Localized Vp-Vs Relationships for the Niger Delta Sediments.

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ABSTRACT

Statistical relationships between compressional and shear velocity (*vp* and *vs*) in the Niger Delta are evaluated from dipole sonic logs to derive, using linear regression analysis, a localized relationship between *vp* and *vs* suitable for the Niger Delta sediments. The derived relationship is compared with the Castagna's mud-rock line. The study shows that *vp* and *vs* can be well related in the Niger Delta. The localized relationship predicts *vs* from raw *vp* to about 1% to 3% error. Comparison to the Castagna's mud-rock line shows that velocities predicted with the Castagna's relation are between 6% to 8% lower than the raw values obtained from the wells studied. Accurate velocity information is important in depth imaging and interpretation of seismic amplitudes – the overall benefit would be a reduction in risking the presence of hydrocarbons.

(Keywords: compressional and shear velocity, Castagna's mud-rock line, hydrocarbon exploration)

INTRODUCTION

Only a few dozen oil wells in the Niger Delta have dipole shear data. It becomes necessary, therefore, in some studies within the Niger Delta, to estimate shear velocity from compressional sonic data in order to perform some log-based analyses. Most of such estimates have been based on published empirical relations (e.g. Castagna et al., 1985). These relations need to be modified in order to become adapted to local sedimentary basins.

In this study, the empirical relationship between *vp* and *vs* is evaluated by regression analysis, using dipole sonic logs comprising compressional and shear data acquired between 2000 and 2002 in some petroleum wells in the Niger Delta. The purpose is to derive a local *vp* – *vs* relationship suitable for the Niger Delta sediments. In this evaluation, only one trend line is attempted to be derived for each well, and no further analysis is done by differentiating the lithology in the wells.

DATA TREATMENT

Paper copies of these logs were rasterized using a Contex scanning technology, and then digitized at 0.5 ft sample rate with the NeuraLog® software. They were finally re-sampled to 2 ft sample rate to have log values at every 2 ft along the entire measured depth of each well. The main analysis was done with the HRS eLOG® petrophysical tool.

The dipole sonic log data comprised the interval transit time, which is defined as the time necessary for elastic waves (compressional or shear) to travel 1ft of formation. The log data were recorded in μsec/ft. The interval transit times were transformed to compressional and shear velocity in m/s , respectively, using:

$$v_p = \frac{1000000 * 0.305}{\Delta_{tp}} \quad (1)$$

$$v_s = \frac{1000000 * 0.305}{\Delta_{ts}} \quad (2)$$

where $\Delta t\ p$ and Δts are the interval transit times recorded by the compressional and shear sonic logs respectively, in μsec/ft.

We carried out a regression analysis by cross plotting the transformed velocities for each well. Using the linear regression obtained, we predicted *vs* from *vp* in each of the remaining wells.

At each prediction, we made a comparison between the predicted *vs* and the raw *vs* recorded at each well and noted the difference between the predicted and measured *vs* at each depth level in the well. The regression that best predicted *vs* from *vp* (shown in Figure 1) was then selected to give a local trending of *vs* and *vp* .

DISCUSSION

The cross plots show good linear relationships between *vp* and *vs* in most of the wells investigated. Figure 2 shows a plot of predicted and measured *vs* displayed in the same log track with the same scale for one well, using regression lines from other wells. The figure shows a near-perfect overlay between the predicted and measured *vs* from W7 regression line. The best linear regression that predicts *vs* from *vp* for all the wells is given below:

$$V_p = 1.11702 V_s + 1279.08 \qquad 3$$

where the units are in *m/ s* . Equation 3 compares reasonably well with the Castagna's *vp* - *vs* relation for sedimentary basins, given in Equation 4 below:

