Authors Response

Reviewer 1

General Comment

The reviewer expressed concerns about the unavailability of mathematical equations to support the geological processes that were applied in the forward stratigraphic simulation. Also, the reviewer suggests that proper formatting and modification is done to Table 1, Table, and Figure 12. Finally, the reviewer called for necessary corrections done to formatting styles and spelling mistakes.

Author Response: We agree with comments from the reviewer. Additional information on how geological processes in GPM^{TM} operate have been included in the manuscript.

Author Changes: Changes made in the manuscript include:

Steady and Unsteady Flow Process

Appropriate equations for fluid/sediment movement has been provided to illustrate the mathematical basis for these processes:

The simplified Navier-Stokes comprises of two key parameters that partly rely on channel geometry and flow velocity. The Navier-Stokes equation combines the continuity equation (2) and the momentum equation (3) to generate the equation on which the steady and unsteady flow processes evolve.

The continuity equation integrates the conservation of mass:

$$\frac{\partial \rho}{\partial t} + \nabla . \rho \mathrm{q} = 0 \qquad (1)$$

Where ρ is fluid density, t is time, and q the flow velocity vector.

The equation that shows the changes in momentum by the fluid:

$$p.(\frac{\partial q}{\partial t} + (q.\nabla)q) = -\nabla\rho + \nabla.\mu U + \rho(g + \Omega q) \qquad (2)$$

Where P is pressure, t is time, μ is fluid viscosity, and U is the Navier Stokes tensor.

Keeping density (ρ) and viscosity (μ) as constant, a simple flow equation is obtained:

$$\frac{\partial q}{\partial t} + (q\ .\nabla)q = -\nabla\Phi + v\nabla^2 q + g \qquad (3)$$

Where, Φ is the ratio of pressure to constant density (i.e. P/ρ), and v is the kinematic viscosity (i.e. μ/ρ)

The solution of the framework formed in (3) is completely obtained by specifying various boundary conditions that are used in the steady and or unsteady flow processes.

Diffusion Process

Like the unsteady/steady flow process, the guiding equation for sediment diffusion was also provided in the manuscript:

$$F_e = \alpha_e M_e + \alpha_e \Phi_D.\frac{U_{fi} - U_{ei}}{T_p} \qquad (4)$$

M_e is the resultant force of other forces with the exception of drag force, T_p stokes relation time, expressed as: $T_p = \rho_\rho D^2/(18\rho_f V_f)$, with ρ_f and V_f as density and viscosity of fluid respectively. Φ_D is a coefficient that accounts for the non-linear dependence of drag force on grain slip Reynolds number (R_p).

$$\Phi_D = \frac{Rp}{24} C_D \qquad (5)$$, with C_D sediment grain coefficient.

With the flow component in place, the diffusion coefficient (D_i) is deduced from the Einstein equation. Using an assumption that the diffusion coefficient decreases with increasing grain size and rise in temperature, and that the coefficient f is known, the expression for D_i is:

$$D_i = \frac{K_B.T}{f} \qquad (6)$$

Meanwhile, f is a function of the dimension of the spherical particle involved at a particular time (t). In accounting for f, the equation for D_i changes into:

$$D_i = \frac{K_B.T}{6.\pi.\eta_o.r} \qquad (7)$$

The rate diffusion of diffusion relative to topography in the simulator is achieved through;

$$\frac{\partial z}{\partial t} = D_i \nabla^2 z \qquad (8)$$

where **z** is topographic elevation, **k** the diffusion coefficient, **t** for time, and $\nabla^2 z$ is the laplacian.

Sediment Accumulation

Based on Tetzlaff & Harbaugh (1989), sediment accumulation in the stratigraphic simulator is also supported with the following equations:

$$(H - Z)\frac{Dl_{Ks}}{Dt} = f(Q, \nabla H, \nabla Z, L, F, K_s, k(Z)) \qquad (9)$$

Where;

H is the free surface elevation to sea level, Z is the topographic elevation for sea level, $K_s$is the sediment type, $l_{ks,}$ is the volumetric sediment concentration of a specific type (k), L is the vector that defines sediment concentration of each type, F is the matrix of coefficients that define each sediment type, and t is the time.

Sediment accumulation relies on (i) basin geometry and tectonics (Bajpai et al. 2001) (ii) erosion and volume of sediment transported (Cheng, et al. 2018), (iii) prevailing accommodation.

