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Enhancement of VSP Checkshot data, applying Velocity Analysis, Offshore Nile Delta, Egypt

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Abstract:
Background:*The Mediterranean Basin is an emerginggiantgas province with provenreserves. Provenreservoirsvary in agefromOligocene through Pleistocene. Hence, to verify the actualreservoir markers (depthdomain) over seismic data (time domain), a good well to seismictie (Synthetics) shouldbeapplied over the whole vertical section of the well.*
Vertical Seismic Profile (VSP) is useful in the well tie process, because it is providing a link between wells and seismic data at the correct scale. High density sampling gives good control on the time depth relation (TDR), which also called checkshot (CS) data. Checkshot data considered as the key for calibrating the well Markers (Depth domain) with the Seismic Markers (Time domain).
Materials and Methods: *This work deals with the Checkshot velocity analysis for 4 "four" wells over Sr-So field, offshore Nile Delta, as it affects the process of well to seismic tie and also depth conversion methodologies.*
There is no doubt that there is a human error in acquisition and checkshot calculation. Time and depth have a directly proportional relationship, so while plotting Time vs. Depth, it's hard to see the error. Therefore a velocity analysis for the checkshot data will be applied to know where the odd points to be removed are. A relation between (Average Velocity vs. Depth & Interval Velocity vs. Depth) are useful for checkshot data QC, as scattered and odd data will be clear to be removed, also any geological related sequence boundaries will be appeared as a ramp at these plots.The velocity analysis will be applied over the raw checkshot data "time depth table" which measured from the vertical seismic profile, to be used for well to seismic tie "synthetics".
Results: *after applying velocity analysis over the raw checkshot data, we found an odd data, which removed to get the best time depth relation to be used for synthetics (well to seismic tie).*
Conclusion: *From the study, we couldconcludethatraw checkshot data shouldbequalitychecked not only by applying "Time Vs. Depth" crossplot, but also by optimizing a velocityanalysis "AverageVelocity vs. Depth" and "IntervalVelocity vs. Depth". Therefore, the data willbe clean to beused for well to seismictie "synthetics".*
Key Word: *Checkshot Data, Vertical Seismic Profile (VSP), Velocity Analysis, Well to Seismic Tie data enhancement.*

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I. Introduction

Vertical seismic profiles (VSPs) are useful in the well tie process because they provide a link between wells and seismic at the correct scale. The essence of the VSP method is to record a surface seismic source using down-hole geophones. The simplest geometry is for a vertical well (**Figure 1**). A string of geophones is deployed in the well and, by shifting them up between shots, it is possible to record signals at a large number of levels.

The VSP can be particularly useful not only in the vertical wells, but also in highly deviated wells. It is common for well synthetics to tie surface seismic poorly for such wells, perhaps because of anisotropic effects.

Checkhshot survey is a travel-time from surface measurement by placing the receivers at known depths in a well. It's a simplified VSP (Vertical Seismic Profile), which just measure the first arrivals but not the full waveform (Figure 1). These measurements produce accurate time-depth relation and seismic velocities that can be used to calibrate well log data. Velocity survey information is presented as time-depth correlation plots and detailed velocity tables. As named "Checkshot VSP Survey", the final result will be a checkshot data, which presented as a time depth table. A velocity analysis will be applied over the raw checkshot to remove all the odd points which affect the time depth relation, then it will be ready to be used for well to seismic tie "synthetics".

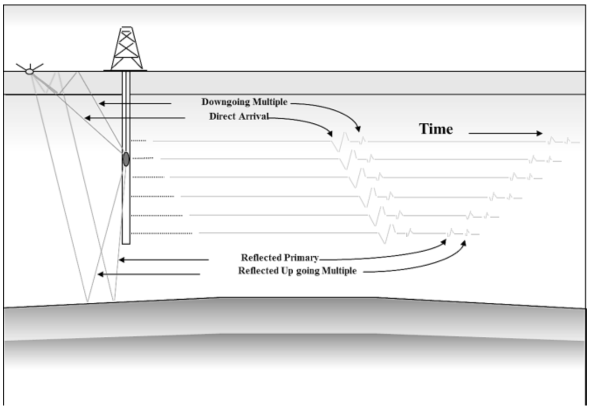

Figure 1: Check-shot generation from Vertical Seismic Profiling (VSP). After Oilfield glossary.

