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Analytical method for predicting pore pressure and corresponding depth using well and seismic Data: A Niger Delta Scenario

S.O. Salufu, O.E. Akhirevbulu, and A. Iyoha

Department of Physics, Ambrose Alli University, Ekpoma, Edo State, Nigeria

Abstract

This work is aimed at correcting over predictions in pore pressure, corresponding depth, and top to overpressure zone, associated with existing models. Analytical method was used to develop a new model to predict pore pressure, corresponding depth of occurrence, and top to overpressure zone, using offset Wells, seismic data, sonic log data, and anisotropic factor. Offset wells, seismic data and sonic log data from three offshore wells in the Niger Delta field were used to validate the model. Pore pressure, corresponding depth, and top to overpressure depth were predicted with the model, and compared with measured field data and existing models. The results of the statistical analysis showed that predicted values by the proposed model are closest to the field data. The study shows that mineral compositions of rock are not the same in both vertical and horizontal directions; hence anisotropic factor is required for its correction in order to have accurate pore pressure prediction.

Keywords: Pore pressure, seismic anisotropy, anisotropic minerals, Niger Delta

Nomenclature

g = Acceleration due to gravity
T = oblique time
V = Vertical velocity
V = the velocity of seismic wave (ft/sec)
t = time of travel (sec) δ = Anisotropy factor
t_0 = Echo-time or two way travel time (sec)
x = offset distance α_r = Rigidity modulu
v_h =Horizontal velocity (seismic)

d_{iso}= Depth under isotropic condition (ft)
P_p = Pore pressure (psi)
α = Hydrostatic pressure gradient (psi/ft)
d_c = Corrected depth of a given strata in the subsurface
$\rho(z)$ =Bulks density at a given depth (lb/ft^3)
φ = wave displacement (pressure, rotation, dilation
d = depth μ = Poison ratio
v_v =Vertical velocity (Sonic)

1.0 Introduction

Present research efforts is geared towards developing a model for estimating and predicting pore pressure such that it will eliminate or reduce over prediction in the existing models. Hence the result of the model will be validated with available seismic, sonic log data; and compared with field data and existing models.

Pore pressure, sometimes called formation-fluid pressure, is the pressure acting upon fluids in the pore space of subsurface rock [1]. When the pore pressure is high enough to cause rock or formation failure, it is called fracture pressure. Pore pressure can be classified by the magnitude of the corresponding pressure gradient in a given area as normal, subnormal and abnormal or overpressure. Normal pressure gradients correspond to the hydrostatic gradient of fresh or saline water [2]. Normal pressure depends on the geographic area or depositional basin. For example, a normal pressure gradient is considered to be 0.465 psi/ft in Niger Delta [3]. Any pore pressure greater than this is regarded as abnormal pressure gradient, while pore pressure less than this is regarded as subnormal pressure.

Corresponding author: ***S.O. Salufu*** E-mail: just4samuel@gmail.com, Tel.: +2347037923493 (A. Iyoha)

The prediction of pore pressure along a proposed Well path is a key input to Well design and to the prediction of future reservoir performance. Accurate predictions of these parameters can have significant impact on the cost of wells (both from design and operational perspectives). Prior knowledge of pore pressure in a given area is an important requirement for successful drilling operation. When pore pressure is not adequately predicted, it could result to drilling problems such as blowout, stuck pipe, lost circulation, hole instability and incurement of excessive costs.

There have been extensive studies on pore pressure prediction using seismic method, overburden stress, and measurement while drilling. Terzaghi [4] developed a model which gives relationship that connects overburden stress (σ_{ob}), vertical stress, and pore pressure together. He demonstrated that effective stress rather than total principal stress controls matrix behaviour with regard to the effect on rock properties and strain deformation. Regrettably, the model could not account for the effect of given cementation on the ability of rock pore pressure to counteract the overburden or other loading. Pennebarker [5] developed the use of seismic method for detecting and quantifying abnormal pressure by relating computed sound velocity and the degree of sediment compaction. However, this model tends to over predict or under predict pore pressure because it does not accommodate anisotropic effect of direction of travelling seismic wave velocity through mineral compositions of subsurface formation.

Guzman [6] gave procedures for predicting pore pressure from seismic reflection data using seismic velocity and velocity travel time. The pitfall of the method of [7] is similar to that of [5]. Draou and Osisanya [7] gave two descriptive models for estimating and detecting abnormal pore pressure. His first model was fundamental compaction while his second model was power law relationship method. The pitfalls of this method was that depth of pore pressure occurrence cannot be directly predicted from the seismic data, rather, equivalent depth of interest is assumed which causes deviation in the value of predicted pore pressure.

2.0 Model Development and Governing Equations

This model was developed using analytical method with assumptions and is based on the assumption that there is deviation from actual pore pressure in the presence of anisotropic minerals and seismic anisotropy. The stress response of rocks and minerals in the subsurface is affected by various factors, including temperature, hydrostatic pressure, and time. As a result, elastic, inelastic and plastic pressure behaviour occurs with various degrees of importance at different depths.

According to Sherriff [8], seismic wave propagation in the subsurface is given mathematically in rectangular coordinates; x, y, z as:

$$\nabla^2\varphi = \frac{\partial^2\varphi}{\partial x^2} + \frac{\partial^2\varphi}{dy^2} + \frac{\partial^2\varphi}{\partial^2 z} = \left(\frac{1}{v^2}\right)\frac{\partial^2}{\partial t^2} \tag{2.1}$$

The solution is given as: $f\left(\ell x + my + nz \pm vt\right)$

In spherical coordinate, for r (radius), θ (the latitude), and φ (the longitude), the seismic wave equation becomes:

$$\left(\frac{1}{r^2}\right)\left[\left(\frac{\partial}{\partial r}\right)\left(r^2\frac{\partial\varphi}{\partial r}\right) + \left(\frac{1}{Sin\theta}\right)\left(\frac{\partial}{\partial\theta}\right)\left(Sin\theta\frac{\partial\varphi}{\partial\theta}\right) + \left(\frac{1}{Sin^2\theta}\right)\frac{\partial^2\varphi}{\partial\phi^2} = \left(\frac{1}{v^2}\right)\frac{\partial^2\varphi}{\partial t^2}\right] \tag{2.2}$$

Equation (2.1) is rearranged as:

$$v = \sqrt{\left[\left(\frac{\partial^2\varphi}{\partial x^2} + \frac{\partial^2\varphi}{dy^2} + \frac{\partial^2\varphi}{\partial^2 z}\right)^{-1}\frac{\partial^2}{\partial t^2}\right]} \tag{2.3}$$

Knowing the velocity of seismic wave being propagated in the subsurface, the depth (d) was computed from the response of seismic reflection at any given horizon using Figure 1.

