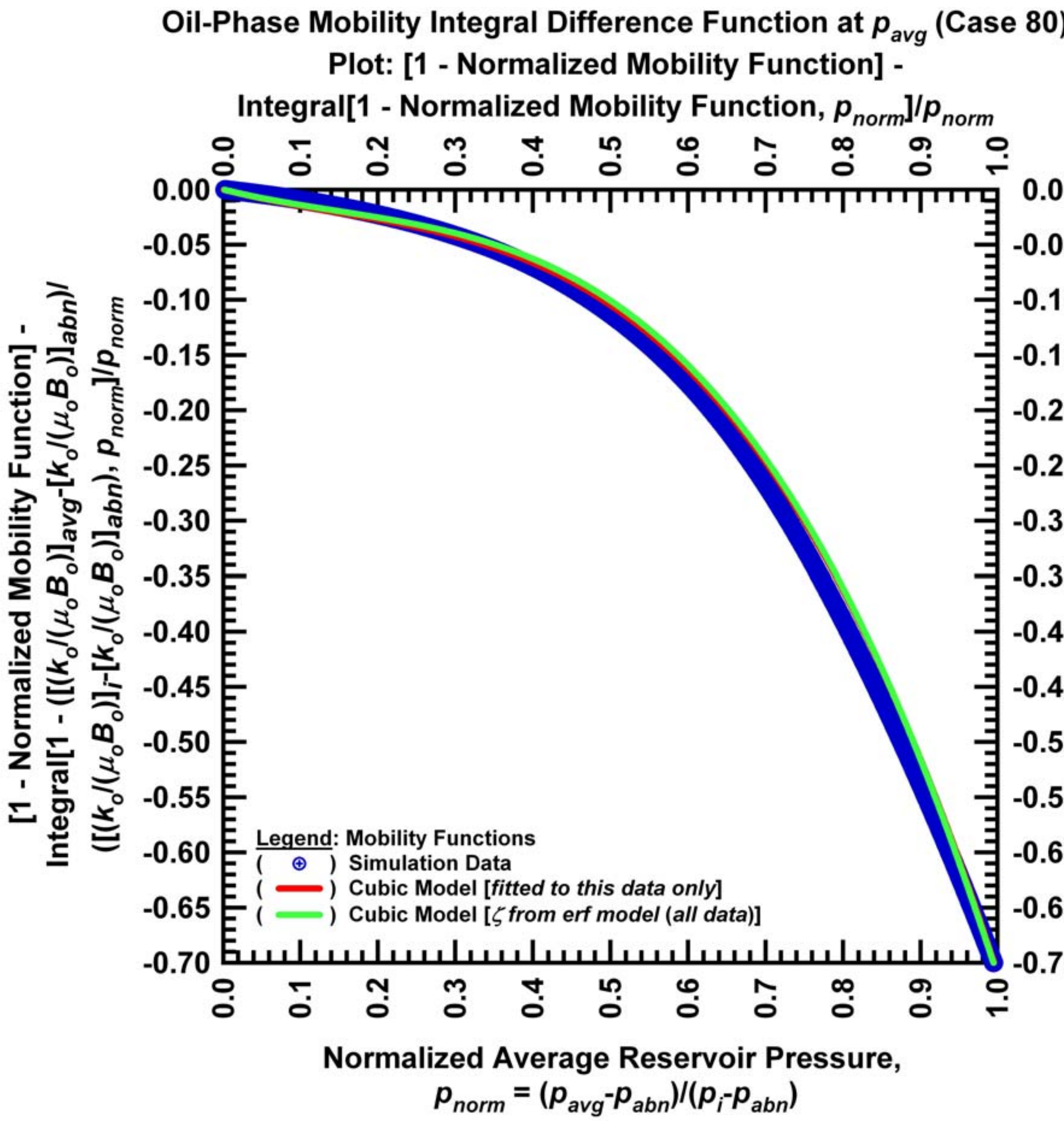

Figure E.5 — Integral difference of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 80).

APPENDIX F
CORRELATION PLOTS FOR THE CUBIC MODEL (CASE 114)

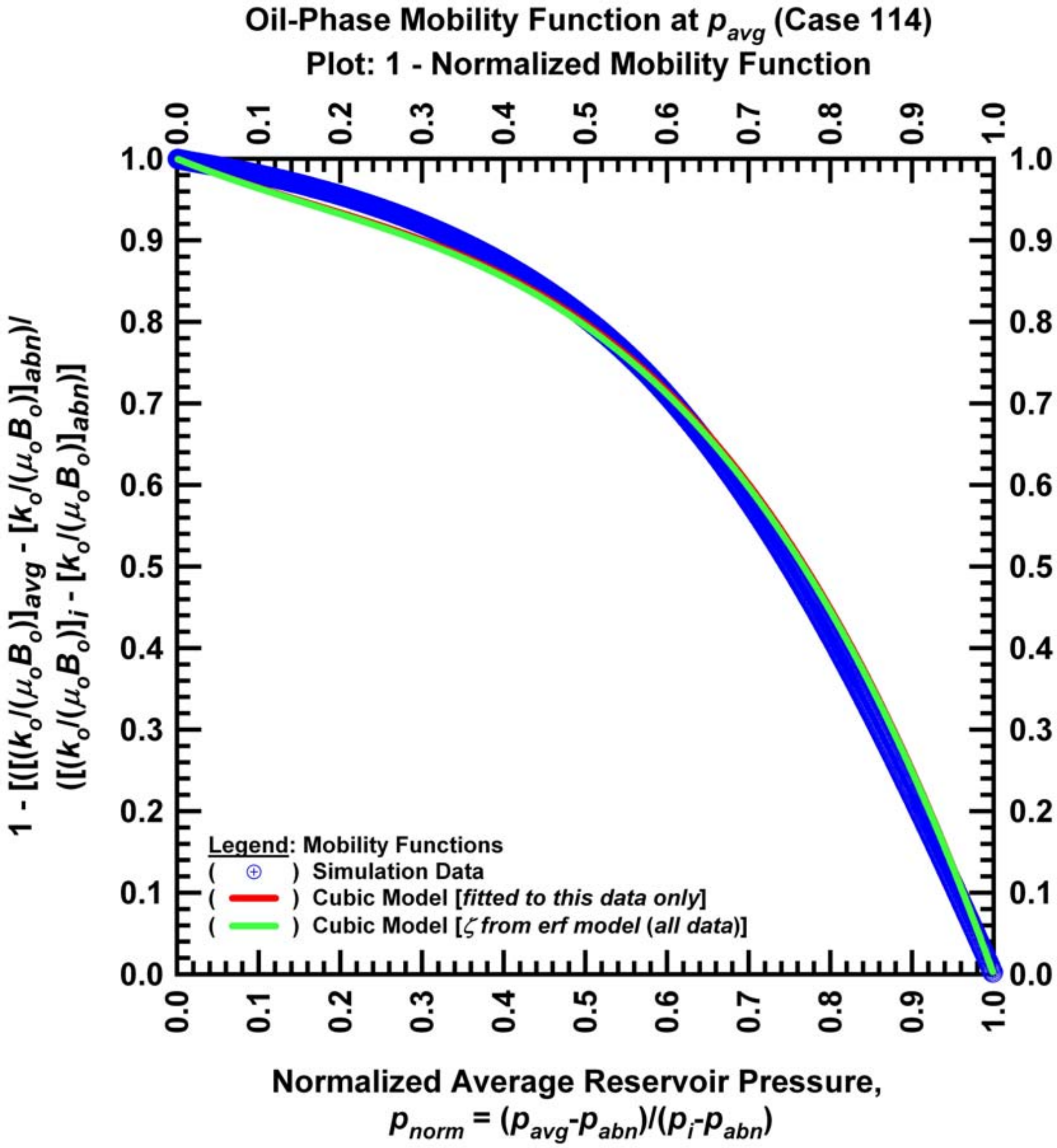

Figure F.1 — Normalized oil-phase mobility function plotted versus the normalized average reservoir pressure function (Case 114).

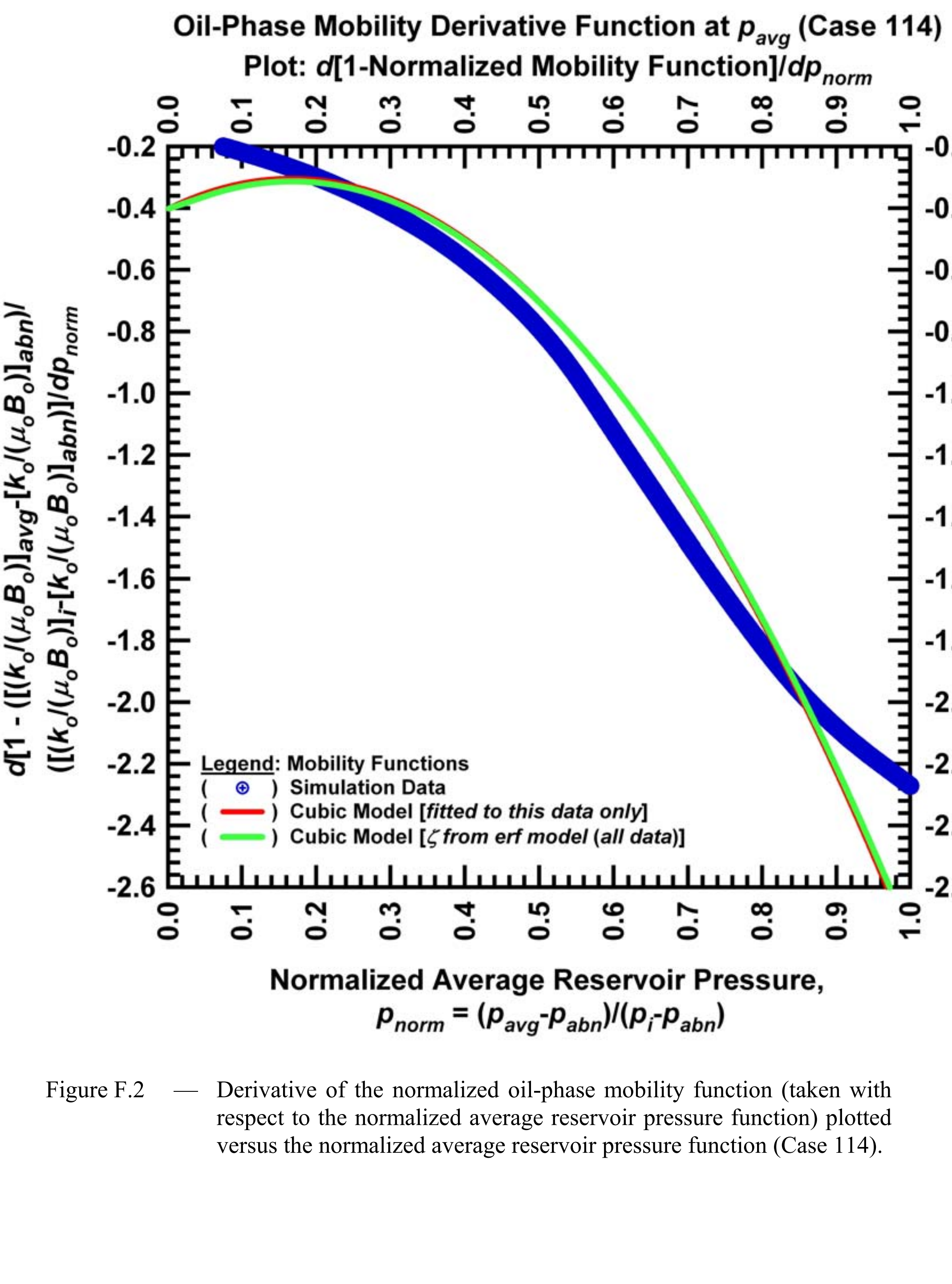

Figure F.2 — Derivative of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 114).

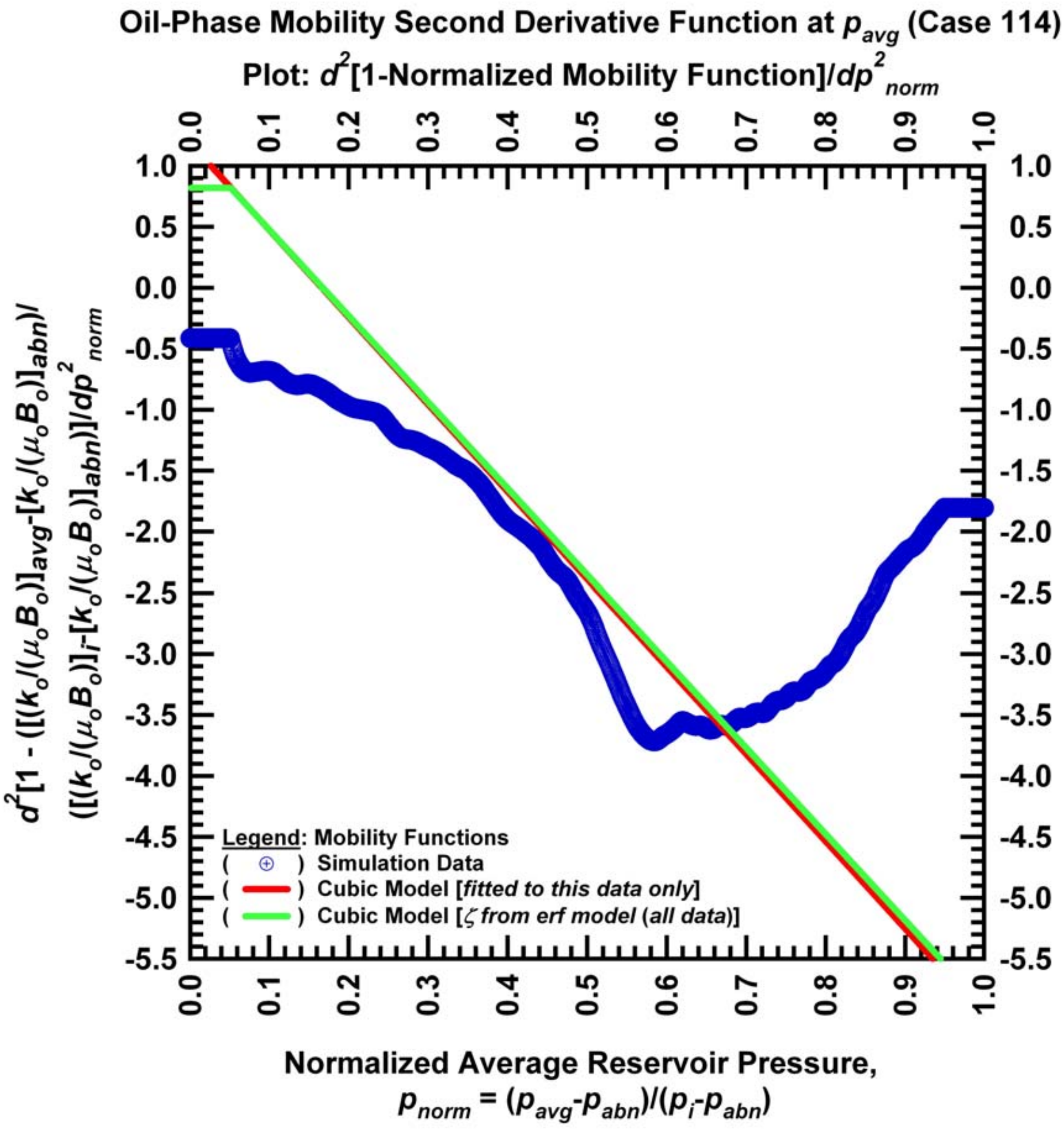

Figure F.3 — Second derivative of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 114).

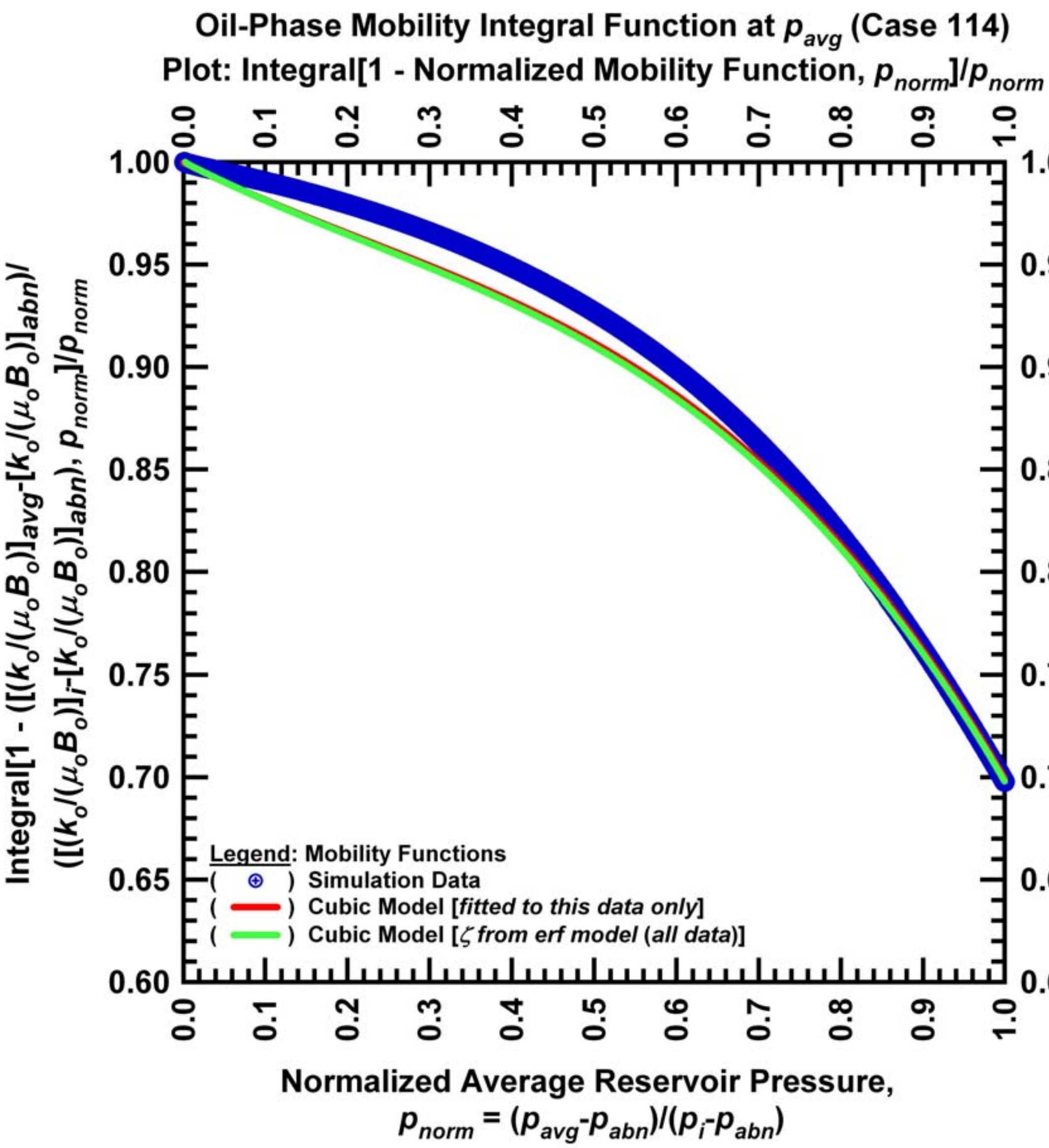

Figure F.4 — Integral of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 114).

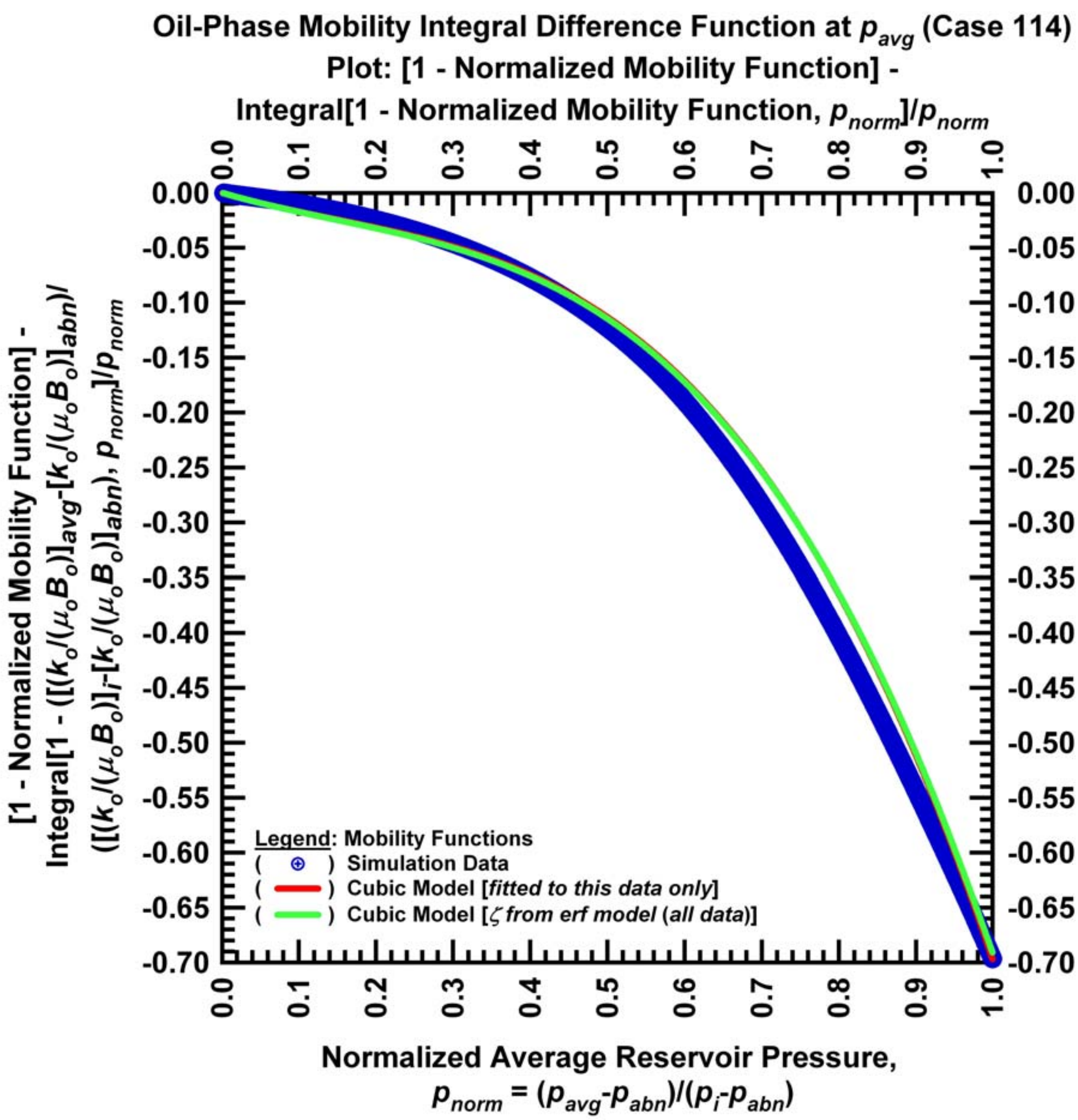

Figure F.5 — Integral difference of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 114).

