Well log analysis of elastic properties from the White Rose oilfield, offshore Newfoundland

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ABSTRACT

This work conducts the analysis of six well logs (A-90, E-09, H-20, J-49, L-08, and N-22) from the White Rose field, offshore Newfoundland. We used dipole sonic, density, gamma-ray, and resistivity logs, for this analysis and plotted Vp and Vs versus depth, Vp and Vs versus gamma-ray, Vp/Vs ratio versus depth, Vp/Vs ratio versus gamma-ray, Vp real versus Vp predicted by Faust relation, Vs real versus Vs predicted by Faust relation, Vs real versus Vs predicted by Castagna relation, and finally density real versus density predicted by Gardner relation. In general, Vp and Vs increase with depth, with the exception of well A-90. Similarly, we observe a decrease with depth of the Vp/Vs value in all the wells with the exception of A-90, where we observe an increase of Vp/Vs ratio with depth. In general, the Faust relation provides a good prediction for Vp, with the Faust's constant of 125.3. Gardner's relation, had difficulty predicting the density value in wells J-49, L-08, and N-22; however, it worked relatively well in wells E-09 and H-20. We applied the Faust equation to predict the Vs from geological time and the depth of burial of rock, the results were encouraging. The Castagna relation predicted Vs from Vp quite well. Better fits can be achieve by dividing the lithologies into regions (those above and below the Wyandot Formation).

INTRODUCTION

The White Rose field is located on the eastern edge of the Jeanne d'Arc Basin, approximately 350 km east of St. John's, Newfoundland (Figure 1), and 50 km equidistant from both Hibernia and Terra Nova oil fields. Structurally, the White Rose is situated in a complexly faulted region located over the deep-seated Amethyst salt ridge and White Rose diapir. In the early eighties (1984 and 1986), White Rose N-22, and J-49 wells were drilled in the larger White Rose domal area. In 1988, White Rose E-09 was drilled: A-90 was drilled in 1989, and during 1999 White Rose L-08 was drilled. In summer 2000, White Rose H-20 was drilled. Details of the White Rose field are provided in Table 1.

The White Rose field (Figure 2) is situated in the northeastern Jeanne d'Arc Basin, 50 km equidistant from Hibernia and Terra Nova oilfields and in water depths of about 120 m. Structurally, the White Rose field is a complexly faulted region located above a deep-seated salt ridge and situated in the hanging wall of the Voyager Fault. The target reservoir is the Avalon sandstone. Figure 3 shows the formations of the White Rose field, from younger to older sequences.

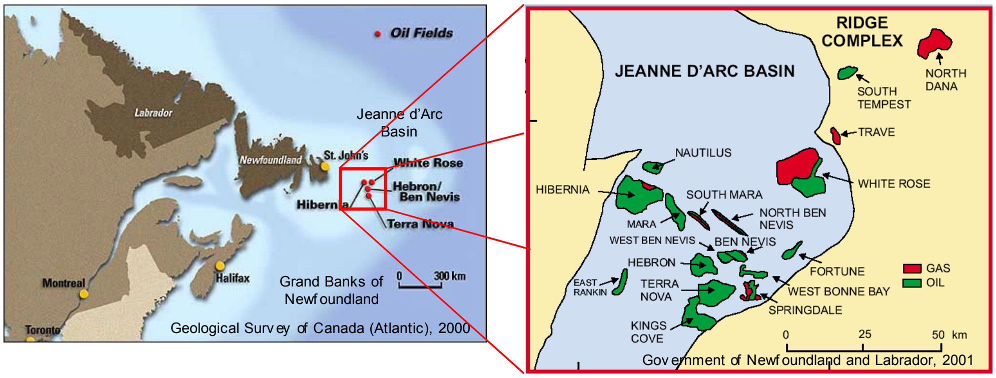

FIG. 1. The location of the White Rose oilfield, Newfoundland (Modified after G.S.N.L., 2001 and G.S.C.A. 2000).

Table 1. White Rose Field information. (Modified after Husky Energy, 2002)

Discovery	1984 (White Rose N-22 well, gas discovery) 1988 (White Rose E-09 well, oil discovery)
Water depth	115-130 m
Reservoir area	40 km^2
Reservoir depth	2,875 m subsea
API gravity	30^0
Production formation	Avalon Formation (Early Cretaceous)
Reservoir character	Well-sorted, fine-grained sandstone
Reserve estimate	40 million cubic metres (250 million barrels)
Estimated development wells	18-25 production and injection (water and gas) wells
Wells to first oil	6-10 production and injection wells
Peak oil production	12,000-18,000 m^3/d (75,000-110,000 barrels/day)
Partners	Husky Oil (82.5%) and Petro-Canada (17.5%).

Avalon Formation (125m) (Barremian to late Aptian)

This Formation is a complex and variable siliciclastic series, subdivisible into 3 subunits, displaying a coarsening upward pattern: Basal subunit (42m): "red mudstone" sequence characterized by varicoloured shales containing a few thin interbeds of sandstone. Middle subunit (37m): thicker sandstone beds, and interbedded grey shales.

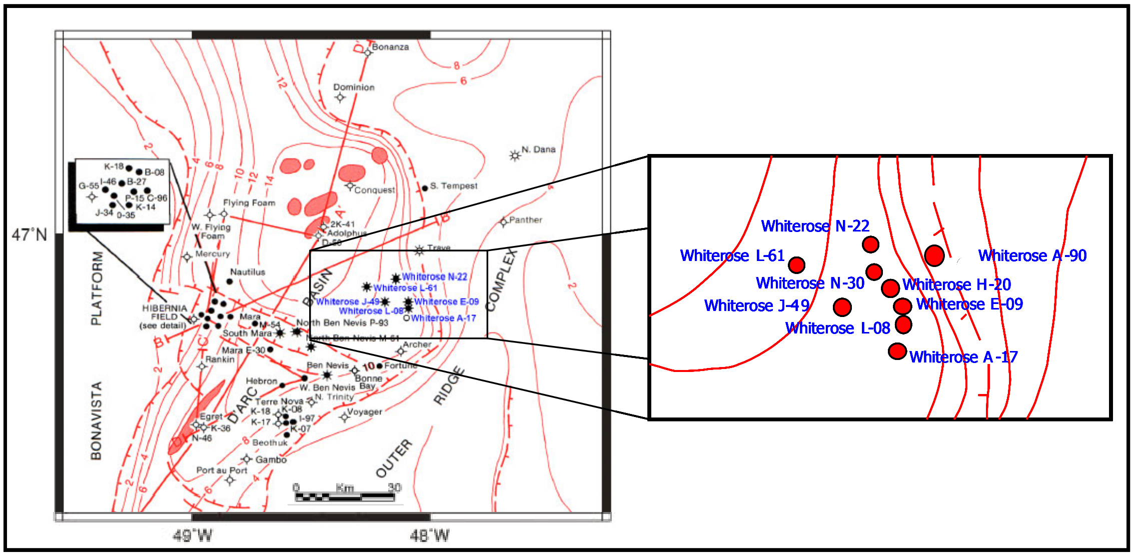

FIG 2. Regional setting of Jeanne d'Arc Basin (Modified after G.S.N.L.1990).