II. Geologic Setting

The Nile Delta province is rapidly emerging as a major gas province, highly prolific, with significant Yet To Find (YTF) estimates.

The study field is a Pliocene gas channel in the West Delta Deep Marine Concession (WDDM) located 100km north Offshore Nile Delta, in water depth of around 500-1000m, lies between latitudes 32o 00' and 32o 25'N and longitudes 30o 35' and 30o 50' E. (**Figure 2**). The channel length is around 35-40km, and its width 500-1000m, with 100-200m thickness. The field discovered in 1999 by Sr-1 exploratory well at the southern part of the channel, then followed by So-1 exploratory well in 2001 at the northern part of the channel, then the southern part developed by two wells Sr-a in 2006 and Sr-c in 2011, with no development wells at the northern part of the channel till now.

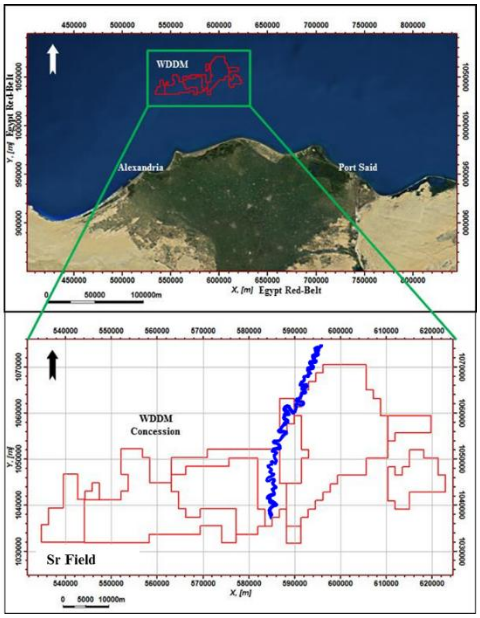

Figure 2: Sr-Field Location Map, West Delta Deep Marine Concession, Offshore Nile Delta. Channel length is about 35-40km, and its width 500-1000m, with 100-200m thickness.

III. Methodology And Results

An important element in any well tie technique is the conversion of depth to time. Typically this will involve the use of checkshot or VSP depth and time data. These data are derived from the direct arrivals of shots from seismic sources suspended over the side of the drilling rig.

Hence, before using the checkshot data in the synthetic generation, we have to make a quality check (QC). Usually, a plot "Time vs. Depth" is applied to get a direct proportional relation, and if there are any odd points away from the trend, will be removed.

However, Time vs. Depth give no error, even if there are some issues between the points. Therefore, a velocity analysis will be applied over the checkshot to identify the odd points to be removed from the data. So, we will have to plots for QC:

- A relation between “Average Velocity vs. Depth” could be useful for CS data QC.
- A relation between “Interval Velocity vs. Depth” could be useful for CS data QC.

The checkshot velocity analysis will be applied over the four wells for the study area. Scattered and odd data should be removed, and also any ramp at the data should be related to a geological reason.

A cross-plot between two-way-time (TWT) in millisecond (ms) and true-vertical-depth subsea (TVDss) in meter (m), “TWT vs. TVDss” shows a direct proportional relation trend for So-1 well. With no clear odd data to be removed (**Figure 3**).

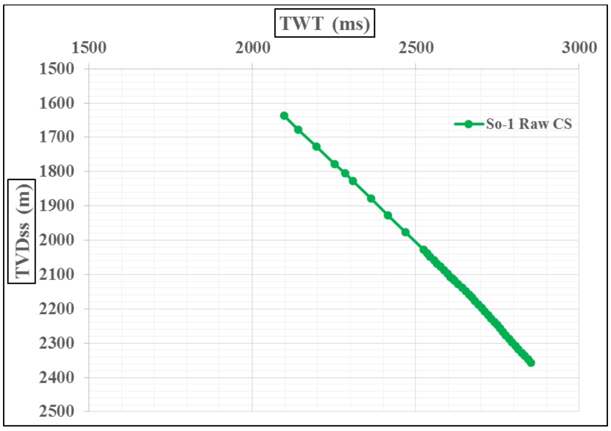

Figure 3:A cross-plot between “TWT vs. TVDss” shows a direct proportional relation trend for So-1 well. With no clear odd data to be removed.