$$V_p = 1.16 V_s + 1360 \qquad 4$$

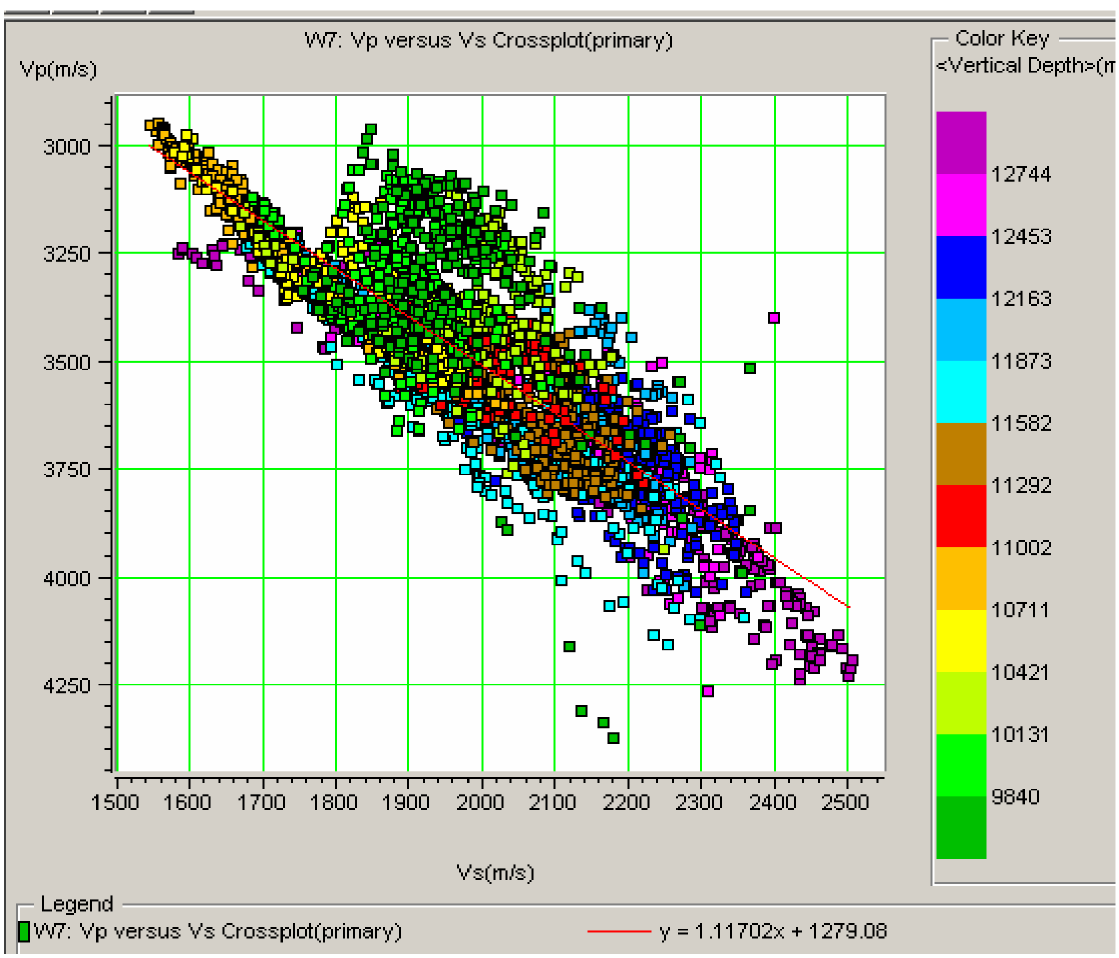

Figure 2: Best Fit Regression for the Niger Delta Wells.