Based on Cheng et al. (2018), sediment accumulation over a period (A_r) is:

$$A_r = V_{er} – V_{es} \qquad (10)$$

V_{es}, is the total volume of sediments that may escapes from the basin. V_{er} is the total volume of sediments eroded into the basin. $V_{er} = A_{er}$ x R_{er} x t; where A_{er} is the average erosion area, R_{er} is the average erosion rate, and t, time.

Because source position for the sediment accumulation process is areal, the volume of sediments accumulated in a specific layer (k) in the basin; excluding porosity, is expressed as:

$$A_r = \sum_{k=1}^{n} A_{rk} \qquad (11)$$

Taking into account the impact of porosity (ϕ) in this process, the equation for the sediment accumulation is:

$$A_r = \sum_{k=1}^{n} [(1 - \phi_0 * e^{-c*z_k}) \; X \; V_{observed_k} \qquad (12)$$

Where; $V_{observedk}$ is the volume of sediment and porosity observed in a specific layer (k), ϕ_0 is the surface porosity, c is the porosity-depth coefficient (after Sclater & Christie, 1980), and Z_k is the average depth of the layer k.

Tables and Figures: Changes include Table 1, Table 5, and Figure 12.

Table 1. Lithofacies-associations in the Hugin formation, Volve Field (after Kieft et al. 2011).

Code	Facies	Description	Thickness (t); Extent (l)	Wireline-log Attribute	Interpretation
	A1	Parallel-laminated mudstone with occasional siltstone inputs. Monospecific pattern of disorder bivalves parallel to bedding.	t = 30 - 425 cm l = 6 - 29 km	GR = 41 - 308 API DT = 225 - 355 μsm^{-1} NPHI = 0.17 - 0.45 v/v RHOB = 2280 - 2820 gcm^{-1}	Restricted marine shale
A	A2	Inter-bedded claystone and very fine-grained sandstone; non-parallel and wavy lamination. Scarecely bivalve shells oriented parallel to bedding.	t = 10 - 725 cm l = 8 - 13 km	GR = 17 - 65 API DT = 189 - 268 μsm^{-1} NPHI =? RHOB = 2280 - 2820 gcm-1	Muddy hallow bay fill
	A3	Fine to medium grained sandstone; moderately to well sorted grain. Wavy bedding, cross bedding, rare wave ripples.	t = 60 - 370 cm l = 1 - 8 km	GR = 18 - 46 API DT = 199 - 268 μsm^{-1} NPHI = 0.07 - 0.52 v/v RHOB = 1690 - 2745 gcm-1	Sandy shallow bay fill
	A4	Parallel-laminated mudstone with occasional siltstone inputs. Monospecific pattern of disorder bivalves parallel to bedding.	t = 30 - 425 cm l = 6 - 29 km	GR = 7 - 35 API DT = 175 - 230 μsm^{-1} NPHI = 0.04 - 0.15 v/v RHOB = 2280 - 2820 gcm-1	Marine channel fill sandstone
	B1	Upward coarsening siltstone to fine-grained; moderatley sorted sandstone. Shell debris and quartz granules.	t = 30 - 480 cm l = 1 - 2 km	GR = 18 - 80 API DT = 168 - 291 μsm^{-1} NPHI = 0.04 - 0.191 v/v RHOB = 2322 - 2723 gcm-1	Distal lower shoreface
B	B2	Very fine-fine grained sandstone. Moderate to well sorted; fine grained carbonaceous laminae, typically low angle cross beds.	t = 130 - 440 cm l = 1.7 - 12 km	GR = 20 - 56 API DT = 179 - 277 μsm^{-1} NPHI = 0.05 - 0.168 v/v RHOB = 2314 - 2696 gcm-1	Proximal lower shoreface
	B3	Coaesening upward, cross laminated, fine to medium grainned sandstone; consist of carbonaceous fragments.	t = 425 - 800 cm l = 1.7 - 8 km	GR = 15 - 25 API DT = 250 - 275 μsm^{-1} NPHI = 0.09 - 0.113 v/v RHOB = 2271 - 2342 gcm-1	Upper shoreface
C	C1	Highly bioturbated siltstone to very fine sandstone, with beds of rounded granules.	t = 175 - 1010 cm l = 7.2 - 19.6 km	GR = 20 - 80 API DT = 230 - 260 μsm^{-1} NPHI = 0.08 - 0.169 v/v RHOB = 2327 - 2521 gcm-1	Distal mouth bar
	C2	Very fine to fine grained sandstone, low angle cross bedding.	t = 290 - 775 cm l = 1 - 5 km	GR = 12 - 58 API DT = 167 - 397 μsm^{-1} NPHI = 0.05 - 0.595 v/v RHOB = 1612 - 2705 gcm-1	Proximal mouth bar
	D1	Fining upward coarse to fine grained sandstone. Stacked fining upward beds with rare coarse grained stringers.	t = 740 - 820 cm l = 1 - 2 km	GR = 8 - 134 API DT = 235 - 335 μsm^{-1} NPHI = 0.14 - 0.46 v/v RHOB = 2284 - 2570 gcm-1	Tidal influenced fluvial channel fill sandstone
D	D2	Fining upward coarse to medium grained sandstone. Carbonaceous laminae and fragments. Sharp and cohessive contact at base of bed.	t = 580 cm l = < 2 km	GR = 9 - 34 API DT = 241 - 297 μsm^{-1} NPHI = 0.14 - 0.289 v/v RHOB = 2168 - 2447 gcm-1	fluvial channel fill sandstone
E	E1	Coal and carbonaceous shale. Basal contact typically parallel, although maybe undulose.	t = 30 - 520 cm l = 6 - 19.6 km	GR = 8 - 56 API DT = 313 - 427 μsm^{-1} NPHI = 0.24 - 0.529 v/v RHOB = 1930 - 2225 gcm-1	Coal
	E2	Alternating dark grey mudstone/claystone and siltstone to very fine grained sandstone. Wavy to non-parallel lamination.	t = 60 cm l = < 2 km	GR = 32 - 60 API DT = 358 - 415 μsm^{-1} NPHI = 0.43 - 0.49 v/v RHOB = 1994 - 2148 gcm-1	Coastal plain fines
F	F	Mudstone with rare siltstone beds. Parallel lamination, soft sediment deformation developed locally on top of beds.	t = section tot completely penetrated l = 1.7 - 36.7 km	GR = 4 - 134 API DT = 187 - 450 μsm^{-1} NPHI = 0.114 - 0.618 v/v RHOB = 1730 - 2925 gcm-1	Open marine shale