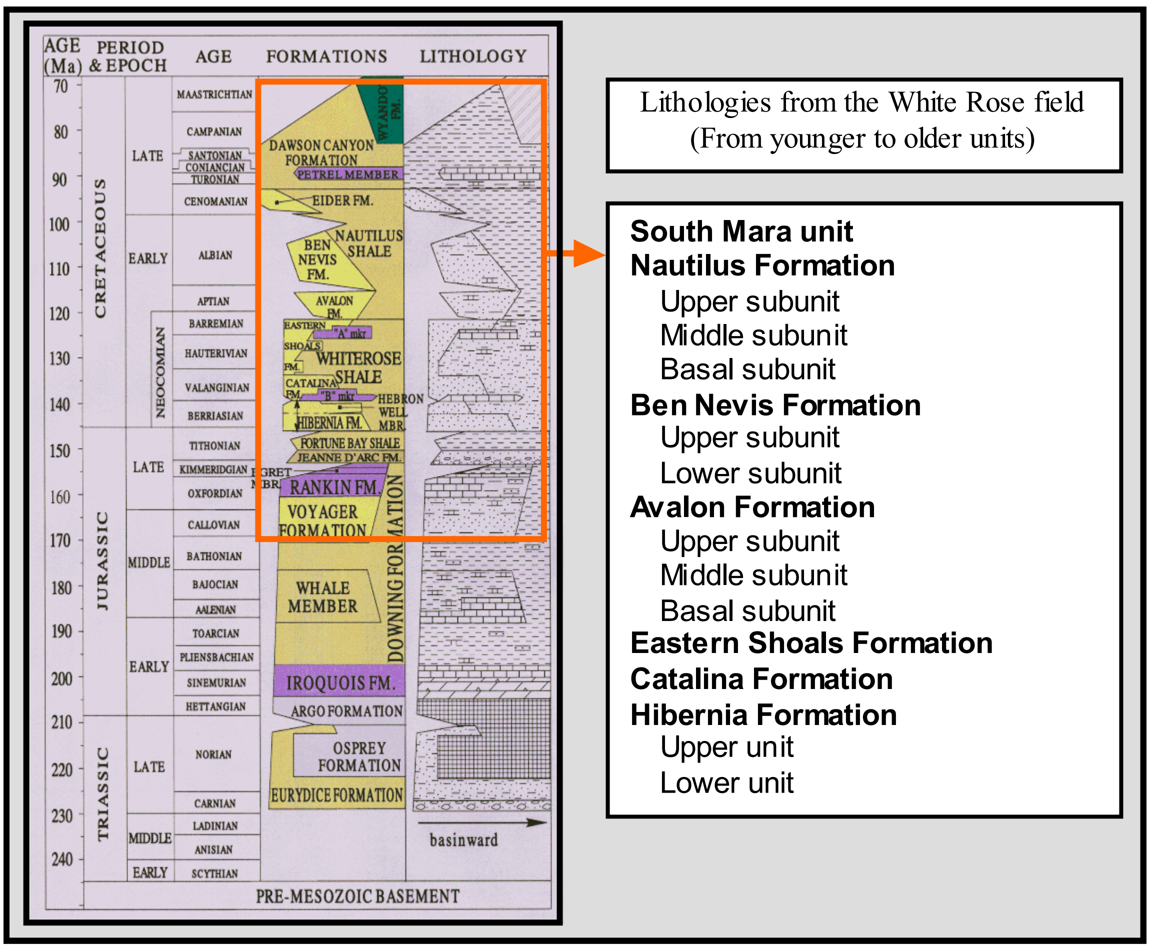

FIG 3. Stratigraphy of Grand Banks. (Modified after G.S.C.A., 2000)

Upper subunit (46m): slightly coarsening upward, sandstone-dominated unit, with silstone at the top.

The lower contact with the Eastern Shoals Formation is always sharp. The upper contact with the Ben Nevis Formation is sharp and unconformable at the basin margins and over major structures, becoming disconformable to conformable toward the basin axis. The Avalon Formation grades laterally into the Nautilus Shale. The environment of deposition is a flat, low-lying coastal plain containing brackish lagoons and swamps bordering a large, tide-dominated shallow estuary (McAlpine, 1990).

WELL-LOG ANALYSIS

For most of the wells, the following analysis (Table 2) was made. There were some wells that did not have all the well logs to work with but still some analysis was made.

Vp and Vs versus depth:

As an example, the A-90 well is plotted in Figure 4 (Table 3). Notice that below the Wyandot Formation Vp and Vs decrease with depth. This could be indicative that the geology below the Wyandot, unlike all the other wells, maybe over-pressured. This well is a dry hole located at the fault at the edge of the field. For wells E-09, H-20, L-08, J-49, and N-22 the Vp and Vs values increase with depth (Figure 5), the representative line fit equation in Figure 5 for Vp is $y=0.9653x+1132.1$ and for $Vs=0.8288x-185.44$.

Table 2. Wells analyzed and crossplots done

	A-90	**E-09**	**H-20**	**J-49**	**L-08**	**N-22**
Vp and Vs versus depth	✓	✓	✓	✓	✓	✓
Vp and Vs versus GR	✓	✓	✓	✓	✓	✓
Vp/Vs versus depth	✓	✓	✓	✓	✓	✓
Vp/Vs versus GR	✓	✓	✓	✓	✓	✓
Real Vp versus Faust Vp	✓	✓	✓	✓	✓	✓
Real Vs versus Faust Vs	✗	✗	✓	✗	✓	✗
Real Vs versus Castagna Vs	✗	✗	✓	✗	✓	✗
Real Density versus Gardner's density from Vp	✗	✓	✓	✓	✗	✓
Real Density versus Gardner's density from Vs	✗	✗	✓	✗	✓	✗