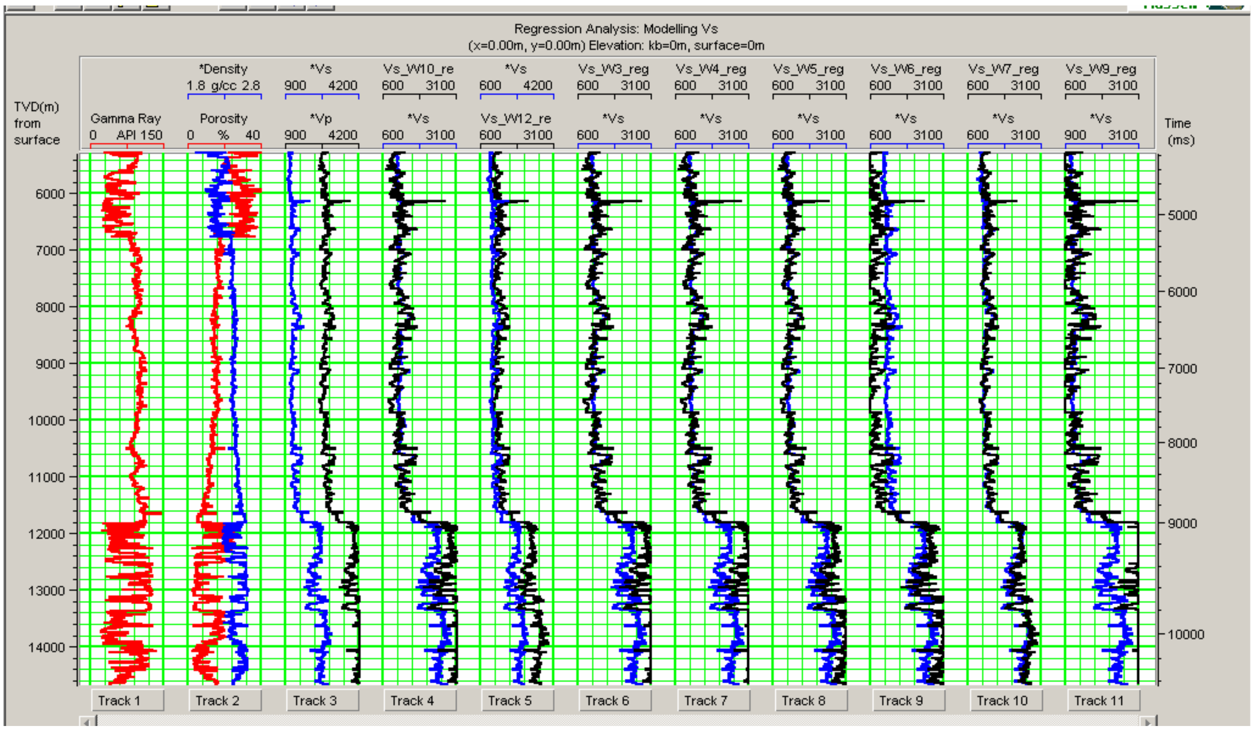

Figure 2: Regressional Analysis for Vs Prediction.

In this figure, the regression lines obtained for all of the wells were used to predict Vs for one particular well. The figure shows that the Vs was best predicted with the linear regression for W7.

Table 1: Comparison Between Localized Vp – Vs Model and Castagna's Relation.

Depth (ft)	GR API	Poro %	RHOB G/CC	Vp m/s	Vs m/s	Vs Predicted	Vs Castagna	Vs_diff Predicted	% prediction erroe	Vs_Cast Castagna	% Castagna error
10040	95	13.4	2.441	2699	1254	1271	1154	-17	-1.4	100	8
10045	94	13.46	2.44	2655	1218	1232	1116	-14	-1.1	102	8.4
10049	93	12.82	2.45	2674	1211	1249	1133	-38	-3.1	78	6.4
10053	96	13.27	2.443	2674	1196	1249	1133	-53	-4.4	63	5.3
10058	97	12.63	2.453	2665	1200	1240	1125	-40	-3.3	75	6.3
10062	95	13.46	2.44	2659	1207	1235	1120	-28	-2.3	87	7.2
10066	95	13.4	2.441	2664	1200	1240	1124	-40	-3.3	76	6.3
10071	93	13.14	2.445	2685	1220	1258	1142	-38	-3.1	78	6.4
10075	91	12.82	2.45	2672	1224	1247	1131	-23	-1.9	93	7.6
10080	90	13.27	2.443	2751	1285	1317	1199	-32	-2.5	86	6.7
10084	89	13.08	2.446	2782	1325	1345	1226	-20	-1.5	99	7.5
10089	91	13.21	2.444	2772	1323	1336	1217	-13	-1	106	8
10093	89	14.17	2.429	2755	1317	1321	1203	-4	-0.3	114	8.7
10098	87	13.78	2.435	2747	1294	1314	1196	-20	-1.5	98	7.6
10102	90	14.29	2.427	2720	1283	1290	1172	-7	-0.5	111	8.7
10107	94	13.53	2.439	2672	1253	1247	1131	6	0.5	122	9.7
10111	92	14.49	2.424	2636	1214	1215	1100	-1	-0.1	114	9.4
10115	88	15.32	2.411	2617	1204	1197	1084	7	0.6	120	10

Finally, we used Equation 4 to predict *vs* from *vp* in each of the wells and compared the Castagna's predicted *vs* with *vs* predicted by Equation 3. Example of this comparison is given in Table 1.

It was noticed that Equation 3 predicts *vs* with a higher accuracy than Equation 4.

The Castagna's relation under predicts shear velocity from compressional velocity, assigning too low values to the velocities in the wells studied. The percentage error of the localized prediction is - 3% to 1%, while the Castagna's mud rock line gives error of between 6% and 10%.

CONCLUSION

Using cross plotting and statistical analysis, we derived a local *vs* -*vp* relationship suitable for the Niger Delta sediments. This relation predicts *vs* from *vp* with high level of precision and fits a large population analysis of the wells. Shear velocities predicted by the Castagna's mudrock line are much lower than their measured values for the Niger Delta sediments. It is thought that result from that study may have been biased by the Golf of Mexico and may not be truly applicable to the Niger Delta is precision is required. Additional benefit of the localized regression is that it is able to compute velocities with good accuracy throughout the entire measured depth of *vp*, without the limitation of lithologic units.

REFERENCE

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ABOUT THE AUTHOR

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