Table 5. A comparison of a) porosity, and b) permeability estimates from selected intervals in the original porosity/permeability models and forward modeling-based porosity and permeability models.

a. Validation Well Position 1					
	Depth (m)				
	5 m	10 m	15 m	25 m	35 m
Models	**Measured Porosity**				
Original Model	0.2	0.25	0.27	0.16	0.13
R14	0.22	0.24	0.16	0.22	0.16
R20	0.16	0.19	0.26	0.18	0.15
R26	0.18	0.17	0.23	0.16	0.19
R36	0.22	0.21	0.19	0.22	0.21
R45	0.25	0.2	0.23	0.22	0.15
R49	0.21	0.17	0.22	0.17	0.18
Validation Well Position 2					
	Depth (m)				
	5 m	10 m	15 m	25 m	35 m
Models	**Measured Porosity**				
Original Model	0.17	0.21	0.21	0.17	0.19
R14	0.17	0.16	0.24	0.15	0.25
R20	0.21	0.22	0.2	0.21	0.23
R26	0.21	0.2	0.21	0.25	0.24
R36	0.2	0.22	0.21	0.21	0.19
R45	0.22	0.19	0.2	0.19	0.21
R49	0.26	0.24	0.23	0.16	0.21

b. Validation Well Position 1					
	Depth (m)				
	5 m	10 m	15 m	25 m	35 m
Models	**Measured Permeability_Z (mD)**				
Original Model	352.74	312.38	201.08	199.76	508.2
R14	163.95	312.38	69.84	310.16	508.2
R20	290.84	315.09	105.66	273.04	200.63
R26	375.92	203.81	166.23	189.92	348.12
R36	418.03	203.27	190.9	168.9	370.56
R45	337.6	412.67	199.66	156.71	305.92
R49	370.89	129.33	291.77	175.53	551.18
Validation Well Position 2					
	Depth (m)				
	5 m	10 m	15 m	25 m	35 m
Models	**Measured Permeability_Z (mD)**				
Original Model	6.6	883.6	30.3	496.99	156.6
R14	320.34	336.22	151.08	464.22	132.98
R20	122.66	209.15	161.3	230.58	208.48
R26	151.48	710.07	175.09	384.49	169.48
R36	184.74	344.99	157.08	420.15	136.14
R45	91.44	361.04	77.17	382.85	134.56
R49	134.01	721.73	137.42	636.48	290.06