Figure 1 show the simplest case of seismic reflection in the two-dimensional reflection at a horizontal boundary. Let the reflecting bed be at depth d below the shot-point S. The ray that strikes the boundary at Q is reflected to the surface and recorded by a geophone at the point P, so that the angles of incidence and reflection are equal. Let P be at a horizontal distance x from the short-point. If the P-wave velocity is V, the first signal receives at P is from the direct wave that travels directly along SP. Its travel time is given by:

$$t = \frac{x}{V} \tag{2.4}$$

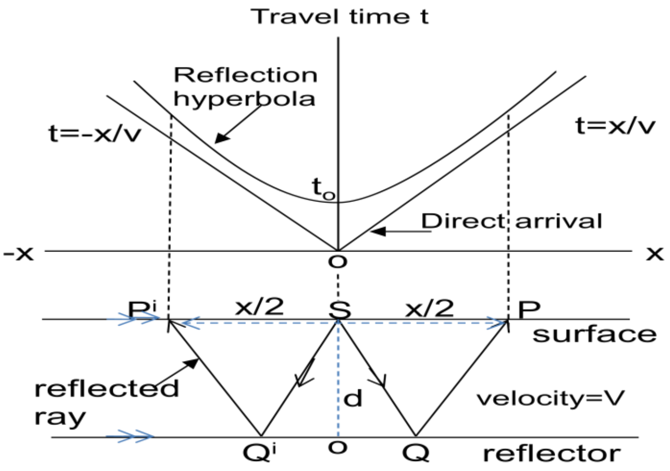


Fig.1: The travel-time vs distance curve for reflection from horizontal boundary (Source: [9])

The travel time t of the reflected ray SQP is given by:

$$t=\frac{(SQ+QP)}{V} \tag{2.5}$$

Assumed that strata are not inclined but lying horizontally

$$SQ=\sqrt{d^2+OQ^2} \tag{2.6}$$

$$SQ=\sqrt{d^2+\left(\frac{X}{4}\right)^2} \tag{2.7}$$

$$P'S=2OQ \tag{2.8}$$

Therefore,

$$OQ=\frac{P'S}{2}=\frac{X}{4} \tag{2.9}$$

Combine Eqn. (2.6) and Eqn. (2.8) to get

$$Q'S=\sqrt{d^2+\left(\frac{X}{4}\right)^2} \tag{2.10}$$

SQ and QP are equal therefore,

$$QP=\sqrt{d^2+\left(\frac{X}{4}\right)^2} \tag{2.11}$$

Combine Eqn. (2.8), Eqn. (2.10), and Eqn. (2.11) to get

$$t=\frac{\sqrt{d^2+\left(\frac{X}{4}\right)^2}+\sqrt{d^2+\left(\frac{X}{4}\right)^2}}{v} \tag{2.12}$$

Further rearrangement

$$t = \frac{1}{v}\sqrt{2d^2 + 2\left(\frac{X}{4}\right)^2} \tag{2.13}$$

$$t = \frac{1}{v}\sqrt{4d^2 + \frac{X^2}{2}} \tag{2.14}$$

$$t = \frac{2d}{v}\left(\sqrt{1 + \frac{X^2}{2}}\right) \tag{2.15}$$

At x=0 Eqn. (2.15) becomes:

$$t = \frac{2d}{V} \tag{2.16}$$

Equation (2.18) is similar to echo time t_o of [9], hence

$t = t_o$ at x = 0

Therefore,

$$t_o = \frac{2d}{V} \tag{2.17}$$

Distance travelled by seismic wave from surface through a stratum is:

$$d = \frac{t_o v}{2} \tag{2.18}$$

Total distance travelled for a sequence of strata in Figure 2 is:

$$d_t = \frac{t_1 v_1}{2} + \frac{t_2 v_2}{2} + \frac{t_3 v_3}{2} + \cdots + \frac{t_n v_n}{2} \tag{2.19}$$

$$d_t = \frac{1}{2}\sum_{i=1}^{n} t_i v_i \tag{2.20}$$

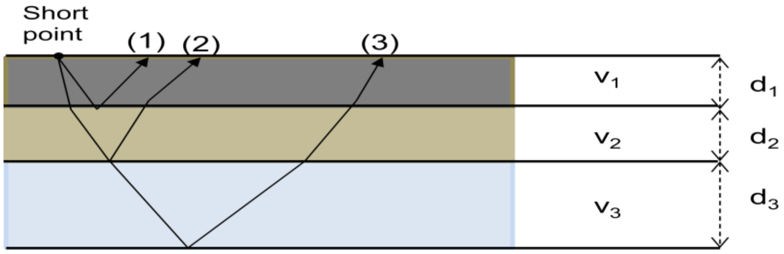


Fig.2: Illustration of traveling seismic wave from the surface through sequence of strata

Since sedimentary rocks within a basin are assumed to be elasto-plastic bodies due to their subjection to long lasting stress thus caused deviation of the seismic from those of the actual geological depth formed in the environment of long lasting stress, therefore it is necessary to input anisotropic factor to correct for the deviation.

According to Stoep [10] the anisotropic factor is:

$$\delta = \frac{V_h}{Vv} \tag{2.21}$$

Therefore actual depth is:

Actual depth = $$d_c = \frac{d_{is}}{\delta} \tag{2.22}$$

Therefore, Eqn. (2.20) becomes:

$$d_t = \frac{1}{2\delta}\sum_{i=1}^{n} t_i v_i \tag{2.23}$$

Hydrostatic pressure gradient is given as:

$$\alpha = \frac{P_p}{d_c} = \rho\ g \tag{2.24}$$

While $$\rho = \frac{\alpha}{g} \tag{2.25}$$

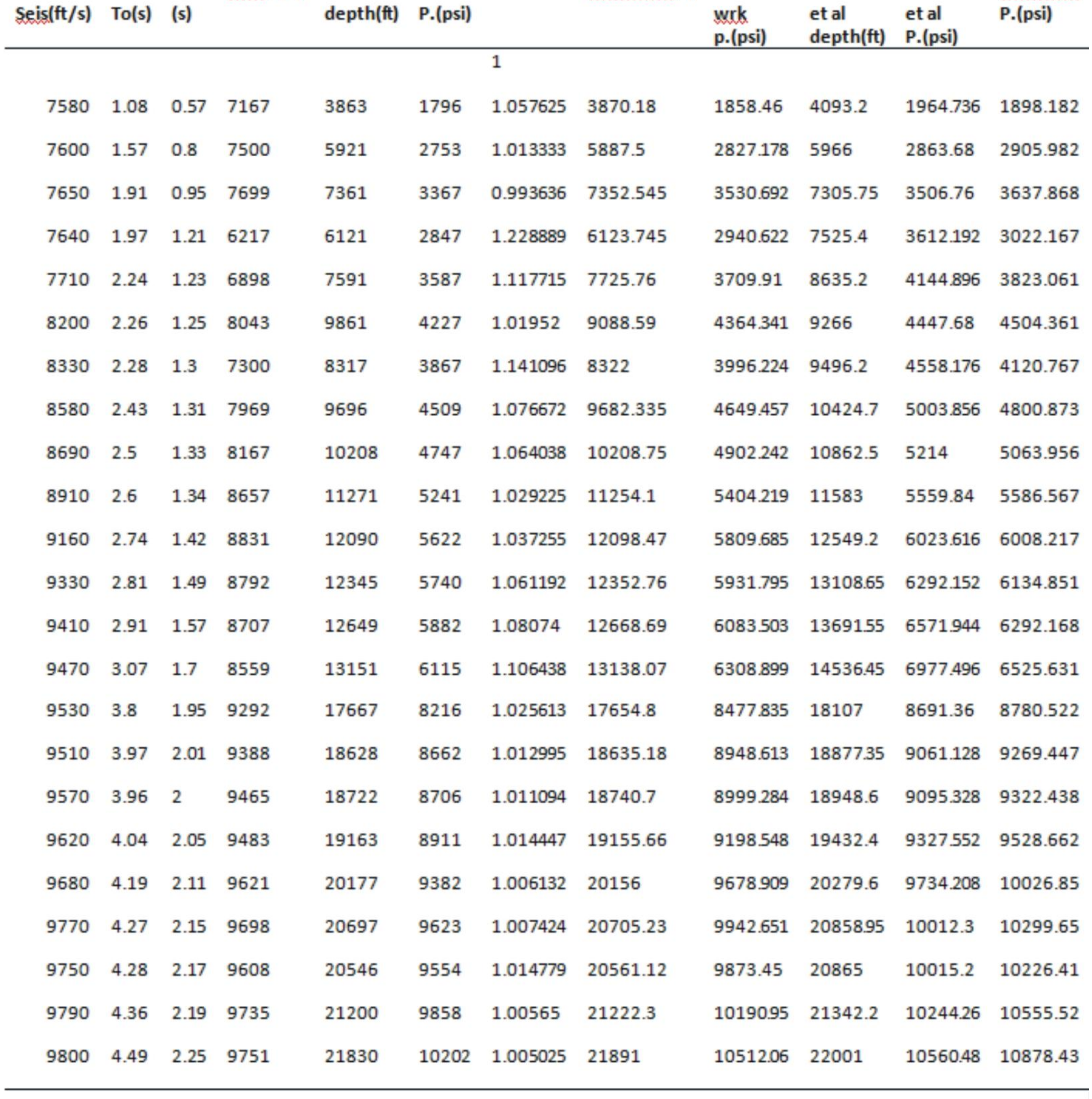
$$P_p = \rho g\ \frac{t_0 v}{2\delta} \tag{2.26}$$

3.0 RESULTS AND DISCUSSION

The present model for predicting pore pressure was validated using data from three offshore wells in the Niger Delta. The proposed model was used to estimate the pore pressure by computing the seismic and sonic log data from the three offshore wells using Eqns. (2.25) and (2.26) respectively. Table 1, 2 and 3 show the predicted pore pressure and depths and Table 4 shows statistical errors values in predicting pore pressure.

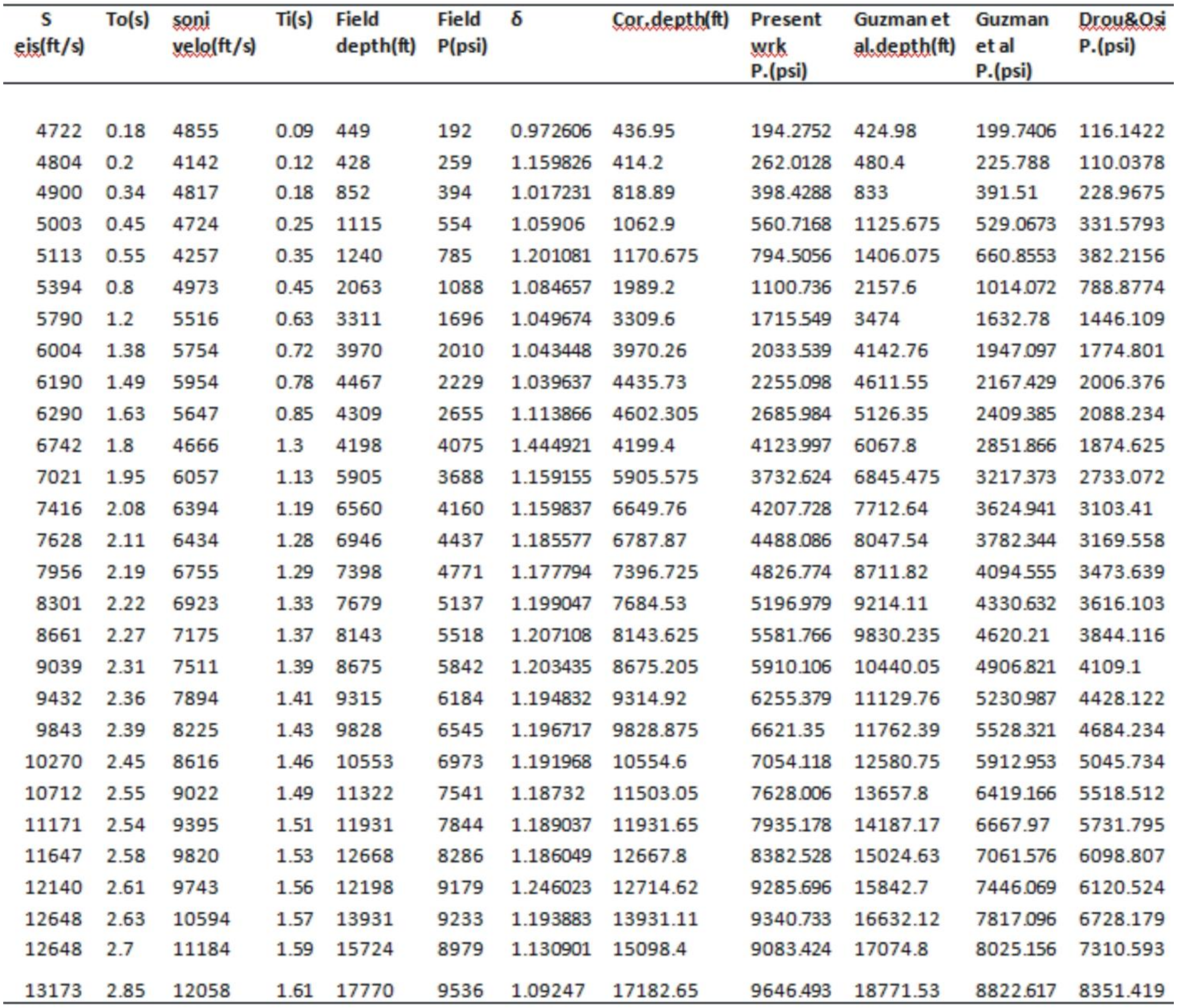
Figure 3 to 5 are the comparison plots for the prediction models for pore pressure. However, these plots do not reveal as the statistical error analysis (See Table 2). On the other hand, the correlation coefficients displayed on the plots clearly show that, the proposed model for estimating pore pressure is the closest to the field pressure with correlation coefficients (R^2) of 1 in the three Wells, compared to the method in [7] that ranges from 0.9974 to 1 and also [6] that ranges from 0.9873 to 0.9909 (Figures 4). Figures 3 to 5 show that the models in [7] and [6] over-predict pore pressure. The measured pore pressure of well A is considerably lower than well B and well C obtained from the two models. However, the results obtained from the model of this study compare favourably well with the measured pore pressure.