Instantaneous average velocity calculated for each point of the checkshot data (V=D/T), and also instantaneous interval velocity calculated between each two points of the checkshot data (V=ΔD/Δt). Then, a cross-plot between “Average velocity vs. Depth” and another cross-plot between “Interval Velocity vs. Depth” will be established to quality check (QC) the checkshot data at So-1 well. Therefore, if there are any odd data it will be removed and then another plots will be established to make sure that the data is good to be used for synthetics generation.

A cross-plot between average velocity (Vavg) in meter/second (m/s) and true-vertical-depth subsea (TVDss) in meter (m), “Average Velocity vs. TVDss” shows a direct relation with two trends for So-1 well. With no clear odd data to be removed (**Figure 4**).

A cross-plot between interval velocity (Vint) in meter/second (m/s) and true-vertical-depth subsea (TVDss) in meter (m), “Interval Velocity vs. TVDss” shows a major trends for So-1 well. With a clear odd data outside the trends (**Figure 5**).

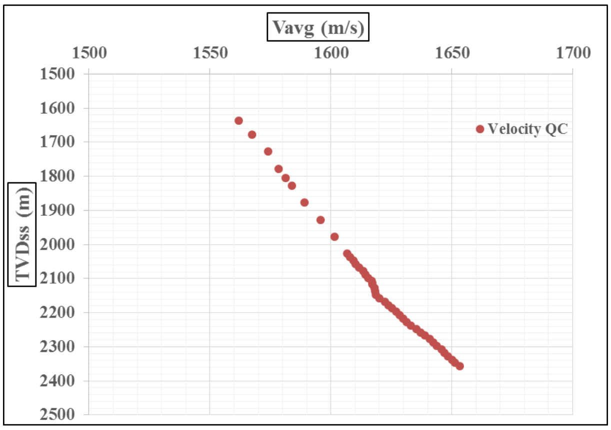

Figure 4:A cross-plot between “Average Velocity vs. TVDss” shows a direct relation with two trends for So-1 well. With no clear odd data to be removed.

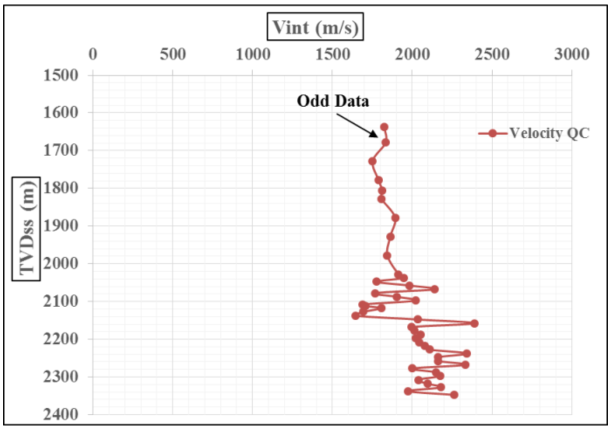

Figure 5:A cross-plot between "Interval Velocity vs. TVDss" shows a major trends for So-1 well. With a clear odd data outside the trends.

A cross-plot between "Average Velocity vs. TVDss" after removing the odd data, shows a direct relation with two major trends for So-1 well (**Figure 6**).

A cross-plot between "Interval Velocity vs. TVDss" after removing the odd data, shows a major trends for So-1 well (**Figure 7**).

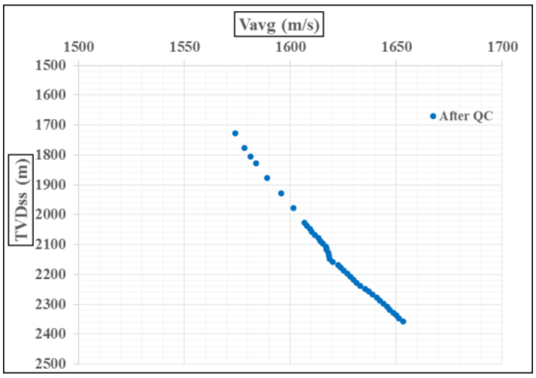

Figure 6:A cross-plot between "Average Velocity vs. TVDss" after removing the odd data, shows a direct relation with two major trends for So-1 well.