APPENDIX G
CORRELATION PLOTS FOR THE CUBIC MODEL (CASE 173)

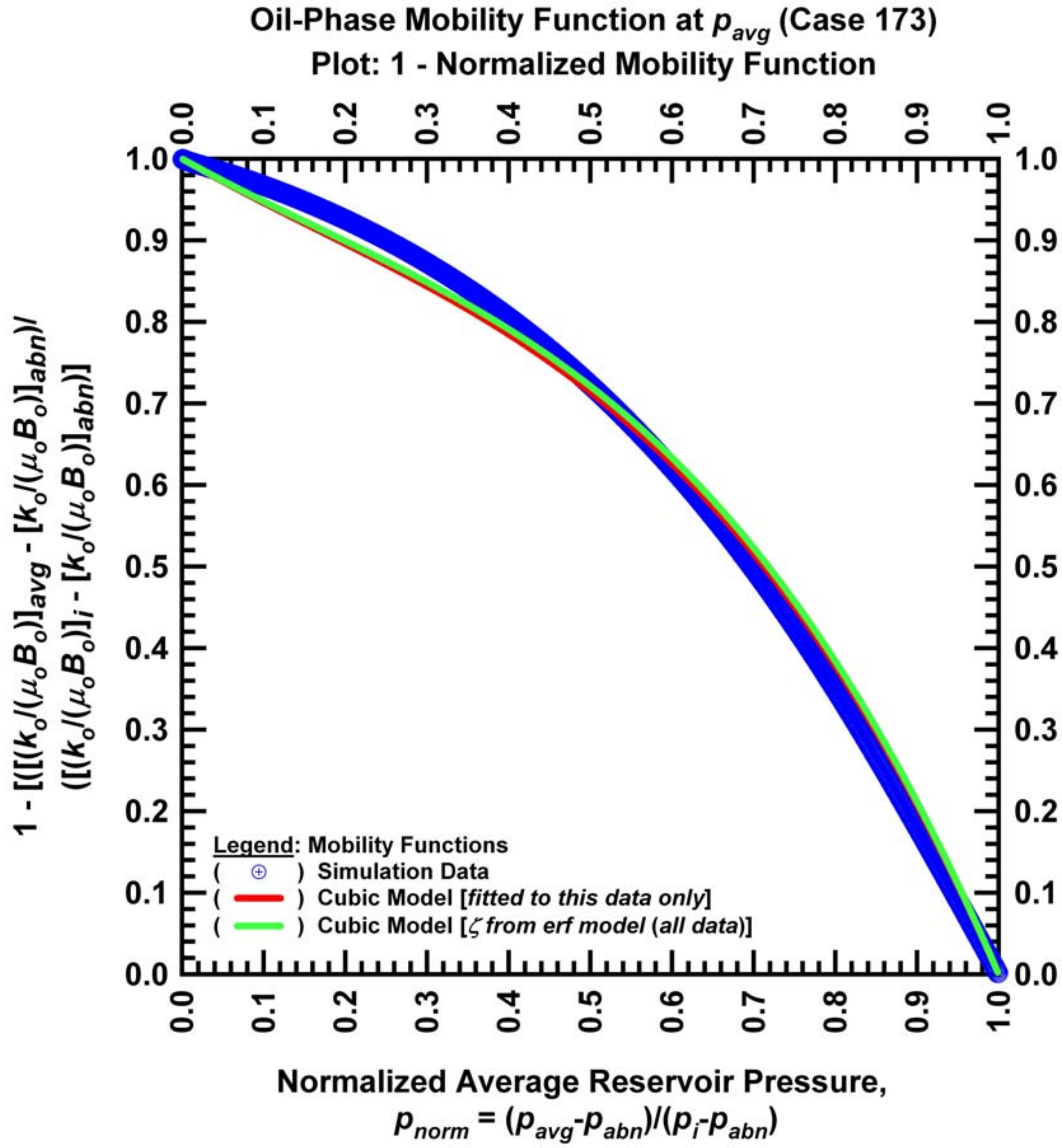

Figure G.1 — Normalized oil-phase mobility function plotted versus the normalized average reservoir pressure function (Case 173).

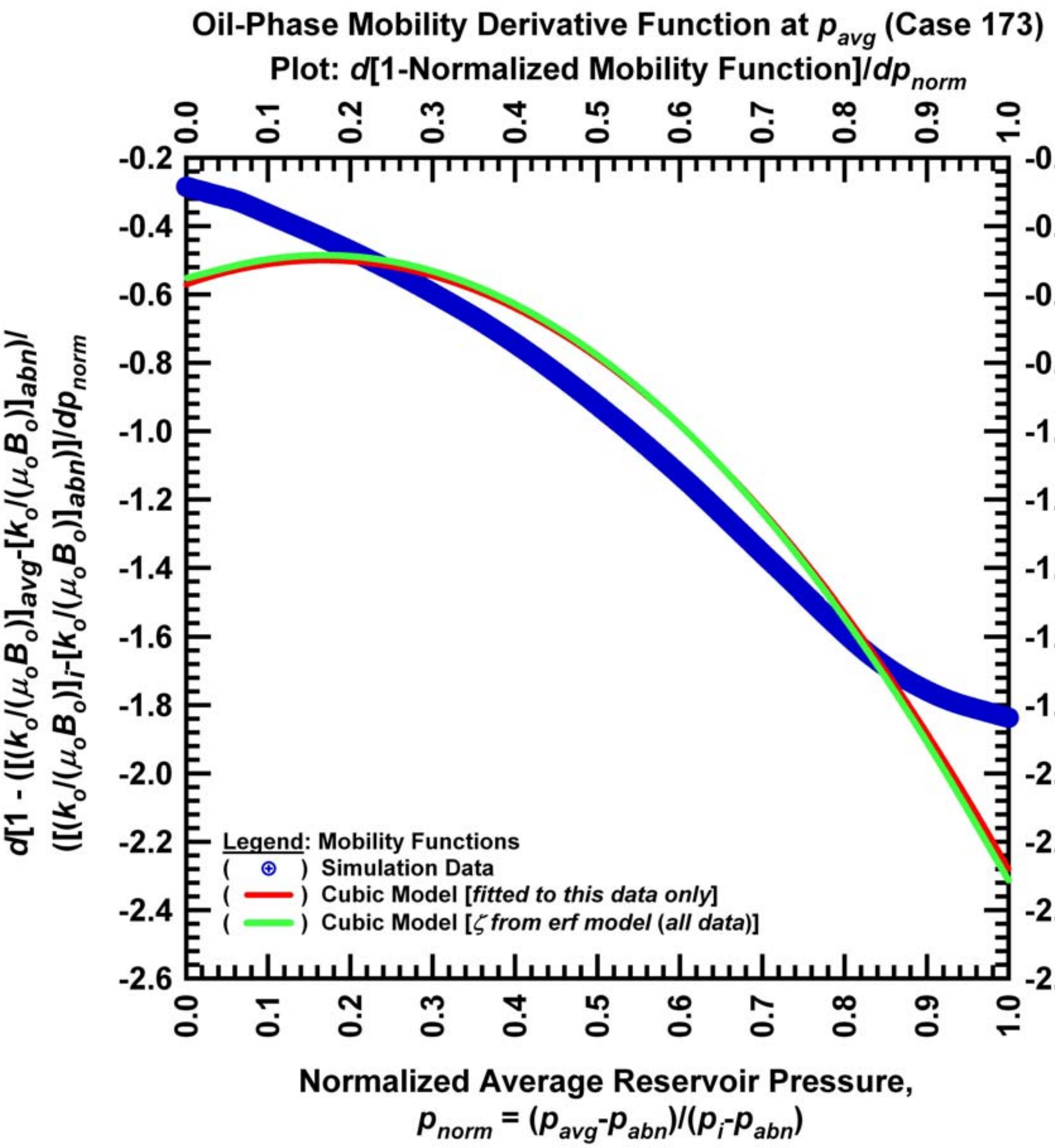

Figure G.2 — Derivative of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 173).

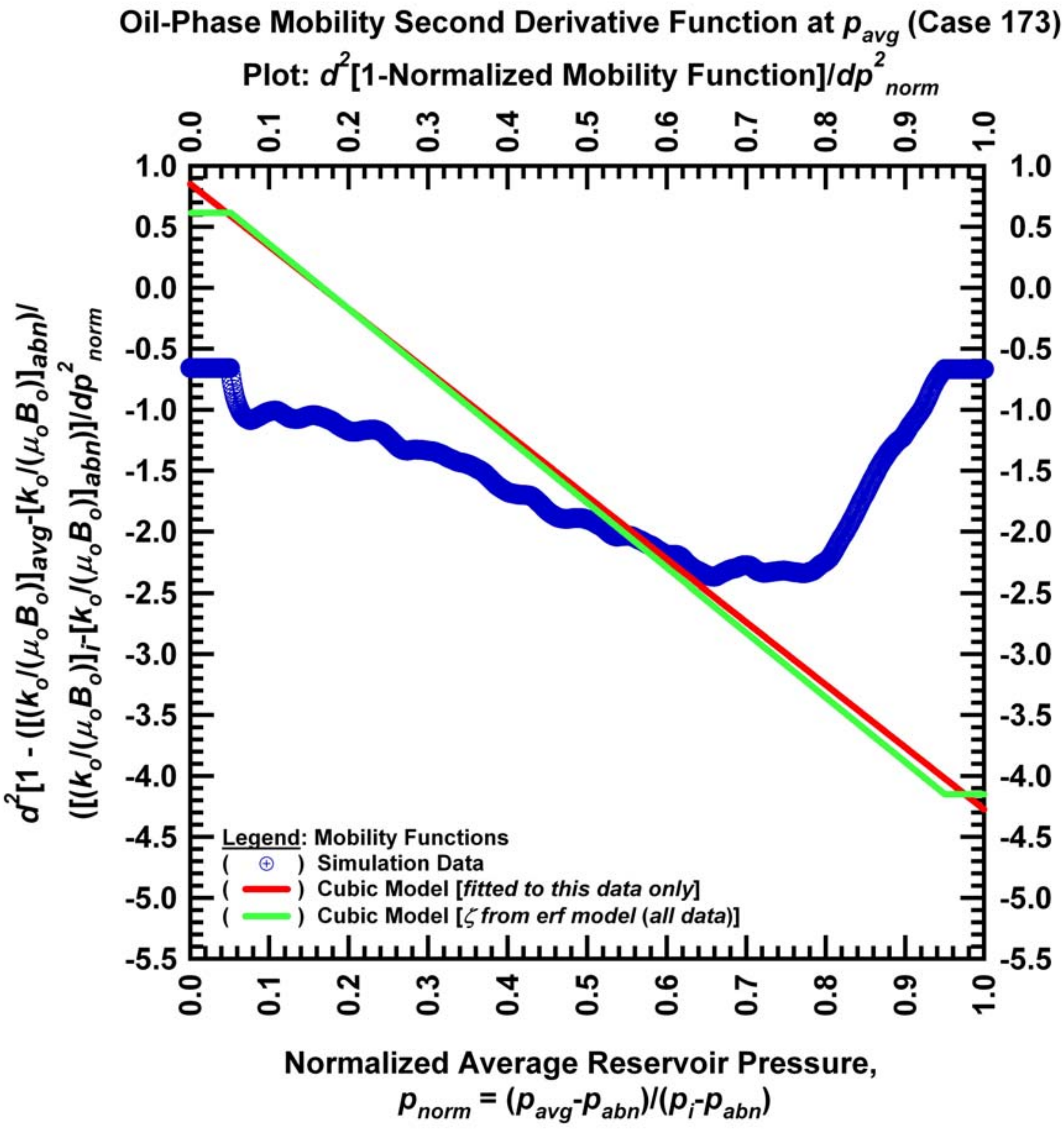

Figure G.3 — Second derivative of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 173).

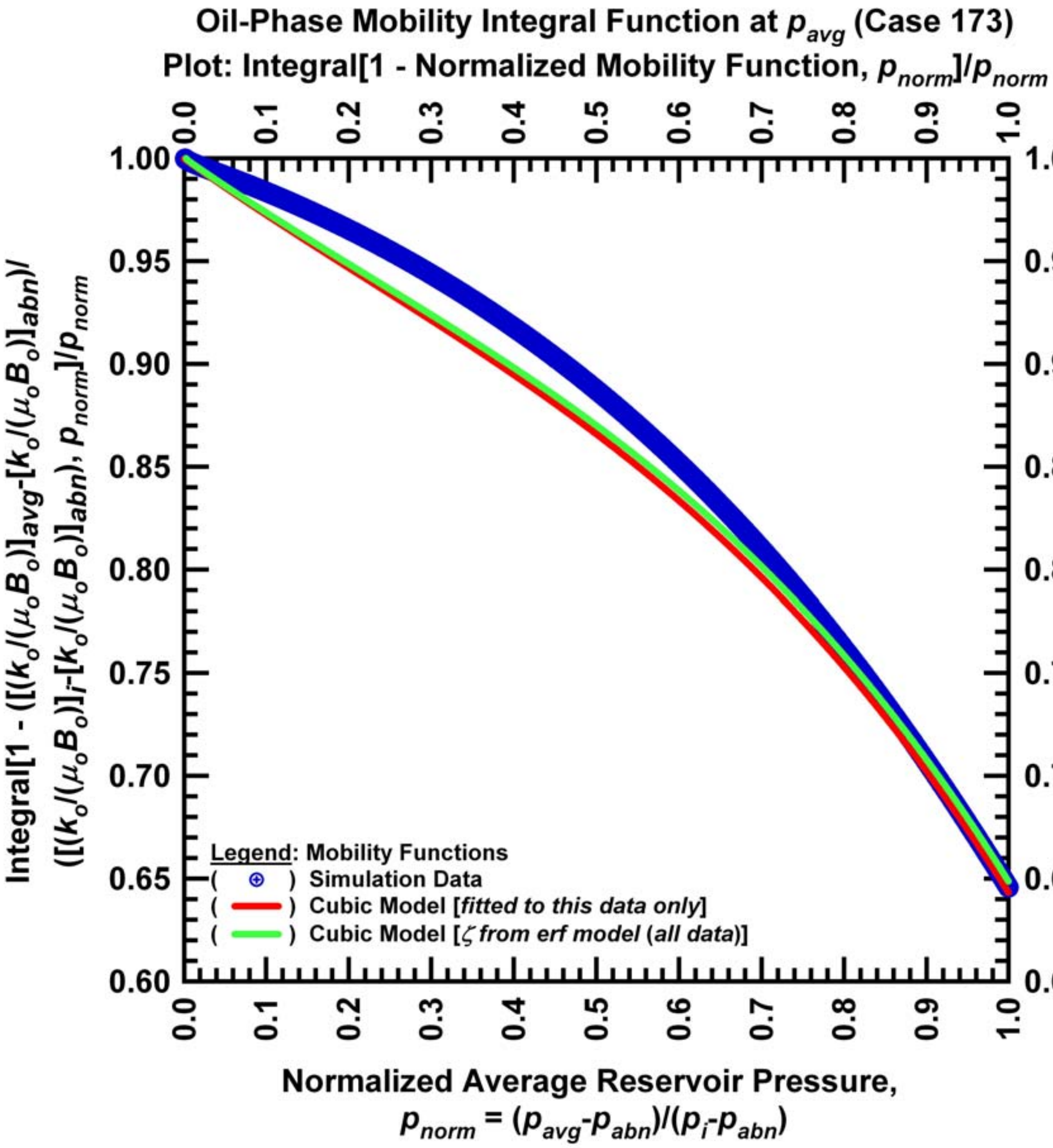

Figure G.4 — Integral of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 173).

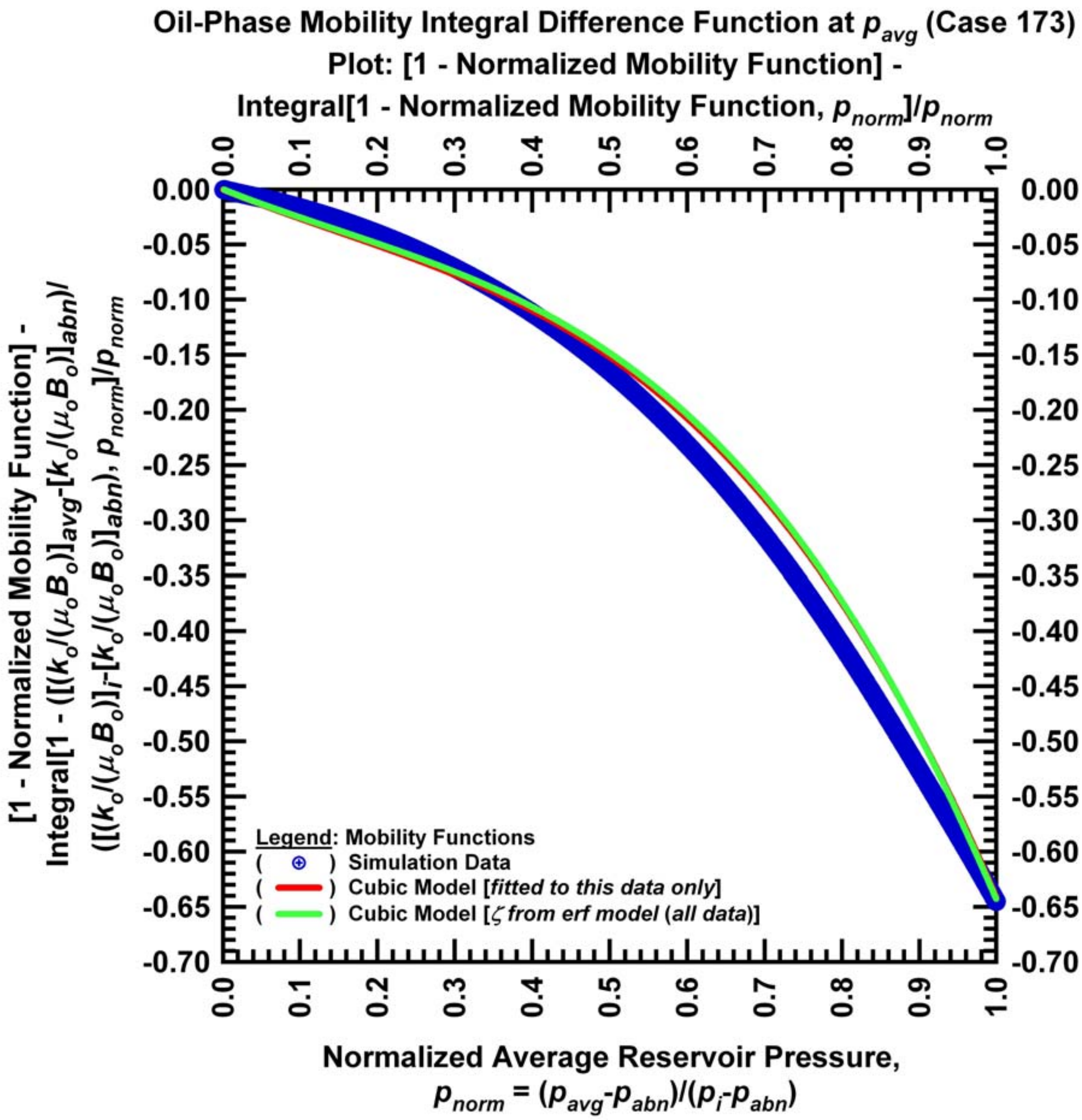

Figure G.5 — Integral difference of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 173).

APPENDIX H

CORRELATION PLOTS FOR THE CUBIC MODEL (CASE 190)

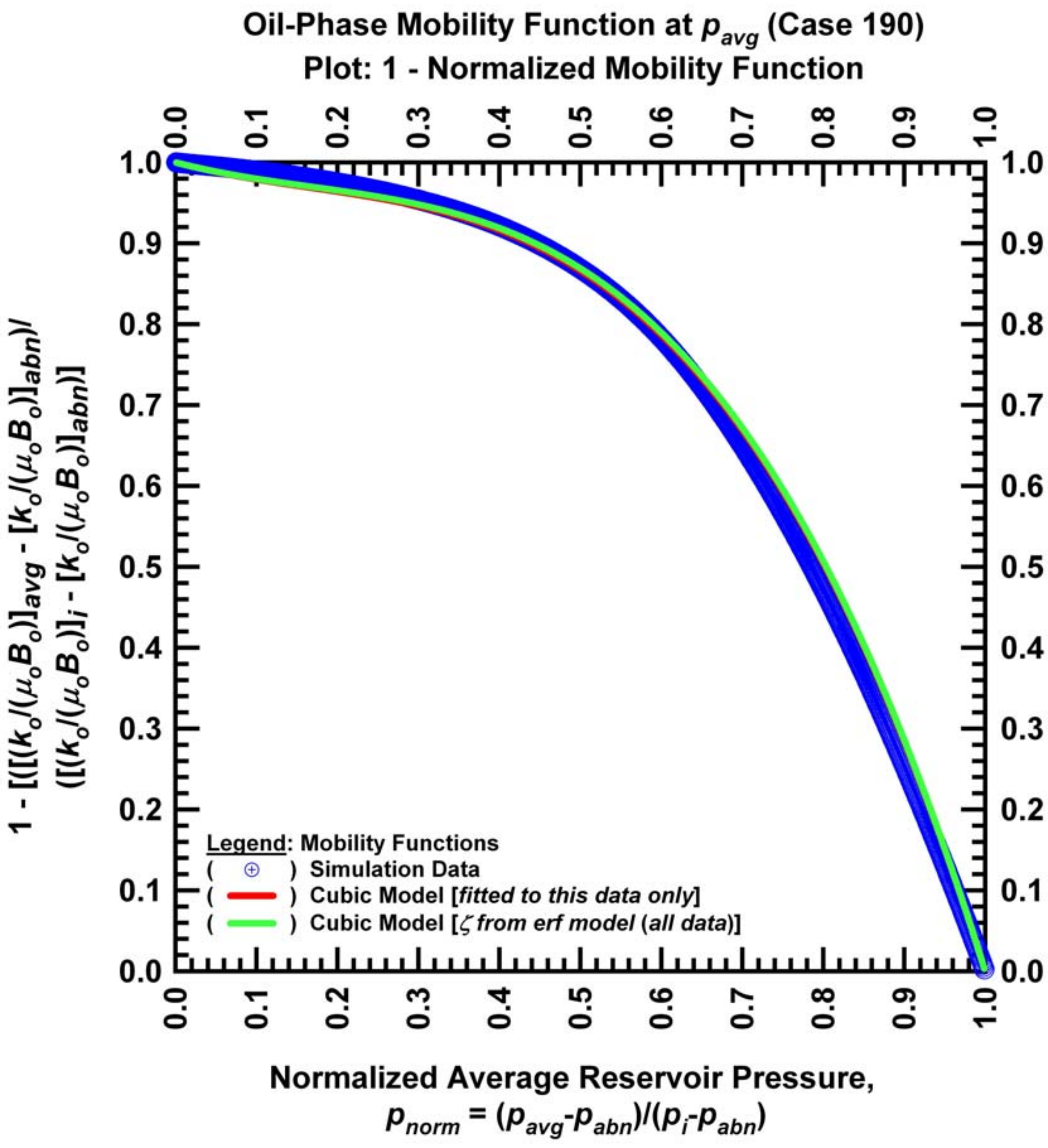

Figure H.1 — Normalized oil-phase mobility function plotted versus the normalized average reservoir pressure function (Case 190).

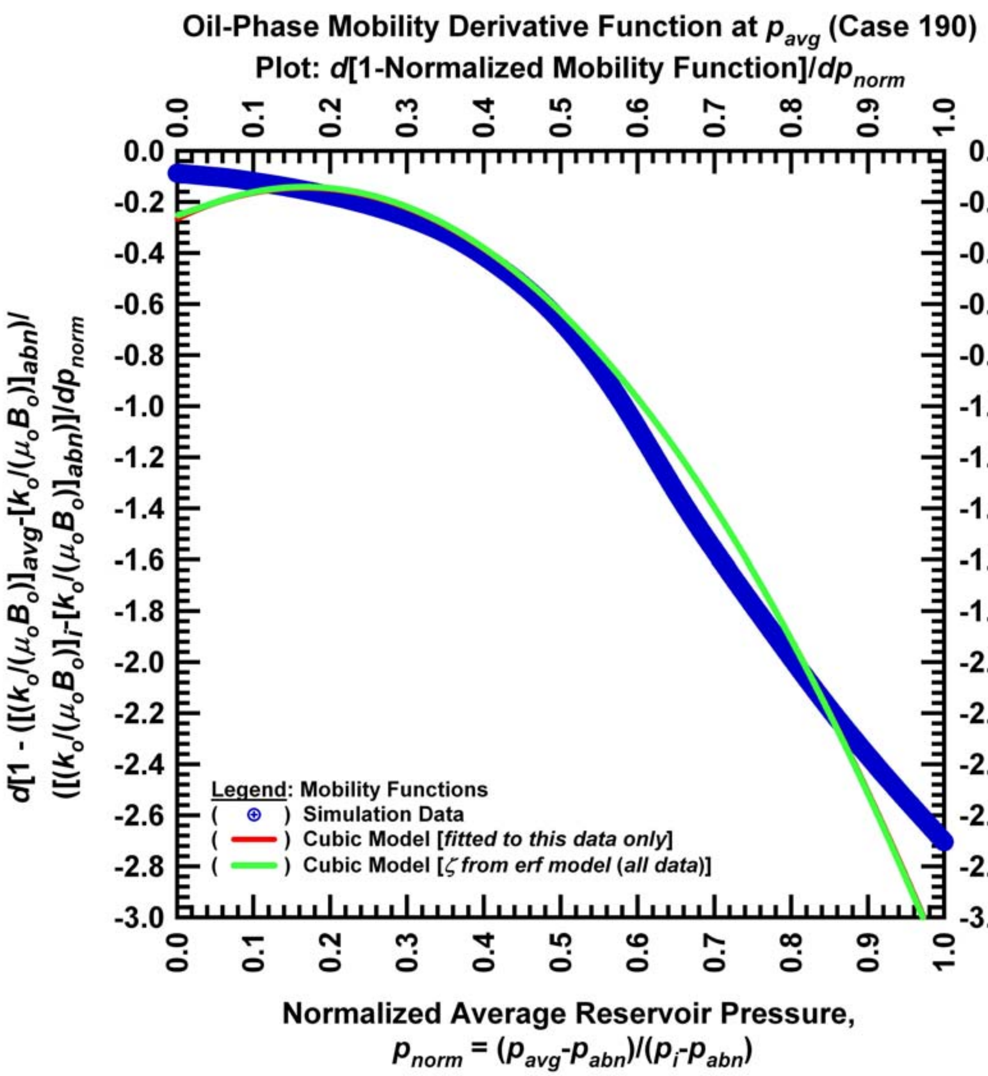

Figure H.2 — Derivative of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 190).