Table 1: Input data, field and predicted pore pressure for Well A. (Well 1@0.48psi/ft)



Seis(ft/s)	To(s)	Ti (s)	Soni(ft/s)	Field depth(ft)	Field P.(psi)	δ	Cor.depth(ft)	Present wrk p.(psi)	Guzman et al depth(ft)	Guzman et al P.(psi)	Drou&Osi P.(psi)
						1					
7580	1.08	0.57	7167	3863	1796	1.057625	3870.18	1858.46	4093.2	1964.736	1898.182
7600	1.57	0.8	7500	5921	2753	1.013333	5887.5	2827.178	5966	2863.68	2905.982
7650	1.91	0.95	7699	7361	3367	0.993636	7352.545	3530.692	7305.75	3506.76	3637.868
7640	1.97	1.21	6217	6121	2847	1.228889	6123.745	2940.622	7525.4	3612.192	3022.167
7710	2.24	1.23	6898	7591	3587	1.117715	7725.76	3709.91	8635.2	4144.896	3823.061
8200	2.26	1.25	8043	9861	4227	1.01952	9088.59	4364.341	9266	4447.68	4504.361
8330	2.28	1.3	7300	8317	3867	1.141096	8322	3996.224	9496.2	4558.176	4120.767
8580	2.43	1.31	7969	9696	4509	1.076672	9682.335	4649.457	10424.7	5003.856	4800.873
8690	2.5	1.33	8167	10208	4747	1.064038	10208.75	4902.242	10862.5	5214	5063.956
8910	2.6	1.34	8657	11271	5241	1.029225	11254.1	5404.219	11583	5559.84	5586.567
9160	2.74	1.42	8831	12090	5622	1.037255	12098.47	5809.685	12549.2	6023.616	6008.217
9330	2.81	1.49	8792	12345	5740	1.061192	12352.76	5931.795	13108.65	6292.152	6134.851
9410	2.91	1.57	8707	12649	5882	1.08074	12668.69	6083.503	13691.55	6571.944	6292.168
9470	3.07	1.7	8559	13151	6115	1.106438	13138.07	6308.899	14536.45	6977.496	6525.631
9530	3.8	1.95	9292	17667	8216	1.025613	17654.8	8477.835	18107	8691.36	8780.522
9510	3.97	2.01	9388	18628	8662	1.012995	18635.18	8948.613	18877.35	9061.128	9269.447
9570	3.96	2	9465	18722	8706	1.011094	18740.7	8999.284	18948.6	9095.328	9322.438
9620	4.04	2.05	9483	19163	8911	1.014447	19155.66	9198.548	19432.4	9327.552	9528.662
9680	4.19	2.11	9621	20177	9382	1.006132	20156	9678.909	20279.6	9734.208	10026.85
9770	4.27	2.15	9698	20697	9623	1.007424	20705.23	9942.651	20858.95	10012.3	10299.65
9750	4.28	2.17	9608	20546	9554	1.014779	20561.12	9873.45	20865	10015.2	10226.41
9790	4.36	2.19	9735	21200	9858	1.00565	21222.3	10190.95	21342.2	10244.26	10555.52
9800	4.49	2.25	9751	21830	10202	1.005025	21891	10512.06	22001	10560.48	10878.43

Table2: Input data, field and predicted pore pressure for well B (Well 2 @0.47psi/ft)