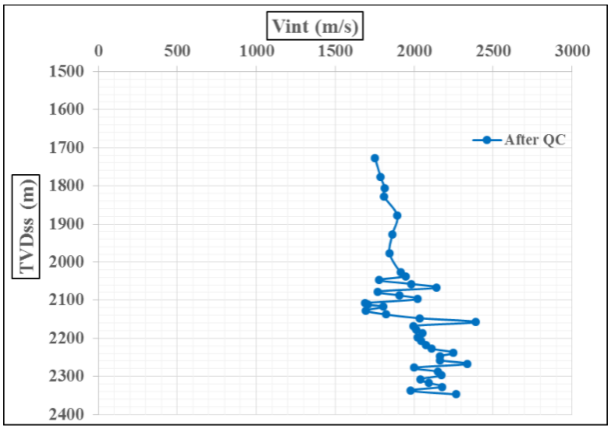

Figure 7:A cross-plot between "Interval Velocity vs. TVDss" after removing the odd data, shows a major trends for So-1 well.

The same methodology has been applied over Sr-1 well. A cross-plot between two-way-time (TWT) in millisecond (ms) and true-vertical-depth subsea (TVDss) in meter (m), "TWT vs. TVDss" shows a direct proportional relation trend for Sr-1 well. With no clear odd data to be removed (**Figure 8**).

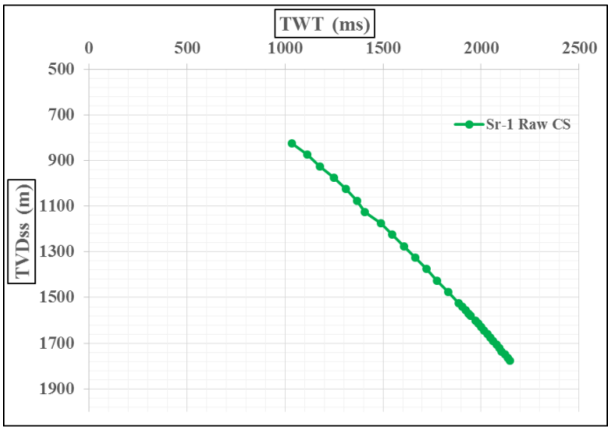

Figure 8:A cross-plot between "TWT vs. TVDss" shows a direct proportional relation trend for Sr-1 well. With no clear odd data to be removed.

Instantaneous average velocity calculated for each point of the checkshot data (V=D/T), and also instantaneous interval velocity calculated between each two points of the checkshot data (V=ΔD/Δt). Then, a cross-plot between "Average velocity vs. Depth" and another cross-plot between "Interval Velocity vs. Depth" will be established to quality check (QC) the checkshot data at Sr-1 well. Therefore, if there are any odd data it will be removed and then another plots will be established to make sure that the data is good to be used for synthetics generation.

A cross-plot between average velocity (Vavg) in meter/second (m/s) and true-vertical-depth subsea (TVDss) in meter (m), "Average Velocity vs. TVDss" shows a direct relation with two trends for Sr-1 well. With a clear odd data outside the trends to be removed (**Figure 9**).

A cross-plot between interval velocity (Vint) in meter/second (m/s) and true-vertical-depth subsea (TVDss) in meter (m), "Interval Velocity vs. TVDss" shows a major trends for Sr-1 well. With a clear odd data outside the trends (**Figure 10**).

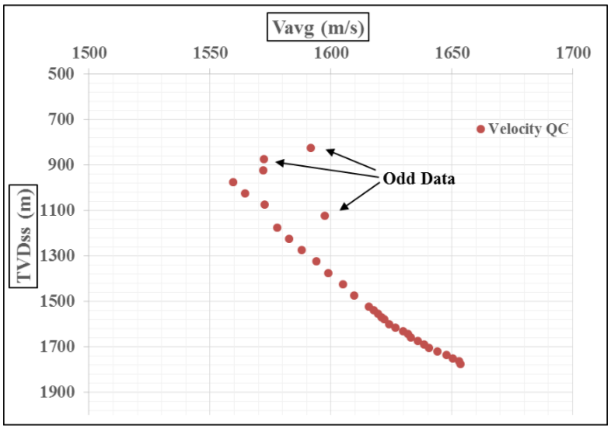

Figure 9:A cross-plot between "Average Velocity vs. TVDss" shows a direct relation with two trends for Sr-1 well. With a clear odd data outside the trend to be removed.