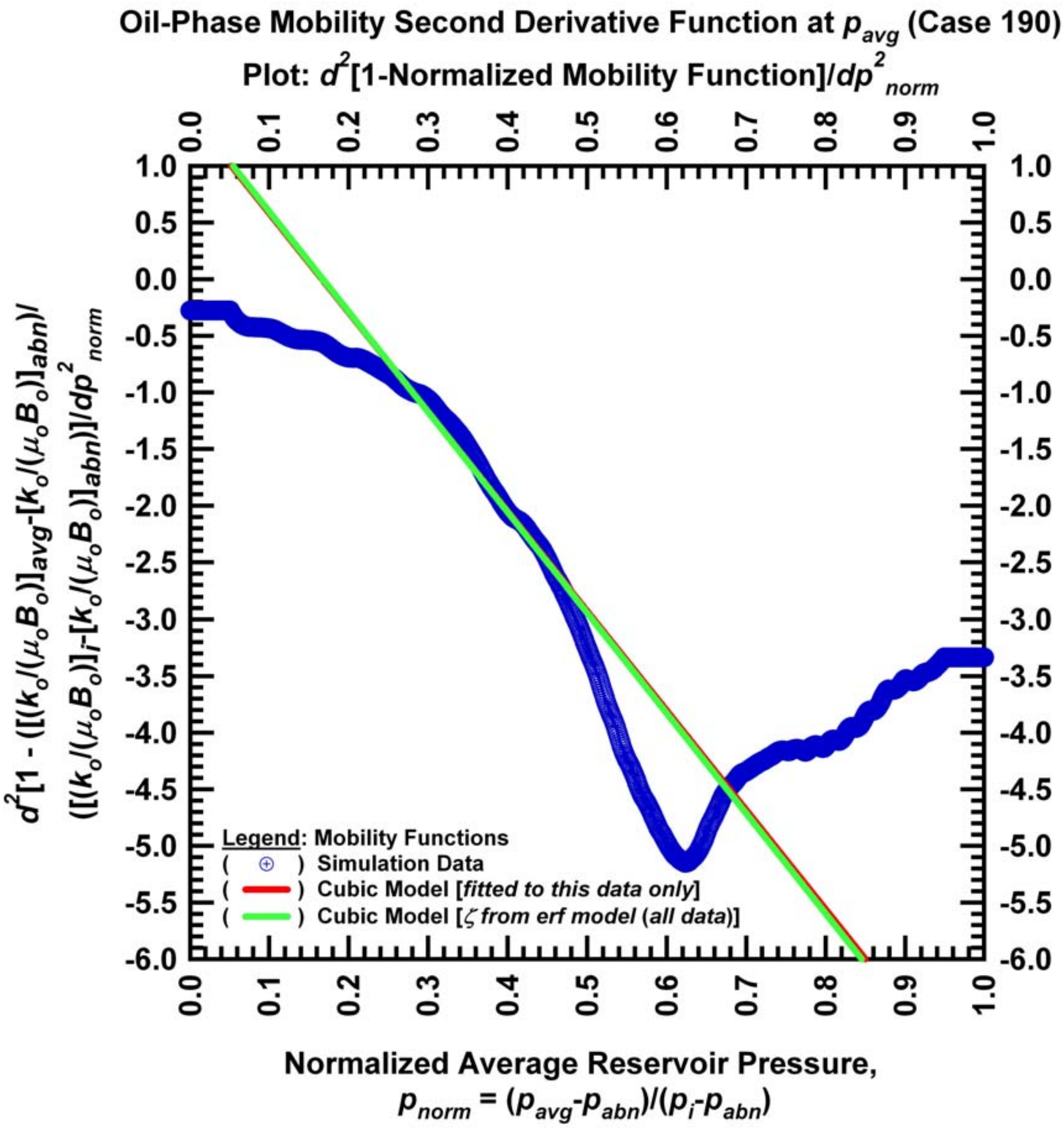

Figure H.3 — Second derivative of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 190).

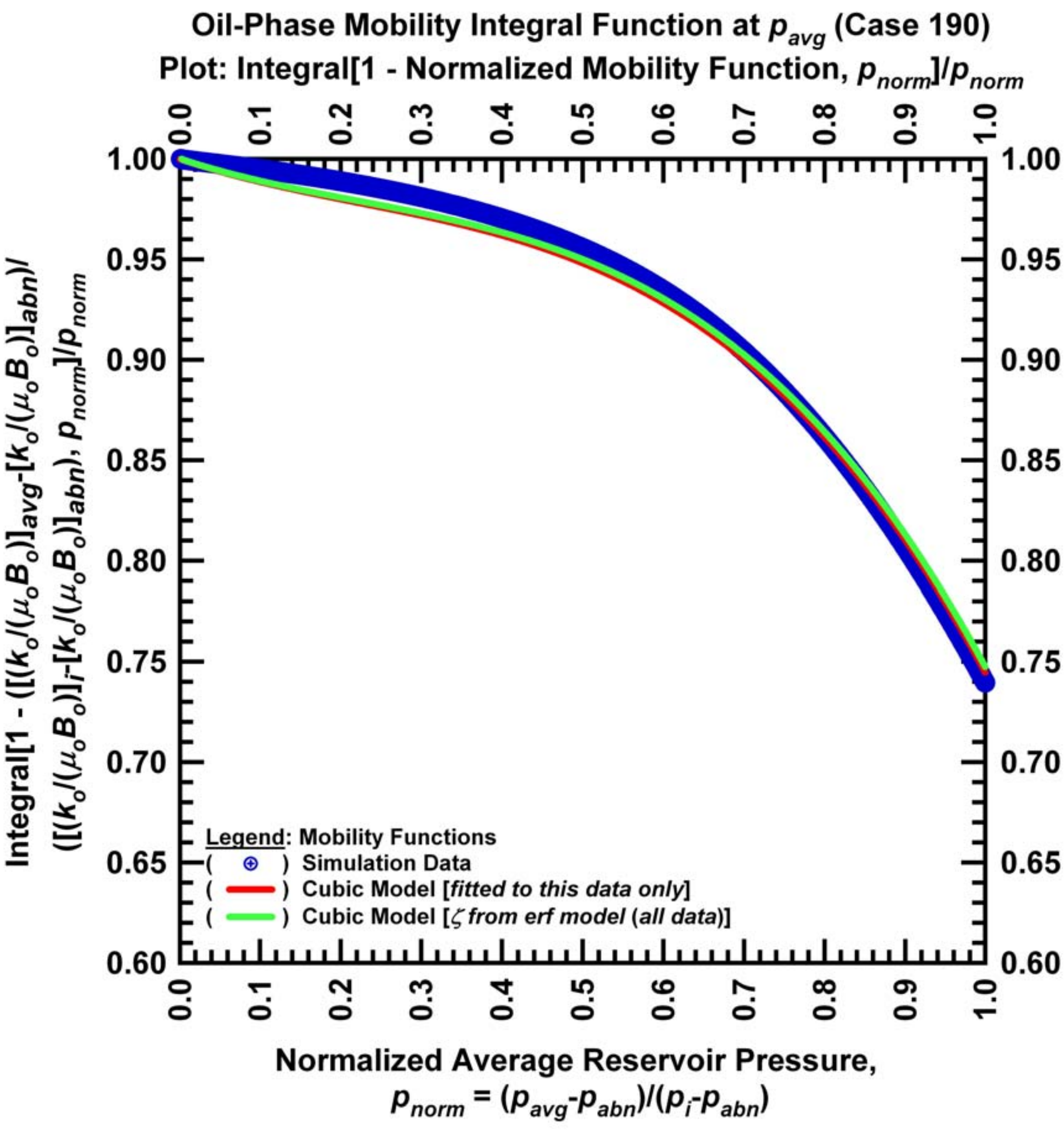

Figure H.4 — Integral of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 190).

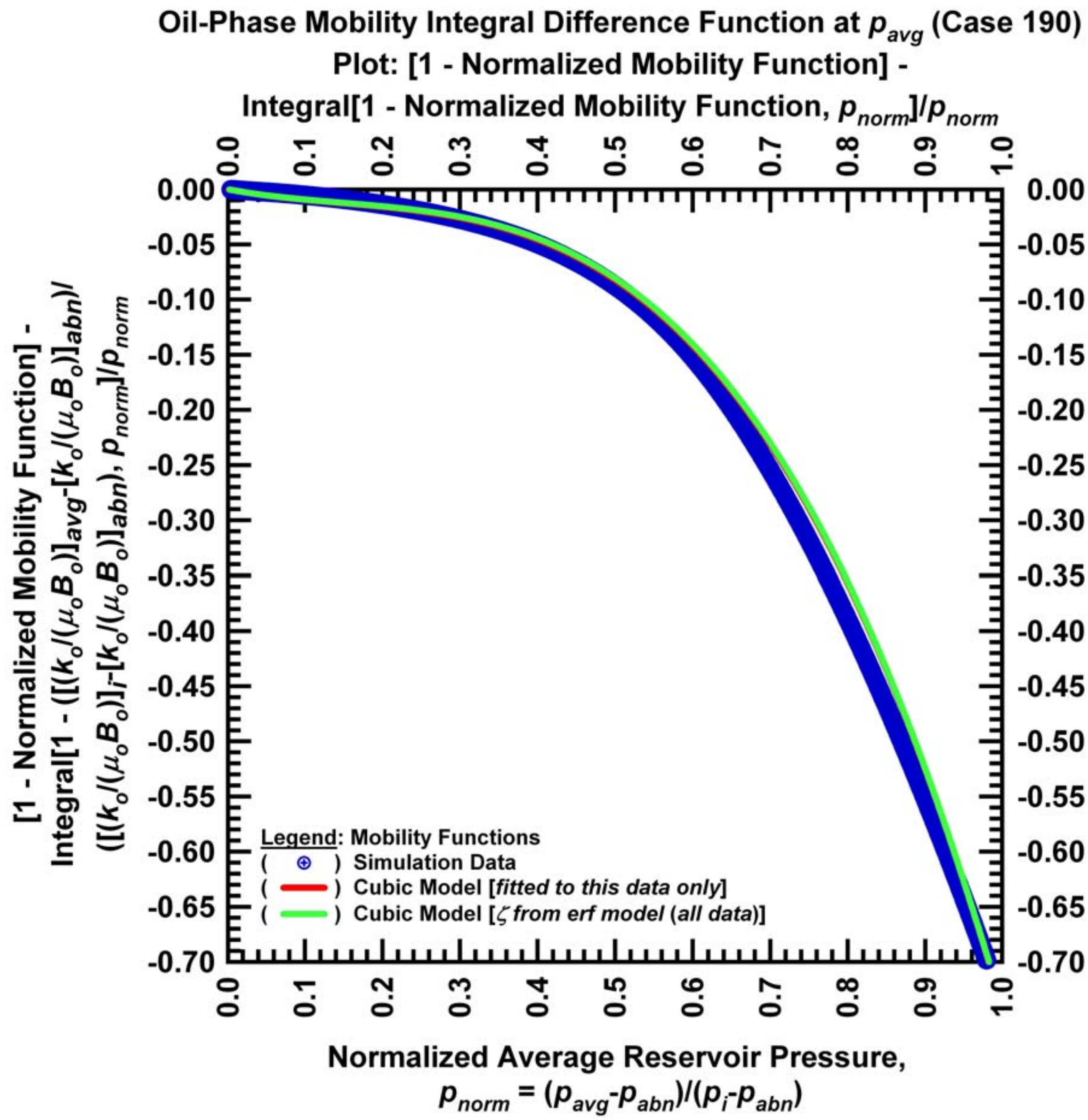

Figure H.5 — Integral difference of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 190).

APPENDIX I

CORRELATION PLOTS FOR THE CUBIC MODEL (CASE 505)

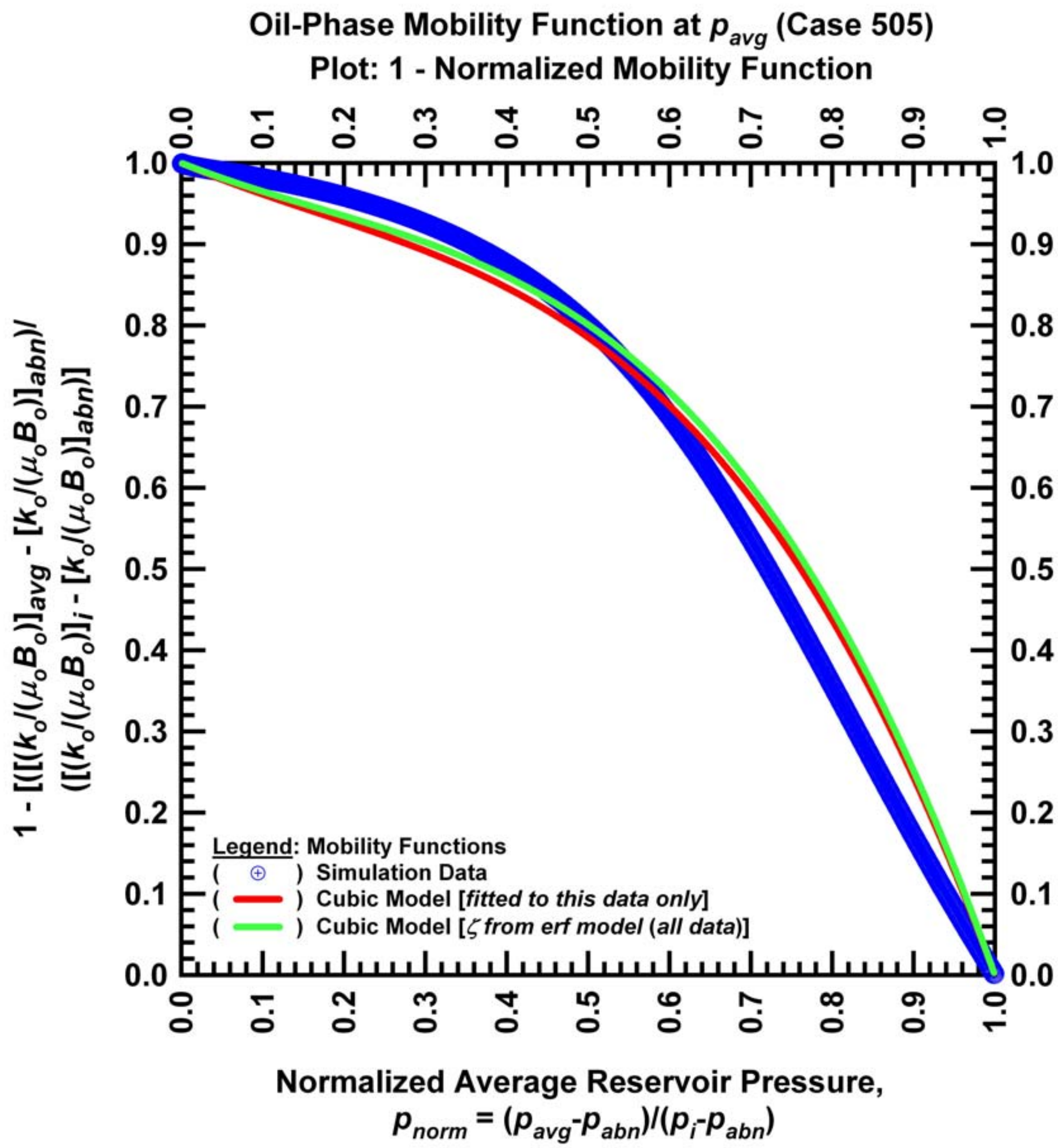

Figure I.1 — Normalized oil-phase mobility function plotted versus the normalized average reservoir pressure function (Case 505).

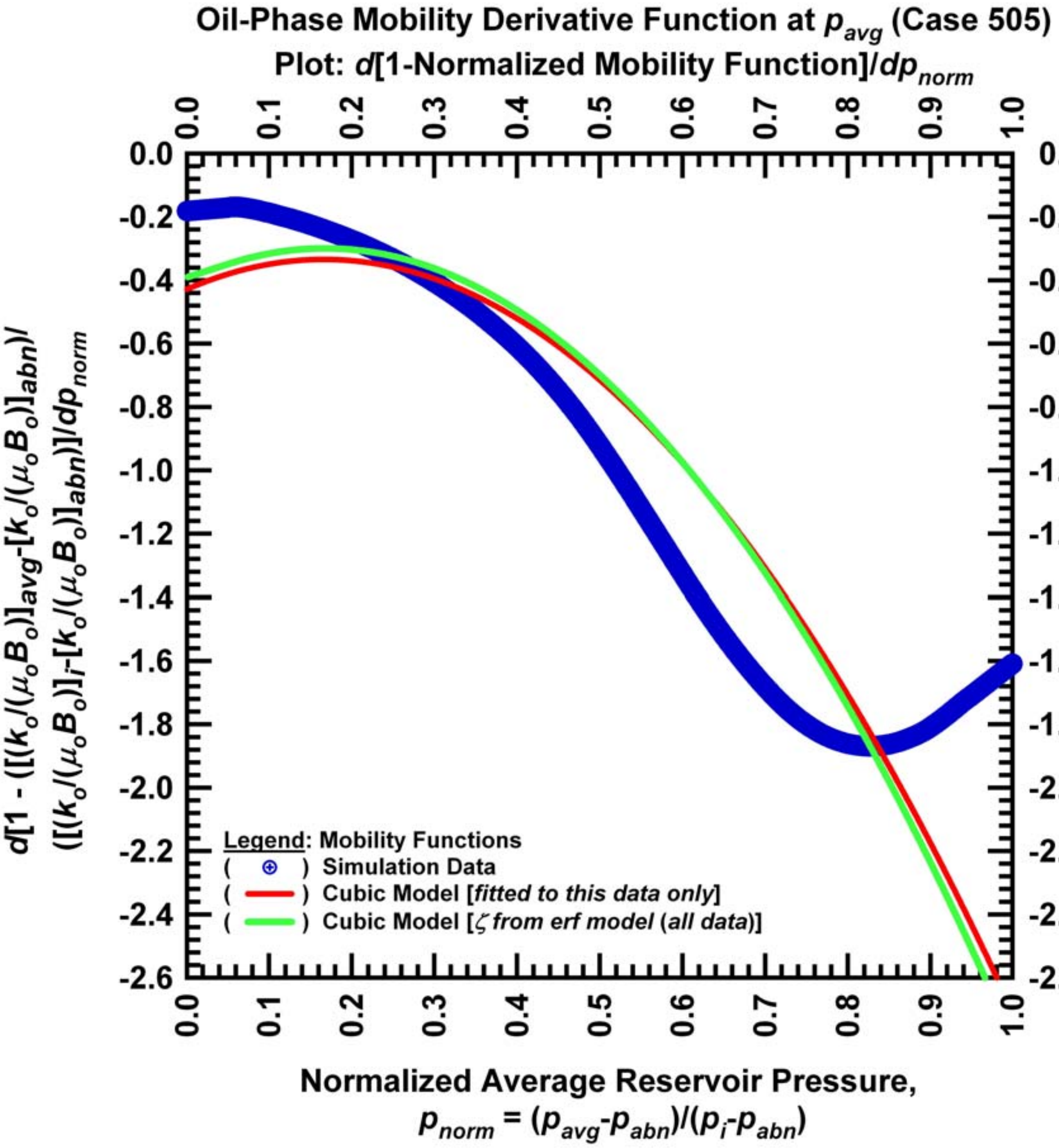

Figure I.2 — Derivative of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 505).

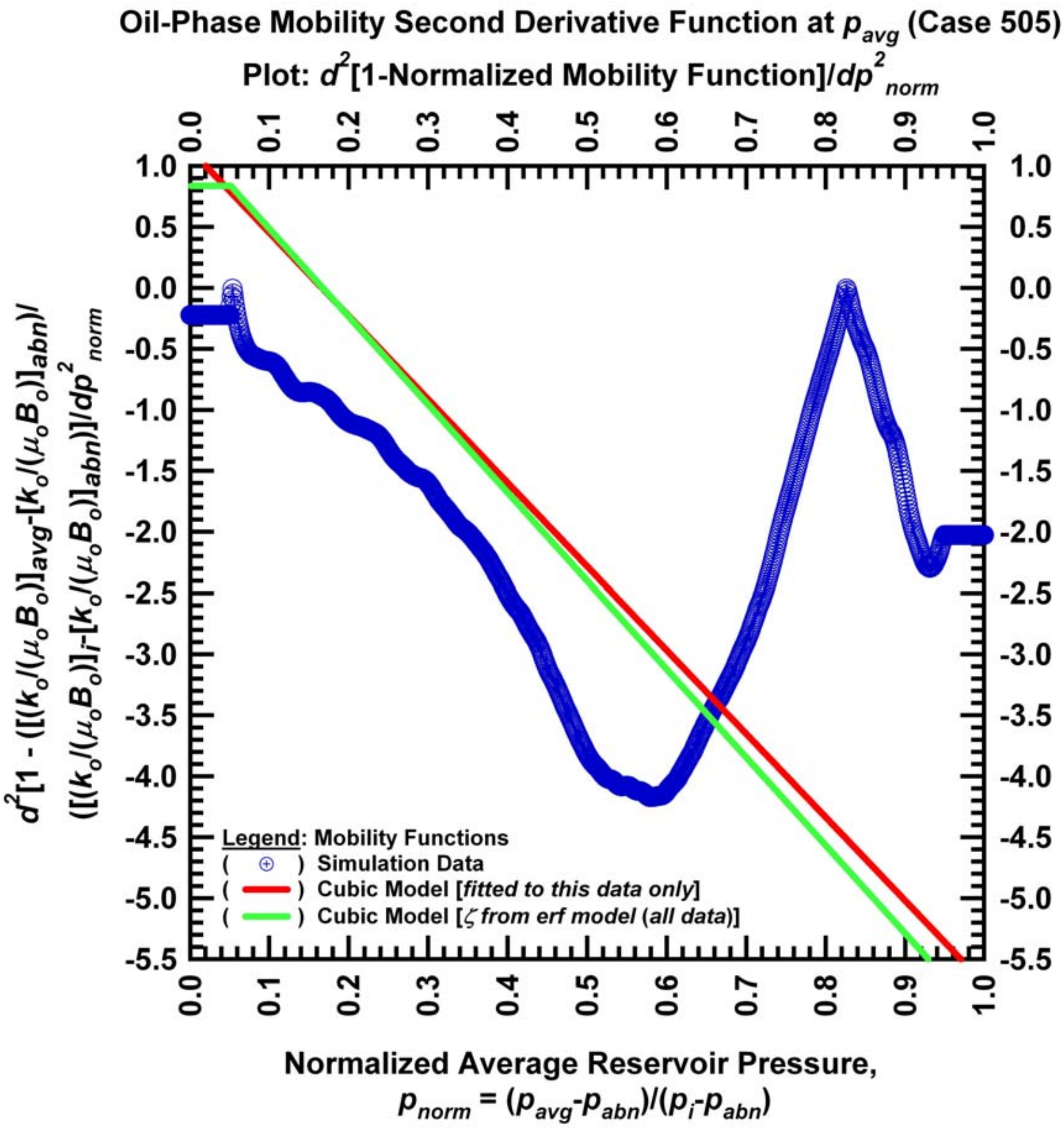

Figure I.3 — Second derivative of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 505).