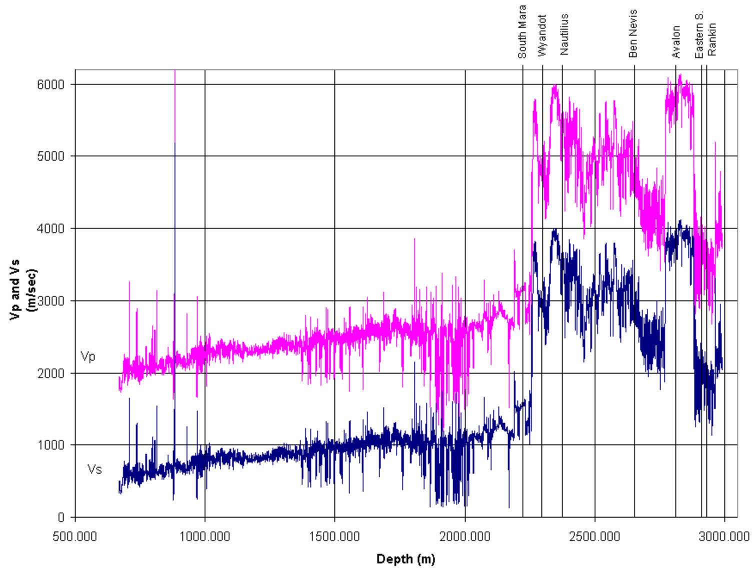

FIG 4. Vp and Vs versus depth for entire well A-90

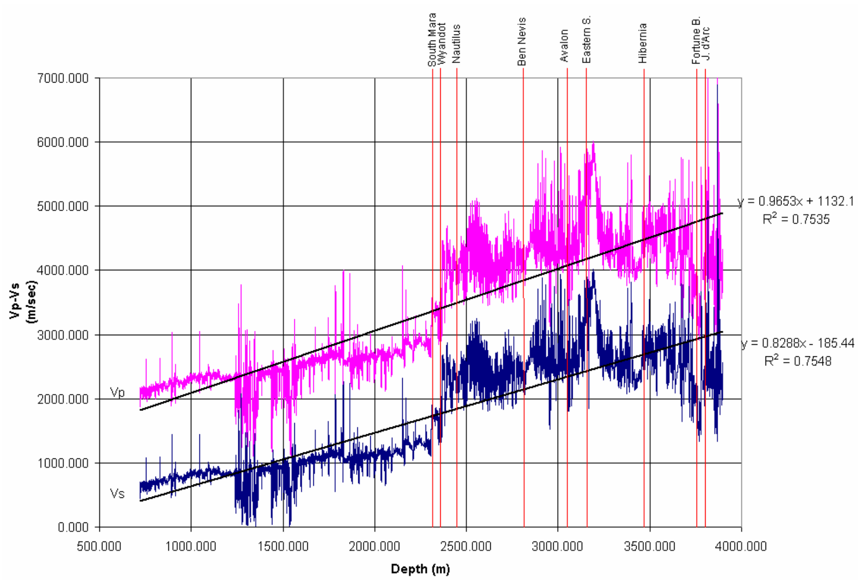

FIG 5. Vp and Vs versus depth for entire well E-09

Vp and Vs versus GR

The wells were broken down into their main behaviour according to the GR values (Table 4, 5, 6, 7, 8, and 9). In A-90, H-20, J-49 and L-08, the GR values decrease with depth, and velocities increase with depth; in E-09, GR values keep constant for most of the well, between 26-140, and the velocity values increases with depth, and, in N-22, values of GR increases from 100-134 with depth, also the velocities increase with depth.

Although the Nautilus shale has constant properties (GR, Vp, Vs) throughout the White Rose field, the Avalon sandstone is more variable. The variability of the properties (GR, Vp, Vs) of the Avalon sandstone could be indicative of porosity and shale content.

This knowledge might have an impact on how we identify the interface between the Nautilus and the Avalon on the seismic data.

Table 3. Behaviour of Vp and Vs with depth, for all the wells.

Well (upper section)	Vp (m/sec)	Vs (m/sec)	Trend with depth	Well (lower section)	Vp (m/sec)	Vs (m/sec)	Trend with depth	Bottom of well
A-90	2000-2800	600-1200	Increase	Wyandot @ 2189	5300-4400	3400-2500	Decrease	2992
E-09	2000-2900	600-1300	Increase	Wyandot @ 2365.9	4200-4400	2400-2500	Increase	3903
H-20	2100-2900	700-1300	Increase	Tertiary unc. @ 2384m	4000-4500	2000-2700	Increase	3271
J-49	2000-2900	500-1300	Increase	Wyandot @ 2407	3900-4200	2200-2600	Increase	4562
L-08	2100-2900	700-1400	Increase	Tertiary unc. @ 2316	3700-4500	1900-2800	Increase	3118
N-22	2100-2300	700-1400	Increase	Wyandot @ 2379	3700-4600	2000-2600	Increase	4600

Table 4. Behaviour of GR versus Vp and Vs, for A-90 well.

A-90	**GR (API)**	**Vp (m/sec)**	**Vs (m/sec)**
Top of the well to 2112	105-129	1700-2900	240-1200
2112 to top of South Mara unit	114-88	2600-2900	1000-1300
South Mara	28-51 84-117	2600-3200 3000-3200	1100-1600 1400-1600
Wyandot and Nautilus formation	9-31	4000-6000	2300-4000

Ben Nevis	60-9	3600-5300	2000-3400
Avalon-Eastern shoals	6-21	5500-6100	3500-4000
Rankin	35-80	3000-4200	1400-2400

Table 5. Behaviour of GR versus Vp and Vs, for E-09 well.

E-09	**GR (API)**	**Vp (m/sec)**	**Vs (m/sec)**
Top of the well to South Mara	26-76	1500-3300	300-1700
Wyandot and Nautilus	81-21	3600-4600	1800-2600
Ben Nevis	70-18	4000-5500	2200-3100
Avalon formation:	16-28	3800-5600	2000-3500
Eastern shoals:	80-13	4000-5900	2200-3900
Hibernia – Fortune Bay	114-19	3500-5000	1800-3000
Jeanne d'Arc	15-72	3800-4100	2200-2400
	120-140	3800-4300	2200-2700

Table 6. Behaviour of GR versus Vp and Vs with depth, for H-20 well.

H-20	**GR (API)**	**Vp (m/sec)**	**Vs (m/sec)**
Top of well to top of Eocene	90-120	2000-2900	700-1200
Eocene	100-80	2700-2900	1100-1400
South Mara	108-88	2900-3300	1400-1700
Base of Tertiary Unconformity to top of Avalon sandstone	108-57	3600-4800	1800-2600
Avalon to bottom of well	28-84	4100-5100	2500-3200

Vp/Vs ratio versus depth

In A-90, we observe below the Wyandot an increase of Vp/Vs ratio with depth (Figures 6 and 7, and Table 10), this increase could be indicative of an over-pressure zone for those geological formations. Note also that the top of the Rankin formation in this well is over 1000m shallower than the same top in the N-22 well. Figures 8, 9, 10, and 11 show the relation for wells H-20 and J-49. The representative line-fit equation in

Figure 6 for Vp/Vs ratio is y=-0.7468x+4.0065 and in Figure 7, Vp/Vs ratio is y= -0.0166x + 1.7578.

Table 7. Behaviour of GR versus Vp and Vs, for J-49 well.

J-49	**GR (API)**	**Vp (m/sec)**	**Vs (m/sec)**
Top of well to 2112m	100-120	1800-3000	500-1300
2112 to top of Wyandot	116-88	2400-3300	1000-1700
Wyandot and Petrel Member	120-75	3200-4100	1600-2300
Nautilus	123-90	3500-4300	1900-2500
Ben Nevis	61-92	4000-4500	2300-2800
Avalon to bottom of well	128-65	3600-5400	2000-3100

Table 8. Behaviour of GR versus Vp and Vs, for L-08 well.

L-08	**GR (API)**	**Vp (m/sec)**	**Vs (m/sec)**
Top of well top of South mara	84-114	2100-2800	600-1400
Top of South Mara - top of Avalon	74-111	3500-4200	1700-2400
Top of Avalon to bottom of well	30-61	3800-4800	2300-2900

Table 9. Behaviour of GR versus Vp and Vs, for N-22 well.

N-22	**GR (API)**	**Vp (m/sec)**	**Vs (m/sec)**
Top of well to top of South Mara	64-106	2600-3000	1000-1400
Wyandot	36-104	3200-3800	1600-2100
South Mara	100-60	2800-3200	1300-1600
Nautilus	113-91	3500-3900	1800-2300
Ben Nevis-Avalon	50-100	3700-4300	2000-2500
Eastern Shoals - Hibernia	131-41	3600-5000	1900-3300

Fortune	44-120	3300-4200	1400-2500
Jeanne d'Arc to bottom of well	100-69	4000-5000	2100-3200

Table 10. Behaviour of Vp/Vs ratio versus depth, for all the wells.