S eis(ft/s)	To(s)	soni velo(ft/s)	Ti(s)	Field depth(ft)	Field P(psi)	δ	Cor.depth(ft)	Present wrk P.(psi)	Guzman et al.depth(ft)	Guzman et al P.(psi)	Drou&Osi P.(psi)
4722	0.18	4855	0.09	449	192	0.972606	436.95	194.2752	424.98	199.7406	116.1422
4804	0.2	4142	0.12	428	259	1.159826	414.2	262.0128	480.4	225.788	110.0378
4900	0.34	4817	0.18	852	394	1.017231	818.89	398.4288	833	391.51	228.9675
5003	0.45	4724	0.25	1115	554	1.05906	1062.9	560.7168	1125.675	529.0673	331.5793
5113	0.55	4257	0.35	1240	785	1.201081	1170.675	794.5056	1406.075	660.8553	382.2156
5394	0.8	4973	0.45	2063	1088	1.084657	1989.2	1100.736	2157.6	1014.072	788.8774
5790	1.2	5516	0.63	3311	1696	1.049674	3309.6	1715.549	3474	1632.78	1446.109
6004	1.38	5754	0.72	3970	2010	1.043448	3970.26	2033.539	4142.76	1947.097	1774.801
6190	1.49	5954	0.78	4467	2229	1.039637	4435.73	2255.098	4611.55	2167.429	2006.376
6290	1.63	5647	0.85	4309	2655	1.113866	4602.305	2685.984	5126.35	2409.385	2088.234
6742	1.8	4666	1.3	4198	4075	1.444921	4199.4	4123.997	6067.8	2851.866	1874.625
7021	1.95	6057	1.13	5905	3688	1.159155	5905.575	3732.624	6845.475	3217.373	2733.072
7416	2.08	6394	1.19	6560	4160	1.159837	6649.76	4207.728	7712.64	3624.941	3103.41
7628	2.11	6434	1.28	6946	4437	1.185577	6787.87	4488.086	8047.54	3782.344	3169.558
7956	2.19	6755	1.29	7398	4771	1.177794	7396.725	4826.774	8711.82	4094.555	3473.639
8301	2.22	6923	1.33	7679	5137	1.199047	7684.53	5196.979	9214.11	4330.632	3616.103
8661	2.27	7175	1.37	8143	5518	1.207108	8143.625	5581.766	9830.235	4620.21	3844.116
9039	2.31	7511	1.39	8675	5842	1.203435	8675.205	5910.106	10440.05	4906.821	4109.1
9432	2.36	7894	1.41	9315	6184	1.194832	9314.92	6255.379	11129.76	5230.987	4428.122
9843	2.39	8225	1.43	9828	6545	1.196717	9828.875	6621.35	11762.39	5528.321	4684.234
10270	2.45	8616	1.46	10553	6973	1.191968	10554.6	7054.118	12580.75	5912.953	5045.734
10712	2.55	9022	1.49	11322	7541	1.18732	11503.05	7628.006	13657.8	6419.166	5518.512
11171	2.54	9395	1.51	11931	7844	1.189037	11931.65	7935.178	14187.17	6667.97	5731.795
11647	2.58	9820	1.53	12668	8286	1.186049	12667.8	8382.528	15024.63	7061.576	6098.807
12140	2.61	9743	1.56	12198	9179	1.246023	12714.62	9285.696	15842.7	7446.069	6120.524
12648	2.63	10594	1.57	13931	9233	1.193883	13931.11	9340.733	16632.12	7817.096	6728.179
12648	2.7	11184	1.59	15724	8979	1.130901	15098.4	9083.424	17074.8	8025.156	7310.593
13173	2.85	12058	1.61	17770	9536	1.09247	17182.65	9646.493	18771.53	8822.617	8351.419

Table 3: Input data, field and predicted pore pressure for well C (Well 3 @0.47psi/ft)

Seis(ft/s)	To	Soni Vel.	Ti	Field depth	Field P.	δ	Cor Depth	Present wrk P.	Guzman et alDepth	Guzman et al P.	Drou&Osi
3501	2.13	3228	1.15	3423	1730	1.084572	3437.82	1678.969	3728.565	1752.426	1615.775
3581	2.15	3304	1.17	3566	1790	1.083838	3551.8	1735.856	3849.575	1809.3	1669.346
3770	2.18	3482	1.18	3795	1907	1.082711	3795.38	1857.594	4109.3	1931.371	1783.829
3872	2.19	3578	1.19	3934	1972	1.082169	3917.91	1918.806	4239.84	1992.725	1841.418
4285	2.21	3962	1.2	4396	2202	1.081524	4378.01	2148.802	4734.925	2225.415	2057.665
4404	2.23	4074	1.2	4522	2279	1.081001	4542.51	2231.052	4910.46	2307.916	2134.98
4556	2.25	4218	1.21	4725	2383	1.080133	4745.25	2332.368	5125.5	2408.985	2230.268
4484	2.31	4305	1.24	5125	2492	1.04158	4972.275	2445.714	5179.02	2434.139	2336.969
4410	2.37	4235	1.28	5205	2516	1.041322	5018.475	2468.582	5225.85	2456.15	2358.683
4400	2.48	4181	1.33	5283	2585	1.05238	5184.44	2551.257	5456	2564.32	2436.687
4349	2.63	4128	1.41	5524	2702	1.053537	5428.32	2672.657	5718.935	2687.899	2551.31
4465	2.78	4133	1.48	5662	2846	1.080329	5744.87	2830.402	6206.35	2916.985	2700.089
4551	2.92	4096	1.55	5714	2953	1.111084	5980.16	2947.446	6644.46	3122.896	2810.675
4627	3.01	4213	1.6	6138	3125	1.098267	6340.565	3127.166	6963.635	3272.908	2980.066
4699	3.12	4303	1.65	6502	3302	1.092029	6712.68	3312.684	7330.44	3445.307	3154.96
4901	3.22	4382	1.7	6661	3464	1.118439	7055.02	3483.242	7890.61	3708.587	3315.859
5036	3.33	4458	1.76	6946	3639	1.129655	7422.57	3666.156	8384.94	3940.922	3488.608
5471	3.35	4651	1.77	6998	3818	1.176306	7790.425	3849.922	9163.925	4307.045	3661.5
5612	3.38	4781	1.78	7250	3957	1.173813	8079.89	3994.488	9484.28	4457.612	3797.548
5743	3.4	5196	1.79	8415	4325	1.105273	8833.2	4370.97	9763.1	4588.657	4151.604
5891	3.43	5332	1.81	8735	4476	1.104839	9144.38	4526.194	10103.07	4748.441	4297.859
6149	3.46	5459	1.82	8820	4621	1.126397	9444.07	4675.844	10637.77	4999.752	4438.713
6094	3.48	5601	1.83	9421	4766	1.08802	9745.74	4826.475	10603.56	4983.673	4580.498
5995	3.5	5848	1.84	10496	5003	1.025137	10234	5070.392	10491.25	4930.888	4809.98
5942	3.6	5804	1.89	10714	5101	1.023777	10447.2	5175.746	10695.6	5026.932	4910.184
6042	3.71	5718	1.94	10498	5171	1.056663	10606.89	5253.874	11207.91	5267.718	4985.238
6179	3.82	5675	2	10424	5278	1.088811	10839.25	5366.442	11801.89	5546.888	5094.448
6124	3.84	5771	2.01	10931	5394	1.061168	11080.32	5485.955	11758.08	5526.298	5207.75
6204	3.9	5906	2.04	11470	5603	1.050457	11516.7	5697.793	12097.8	5685.966	5412.849