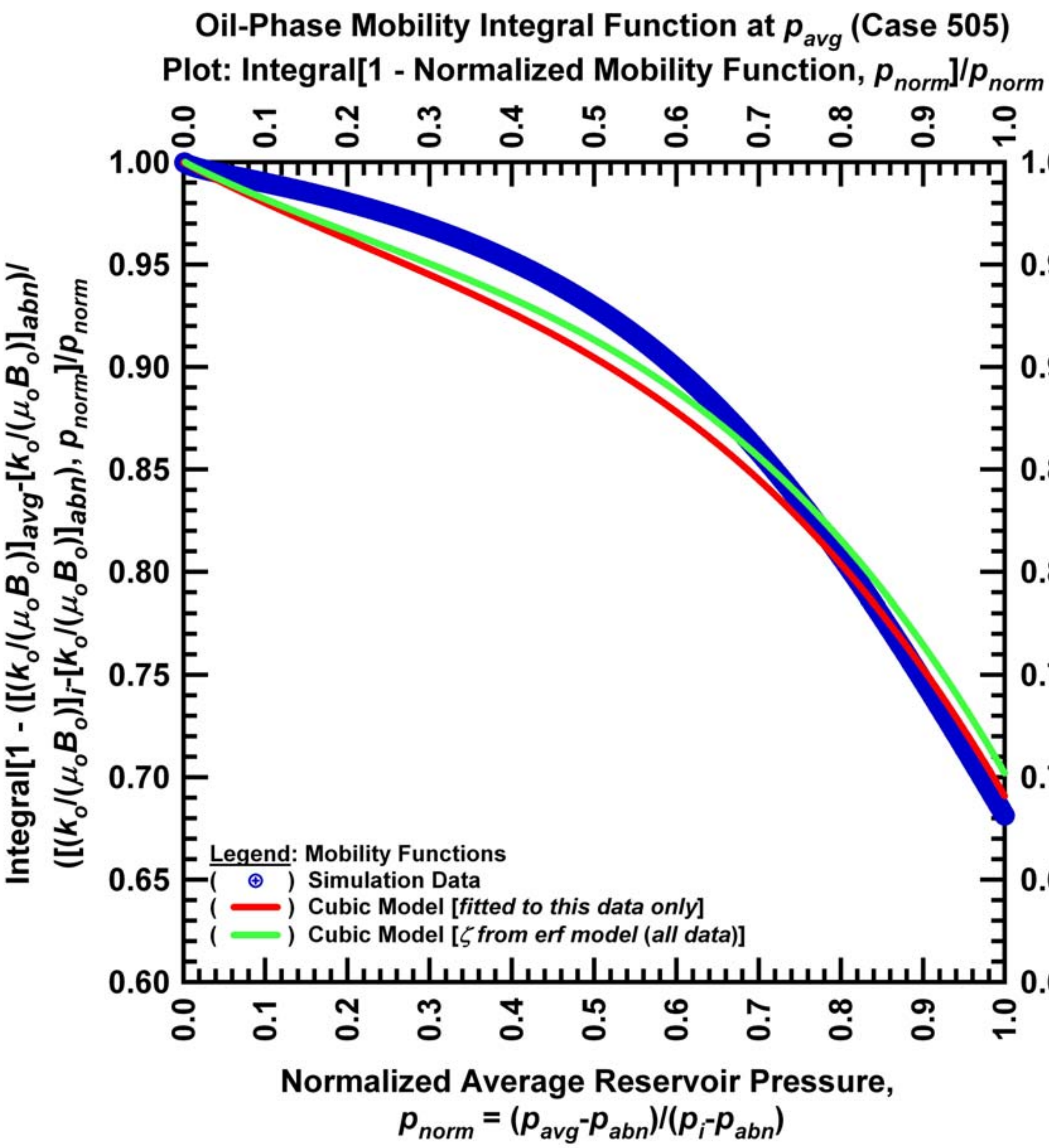

Figure I.4 — Integral of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 505).

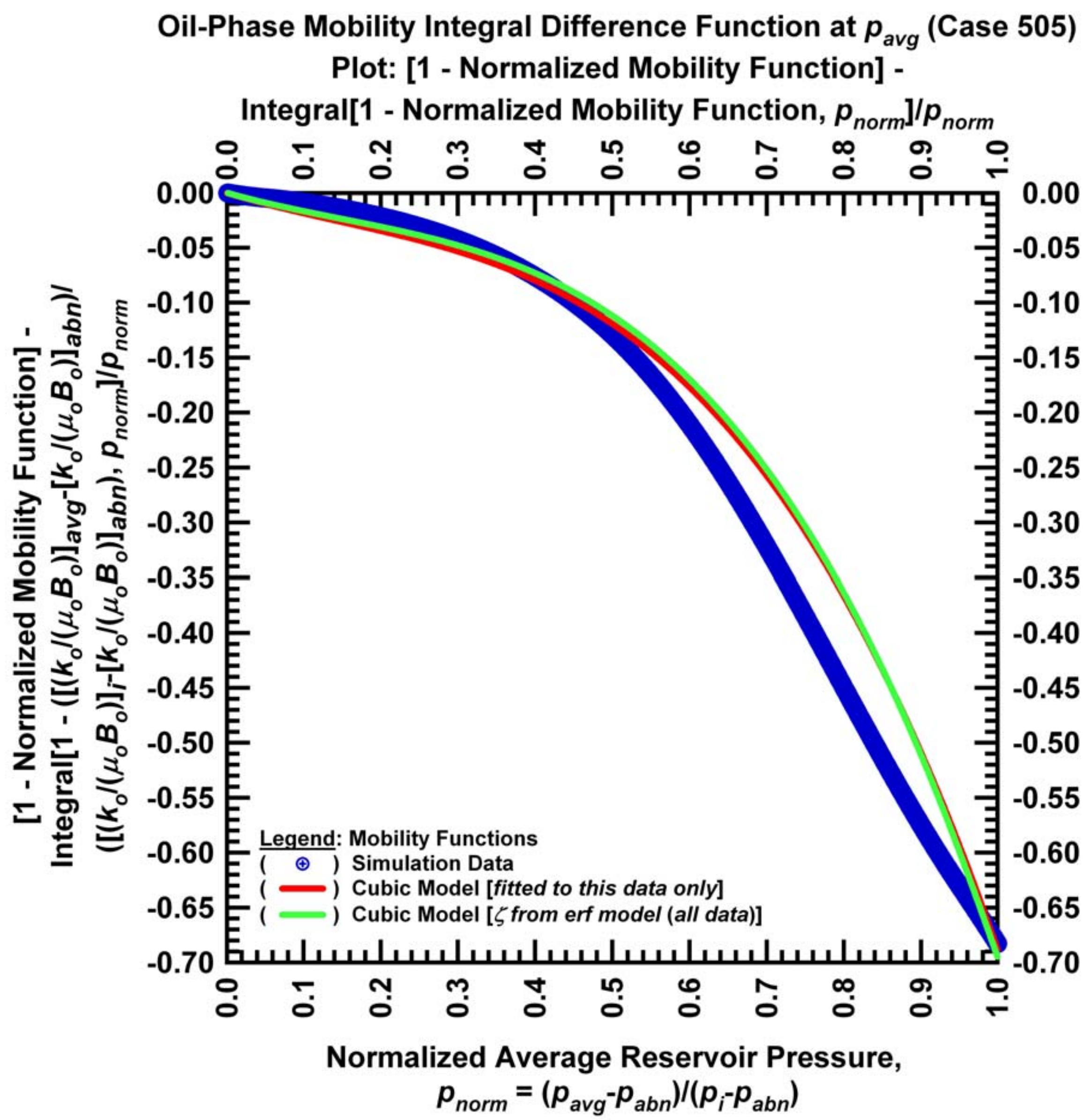

Figure I.5 — Integral difference of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 505).

APPENDIX J
CORRELATION PLOTS FOR THE CUBIC MODEL (CASE 563)

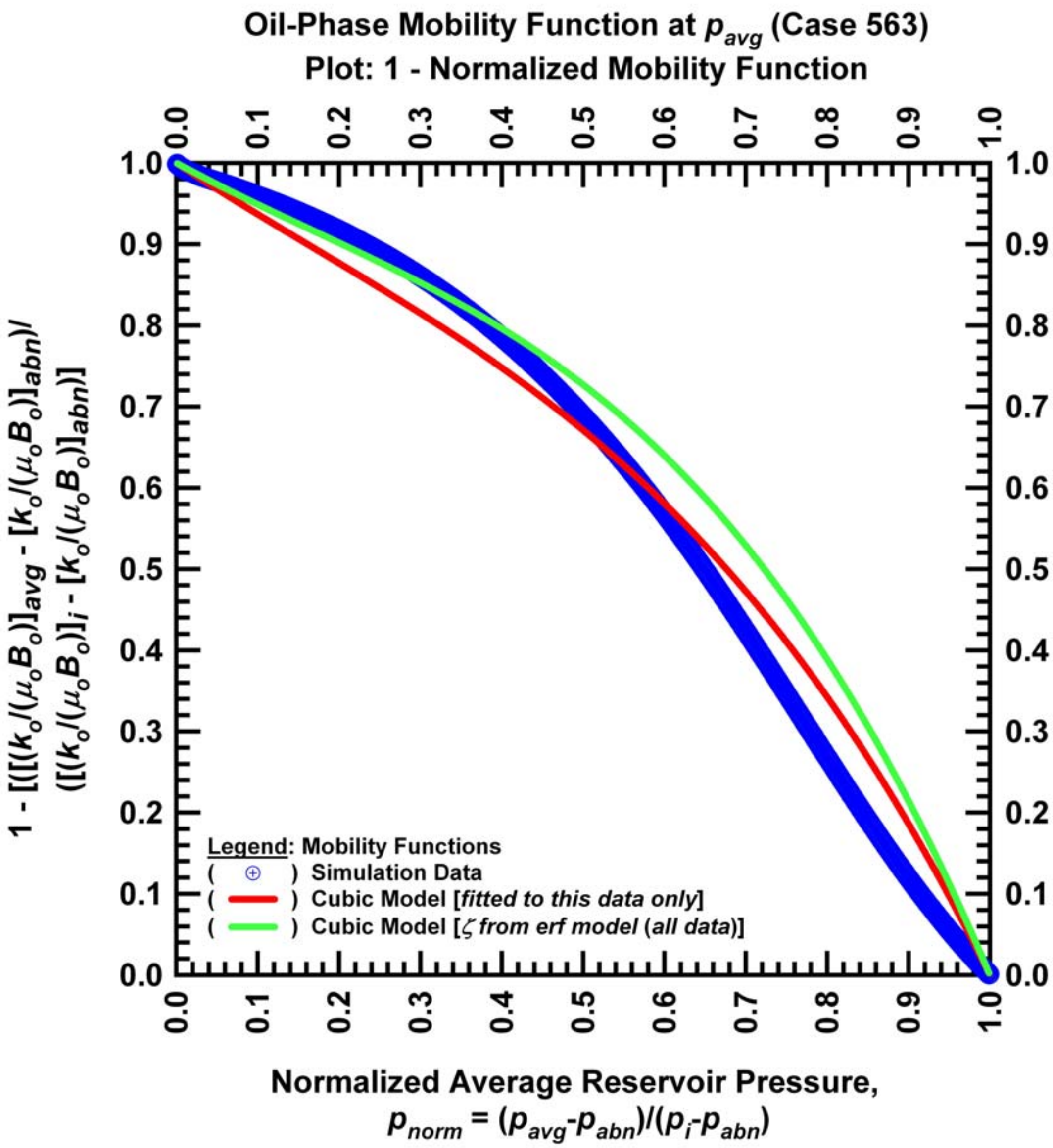

Figure J.1 — Normalized oil-phase mobility function plotted versus the normalized average reservoir pressure function (Case 563).

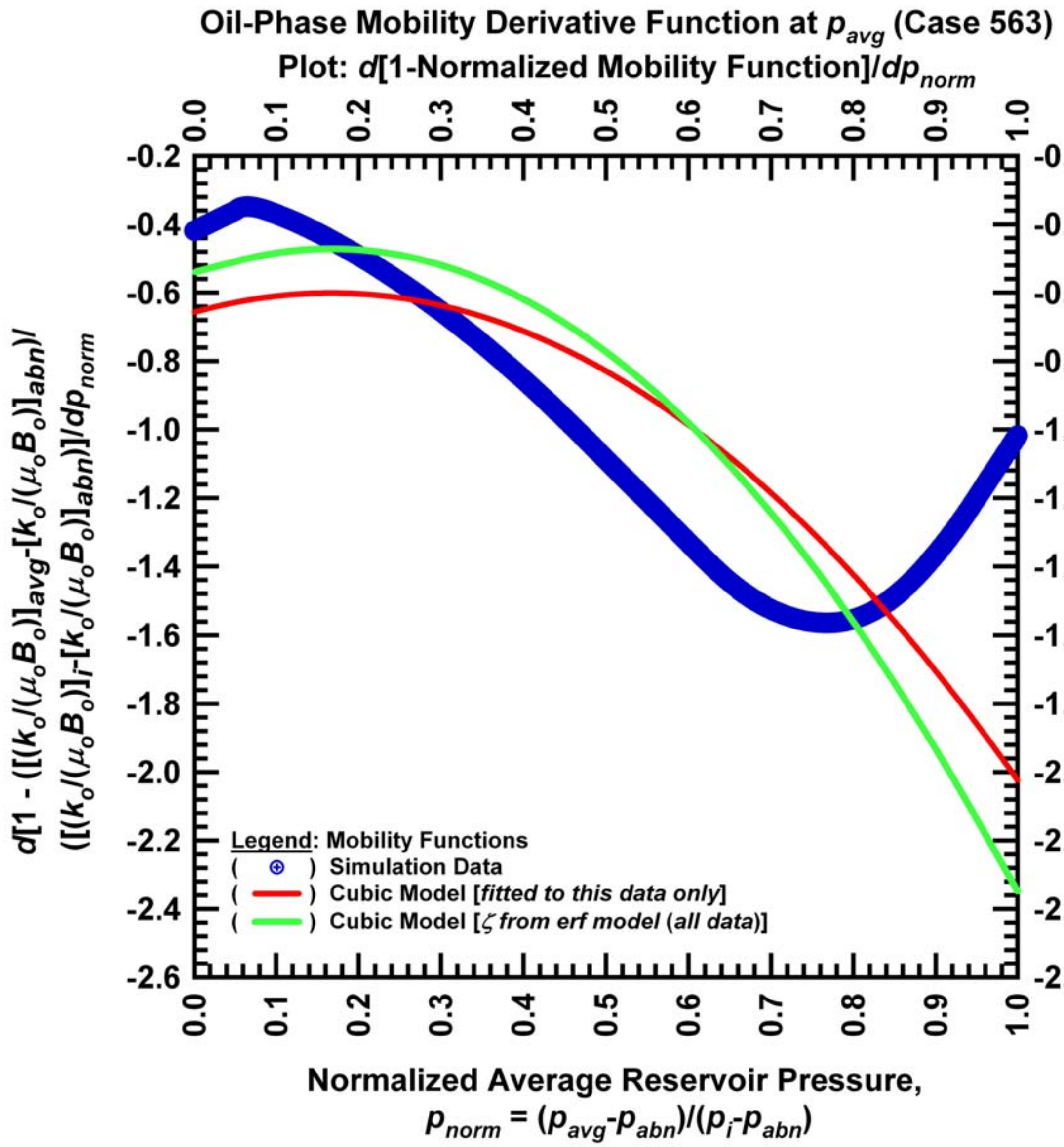

Figure J.2 — Derivative of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 563).

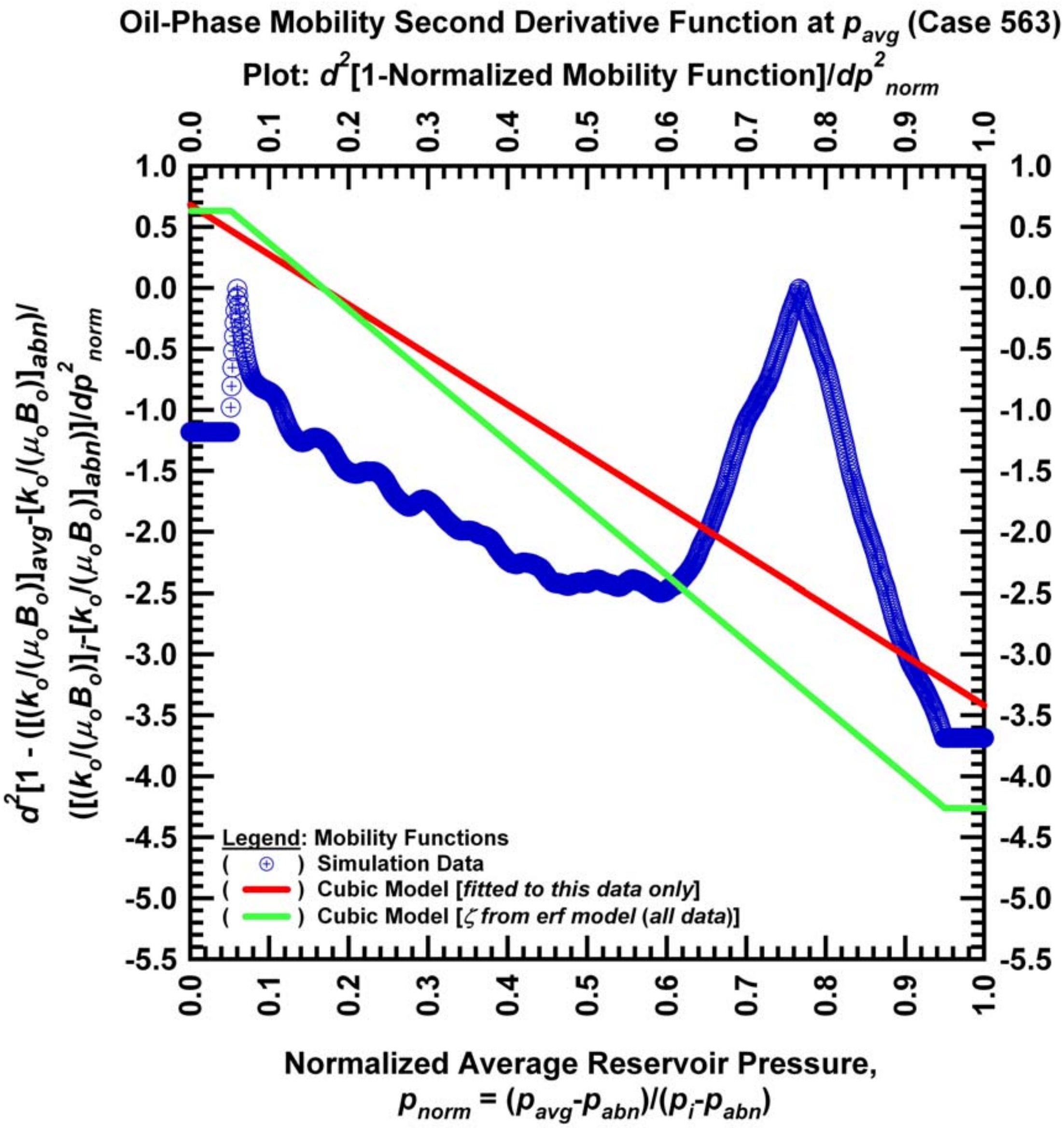

Figure J.3 — Second derivative of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 563).

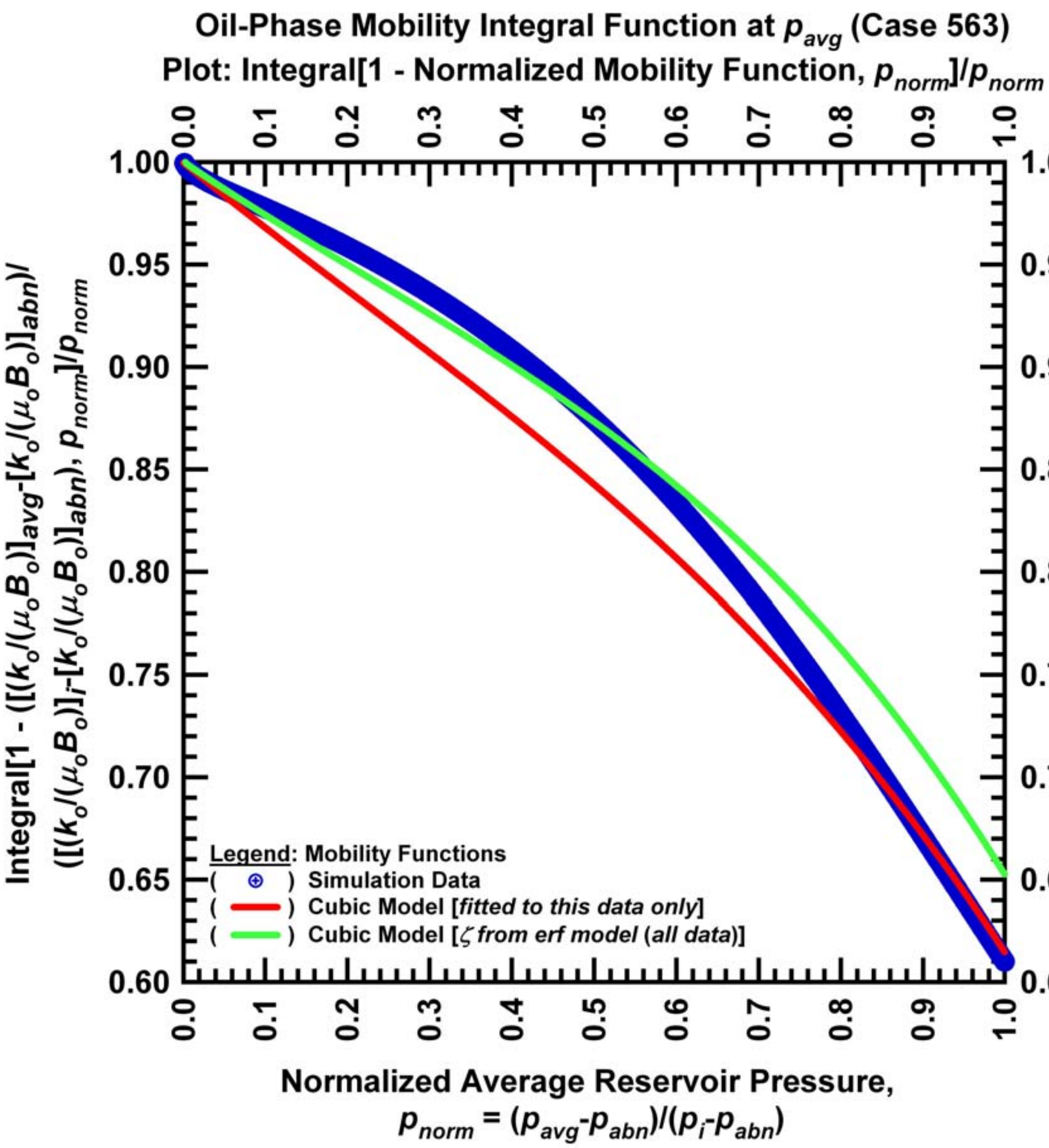

Figure J.4 — Integral of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 563).

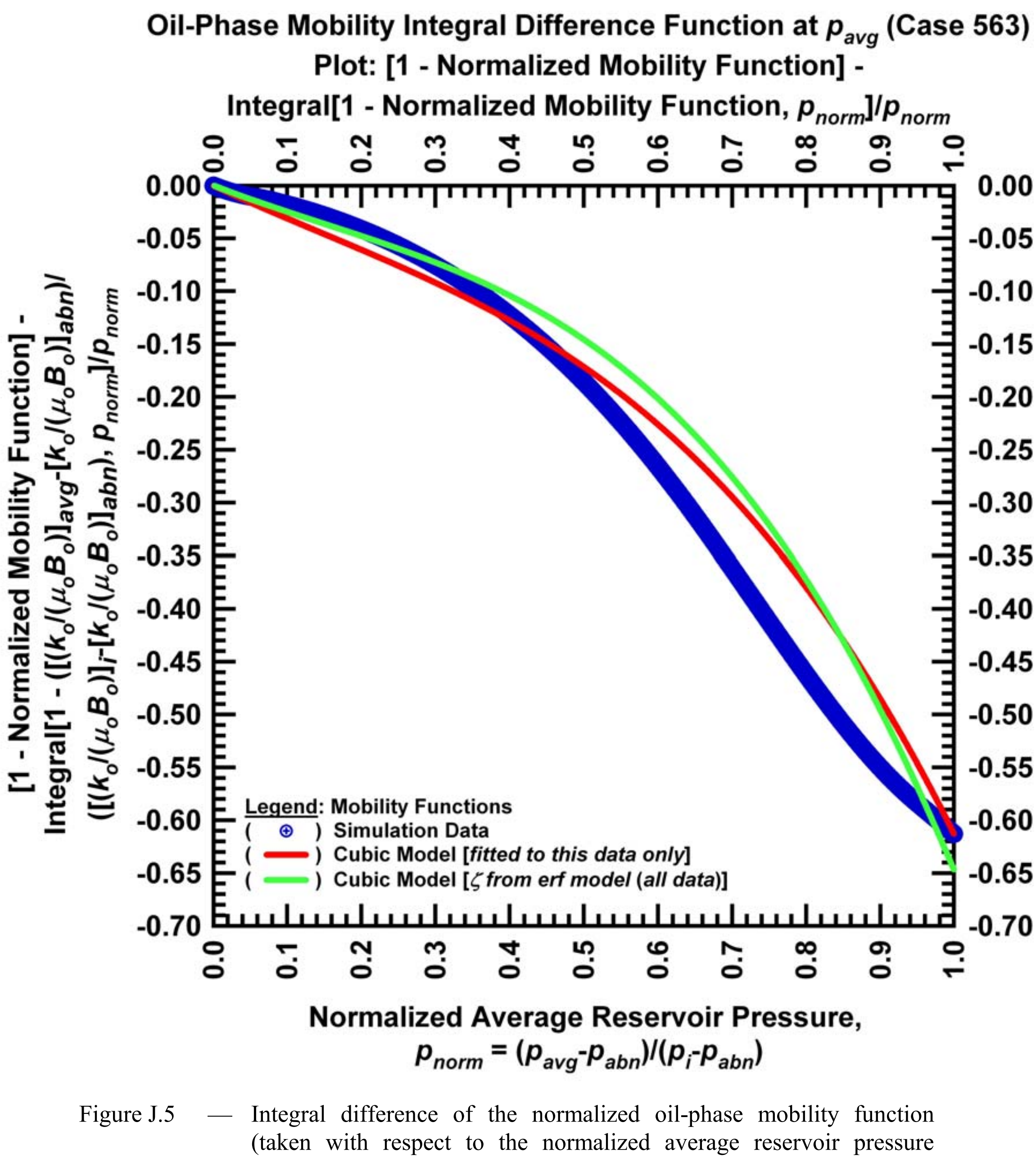

Figure J.5 — Integral difference of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 563).