Well (upper section)	**Vp/vs ratio**	**Trend with depth**	**Well (lower section)**	**Vp/Vs ratio**	**Trend with depth**	**Bottom of well (m)**
A-90	3.22-2.30	Decrease	Wyandot @ 2189	1.55-1.74	Increase	2992
E-09	3.40-2.18	Decrease	Wyandot @ 2365.9	1.71-1.69	Decrease slightly	3903
H-20	2.61-2.20	Decrease	Tertiary unc. @ 2384m	1.94-1.63	Decrease	3271
J-49	3.31-2.06	Decrease	Wyandot @ 2407	1.75-1.71	Decrease slightly	4562
L-08	3.18-1.82	Decrease	Tertiary unc. @ 2316	1.88-1.63	Decrease	3118
N-22	3.01-2.07	Decrease	Wyandot @ 2379	1.84-1.60	Decrease slightly	4600

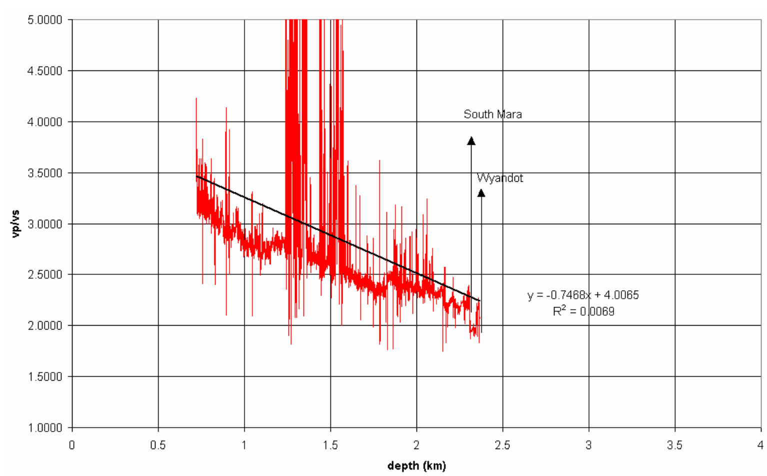

FIG. 6. Vp/Vs ratio versus depth for well A-90, from top of well to 2257m (top of Wyandot Formation)

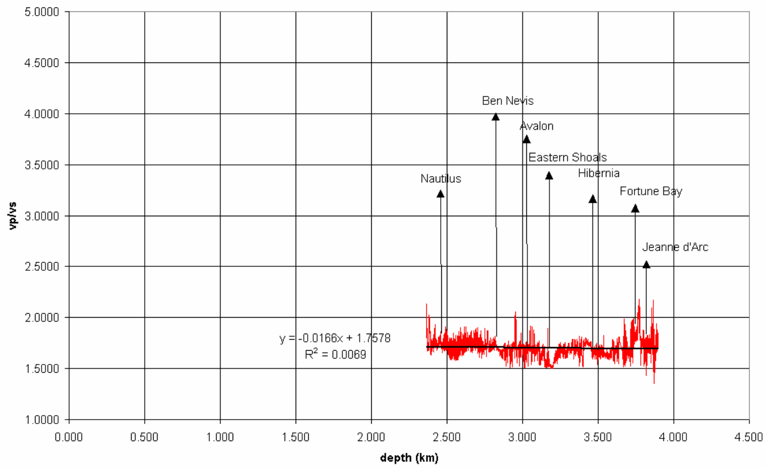

FIG. 7. Vp/Vs ratio versus depth for well A-90, from top of top of Wyandot (2257m) to bottom of well (2992m)

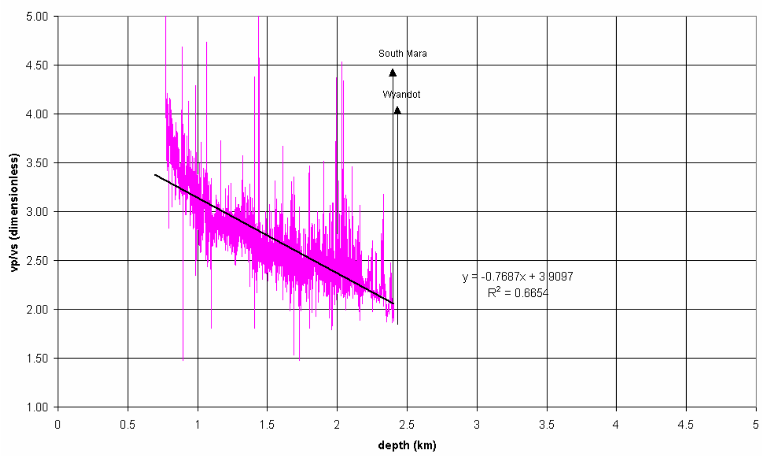

FIG. 8. Vp/Vs ratio versus depth for well J-49, from top of well (690m) to top of Wyandot Formation (2407m). Representative line-fit equation for Vp/Vs ratio is y=-0.7687x + 3.9097

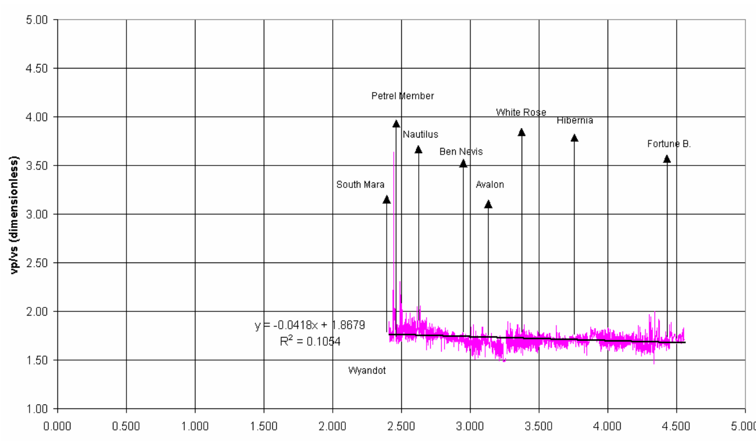

FIG. 9. Vp/Vs ratio versus depth for well J-49, from top of Wyandot Formation (2407m) to bottom of well (4562m). Representative line-fit equation for Vp/Vs ratio is y= -0.0418x + 1.8679

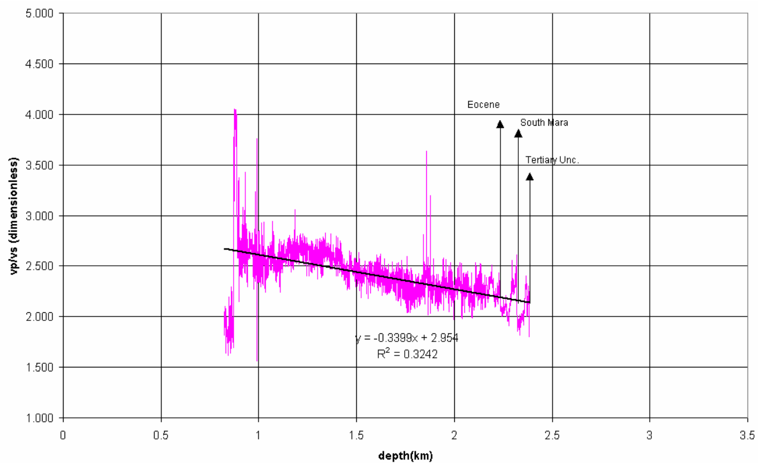

FIG. 10. Vp/Vs ratio versus depth for well H-20, from top of well (874m) to Base of Tertiary Unconformity (2384m). Representative line-fit equation for Vp/Vs ratio is y= -0.3399x + 2.954