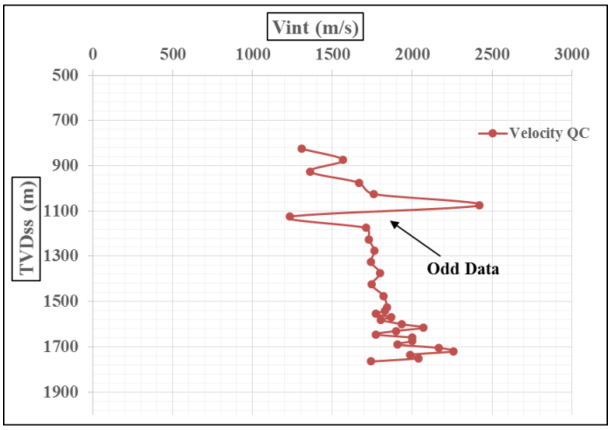

Figure 10:A cross-plot between "Interval Velocity vs. TVDss" shows a major trends for Sr-1 well. With a clear odd data outside the trends to be removed.

A cross-plot between "Average Velocity vs. TVDss" after removing the odd data, shows a direct relation with two major trends for Sr-1 well (**Figure 11**).

A cross-plot between "Interval Velocity vs. TVDss" after removing the odd data, shows a major trends for Sr-1 well (**Figure 12**).

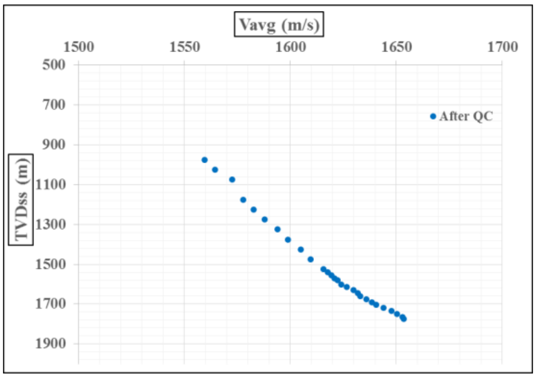

Figure 11:A cross-plot between "Average Velocity vs. TVDss" after removing the odd data, shows a direct relation with a major trends for Sr-1 well.

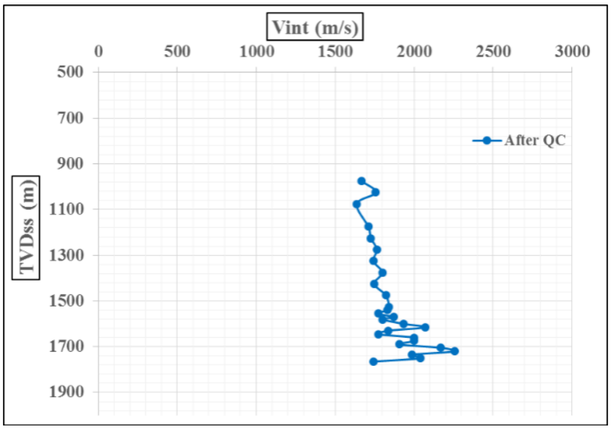

Figure 12:A cross-plot between "Interval Velocity vs. TVDss" after removing the odd data, shows a major trends for Sr-1 well.

The same methodology has been applied over Sr-a well.A cross-plot between two-way-time (TWT) in millisecond (ms) and true-vertical-depth subsea (TVDss) in meter (m), "TWT vs. TVDss" shows a direct proportional relation trend for Sr-a well. With no clear odd data to be removed (**Figure 13**).

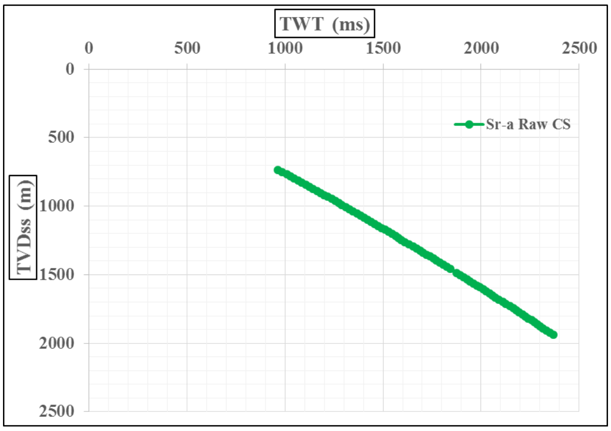

Figure 13:A cross-plot between "TWT vs. TVDss" shows a direct proportional relation trend for Sr-a well. With no clear odd data to be removed.