Table 4: Statistical error analysis for the predicted pore pressure

	Errors	**This work**	**Guzman. et al.[6]**	**Draou & Osisanya[7]**
Well A	AAPRE	3.439717	9.393913	7.008873
	AAD	216.1566	524.3412	449.4223
	Max. Error	4.86166	26.87713	8.044773
	Min. Error	2.964424	3.513821	5.556933
Well B	AAPRE	1.207721	12.26459	4.698316
	AD	55.84486	676.1342	139.2692
	Max. Error	1.212419	30.0499	42.8537
	Min. Error	1.147308	0.61398	0.48658
Well C	AAPRE	0.256123	3.328329	13.16247
	AD	10.81596	130.2899	509.0281
	Max. Error	3.02479	8.196319	5.304815
	Min. Error	0.069312	0.8	20.43447

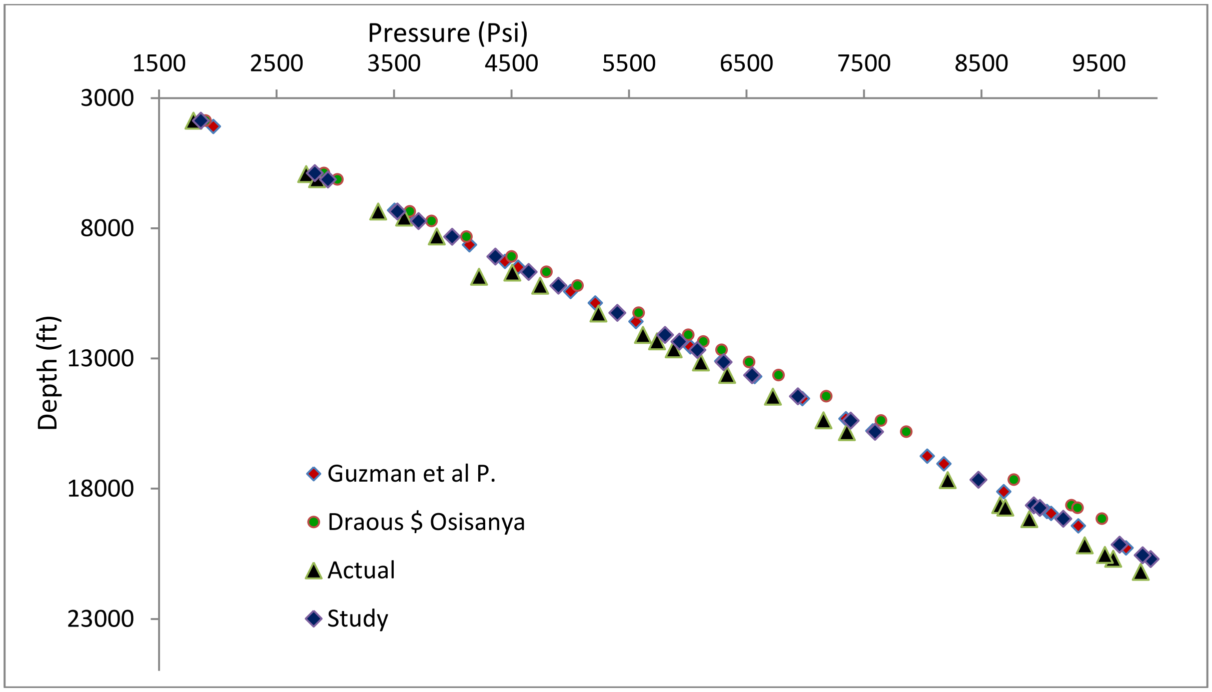


Fig.3: Pore pressure with depth for well A

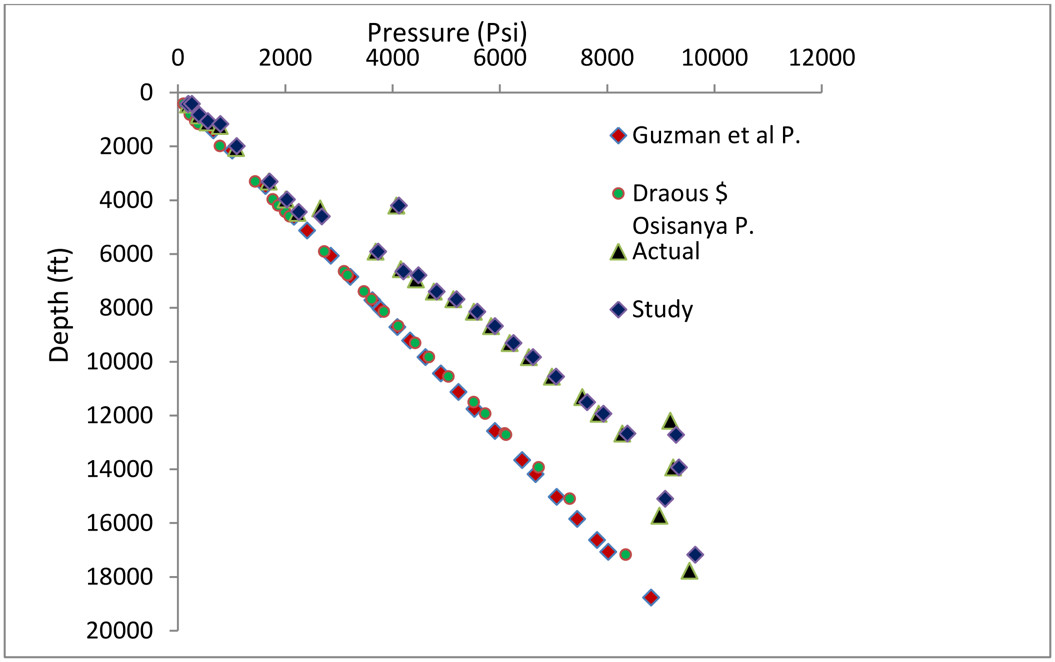


Fig.4: Pore pressure with depth for well B

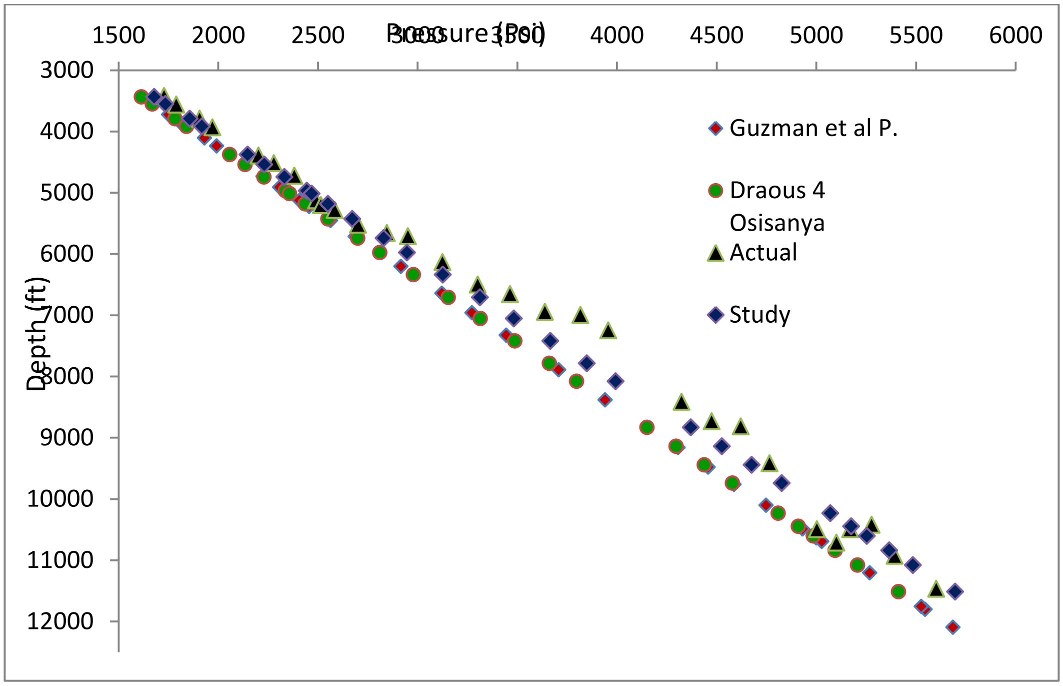


Fig.5: Pore pressure with depth for well C

Figure 5 show occurrence of top of overpressure depth at 6121ft and 12345ft for well A, 4199ft, and 11503ft for well B, and in well C, top of the abnormal pressure occurs at 4543ft and 9746ft as predicted by the propose model. These values are very close to the actual field value of occurrence of top of the abnormal pressure (6121ft and 12345ft for well A, 4198ft and 11322ft for well B, and 4522ft and 9421ft for well C). However, Guzman et al.'s model [6] overpredicts depth of abnormal pressure occurrence far from the actual measured field values (Figures 5). Over prediction in occurrence of top of abnormal pressure by Guzman et al.'s model [6] is due to the assumption that mineral properties in x, y, and z directions are the same (Isotropic in nature) but practically, they are anisotropic in nature. The predictions by the proposed model show good agreement with the measured field data and therefore more reliable for predicting pore pressure.

The plots of depth vs. interval seismic travelling time in Figure 7 show depth of occurrence of top of overpressured and their corresponding values of overpressure respectively at 6121ft, 4124psi and 12345ft, 7628psi for well A; 4199ft, 4124psi and 11503ft, 7628psi for well B, and 4543ft, 2231psi and 9746ft, 2231psi for well C. The actual field pressures are 2447psi and 5740psi; 4075psi and 7541psi; and 22279psi and4766psi respectively at these depths. However, the equivalent pore pressure values at these depth for Guzman et al.'s model (1997) are 3612psi and 6292psi for well A; 2852psi and 6419psi for well B; and 2308psi and 4983psi for well C while the equivalent pore pressure values at the same depth for Draou and Osisanya's model are 2906psi and 6135psi for well A; 1875psi and 5519psi for well B; and 2135psi and 4580psi for well C.