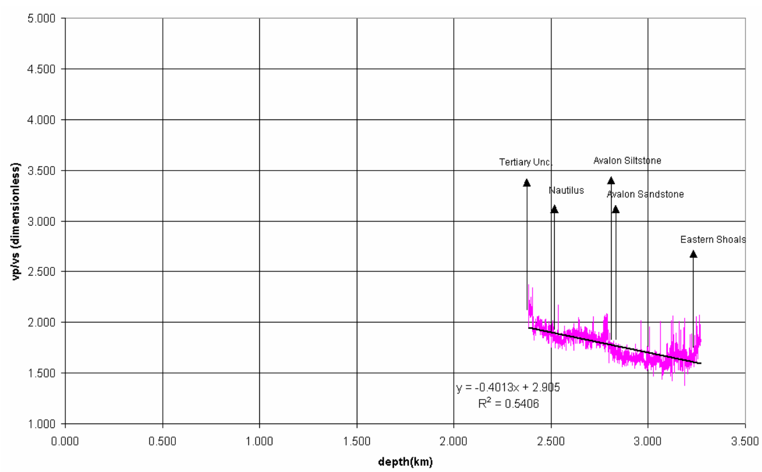

FIG. 11. Vp/Vs ratio versus depth for well H-20, from Base of Tertiary Unconformity (2384m) to bottom of well (3271m). Representative line-fit equation for Vp/Vs ratio is y= -0.4013x + 2.905

Vp/Vs versus GR

In A-90, H-20, J-49, and L-08 wells, GR values and Vp/Vs ratio decrease with depth. In E-09 and N-22 wells, GR values increase with depth and Vp/Vs decrease with depth (Figure 12 and Tables 11, 12, 13, 14, 15, and 16).

Although GR value is largely different between the Nautilus shale (84-110) and the Avalon formation (32-67) their VpP/Vs ratio are very close to each other (1.7-1.96 versus 1.55-1.79). Therefore this could make it difficult to differentiate the two lithologies based solely on Vp/Vs ratio

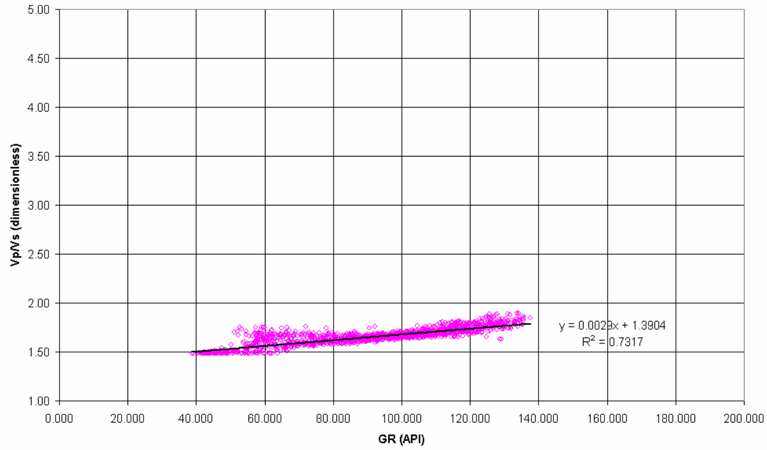

FIG. 12. Vp/Vs ratio versus GR for well J-49, Avalon Formation (3131-3392m). Representative line fit equation for Vp/Vs ratio is y= 0.0031x + 1.3974

Table 11. Behaviour of Vp/Vs ratio versus GR, for A-90 well.

	GR (API)	**Vp/Vs ratio**
From top of the well to 2112m	107-132	2.23-4.25
2112m to top of South Mara unit	91-115	2.15-2.44
South Mara formation	47-31 84-120	1.99-2.34 2.00-2.18
Top of Wyandot to bottom of well	6.5-80	1.51-2.07

Table 12. Behaviour of Vp/Vs ratio versus GR, for E-09 well.

	GR (API)	**Vp/Vs ratio**
From the top of the well to 2112m	36-75	2.20-5.00
From 2112m to top of South Mara	40-80	2.08-2.47
South Mara unit	52-80	1.89-2.24
Wyandot-Nautilus	20-86	1.61-1.91
Ben Nevis-Avalon	15-71	1.52-1.97
Eastern Shoals	8-131	1.51-1.93
Jeann d'Arc to bottom of well	15-58, 128-200	1.55-1.77, 1.64-1.75

Table 13. Behaviour of Vp/Vs ratio versus GR, for H-20 well.

	GR (API)	**Vp/Vs ratio**
Top of the well to top of Eocene	66-76 92-112	1.64-2.10 2.05-2.88
Eocene	80-108	1.95-2.43
South Mara unit to top of Nautilus	58-107	1.81-2.20
Nautilus-Avalon siltstone	56-113	1.71-1.92
Avalon sandstone to bottom of well	28-104	1.54-1.90

Table 14. Behaviour of Vp/Vs ratio versus GR, for J-49well.

	GR (API)	**Vp/Vs ratio**
Top of the well to 2112	100-120	2.12-3.97
2112 to top of Wyandot	86-120	1.97-2.54
Wyandot-to Avalon	71-126	1.69-2.00
Ben Nevis	53-100	1.60-1.75
Top of Avalon to bottom of well	40-133	1.50-1.87

Table 15. Behaviour of Vp/Vs ratio versus GR, for L-08 well.

	GR (API)	**Vp/Vs ratio**
Top of well to Base of Tertiary unconformity	115-95	1.88-3.50
Tertiary unconformity to top of Nautilus	60-121	1.84-1.98
Nautilus	84-110	1.70-1.96
top of Avalon to base of well	31-60	1.55-1.80

Vp real versus Vp Faust

The Faust equation predicts compressional velocities with geological time and depth of burial of the rock, using a constant of 125.3 (Faust, 1951). This section compares the predicted Vp from the Faust relation with actual Vp value. We observe that for all the wells in the section shallower than the Wyandot, the constant that provides a better fit is lower than 125.3 (Table 17). On the other hand, deeper than the Wyandot the constant that provides a better fit is higher than 125.3, in particular. Again, we observe that the largest extremes of the constant occurs in the well A-90 (values of 107 and 165). Figures 13, 14, 15, 16, 17, and 18 show the relation for wells A-90, E-09, and H-20.

Table 16. Behaviour of Vp/Vs ratio versus GR, for N-22 well.