APPENDIX K
CORRELATION PLOTS FOR THE CUBIC MODEL (CASE 576)

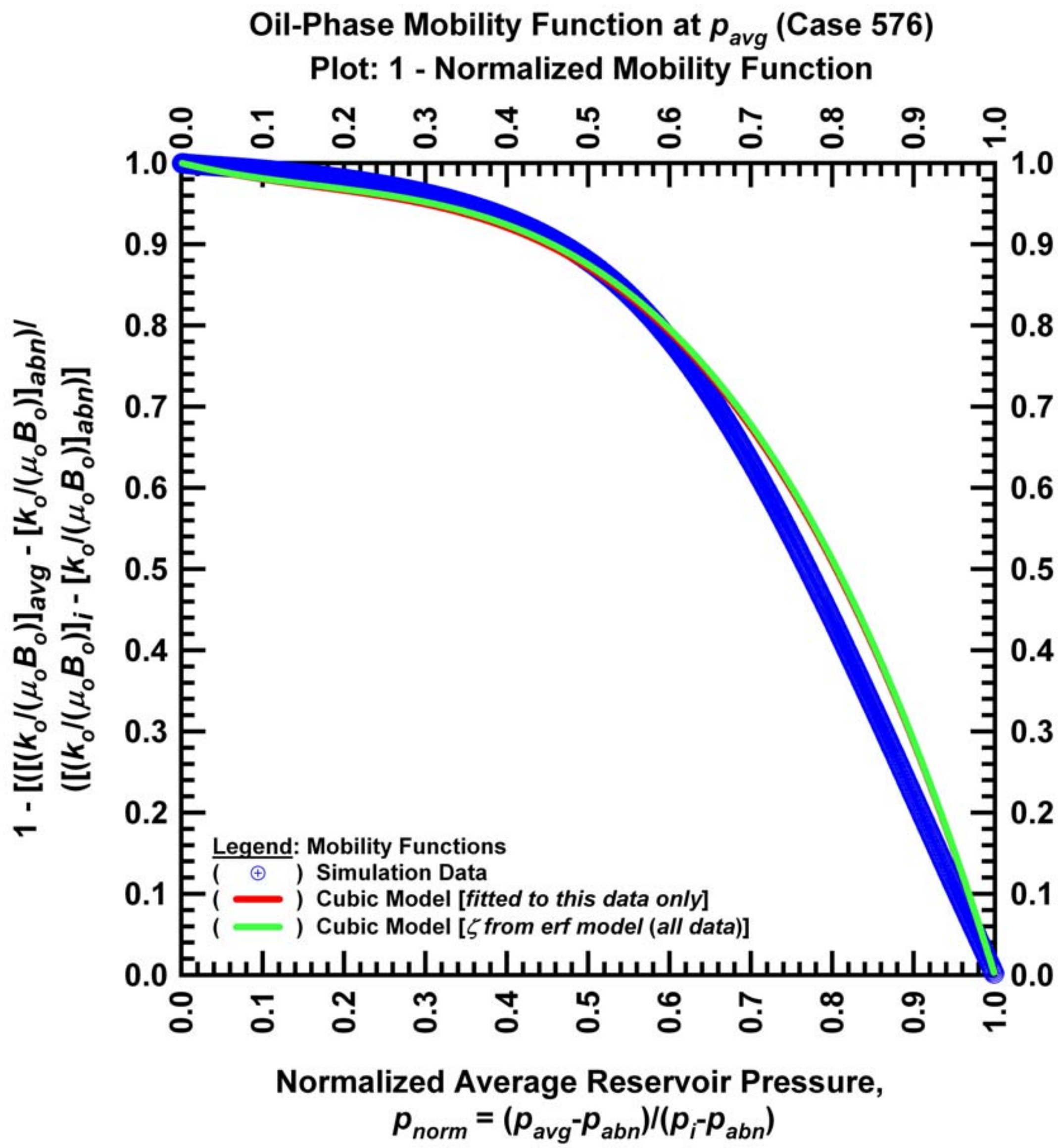

Figure K.1 — Normalized oil-phase mobility function plotted versus the normalized average reservoir pressure function (Case 576).

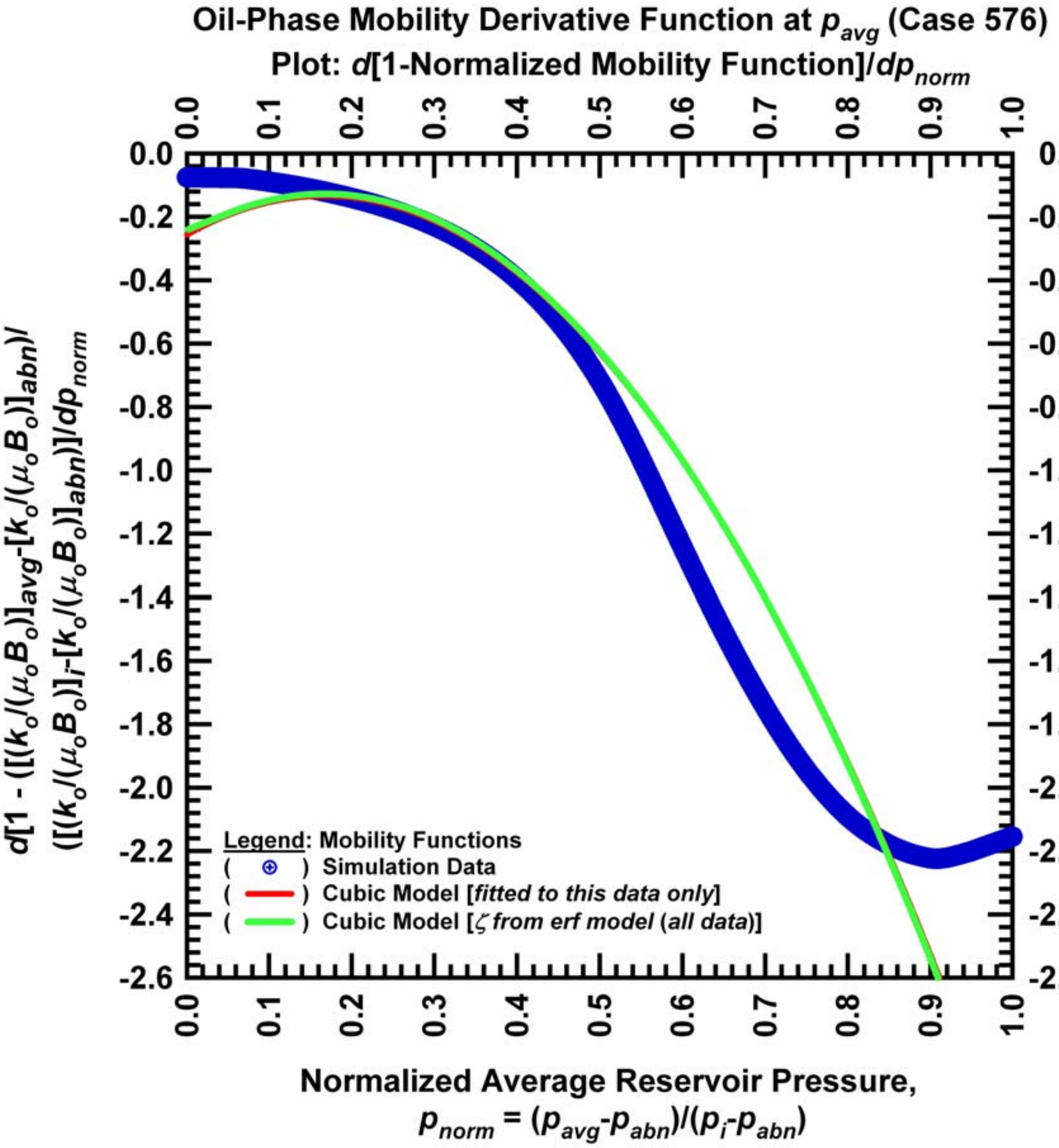

Figure K.2 — Derivative of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 576).

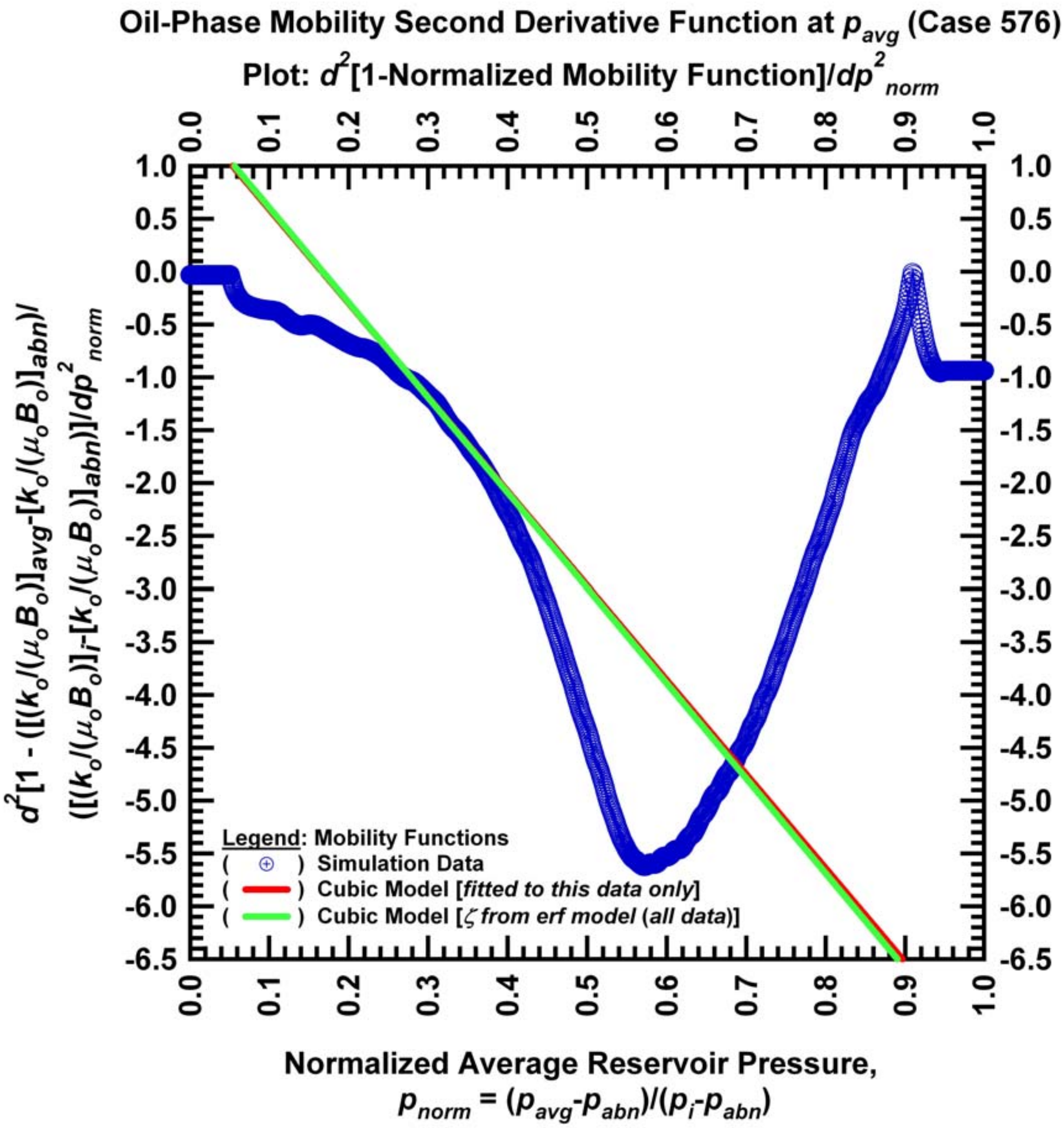

Figure K.3 — Second derivative of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 576).

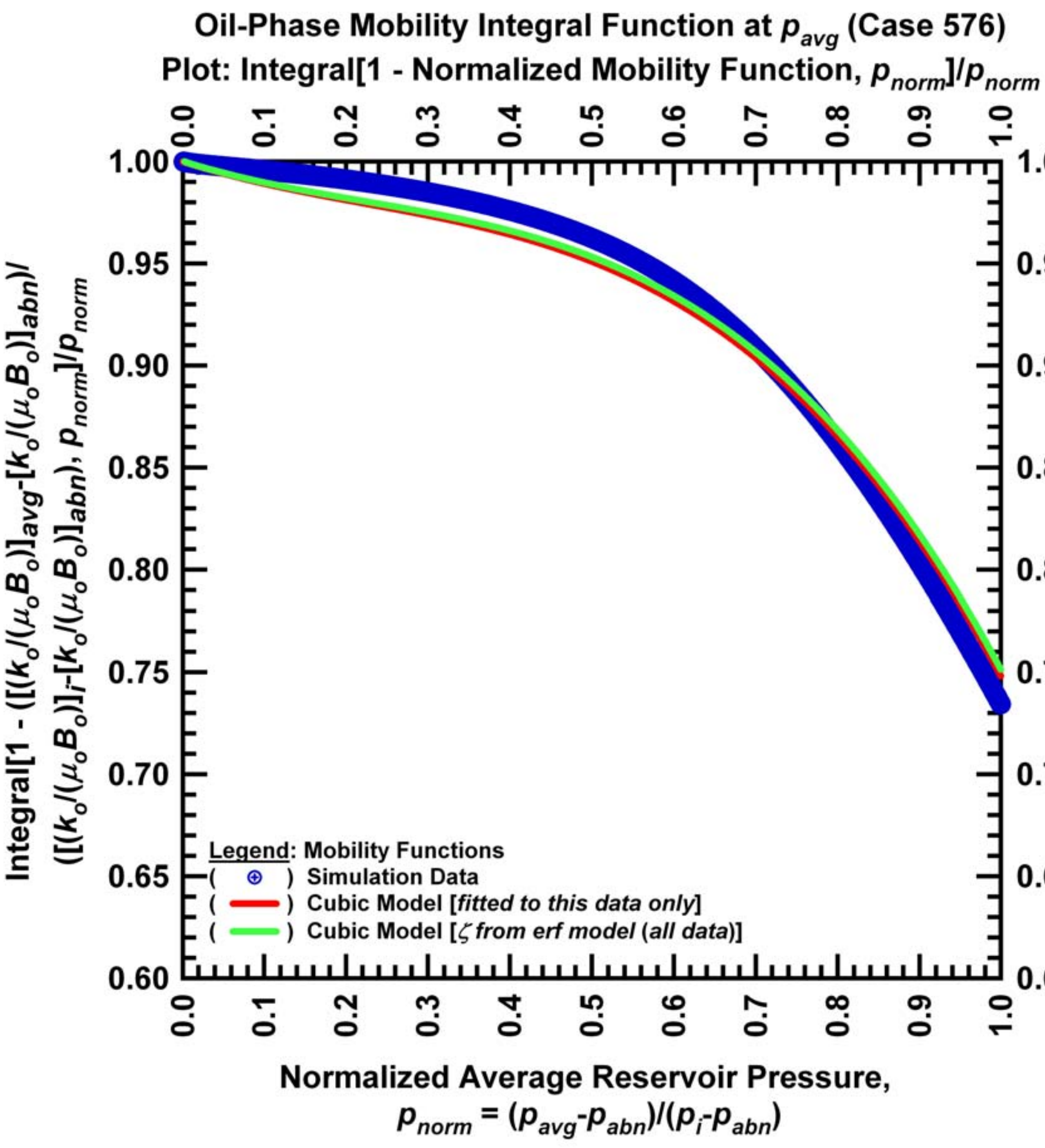

Figure K.4 — Integral of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 576).

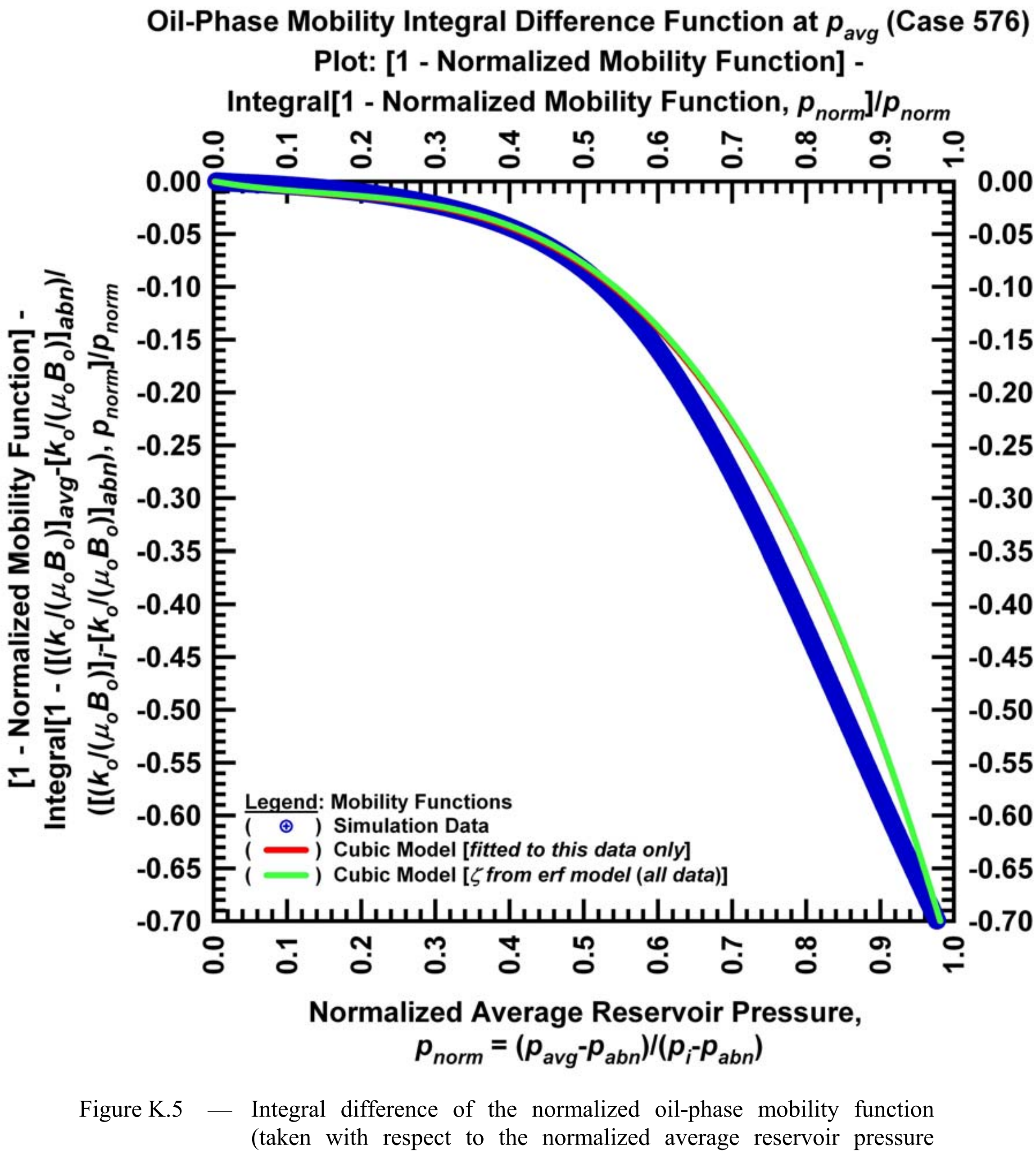

Figure K.5 — Integral difference of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 576).

APPENDIX L
CORRELATION PLOTS FOR THE CUBIC MODEL (CASE 610)

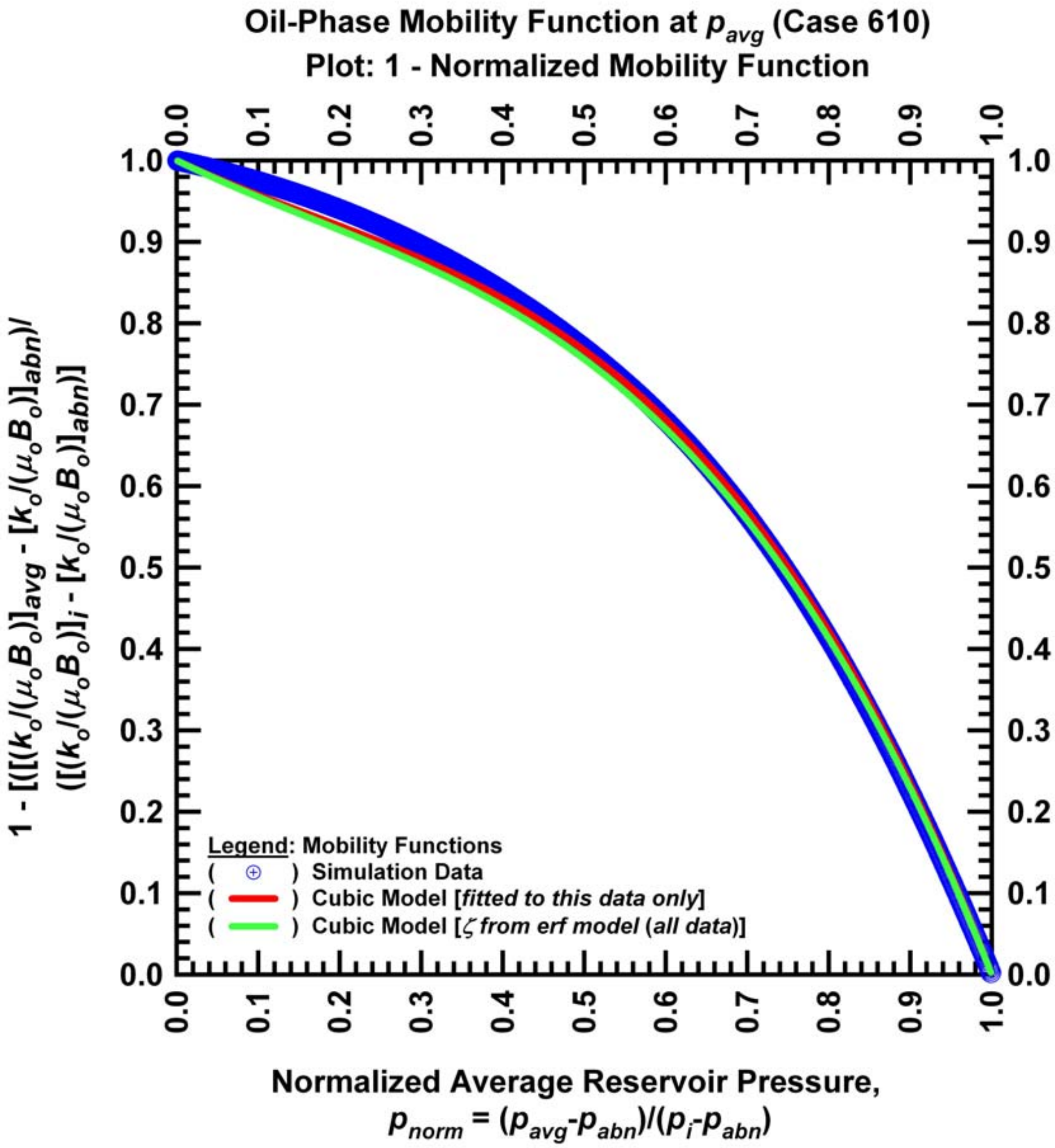

Figure L.1 — Normalized oil-phase mobility function plotted versus the normalized average reservoir pressure function (Case 610).