Instantaneous average velocity calculated for each point of the checkshot data (V=D/T), and also instantaneous interval velocity calculated between each two points of the checkshot data (V=ΔD/Δt). Then, a cross-plot between "Average velocity vs. Depth" and another cross-plot between "Interval Velocity vs. Depth" will be established to quality check (QC) the checkshot data at Sr-a well. Therefore, if there are any odd data it will be removed and then another plots will be established to make sure that the data is good to be used for synthetics generation.

A cross-plot between average velocity (Vavg) in meter/second (m/s) and true-vertical-depth subsea (TVDss) in meter (m), "Average Velocity vs. TVDss" shows a direct relation with two trends for Sr-a well. With a clear odd data outside the trends to be removed (**Figure 14**).

A cross-plot between interval velocity (Vint) in meter/second (m/s) and true-vertical-depth subsea (TVDss) in meter (m), "Interval Velocity vs. TVDss" shows a major trends for Sr-a well. With a clear odd data outside the trends (**Figure 15**).

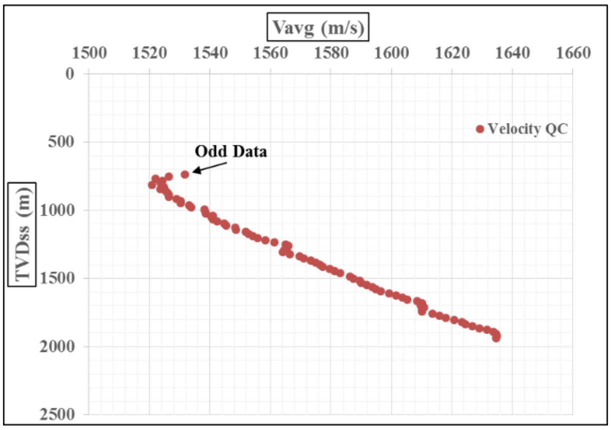

Figure 14:A cross-plot between "Average Velocity vs. TVDss" shows a direct relation with different trends for Sr-a well. With a clear odd data outside the trend to be removed.

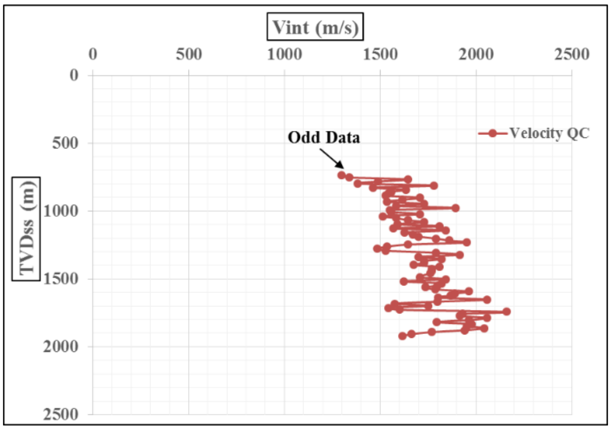

Figure 15:A cross-plot between “Interval Velocity vs. TVDss” shows a major trends for Sr-a well. With a clear odd data outside the trends to be removed.

A cross-plot between “Average Velocity vs. TVDss” after removing the odd data, shows a direct relation with two major trends for Sr-a well (**Figure 16**).

A cross-plot between “Interval Velocity vs. TVDss” after removing the odd data, shows a major trends for Sr-a well (**Figure 17**).

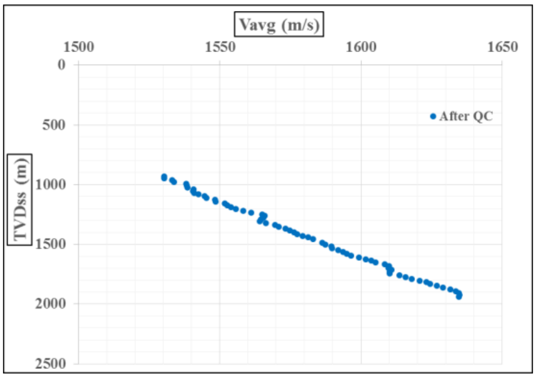

Figure 16:A cross-plot between “Average Velocity vs. TVDss” after removing the odd data, shows a direct relation with a major trends for Sr-a well.