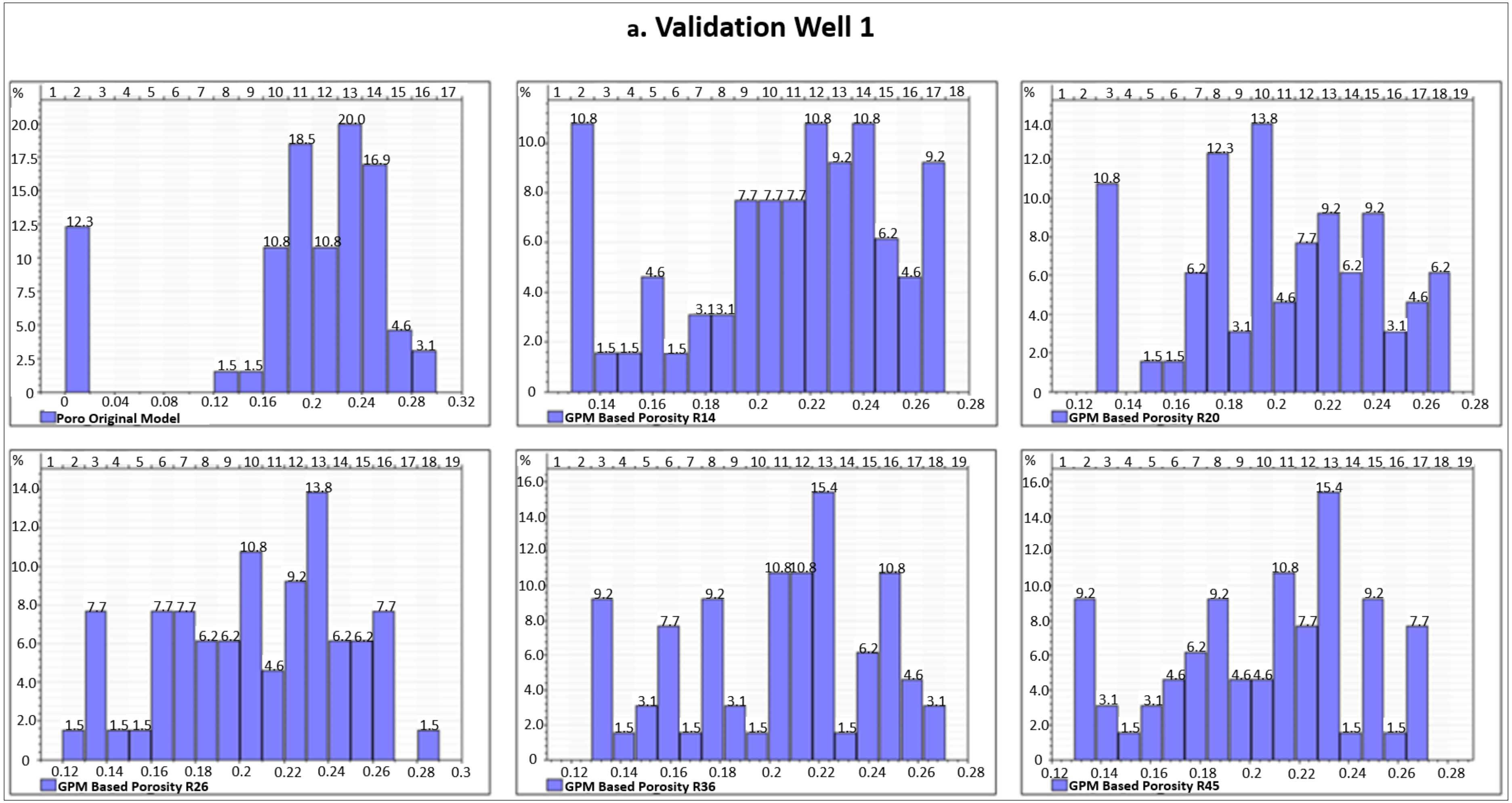

Figure 12a. Comparing porosity in validation Well 1 in five stratigraphic-based realizations, and the original model at similar vertical intervals.

