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Research Article

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Comparison study between the elevation and datum statics in NC 210, western Libya

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Abstract

This research compares the results of each method to solve problems caused by sand dunes, In the southwestern region of Libya, the Murzuq basin is covered with sand dunes, which are a significant source of noise in land seismic data, which caused issues in seismic processing, also sand dunes cause increases of travel time of reflected events in seismic data, procuring false structures this problem caused by residual static errors.
The presence of extensive sand dunes causes logistic and technical difficulties for seismic reflection prospecting, Due to the steep angle of repose of the sand dunes faces and the low seismic velocity within them, which causes significant time delay to the reflected waves.
In this research, three seismic lines (202, 207, 209), of total length 12 km, have been completely reprocessed at Western Geco processing center (Tripoli) using omega software. the methods of gain corrections: time function gain and geometric spreading. Spreading amplitude compensation, has been proceed the results will be compared to another method of gain corrections called residual amplitude analysis compensation (RAAC) which is has better results for static problems the conventional method of computing field statics has been implemented and the result is compared with elevation static. It is obtained by using uphole method (conventional method) yielded a significant improvement over the elevation method.

Keywords: *Static Correction; Elevation Statics; Datum Statics; Seismic Processing; Sand Dunes Problems.*

1. Introduction

The Concession NC210, located in the north-western part of the Murzuq basin of western Libya, is one of the most difficult areas of the Libyan desert (Fig. 1.A). Seismic lines (202, 207, and 209) are located in this area, however, in order to tie those lines into a grid; some lines have to be acquired across the dunes. The area comprises complex dune topography, which are typically about 1.5 km wide and about 100m high. Seismic exploration activities in the area of study have been carried out since 1960. The base map shown in Fig. 1.B shows some of the seismic lines that were acquired in 2005. Weight drops and dynamite, for older surveys, were mainly used as the sources for generating seismic waves, while in more recent surveys Vibrioses has most commonly been used, although dynamite has also been used in some places.
Number of wells has been drilled in the Atchan field area, which extends eastwards from the area of study. One of these wells is located within the area of study. Well, F1-NC210 (wild cat) was drilled in 1998 and is located at 27° 37'38.111 N, 10° 41' 57.2" E (Fig. 1.C). The total depth of F1-NC210 is 5575 ft. and it produces gas. Production tests were run over the depth interval 4856-5015 ft. in sandstones of Ordovician age.
The difficulty in calculating static corrections is due not only to the severe topography of the dunes but also to the fact that the sand in the dunes is dry and thus has very low velocity. It can also be saturated of hydrocarbon.

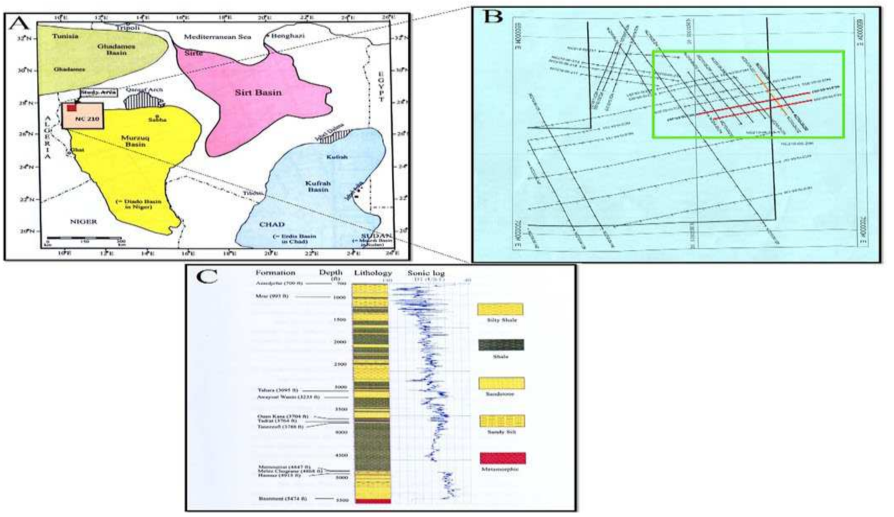

Fig. 1: Generalized Location Map of the Sedimentary Basins Showing the Study Area in Concession N 210 (A) the Seismic Lines (B) Lithological Sequence and Sonic Log Recorded in Well F 1-NC 210 (C).