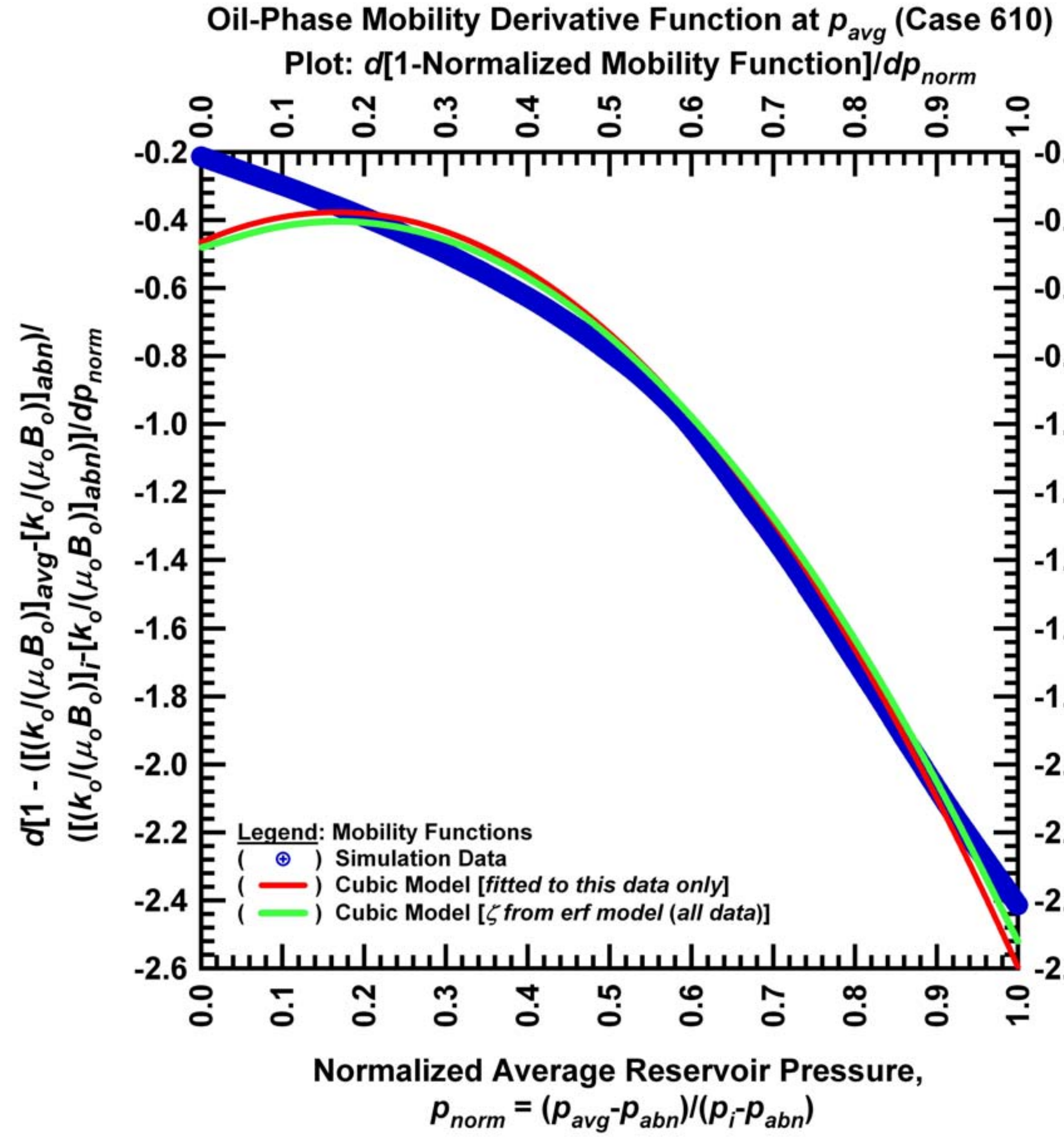

Figure L.2 — Derivative of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 610).

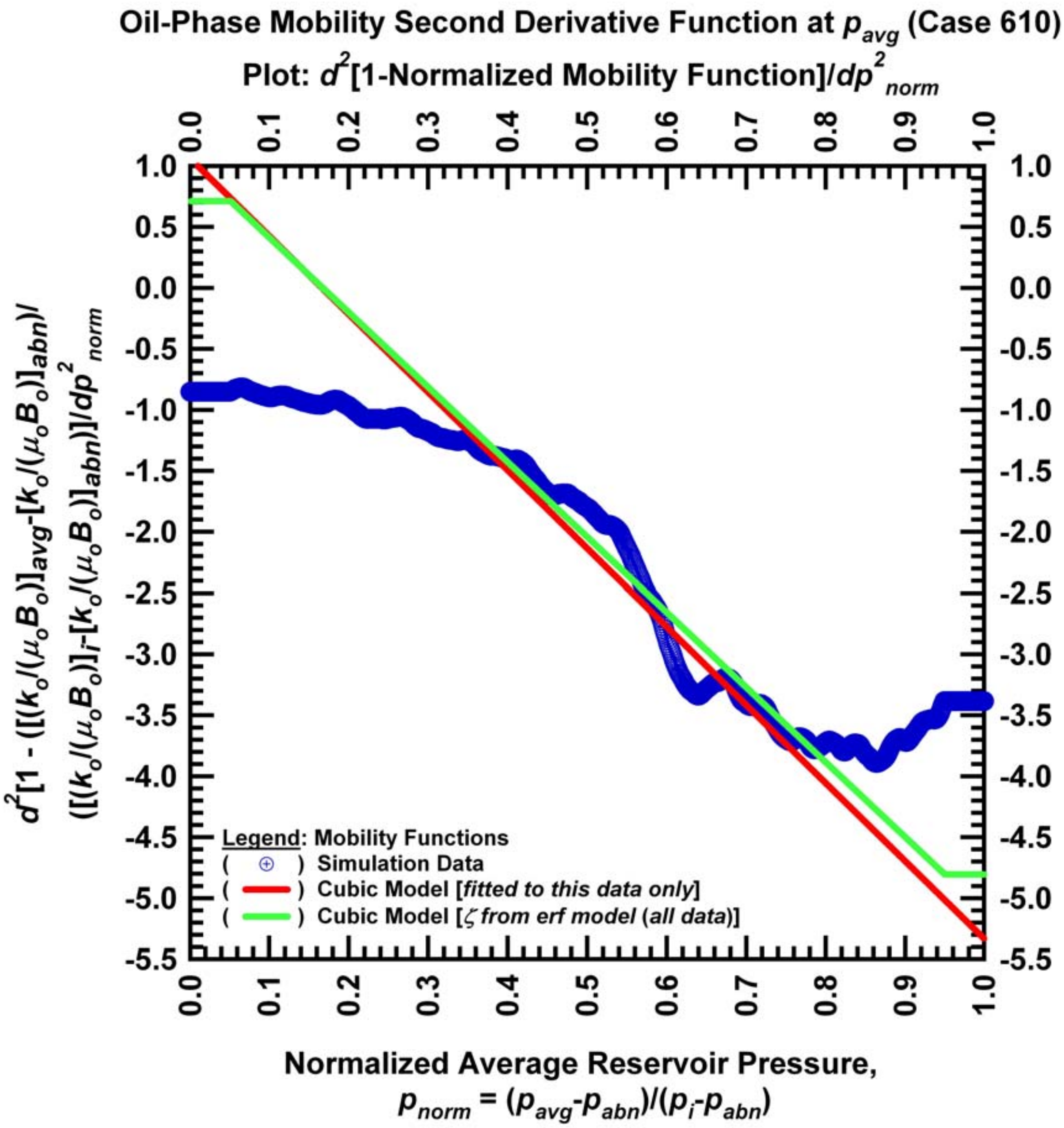

Figure L.3 — Second derivative of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 610).

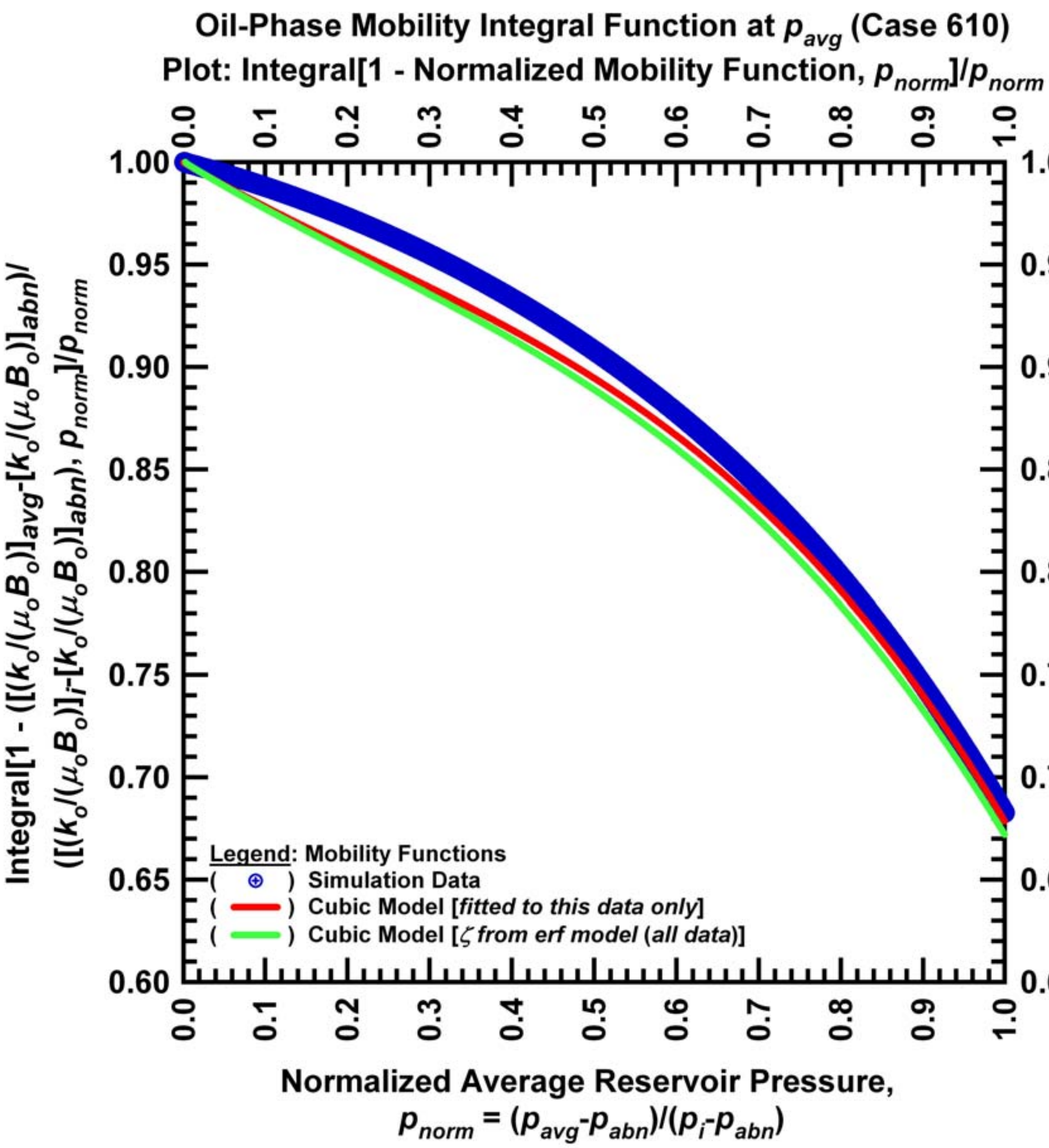

Figure L.4 — Integral of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 610).

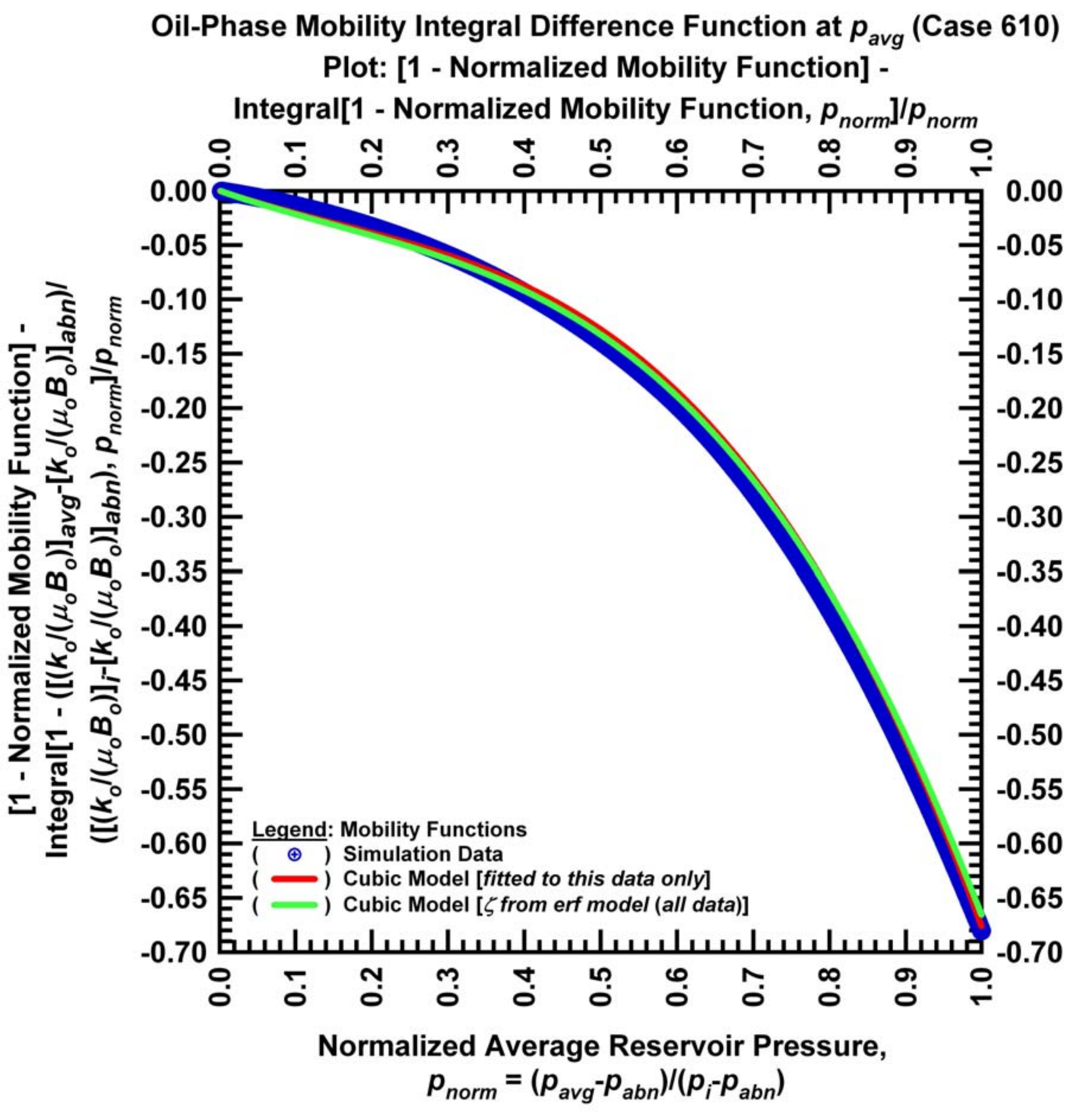

Figure L.5 — Integral difference of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 610).

APPENDIX M
CORRELATION PLOTS FOR THE CUBIC MODEL (CASE 660)

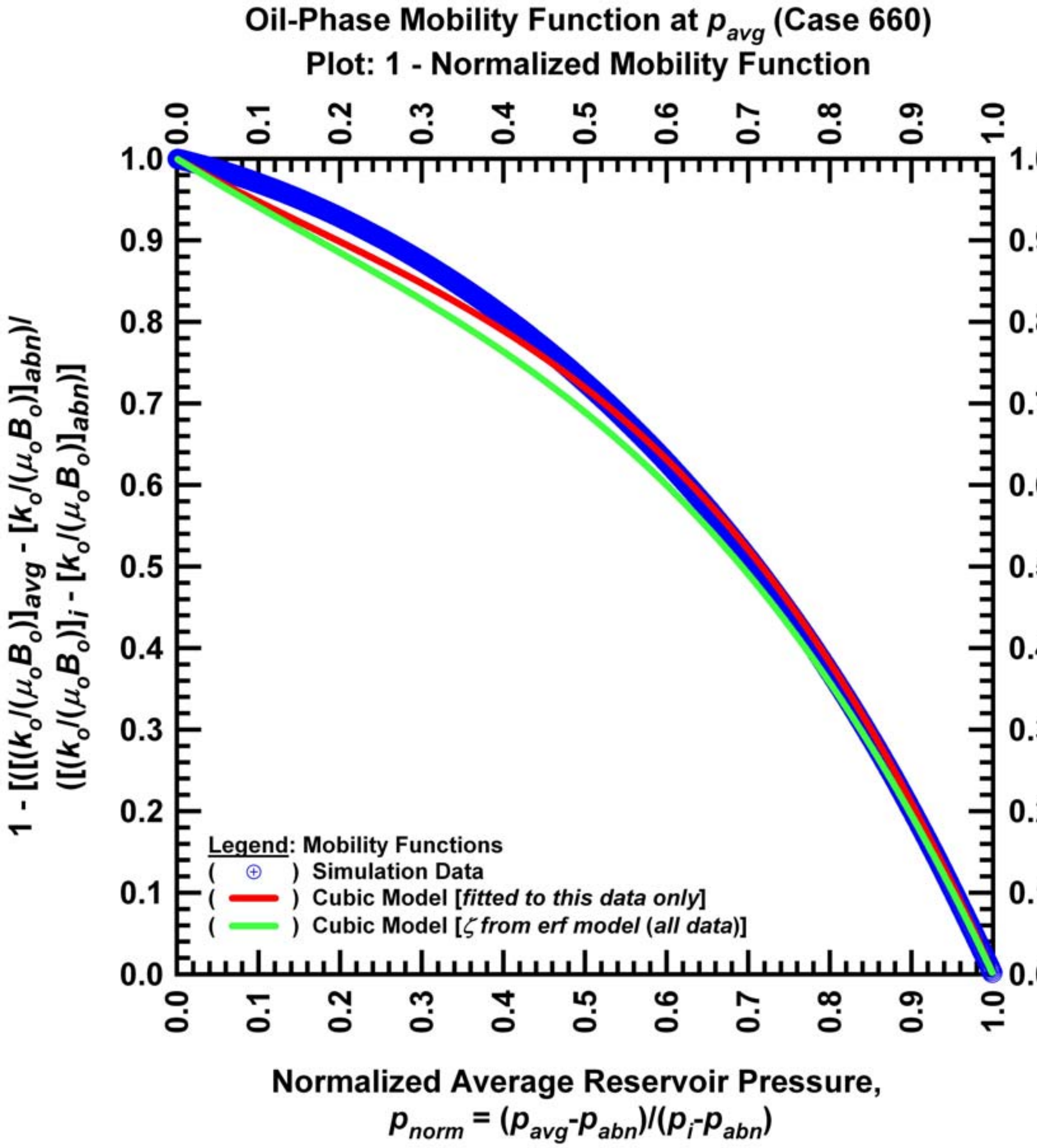

Figure M.1 — Normalized oil-phase mobility function plotted versus the normalized average reservoir pressure function (Case 660).

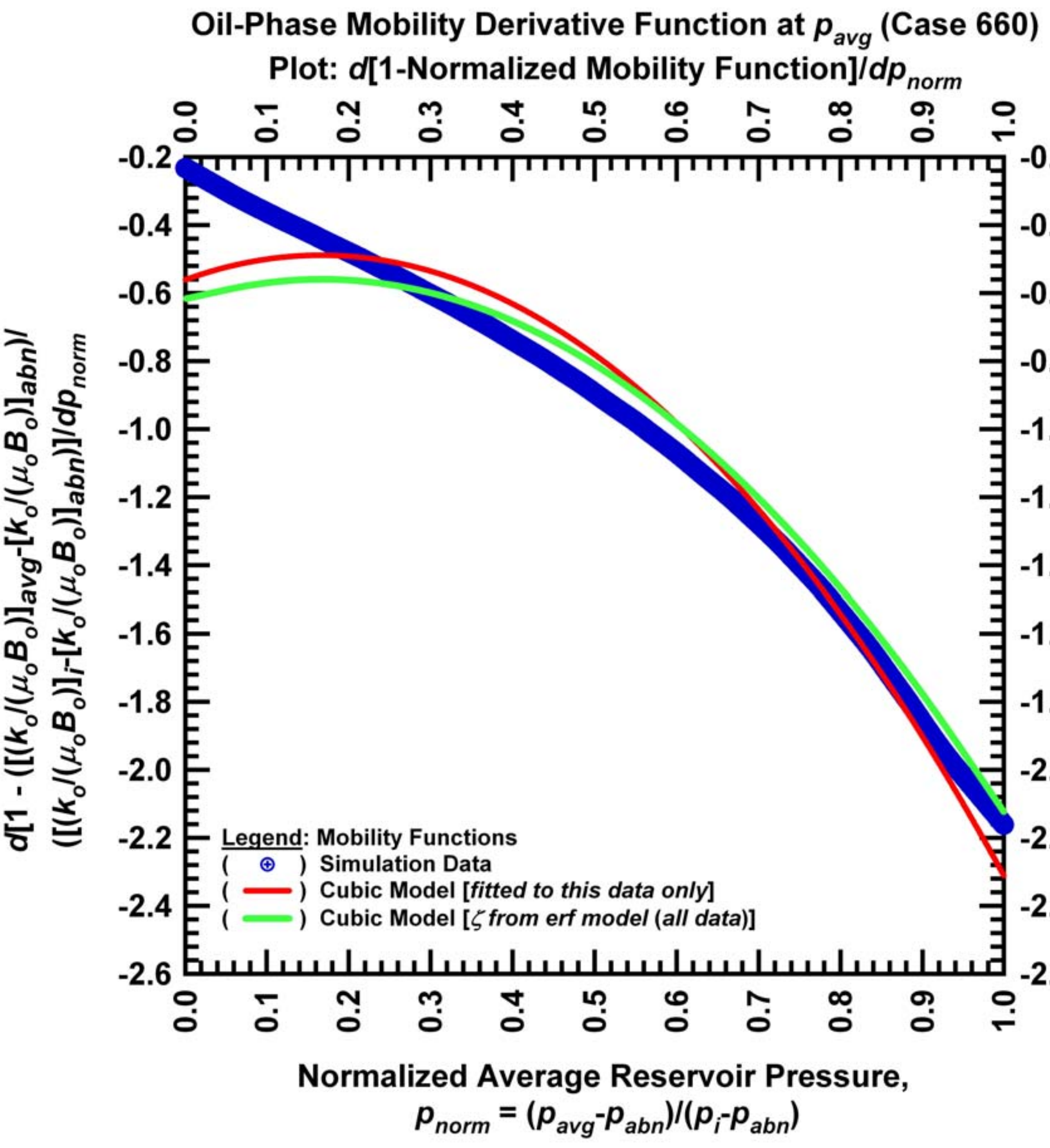

Figure M.2 — Derivative of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 660).