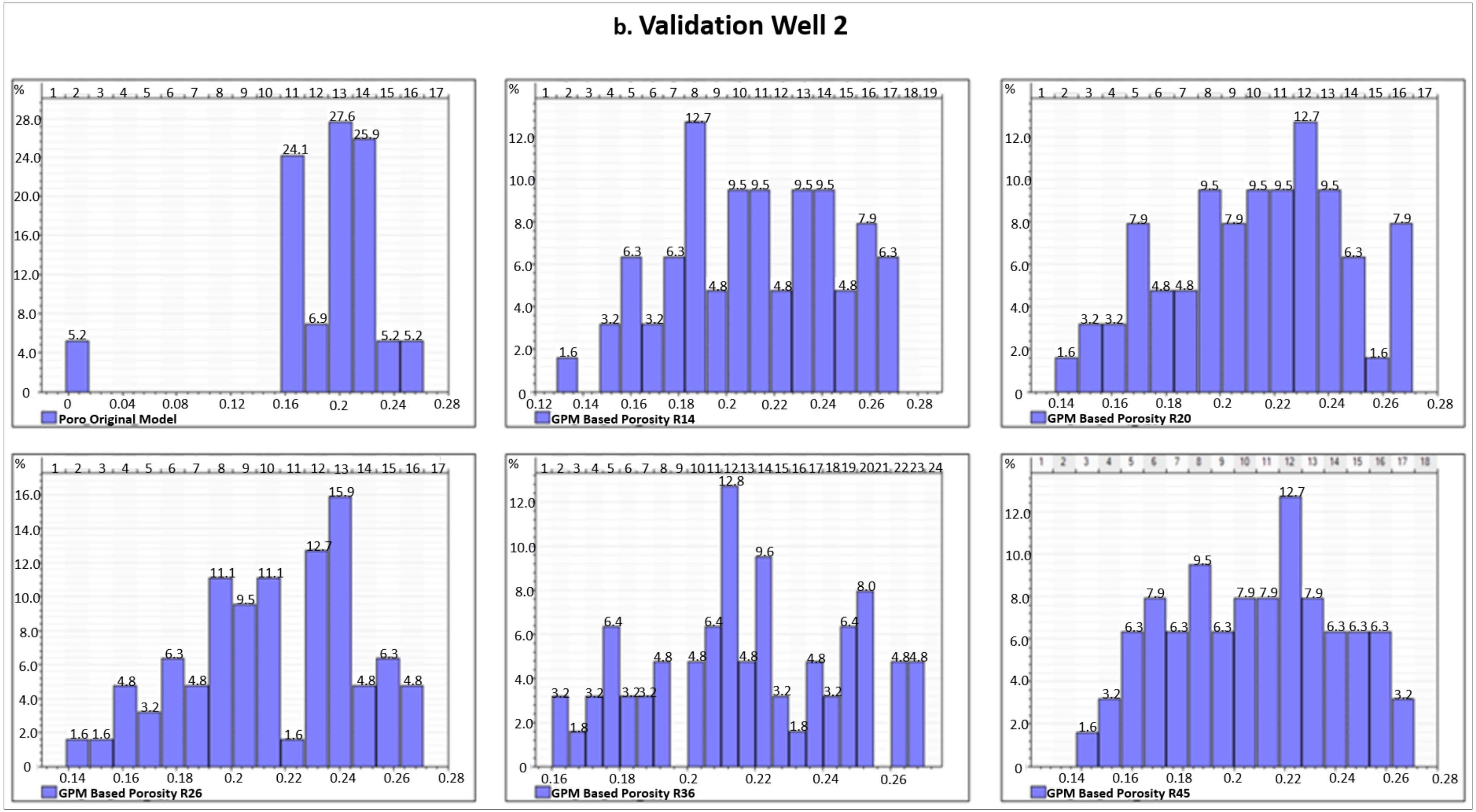

Figure 12b. Comparing porosity in validation Well 2 in five stratigraphic-based realizations, and the original model at similar vertical intervals.

Reviewer 2

General Comments

The reviewer advised that we double check for all typographical errors (misspellings, punctuation etc.) in the text before final publication.

Authors Response

The necessary correction have been effected to address concerns of the reviewer.