	GR (API)	**Vp/Vs ratio**
Top of well- to top of South Mara	63-105	2.15-2.42
South Mara	50-100	2.00-2.32
Wyandot	35-109	1.80-2.00
Top of Nautilus-top of Fortune	40-130	1.54-1.95
Fortune	46-120	1.68-2.04
Jeanne d'Arc	59-100	1.62-1.90
Top of Rankin to bottom of well	40-117	1.50-1.72

Table 17. Synthesis of the observed relations from the graphs Vp real versus Vp Faust

Well (upper section)	**Constant by Faust**	**Constant for better fit to the well data**	**Well (lower section)**	**Constant for better fit to the well data**	**Bottom of well**
A-90	125.3	107	Wyandot @ 2189	165	2992
E-09	125.3	120	Wyandot @2365.9	140	3903
H-20	125.3	117	Tertiary unc. @ 2384m	140	3271
J-49	125.3	110	Wyandot @ 2407	135	4562
L-08	125.3	115	Tertiary unc. @ 2316	132	3118
N-22	125.3	112	Wyandot @ 2379	130	4600

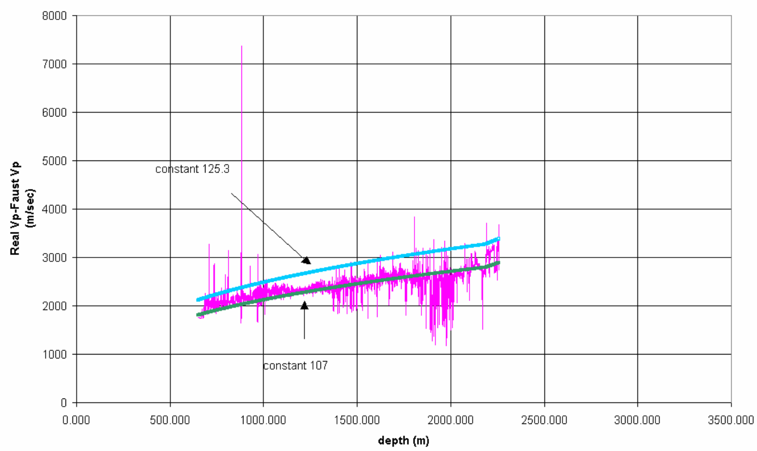

FIG. 13. Vp real and Vp Faust versus depth for well A-90, from top of well (651m) to top of Wyandot Formation (2257m).

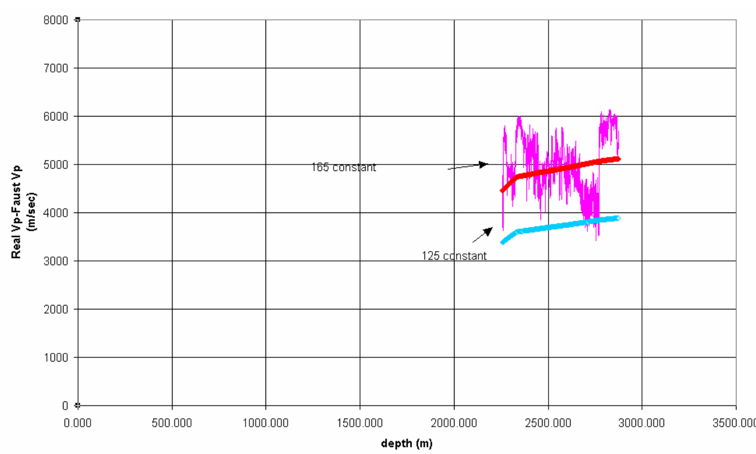

FIG. 14. Vp real and Vp Faust versus depth for well A-90, from top of Wyandot Formation (2257m) top of Eastern Shoals (2873m)

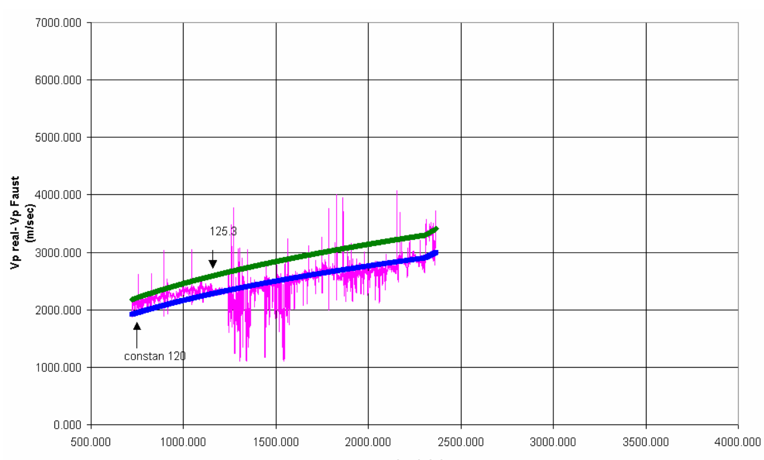

FIG. 15. Vp real and Vp Faust versus depth for well E-09, from top of well (719m) to top of Wyandot Formation (2365m)

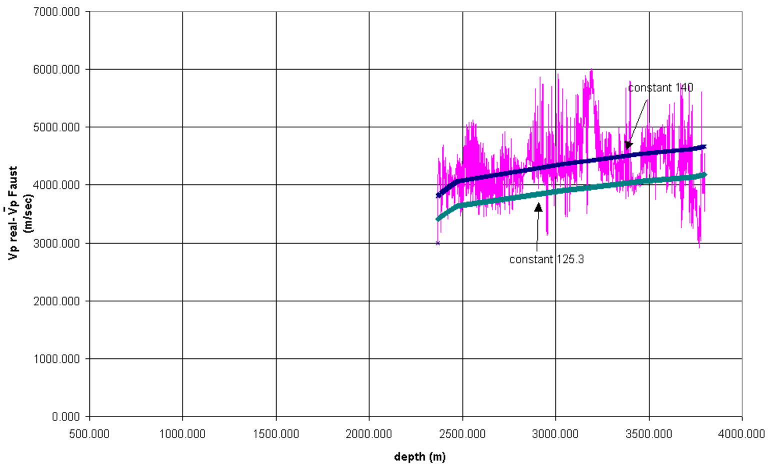

FIG. 16. Vp real and Vp Faust versus depth for well E-09, from top of Wyandot Formation (2365m) to top of Jeanne d'Arc Fromation (3800m)

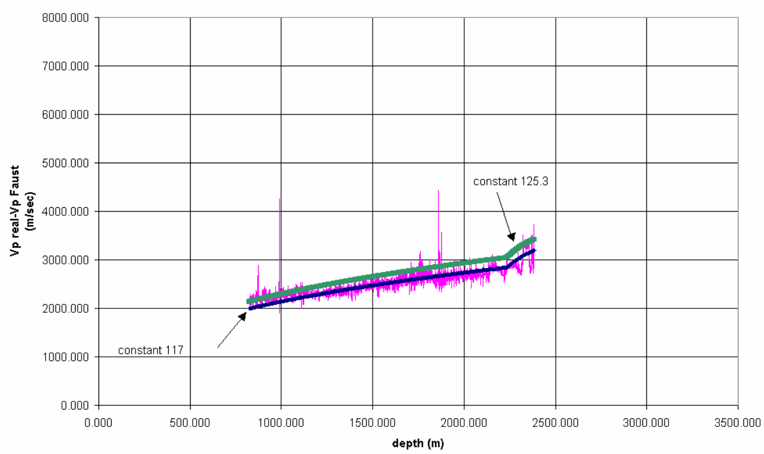

FIG. 17. Vp real and Vp Faust versus depth for well H-20, from top of well (823m) to Base of Tertiary Unconformity (2384m)