2. Methodology

The most important processing step for land data is commonly the application of static corrections. This is particularly true in rough terrain where the near-surface velocity is highly variable. Seismic lines NC 202, NC 207 and NC 209 cross sand dunes and the near surface velocity field is very inhomogeneous. Four upholes were drilled at selected locations at interval about 4 km apart along for each seismic lines NC 210, NC 202 and NC 207, meanwhile two upholes were drilled at selected locations where the interval is about 4 km from seismic line NC 210 – 209.

As defined by Sheriff (1991), to compensate the varying effects of elevation, thickness of weathering layer, weathering velocity, or reference to a datum static corrections are "corrections applied to seismic data. Therefore, objective of this study is to determine the reflection arrival times, which would have been observed if all measurements have been made on a flat horizontal plane with no weathering or low-velocity material present. These corrections are based on uphole data, refraction first breaks, and/or event smoothing. A complete statistical solution can be obtained from complete knowledge of the locations and elevations of the sources and receivers, and the velocities and thicknesses of the near-surface layers.

2.1. Basic method of weathering and elevation travel time

Fig (2) shows a near-surface profile with the location of a source, or receiver, at point A on the surface. The weathering travel time (tWA) is the weathering thickness that can be obtained by the division of (ZA) and the weathering velocity (VW) at location A (1),

$$tWA = ZA / VW \quad (1)$$

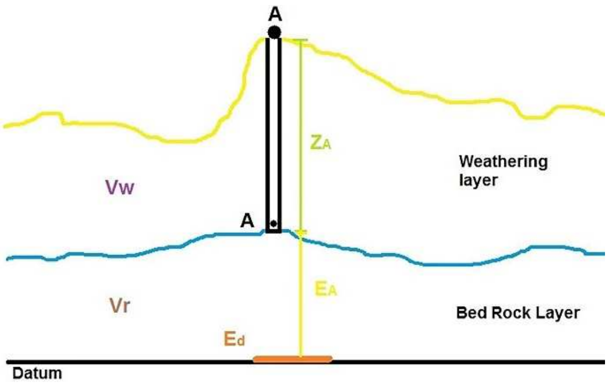

Fig. 2: Computation of Datum Static Corrections with the Source or Receiver at the Surface.

If there is more than one weathered layer, the weathering travel time is the sum of individual layer travel times, each of which is computed from its thickness and velocity. Then elevation travel time is computed by using (2) where elevation travel time (tEA) is the thickness of sub weathered layer above the datum divided by the replacement or datum velocity (vr)

$$tEA = (EA - ZA - Ed)/Vr \quad (2)$$

Where:
EA = elevation of the source (or receiver) at A.
ZA = thickness of the weathered layer at A.
Ed = elevation of the reference datum.
Vr = replacement (or datum) velocity.
If more than one weathered layer is present, the symbol (ZA) in equations (1 and 2) refers to the total thickness of all the weathered layers. Thus, the total datum static correction, (tA), is formed from the sum of weathering and elevation travel times. It is a known convention that static correction is negative for sources and receivers above the datum, as shown:

$$tA = -(tWA + tEA) \quad (3)$$

The low velocity layer is characterized by the following features (Sheriff 1989, pp. 338-339):

- large impedance contrast with material below it,
- acts as a variable low pass filter. Therefore, it would produce a change in upgoing reflected waveform,
- ray paths in the low velocity layer are nearly vertical irrespective of their directions below it,
- thickness and velocity vary - as a result travel time of waves passing through it would vary.

2.2. Uphole survey

One of the biggest problems we face is determination of thickness and velocity of weathering layer. For this purpose, one technique that is commonly used is the uphole survey Fig (3). Boreholes about 50-100 m deep are drilled at selected locations along a seismic line at variable intervals (starting from about 1 km) depending on the survey requirements (Dong and Xiang-Yun, 2006). A source (Vibrioses truck or dynamite in a shallow shot-hole) is located at an offset of a few meters from the top of the borehole, and a string geophone is lowered into the borehole. Hence, travel times of the direct wave first arrivals are measured.