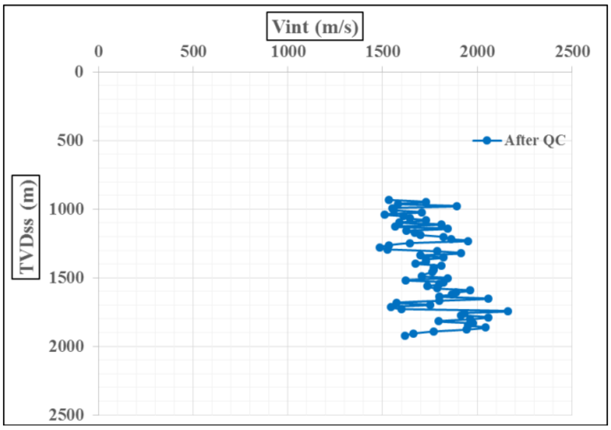

Figure 17:A cross-plot between “Interval Velocity vs. TVDss” after removing the odd data, shows a major trends for Sr-a well.

The same methodology has been applied over Sr-c well.A cross-plot between two-way-time (TWT) in millisecond (ms) and true-vertical-depth subsea (TVDss) in meter (m), “TWT vs. TVDss” shows a direct proportional relation trend for Sr-c well. With no clear odd data to be removed (**Figure 18**).

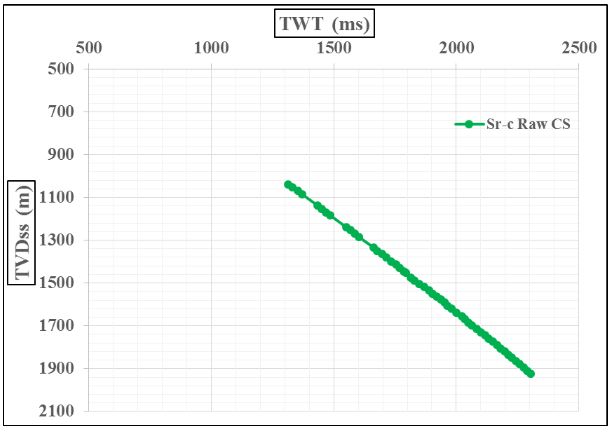

Figure 18:A cross-plot between "TWT vs. TVDss" shows a direct proportional relation trend for Sr-c well. With no clear odd data to be removed.

Instantaneous average velocity calculated for each point of the checkshot data (V=D/T), and also instantaneous interval velocity calculated between each two points of the checkshot data (V=ΔD/Δt). Then, a cross-plot between "Average velocity vs. Depth" and another cross-plot between "Interval Velocity vs. Depth" will be established to quality check (QC) the checkshot data at Sr-c well. Therefore, if there are any odd data it will be removed and then another plots will be established to make sure that the data is good to be used for synthetics generation.

A cross-plot between average velocity (Vavg) in meter/second (m/s) and true-vertical-depth subsea (TVDss) in meter (m), "Average Velocity vs. TVDss" shows a direct relation with two trends for Sr-c well. With a clear odd data outside the trends to be removed (**Figure 19**).

A cross-plot between interval velocity (Vint) in meter/second (m/s) and true-vertical-depth subsea (TVDss) in meter (m), "Interval Velocity vs. TVDss" shows a major trends for Sr-c well. With a clear odd data outside the trends (**Figure 20**).