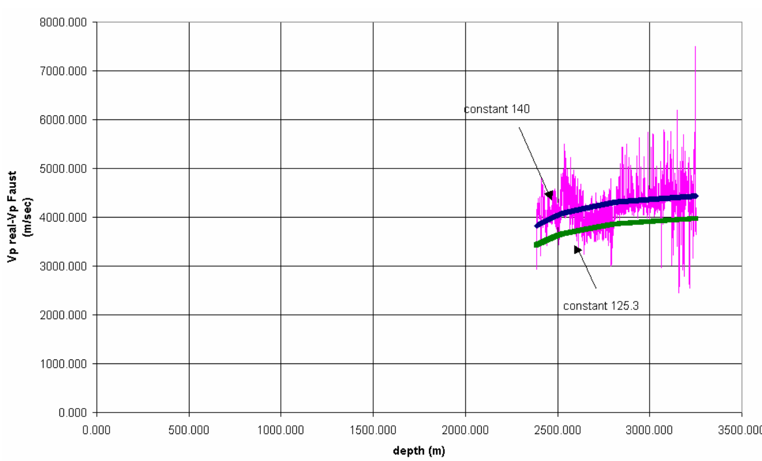

FIG. 18. Vp real and Vp Faust versus depth for well H-20, from Base of Tertiary Unconformity (2384m) to top of Eastern Shoals Formation (3251m)

Vs real versus Vs Faust

We explore the prediction of Vs using a relationship similar to the one used to predict Vp by Faust (1951). In this case, the "Vs Faust equation" attempts to predict shear velocities with geological time and depth of burial of the rock. The constant however is quite likely different than 125.3. We explore this relation in wells H-20 and L-08 where the Vs was acquired. The best fit for this equation is when the constant is equal to 49 above the Wyandot while the constant is equal to 80 below the Wyandot. This observation is similar to the Vp case where the constant was lower above the Wyandot and higher below the Wyandot (Figure 19)

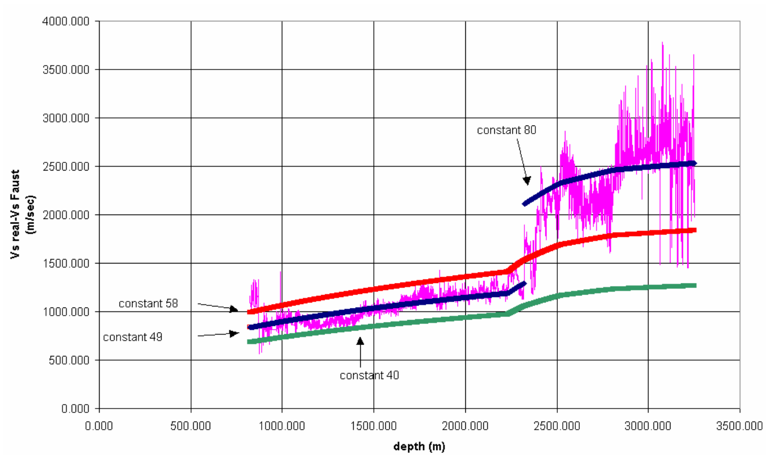

FIG.19. Vs real and Vs Faust versus depth for well H-20, from top of well (824m) to top of Eastern Shoals Formation (3251m)

Vs real versus Vs Castagna

We used Castagna's (1985) relationship [Vs=(Vp-1360)/1.16], to predict Vs from Vp. This equation predicted Vs for the entire well section (above and below the Wyandot) quite nicely. We note that this could be applied only for wells H-20 and L-08 where the real values of Vs were acquired. The reason for the quality of fit is probably caused by the fact that the lithologies in the well are mostly clastics. Nonetheless, note that in L-08 the Petrel member is a limestone and its predicted values are not too erroneous (Figure 20).

Real density versus Gardner's density using Vp

The Gardner's equation predicts density using compressional velocities, a constant of 310 and an exponent of 0.25 (Gardner, 1974). This section compares the predicted density from Gardner with actual density value. We could only do this comparison for the entire well with well L-08. Wells E-09, H-20, J-49 and N-22 were partially logged. For well A-90 the density was not acquired or the log not released.

In particular for the well L-08, Gardner's rule is having difficulty predicting density (there are however three clusters of the data). For the wells N-22 and J-49 Gardner's rule is also experiencing difficulties predicting the density (there are scattering of the data). For the H-20 (Figure 21) and E-09 wells Gardner's rule is doing a better job in predicting the density, in comparison with the other wells.

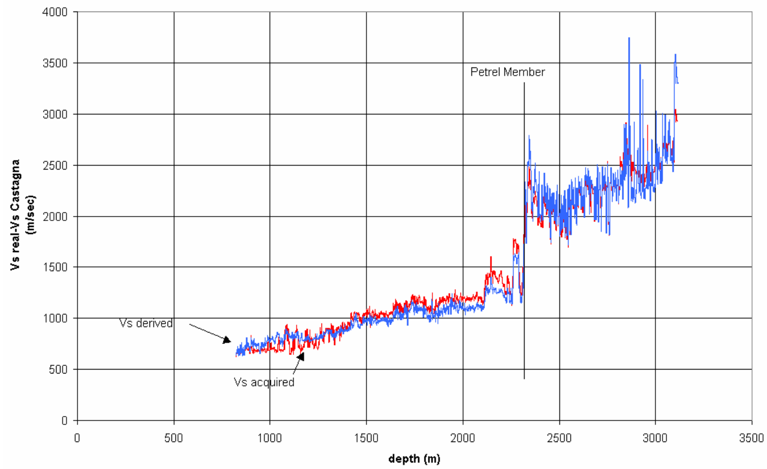

FIG. 20. Vs real and Vs Castagna versus depth for well L-08, from top of well (824m) to bottom of well (3117m)

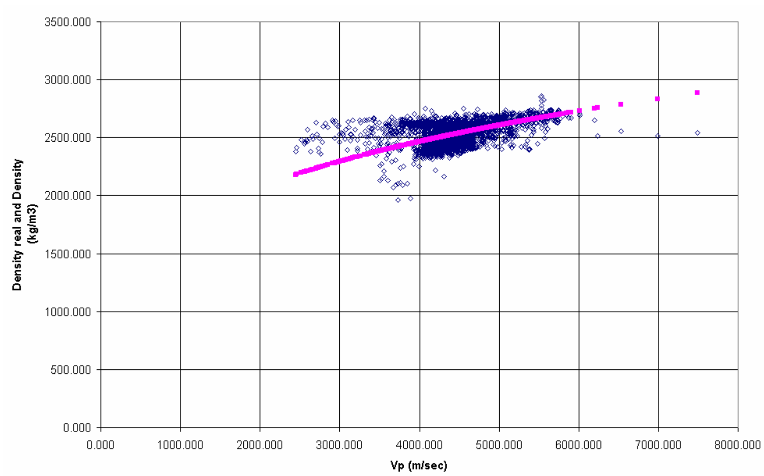

FIG. 21. Real density and Gardner's Density versus real Vp for well H-20, from 2772m to bottom of well (3271m)

Real density versus Gardner's density using Vs

We explored the prediction of density using Vs by using an equation of Gardner's (1974) form. This section compares the predicted density from Gardner with actual density value. We did this comparison for well L-08 entirelyand for a portion of well H-20 (2272-3271m). Wells A-90, E-08, J-49 and N-22 did not have a Vs log.