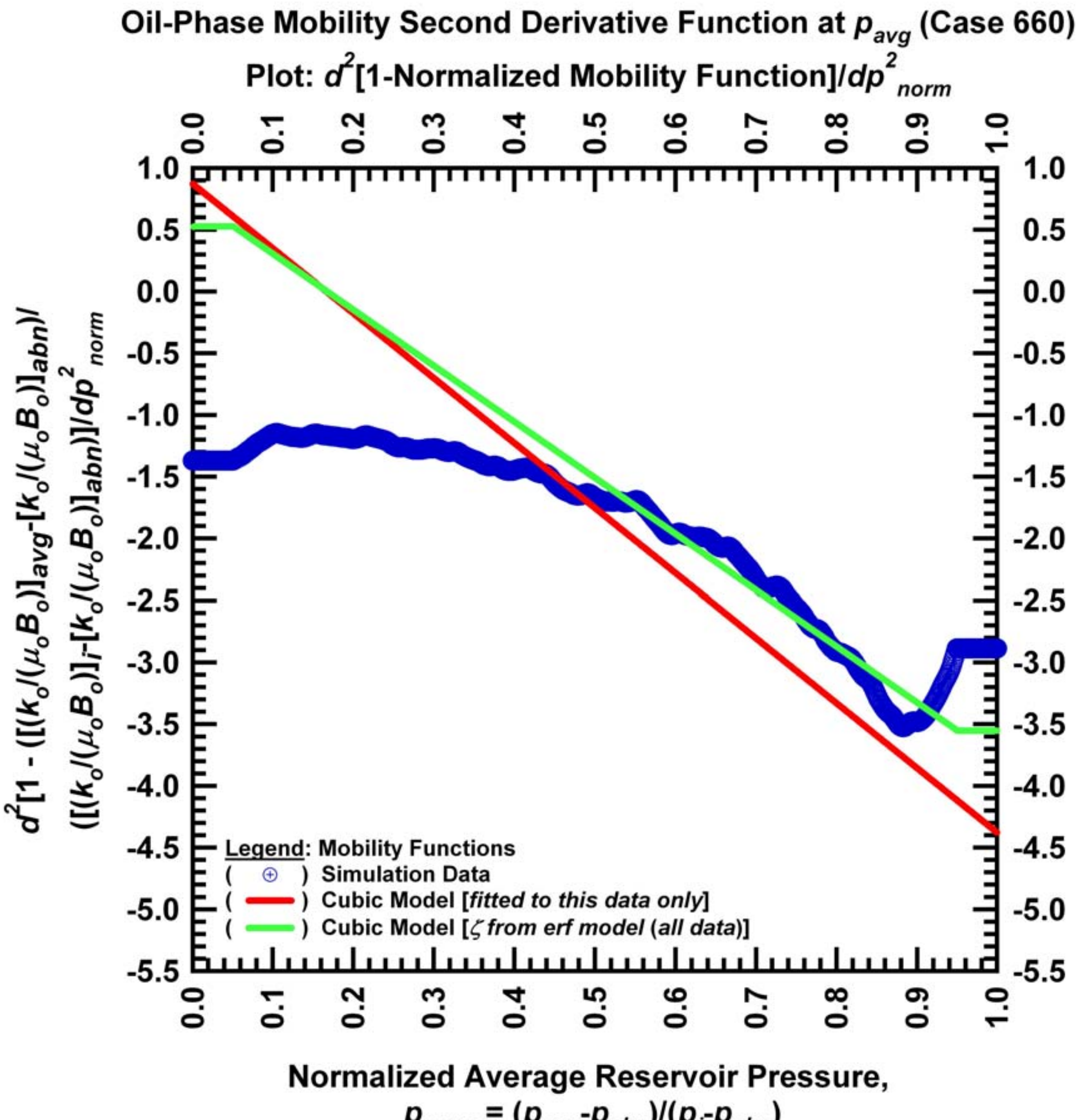

Figure M.3 — Second derivative of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 660).

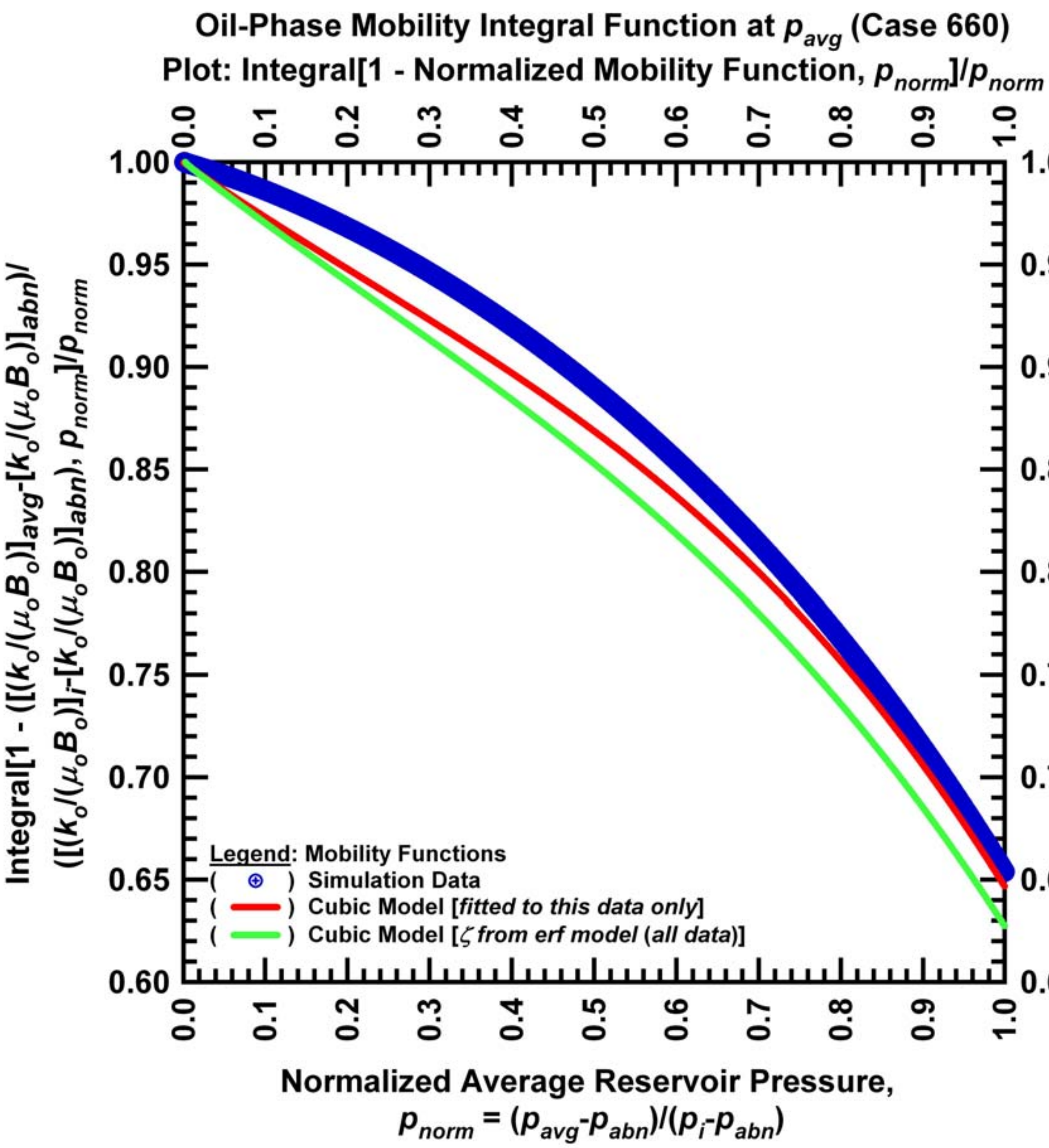

Figure M.4 — Integral of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 660).

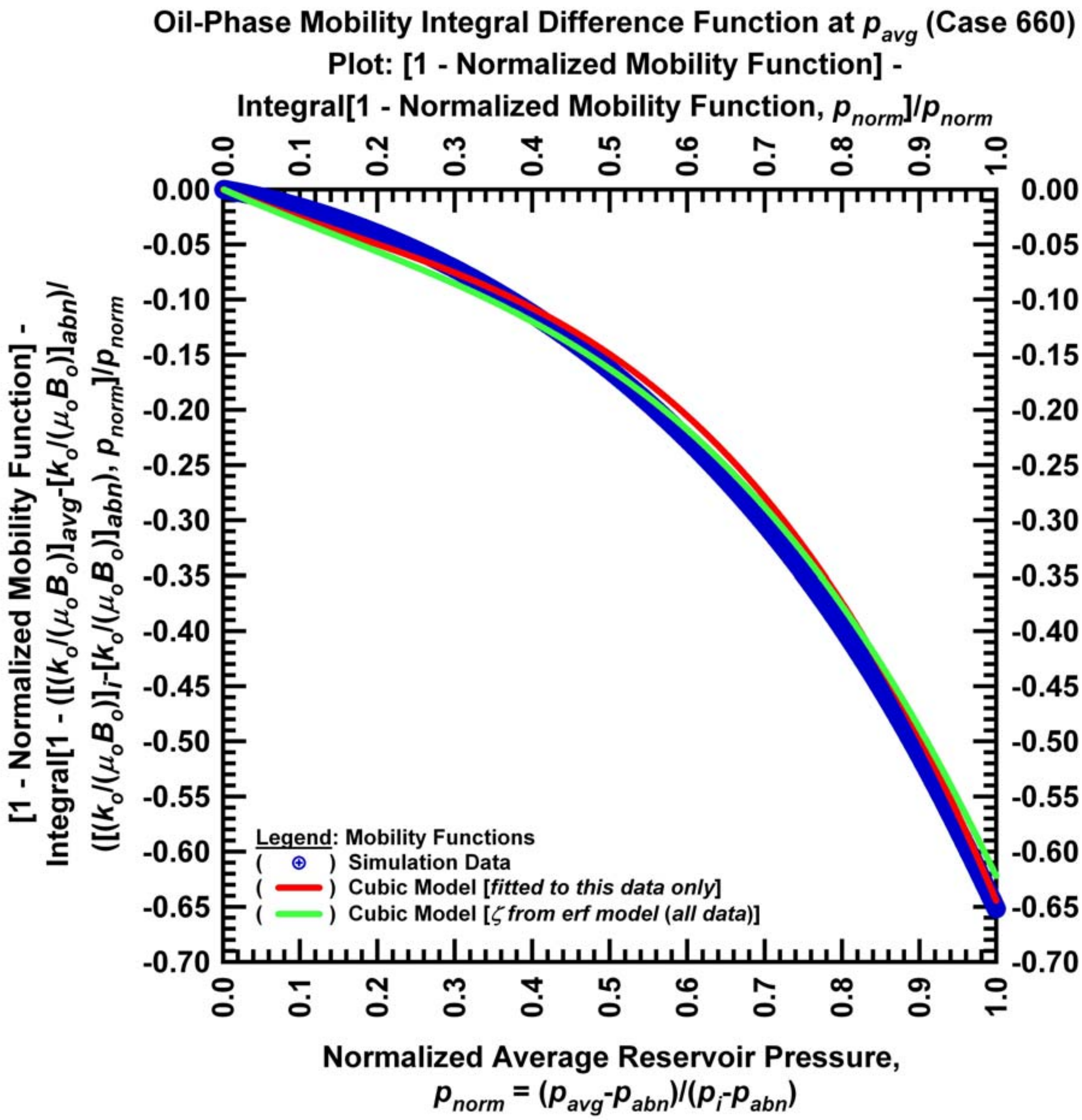

Figure M.5 — Integral difference of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 660).

APPENDIX N
CORRELATION PLOTS FOR THE CUBIC MODEL (CASE 678)

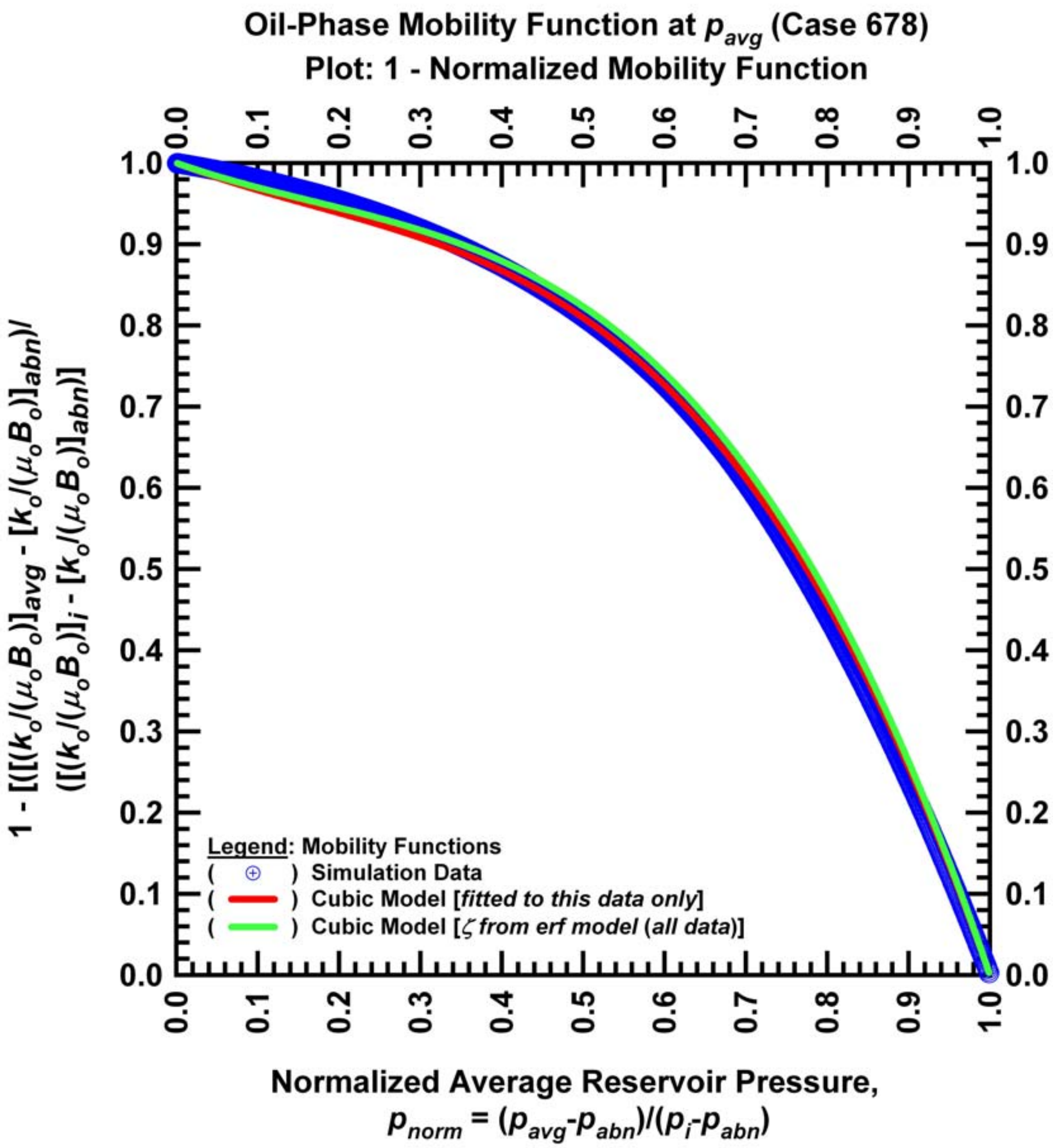

Figure N.1 — Normalized oil-phase mobility function plotted versus the normalized average reservoir pressure function (Case 678).

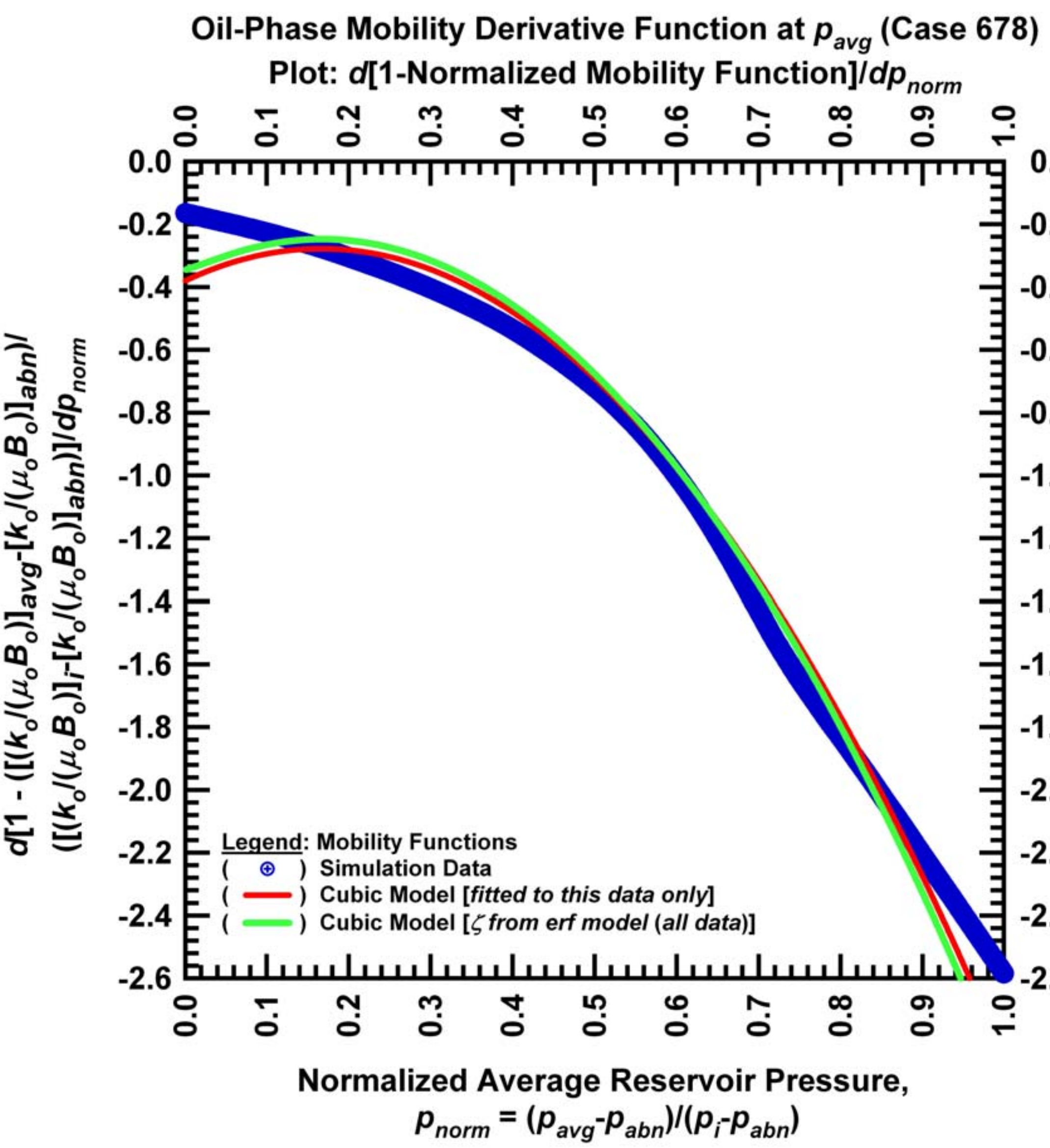

Figure N.2 — Derivative of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 678).

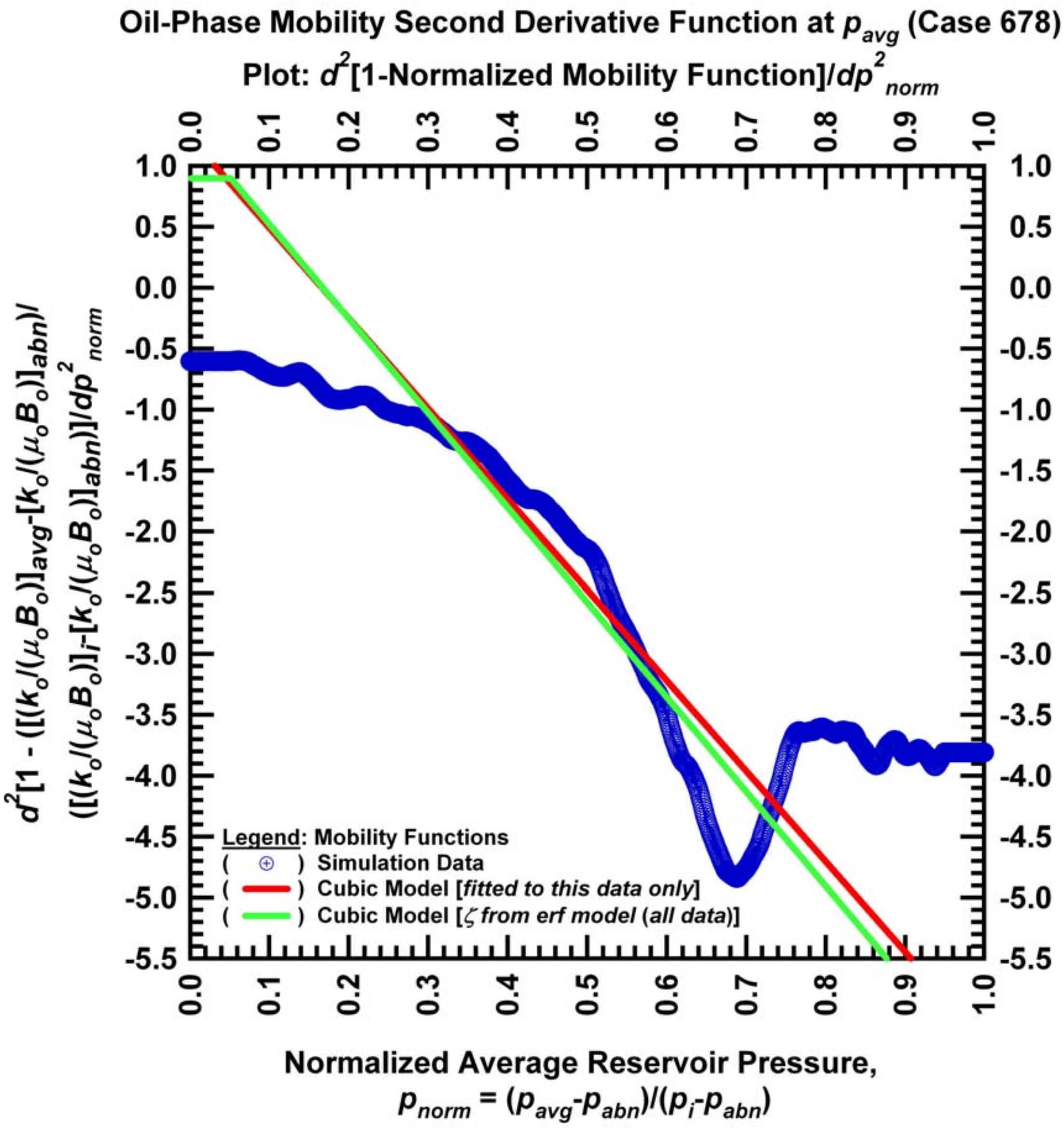

Figure N.3 — Second derivative of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 678).

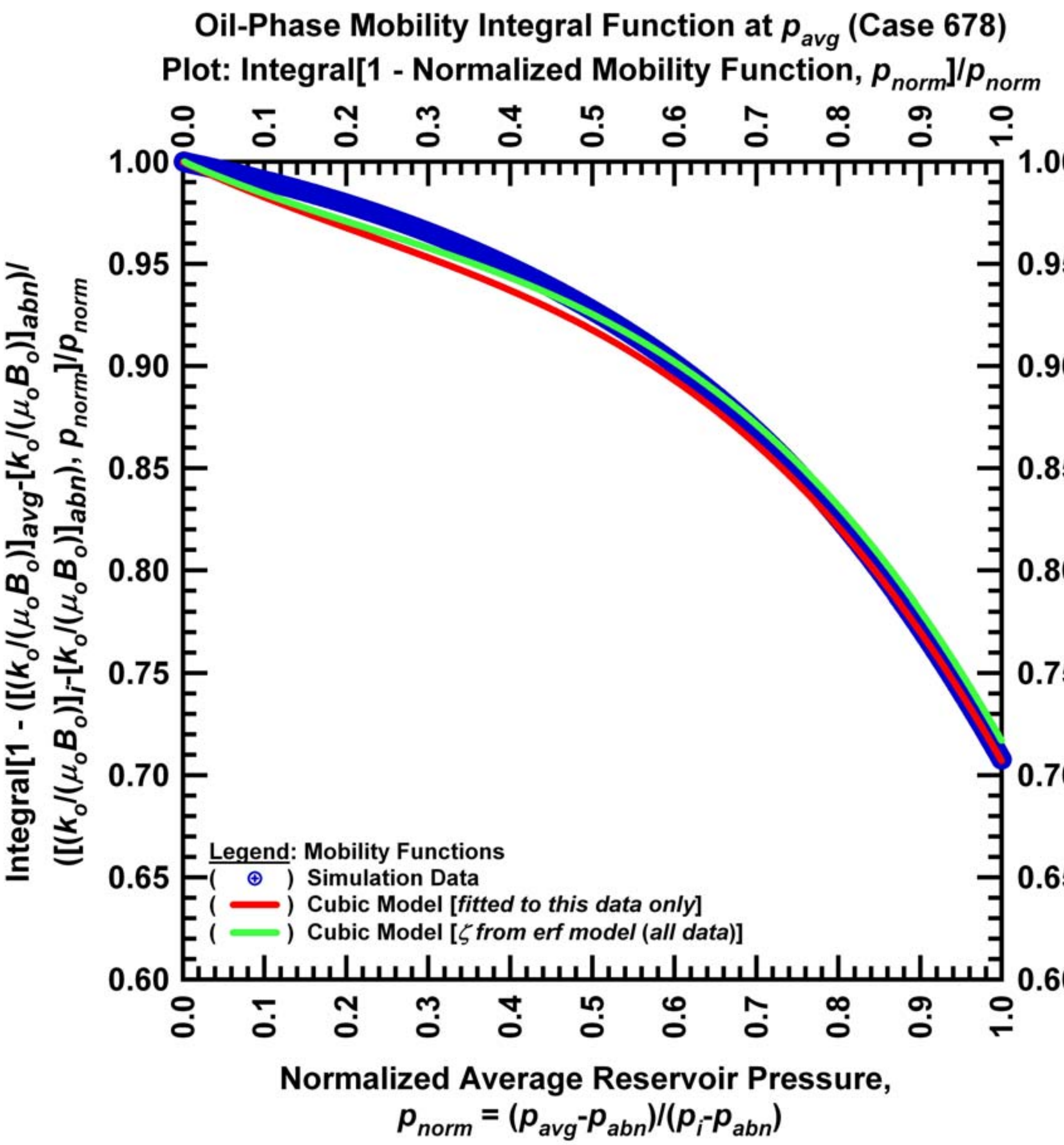

Figure N.4 — Integral of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 678).