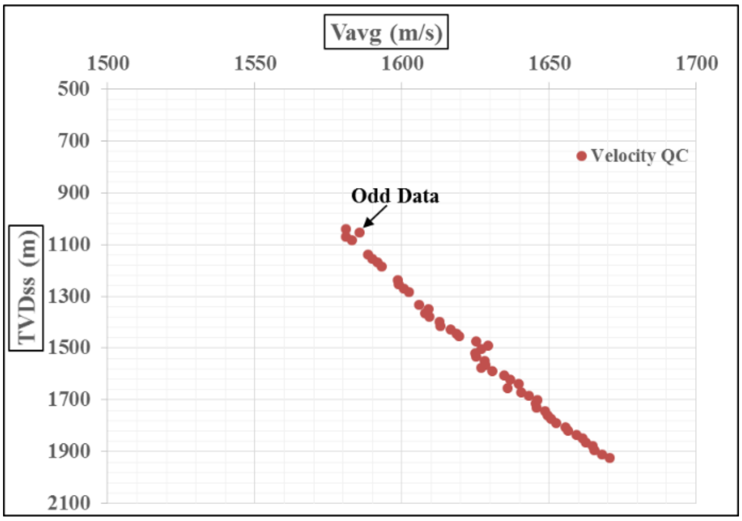

Figure 19:A cross-plot between "Average Velocity vs. TVDss" shows a direct relation with different trends for Sr-c well. With a clear odd data outside the trend to be removed.

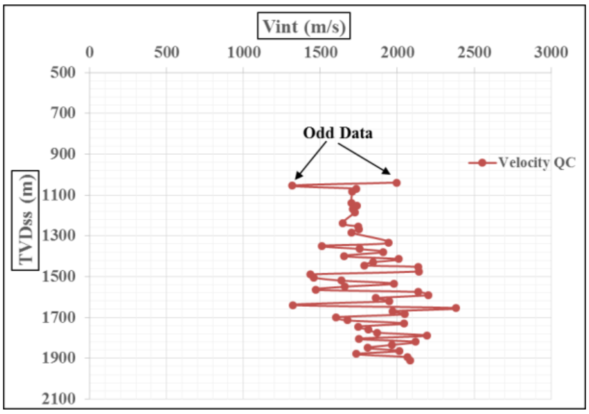

Figure 20:A cross-plot between "Interval Velocity vs. TVDss" shows a major trends for Sr-c well. With a clear odd data outside the trends to be removed.

A cross-plot between "Average Velocity vs. TVDss" after removing the odd data, shows a direct relation with two major trends for Sr-c well (**Figure 21**).

A cross-plot between "Interval Velocity vs. TVDss" after removing the odd data, shows a major trends for Sr-c well (**Figure 22**).

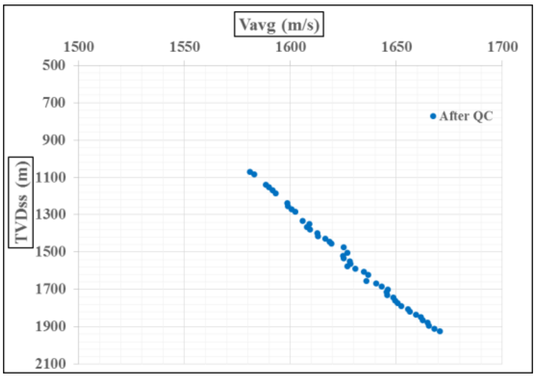

Figure 21:A cross-plot between "Average Velocity vs. TVDss" after removing the odd data, shows a direct relation with a major trends for Sr-c well.

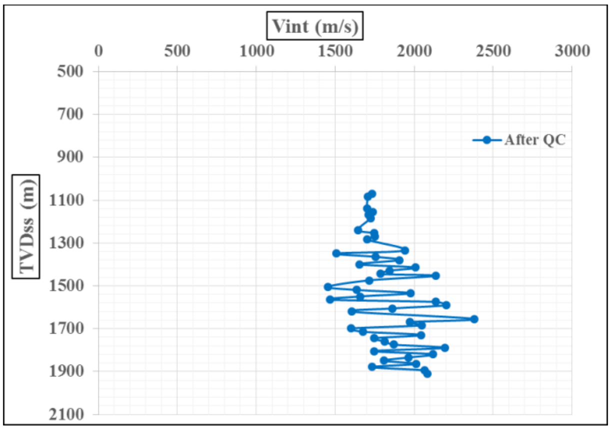

Figure 22:A cross-plot between "Interval Velocity vs. TVDss" after removing the odd data, shows a major trends for Sr-c well.

IV. Conclusion

Checkshot data is the direct data could be obtained from vertical seismic profile "VSP", as it is represented by Time-Depth table.

From the study, we could conclude that raw checkshot data should be quality checked not only by applying "Time Vs. Depth" crossplot, but also by optimizing a velocity analysis "Average Velocity vs. Depth" and "Interval Velocity vs. Depth". Therefore, the data will be clean to be used for well to seismic tie "synthetics".

Acknowledgment

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