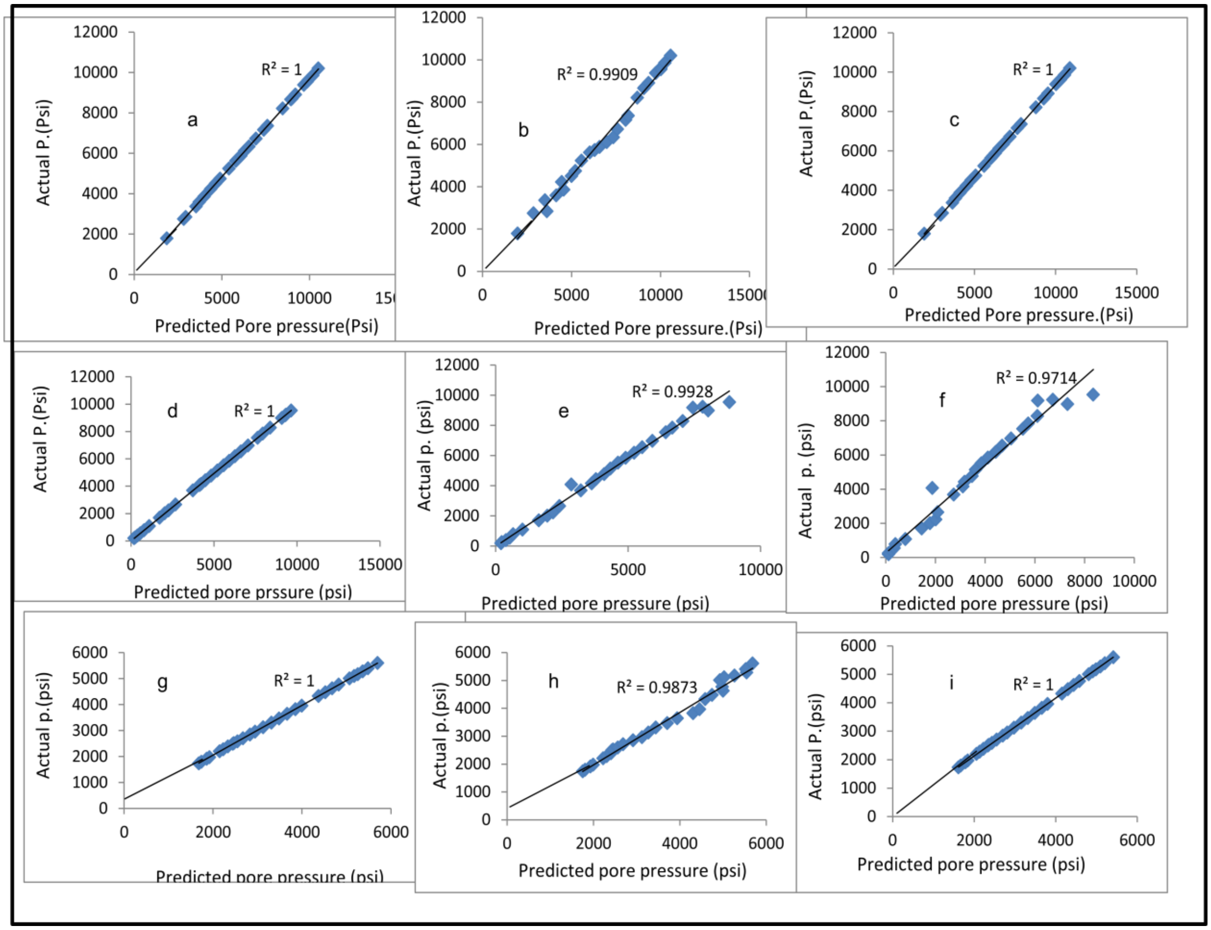


Fig. 6.Crossplots of predicted porepressure

Legend:

a: Crossplot for this work for well A
b: Crossplot for Guzman et al. for well A
c: Crossplot for Draou & Osisanya for well A
d: Crossplot for this work for well B
e: Crossplot for Guzman et al. for well B
f: Crossplot for Draou & Osisanya for well B
g: Crossplot for this work for well C
h: Crossplot for guzman et al. for well C
i: Crossplot for Draou & Osisanya for well C

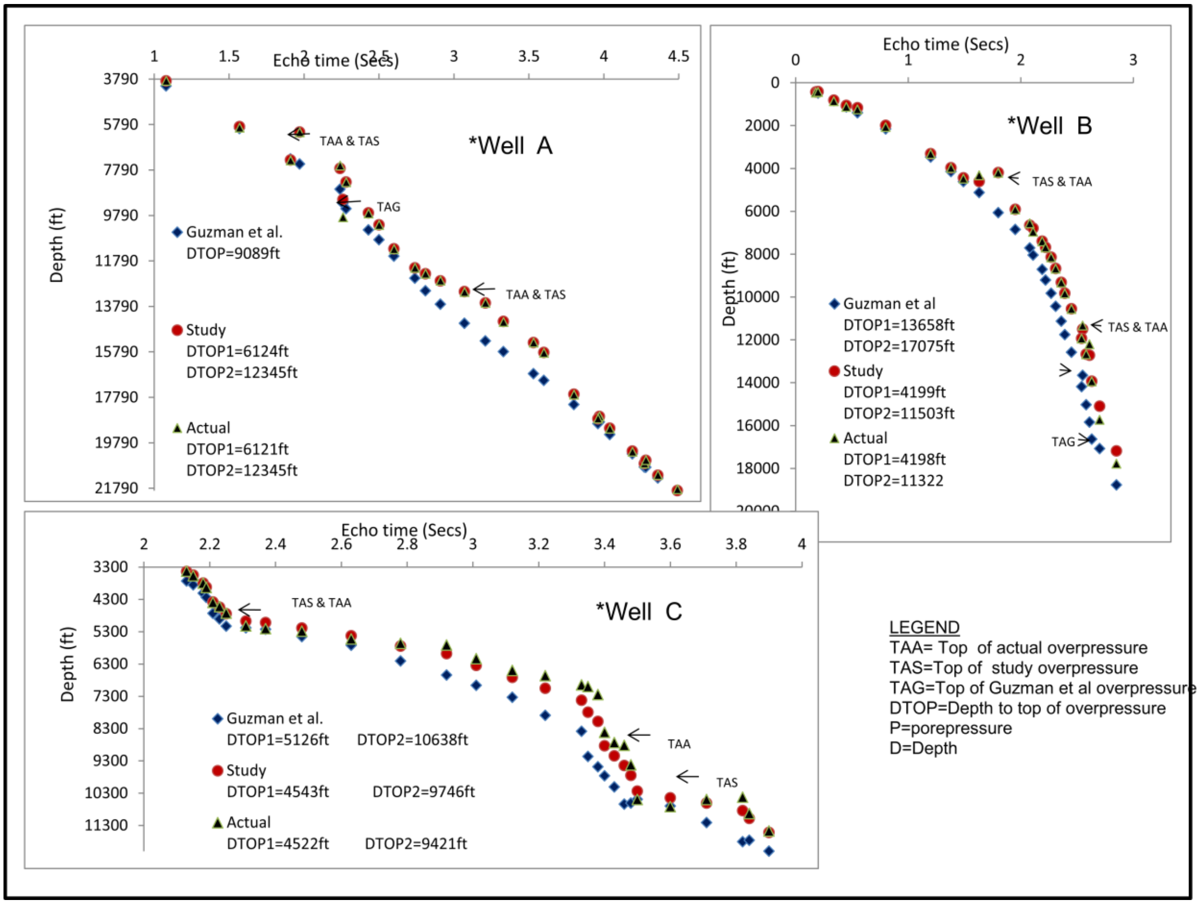


Fig.7: Plot of Depth vs. Echo time

4.0 Conclusion

Model for predicting pore pressure in the subsurface formation has been developed. The model requires the echo time, sonic velocity, hydrostatic pressure gradient, density, anisotropic factor, and acceleration due to gravity in order to predict pore pressure and depth to top of overpressure.

The proposed model has been successfully validated and compared with Well data from Niger Delta Offshore field. The model's predictions compare favourably with the measured values, but perform better than model [6] and [7]. This is due to the incorporation of density and anisotropic factor into the model. The model also predicts depth of occurrence of pore pressure and depth of occurrence to top of overpressured zone independently and more accurately than the model of [7] which uses pore pressure as an input parameter or independent variable. The assumption in [6] that sedimentary rock is isotropic to the propagation of seismic velocity makes their model over predicts depth of pore pressure occurrence.

5.0 References

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