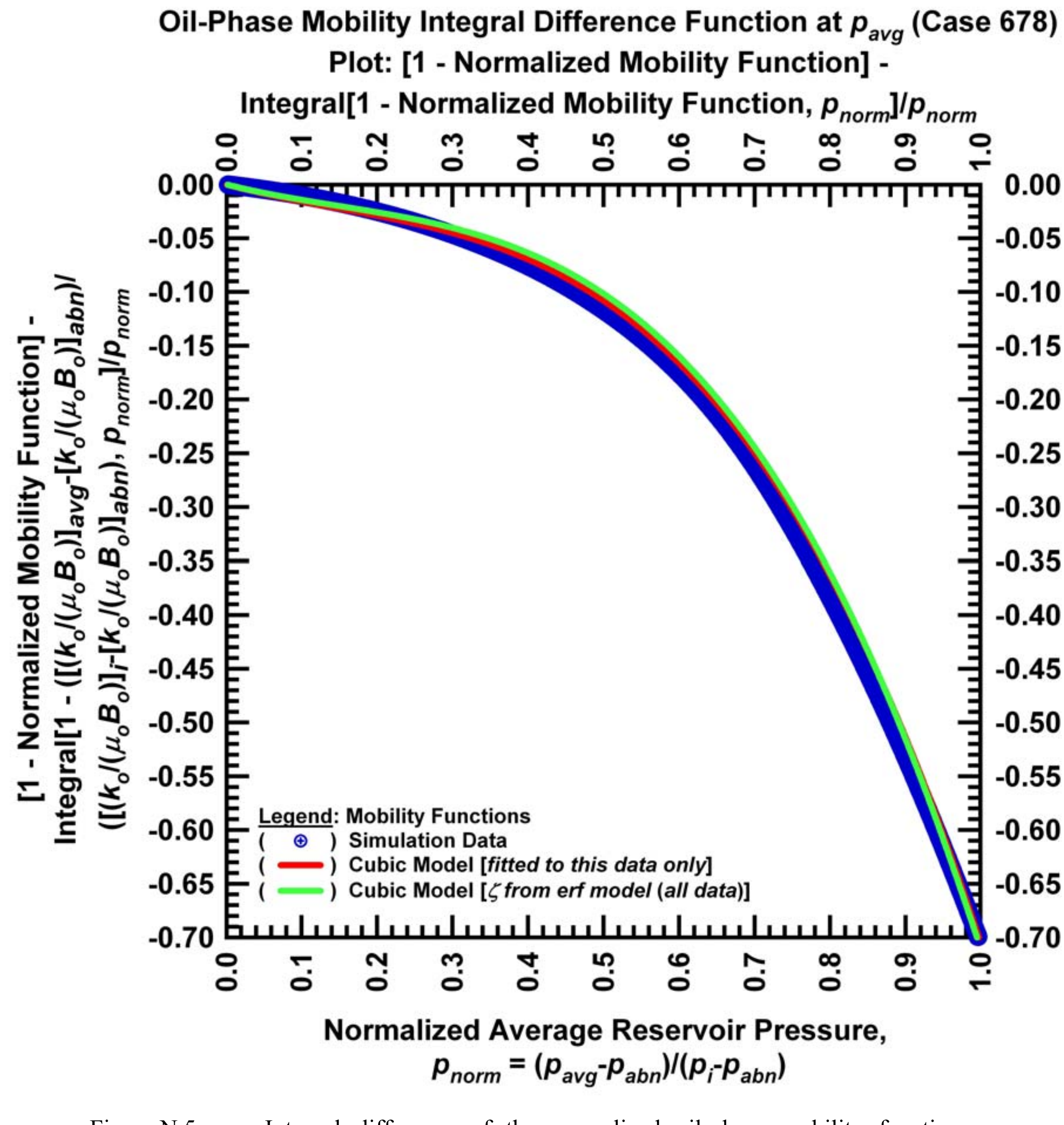

Figure N.5 — Integral difference of the normalized oil-phase mobility function (taken with respect to the normalized average reservoir pressure function) plotted versus the normalized average reservoir pressure function (Case 678).

APPENDIX O
DERIVATION OF THE QUARTIC INFLOW PERFORMANCE RELATIONSHIP (*IPR*) FOR SOLUTION GAS-DRIVE RESERVOIRS USING THE PROPOSED CUBIC MODEL FOR THE OIL MOBILITY FUNCTION

In this Appendix we show that a quartic inflow performance relationship (*IPR*) can be developed based on the pseudosteady-state flow equation for a single well in a solution gas-drive reservoir (based on the oil-phase pseudopressure formulation) and using the proposed cubic model for the mobility of the oil phase. Elements of this derivation were taken from the work by Del Castillo [Del Castillo (2003)], where Del Castillo considered the case of gas condensate reservoirs — but used the Vogel type *IPR* form as a starting point. Ilk *et al* [2007] also present the development of the *IPR* relations using linear, quadratic, and cubic models for the mobility function.

The oil-phase pseudo-pressure for a single well in a solution gas-drive reservoir is given as:

$$p_{po}(p) = \left[\frac{\mu_o B_o}{k_o}\right]_{p_n} \int_{p_{base}}^{p} \left[\frac{k_o}{\mu_o B_o}\right] dp \quad \text{(O-1)}$$

The pseudosteady-state flow equation for the oil-phase in a solution gas-drive reservoir is given by:

$$p_{po}(\overline{p}) = p_{po}(p_{wf}) + q_o b_{pss} \quad \text{(O-2)}$$

Where the pseudo steady-state constant (b_{pss}) is given by:

$$b_{pss} = 141.2\left[\frac{\mu_o B_o}{k_o}\right]_{p_n} \frac{1}{h}\left[\ln\left[\frac{r_e}{r_w}\right] - \frac{3}{4} + s\right] \quad \text{(O-3)}$$

For the solution gas drive case, we propose the following cubic equation for the oil mobility function:

$$\left[\frac{k_o}{\mu_o B_o}\right]_{\overline{p}} = f(\overline{p}) = a + 2b\overline{p} + 3c\overline{p}^2 + 4d\overline{p}^3 \quad \text{(O-4)}$$

Substituting Equation O-4 in Eq. O-1 and completing the integration we obtain the following:

$$p_{po}(\overline{p}) = \left[\frac{\mu_o B_o}{k_o}\right]_{p_n} [(a\overline{p} + b\overline{p}^2 + c\overline{p}^3 + d\overline{p}^4) - (ap_{base} + bp_{base}^2 + cp_{base}^3 + dp_{base}^4)] \quad \text{(O-5)}$$

We can solve for the oil rate (q_o) in Eq O-2:

$$q_o = \frac{1}{b_{pss}}(p_{po}(\overline{p}) - p_{po}(p_{wf})) \quad \text{(O-6)}$$

We can use Equation O-6 to solve for the maximum oil rate case (*i.e.*, p_{wf}= 0)

$$q_{o,\max} = \frac{1}{b_{pss}}(p_{po}(\overline{p}) - p_{po}(p_{wf} = 0)) \quad \text{(O-7)}$$

By dividing Eq. O-6 by Eq. O-7 we obtain the generalized definition of the "*IPR*"-type formulation (*i.e.*, $q_o/q_{o,\max}$) — this formulation is given as:

$$\frac{q_o}{q_{o,\max}} = \frac{p_{po}(\overline{p}) - p_{po}(p_{wf})}{p_{po}(\overline{p}) - p_{po}(p_{wf} = 0)} \quad \text{(O-8)}$$

Substituting Eq. O-5 into Eq. O-8, we can develop equations O-9 to O-13:

$$A = (a\overline{p} + b\overline{p}^2 + c\overline{p}^3 + d\overline{p}^4) \quad \text{(O-9)}$$

$$B = (ap_{base} + bp_{base}^2 + cp_{base}^3 + dp_{base}^4) \quad \text{(O-10)}$$

$$C = (ap_{wf} + bp_{wf}^2 + cp_{wf}^3 + dp_{wf}^4) \quad \text{(O-11)}$$

$$D = (a(0) + b(0) + c(0) + d(0)) \quad \text{(O-12)}$$

$$\frac{q_o}{q_{o,\max}} = \frac{[A - B] - [C - B]}{[A - B] - [D - B]} \quad \text{(O-13)}$$

Recalling the generalized definition of the "*IPR*"-type formulation ($q_o/q_{o,\max}$) for the oil pseudopressure, Eq. O-2, and canceling like terms, we obtain:

$$\frac{q_o}{q_{o,\max}} = \frac{(a\overline{p} + b\overline{p}^2 + c\overline{p}^3 + d\overline{p}^4) - (ap_{wf} + bp_{wf}^2 + cp_{wf}^3 + dp_{wf}^4)}{(a\overline{p} + b\overline{p}^2 + c\overline{p}^3 + d\overline{p}^4)} \quad \text{(O-14)}$$

Dividing through Eq. O-10 by $(a\overline{p}+b\overline{p}^2+c\overline{p}^3+d\overline{p}^4)$ gives us the following result:

$$\frac{q_o}{q_{o,\max}}=1-\frac{ap_{wf}}{(a\overline{p}+b\overline{p}^2+c\overline{p}^3+d\overline{p}^4)}-\frac{bp_{wf}^2}{(a\overline{p}+b\overline{p}^2+c\overline{p}^3+d\overline{p}^4)}-\frac{cp_{wf}^3}{(a\overline{p}+b\overline{p}^2+c\overline{p}^3+d\overline{p}^4)}-\frac{dp_{wf}^4}{(a\overline{p}+b\overline{p}^2+c\overline{p}^3+d\overline{p}^4)} \quad \text{(O-15)}$$

Writing Eq. O-15 in terms of the "*IPR*" variable ($p_{wf}/\overline{p}$), we have:

$$\frac{q_o}{q_{o,\max}}=1-\frac{1}{(1+\frac{b}{a}\overline{p}+\frac{c}{a}\overline{p}^2+\frac{d}{a}\overline{p}^3)}\left[\frac{p_{wf}}{\overline{p}}\right]-\frac{1}{(\frac{a}{b}\frac{1}{\overline{p}}+1++\frac{c}{b}\overline{p}+\frac{d}{b}\overline{p}^2)}\left[\frac{p_{wf}^2}{\overline{p}^2}\right]-\frac{1}{(\frac{a}{c}\frac{1}{\overline{p}^2}+\frac{b}{c}\frac{1}{\overline{p}}+1+\frac{d}{c}\overline{p})}\left[\frac{p_{wf}^3}{\overline{p}^3}\right]-\frac{1}{(\frac{a}{d}\frac{1}{\overline{p}^3}+\frac{b}{d}\frac{1}{\overline{p}^2}+\frac{c}{d}\frac{1}{\overline{p}}+1)}\left[\frac{p_{wf}^4}{\overline{p}^4}\right] \quad \text{(O-16)}$$

At this point we define the following parameters; $\tau = b/a$, $\beta = c/a$, $\eta = d/a$, $\beta/\tau = c/b$, $\eta/\tau = d/b$, $\eta/\beta = d/c$ and Eq. O-16 can be written in terms of these parameters as:

$$\frac{q_o}{q_{o,\max}}=1-\frac{1}{(1+\tau\,\overline{p}+\beta\,\overline{p}^2+\eta\,\overline{p}^3)}\left[\frac{p_{wf}}{\overline{p}}\right]-\frac{1}{(\frac{1}{\tau}\frac{1}{\overline{p}}+1++\frac{\beta}{\tau}\overline{p}+\frac{\eta}{\tau}\overline{p}^2)}\left[\frac{p_{wf}^2}{\overline{p}^2}\right]-\frac{1}{(\frac{1}{\beta}\frac{1}{\overline{p}^2}+\frac{\tau}{\beta}\frac{1}{\overline{p}}+1+\frac{\eta}{\beta}\overline{p})}\left[\frac{p_{wf}^3}{\overline{p}^3}\right]-\frac{1}{(\frac{1}{\eta}\frac{1}{\overline{p}^3}+\frac{\tau}{\eta}\frac{1}{\overline{p}^2}+\frac{\beta}{\eta}\frac{1}{\overline{p}}+1)}\left[\frac{p_{wf}^4}{\overline{p}^4}\right] \quad \text{(O-17)}$$

Upon algebraic manipulation, Eq. O-17 can be written as:

$$\frac{q_o}{q_{o,\max}}=1-\frac{1}{(1+\tau\,\overline{p}+\beta\,\overline{p}^2+\eta\,\overline{p}^3)}\left[\frac{p_{wf}}{\overline{p}}\right]-\frac{\tau\,\overline{p}}{(1+\tau\,\overline{p}+\beta\,\overline{p}^2+\eta\,\overline{p}^3)}\left[\frac{p_{wf}^2}{\overline{p}^2}\right]-\frac{\beta\,\overline{p}^2}{(1+\tau\,\overline{p}+\beta\,\overline{p}^2+\eta\,\overline{p}^3)}\left[\frac{p_{wf}^3}{\overline{p}^3}\right]-\frac{\eta\,\overline{p}^3}{(1+\tau\,\overline{p}+\beta\,\overline{p}^2+\eta\,\overline{p}^3)}\left[\frac{p_{wf}^4}{\overline{p}^4}\right] \quad \text{(O-18)}$$

We define the "lumped parameter," ν, for this case as:

$$\nu = \frac{1}{(1+\tau\,\overline{p}+\beta\,\overline{p}^2+\eta\,\overline{p}^3)} \quad \text{or} \quad \frac{1}{(1+\frac{b}{a}\,\overline{p}+\frac{c}{a}\,\overline{p}^2+\frac{d}{a}\,\overline{p}^3)} \quad \text{(O-19)}$$

Inserting the "lumped parameter," ν, in Eq. O-19:

$$\frac{q_o}{q_{o,\max}} = 1-\nu\left[\frac{p_{wf}}{\overline{p}}\right]-\nu\tau\,\overline{p}\left[\frac{p_{wf}^2}{\overline{p}^2}\right]-\nu\beta\,\overline{p}^2\left[\frac{p_{wf}^3}{\overline{p}^3}\right]-\nu\eta\,\overline{p}^3\left[\frac{p_{wf}^4}{\overline{p}^4}\right] \quad \text{(O-20)}$$

In Eq. O-20, the ν, τ, β and η terms are defined as the parameters that contain the characteristic mobility function.

For reference we present the characteristic model for the oil mobility function according to our normalized variables as:

$$\left[1-\frac{[k_o/(\mu_o B_o)]_{\overline{p}}-[k_o/(\mu_o B_o)]_{p_{abn}}}{[k_o/(\mu_o B_o)]_{p_i}-[k_o/(\mu_o B_o)]_{p_{abn}}}\right] = 1-\zeta\left[\frac{\overline{p}-p_{abn}}{p_i-p_{abn}}\right]+(1-\zeta)\left[\frac{\overline{p}-p_{abn}}{p_i-p_{abn}}\right]^2-2(1-\zeta)\left[\frac{\overline{p}-p_{abn}}{p_i-p_{abn}}\right]^3 \quad \text{(O-21)}$$

We note that $\zeta \leq 1$. We rearrange Eq. O-21 (*i.e.* the characteristic model) in terms of the oil mobility function evaluated at any average reservoir pressure as:

$$f(\overline{p}) = f(p_{abn})+\frac{f(p_i)-f(p_{abn})}{p_i-p_{abn}}\zeta\,(\overline{p}-p_{abn})-\frac{f(p_i)-f(p_{abn})}{(p_i-p_{abn})^2}(1-\zeta)(\overline{p}-p_{abn})^2 + \frac{f(p_i)-f(p_{abn})}{(p_i-p_{abn})^3}2(1-\zeta)(\overline{p}-p_{abn})^3 \quad \text{(O-22)}$$

where the following relationships are established:

$f(\overline{p}) = [k_o/(\mu_o B_o)]_{\overline{p}}$,
$f(p_i) = [k_o/(\mu_o B_o)]_{p_i}$,
$f(p_{abn}) = [k_o/(\mu_o B_o)]_{p_{abn}}$

Recalling the "general" cubic model to represent the oil-phase mobility function which is given in Eq. O-4 as:

$$f(\overline{p}-p_{abn}) = a + 2b(\overline{p}-p_{abn}) + 3c(\overline{p}-p_{abn})^2 + 4d(\overline{p}-p_{abn})^3 \quad \text{(O-23)}$$

Eq. O-19 implies that the parameter *a* in Eq. O-4 (*i.e.*, the intercept where average reservoir pressure is equal to zero) will be equal to the value of the oil mobility at the abandonment pressure for our purposes. Referring to the proposed characteristic model for the oil mobility function, the parameters in Eq. O-1 correspond to the following:

$$\begin{aligned} a &= f(p_{abn}) \\ b &= \frac{f(p_i)-f(p_{abn})}{2(p_i-p_{abn})}\zeta \\ c &= \frac{f(p_i)-f(p_{abn})}{3(p_i-p_{abn})^2}(\zeta-1) \\ d &= \frac{f(p_i)-f(p_{abn})}{4(p_i-p_{abn})^3}2(1-\zeta) \end{aligned} \quad \text{(O-24)}$$

Combining the previous definitions of, $\tau = b/a$, $\beta = c/a$, $\eta = d/a$, $\beta/\tau = c/b$, $\eta/\tau = d/b$ and $\eta/\beta = d/c$, with the parameters given in Eq. O-24, we have:

$$\begin{aligned} \tau &= \frac{[f(p_i)-f(p_{abn})]}{2(p_i-p_{abn})}\frac{\zeta}{f(p_{abn})} \\ \beta &= \frac{[f(p_i)-f(p_{abn})]}{3(p_i-p_{abn})^2}\frac{(\zeta-1)}{f(p_{abn})} \\ \eta &= \frac{[f(p_i)-f(p_{abn})]}{4(p_i-p_{abn})^3}\frac{2(1-\zeta)}{\zeta\, f(p_i)} \\ \beta/\tau &= \frac{2}{3}\frac{(\zeta-1)}{\zeta}\frac{1}{(p_i-p_{abn})} \\ \eta/\tau &= \frac{(1-\zeta)}{\zeta}\frac{1}{(p_i-p_{abn})^2} \\ \eta/\beta &= \frac{-3}{2}\frac{1}{(p_i-p_{abn})} \end{aligned} \quad \text{(O-25)}$$

Finally, substituting the obtained values above (Eq. O-25) in the quartic "*IPR*" relation (Eq. O-20), we have the final form of the "*IPR*" equation in terms of the *characteristic parameter*, *initial pressure*, *abandonment pressure* and the *average reservoir pressure*.

APPENDIX P
GAS AND OIL PVT CORRELATIONS

P.1 Overview

This Appendix covers the thermodynamic properties of oil and gas as well as a set of correlations that were used to calculate such properties. The following table summarizes the fluid property correlation used in the simulation runs:

Table P.1 — Summary Oil and Gas Property Correlations

Property	Correlation
Saturation Pressure (p_b)	Standing
GOR at p_b (R_s)	Standing
Oil FVF (B_o)	Standing
Dead Oil Viscosity (μ_{od})	Beal-Standing
Bubble-point Viscosity (μ_{ob})	Standing
Gas Viscosity (μ_g)	Lee-Gonzalez
Gas FVF (B_g)	Equation of State
z-factor (z)	Hall-Yarborough

For all our calculations we choose specific parameters in order to create a range of data that would be representative of different crude types. These parameters are: API, initial GOR, reservoir temperature and gas gravity.

P.2 Saturation (Bubble-Point) Pressure

We utilize the Standing correlation to calculate the saturation pressure. Standing correlation is given as:

$$p_b = 18.2(A - 1.4) \quad \text{(P-1)}$$

where A can be defined as follows:

$$A = \left[\frac{R_s}{\gamma_g}\right]^{0.83} 10^{(0.00091T - 0.0125\gamma_{API})} \quad \text{(P-2)}$$

In Eq. P-2 R_s is given in scf/STB, T in °F and p_b in psia.

P.3 Oil Formation Volume Factor

We also utilize the Standing Correlation to calculate the oil formation volume factor below the bubble point pressure (B_{ob}=$f(p)$). This correlation is given as:

$$B_{ob} = 0.9759 + (12\,x\,10^{-5})\,A^{1.2} \qquad \text{(P-3)}$$

where A can be defined as follows:

$$A = R_s \left[\frac{\gamma_o}{\gamma_g} \right]^{0.5} + 1.25T \qquad \text{(P-4)}$$

P.4 Dead Oil Viscosity (μ_{od})

Dead oil viscosities are calculated with the Beal-Standing correlation. This correlation states that:

$$\mu_{od} = \left[0.32 + \frac{1.8x10^7}{\gamma_{API}^{4.53}} \right] \left[\frac{360}{T + 200} \right] A \qquad \text{(P-5)}$$

where A is given as:

$$A = 10^{[0.43 + (8.33/\gamma_{API})]} \qquad \text{(P-6)}$$

P.5 Saturation (Bubble-point) Viscosity

Saturated oil viscosities were calculated with the Chew and Conally correlation:

$$\mu_{ob} = A_1 (\mu_{od})^{A_2} \qquad \text{(P-7)}$$

where A_1 and A_2 parameters are described by Standing's best fit equation to Chew and Conally's data:

$$A_1 = 10^{-(7.4x10^{-4})R_s + (2.2x10^{-7})R_s^2} \qquad \text{(P-8)}$$

$$A_2 = \frac{0.68}{10^{(8.62x10^{-5})R_s}} + \frac{0.25}{10^{(1.1x10^{-3})R_s}} + \frac{0.062}{10^{(3.74x10^{-5})R_s}} \qquad \text{(P-9)}$$

P.6 Gas Viscosity (μ_g)

The Lee-Gonzales correlation for gas viscosity is given by:

$$\mu_g = A_1 x10^{-4} \exp[A_2 \rho_g^{A_3}] \qquad \text{(P-10)}$$

where A_1, A_2 and A_3 parameters are given as:

$$A_1 = \frac{(9.379 + 0.01607 M_g) T^{1.5}}{209.2 + 19.6 M_g + T} \qquad \text{(P-11)}$$

$$A_2 = 3.448 + \frac{986.4}{T} + 0.01009 M_g \qquad \text{(P-12)}$$

$$A_3 = 2.447 - 0.2224 A_2 \qquad \text{(P-13)}$$

Where M_g is defined as:

$$M_g = 28.97 \gamma_g \qquad \text{(P-14)}$$

For the Lee-Gonzalez correlation we have μ_g in cp, ρ_g in g/cm3 and T in ^{o}R.

P.7 Gas Formation Volume Factor (B_g) and z-factor:

From the real-gas law that includes the z-factor definition, it is possible to determine that the gas formation volume factor is given by:

$$B_g = 0.02827 \frac{zT}{p} \qquad \text{(P-15)}$$

with T in ^{o}R and p are given in psia.

For the z-factor, Hall and Yarborough presented an accurate representation of the Standing-Katz chart. This calculation requires a Newton-Raphson convergence scheme to solve for the z-factor. The following set of equations summarizes Hall and Yarborough's proposed correlation:

$$z = \alpha \frac{p_{pr}}{y} \qquad \text{(P-16)}$$

$$\alpha = 0.06125t \exp[-1.2(1-t)^2] \qquad \text{(P-17)}$$

and t is given by:

$$t = \frac{1}{T_r} \qquad \text{(P-18)}$$

The y-parameter (y represents the product of a van der Waals co-volume and density) can be obtained by a Newton-Raphson calculation:

$$f(y) = 0 = -\alpha\ p_{pr} + \frac{y + y^2 + y^3 - y^4}{(1-y)^3} - (14.76t - 9.75t^2 + 4.58t^3)y^2 + (90.7t - 242.2t^2 + 42.4t^3)y^{(2.18+2.82t)} \qquad \text{(P-19)}$$

with $df(y)/dy$ being:

$$\frac{df(y)}{dy} = \frac{1 + 4y + 4y^2 - 4y^3 + y^4}{(1-y)^4} - (29.52t - 19.52t^2 + 9.16t^3)y + (2.18 + 2.82t)(90.7t - 242.2t^2 + 42.4t^3)y^{(2.18+2.82t)} \qquad \text{(P-20)}$$

References:

1. Whitson, G.H and Brule, M.R.: "Phase Behavior", SPE (2000), 18-25

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