Using a constant value of 370 in Gardner's rule (with the 0.25 exponent) gives a reasonable overall prediction of the L-08 densities (Figure 22). If we just model the deeper part of the well then the densities fit well with a constant of 345 (Figure 23).

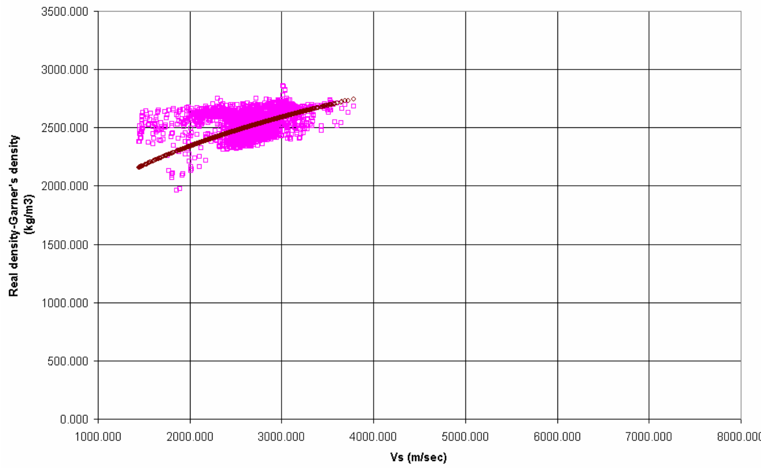

FIG. 22. Real density and Gardner's Density versus real Vs for well H-20, from 2772m to bottom of well (3271m), using a constant of 350.

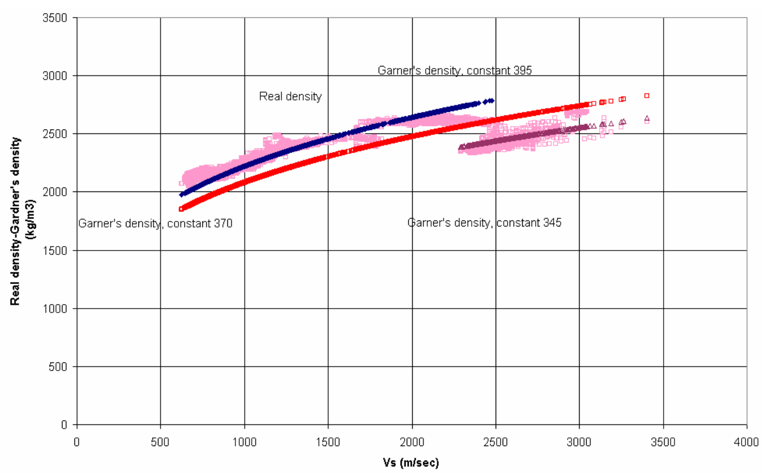

FIG. 23. Real density and Gardner's Density versus real Vs for well L-08, from 823m to bottom of well (3117m), using different constants.

Resistivity versus Velocities

We explored the relationship between the resistivity measurement for wells A-90 and E-09, and we observed that as velocity increased (Vp and Vs), the resistivity values decreased (Figures 24 and 25). In this case, wells A-90 and E-09 did not have a Vs log, then, we used Castagna Vs, to approach the relationship. In Figure 25, we see the manipulated crossplot of *ln(ild)* versus *ln(vs)*. We note it is a complex relationship.

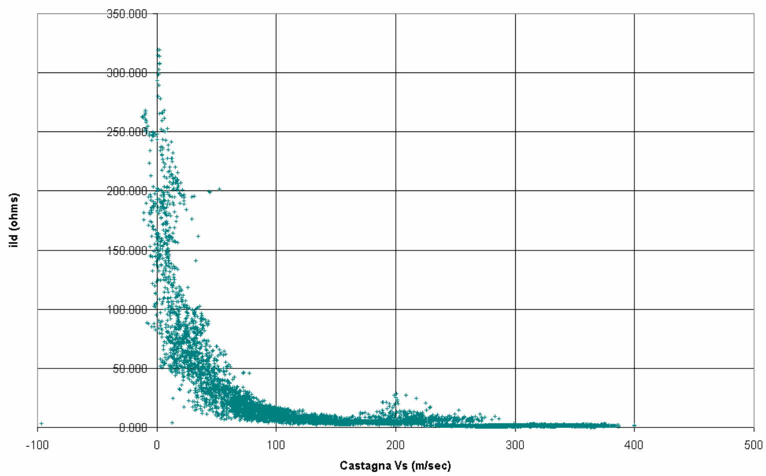

FIG. 24. ILD (ohms) versus Castagna Vs (m/sec) for well A-90.

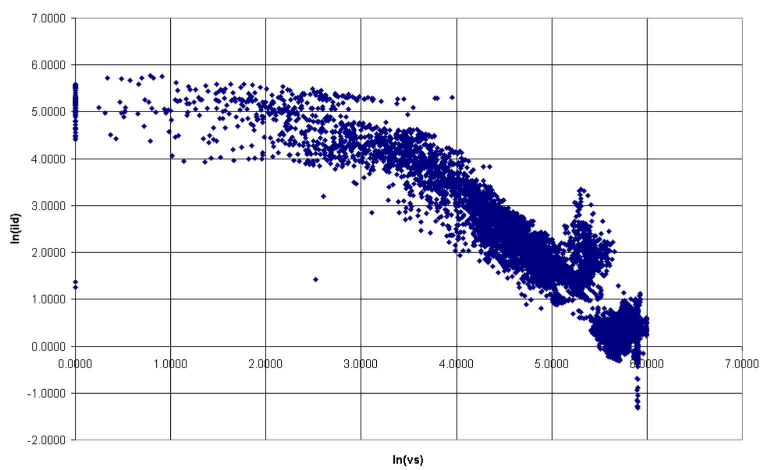

FIG. 25. Ln(ILD) versus Ln(Vs) for well A-90.

CONCLUSIONS

Vp and Vs generally increase with depth (well A-90 has some exceptions). Similarly, we observed a decreasing Vp/Vs ratio with depth in all the wells (except A-90). This anomalous A-90 well may have values reflecting over-pressurization.

Typically, the Faust relation provides a reasonable prediction for Vp, with a constant of 125.3; but for a better fit with the well data it requires a constant above the Wyandot Formation and another constant below the Wyandot. The same conclusion applies to Vs.

Gardner's relation, using Vp values, had difficulty predicting density values in wells J-49, L-08, and N-22. However, it worked relatively well in wells E-09 and H-20. Similar results were found using Vs to estimate density.

We were able to predict with a high level of accuracy the value of Vs using the Castagna relation, which could be applied for the entire well section (above and below the Wyandot Formation).

The correlations between ILD and Vp and Vs for wells A-90 and E-09 show that as velocity increases in the values of resistivity decrease.

FURTHER WORK

We will explore other petrophysical relationships such as predicting density with real Vs for those wells that was not possible to explore for this project (A-90, E-09, J-49 and N-22), and variations of deep resistivity measurement (ILD) with depth for the six wells from White Rose field.

In addition, also using the six wells from the White Rose field, we will elaborate further on the proposed relationship of predicting Vs using Faust relationship.

We will also investigate the high scattering in the prediction of density using Gardner's rule, in wells J-49, L-08, and N-22.

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