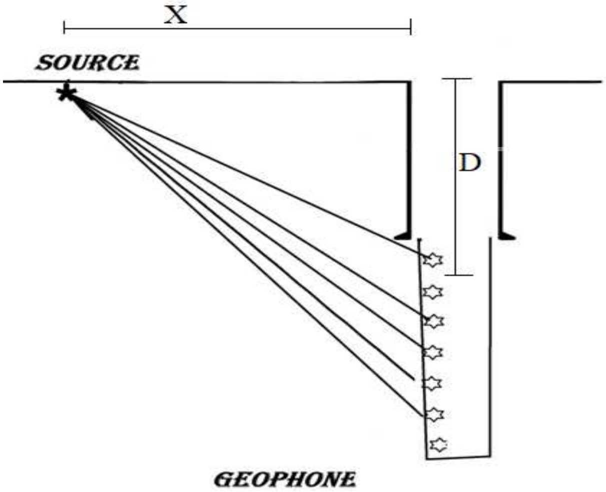

Fig. 3: Shows Uphole Survey.

In calculating the vertical uphole times, it is necessary to correct the measured travel times for the slant travel paths. The vertical travel times are then used to estimate the velocities of the near-surface layers. The relationship between the vertical uphole time (T) and the measured (inclined) uphole time (t) is shown in (4).

$$T = [t(D + E)/\{(D + E)^2 + X^2\}^{0.5}] \quad (4)$$

Where:
D= the depth from the top of the uphole to the down-hole source or receiver.
X= offset (horizontal distance between the top of the up hole and the surface source or receiver).
E= elevation of the surface source or receiver minus the elevation at the top of the uphole.

3. Estimating field statics

The results from one uphole obtained from a borehole drilled high on the flank of a sand dune are shown as an example in Fig (4) by plotting a graph of vertical uphole time versus depth, straight lines are fitted to the plotted points. The slopes of these lines indicate the velocity of each layer, and the breaks in the slope (knee points, where two straight segments intersect) give the depth of each interface. The differences between interface depths give the thicknesses of each layer.
To provide direct measurements of the velocities and thicknesses of the weathering and sub-weathering layers, shown as an example in Fig (5), each uphole has been interpreted as a three-layer case with the thicknesses of the top two layers and the interval velocities of all three layers determined. Datum static corrections (weathering and elevation corrections) calculated for all upholes which are located on seismic lines NC210-(202,207,209) are shown in (Table 1)

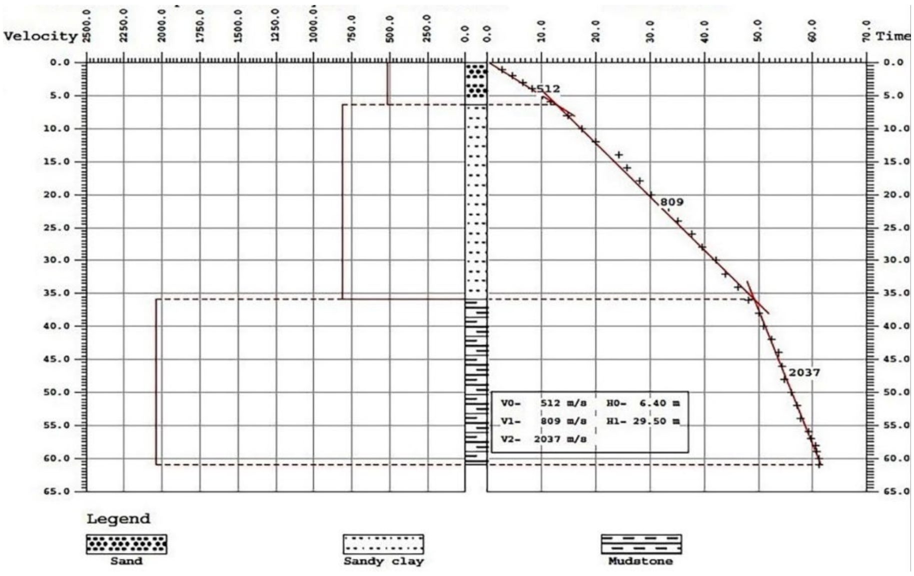

Fig. 4: Interpretation of Uphole (UH05_001_209) Survey Data Depicting Three Geologic Layers.

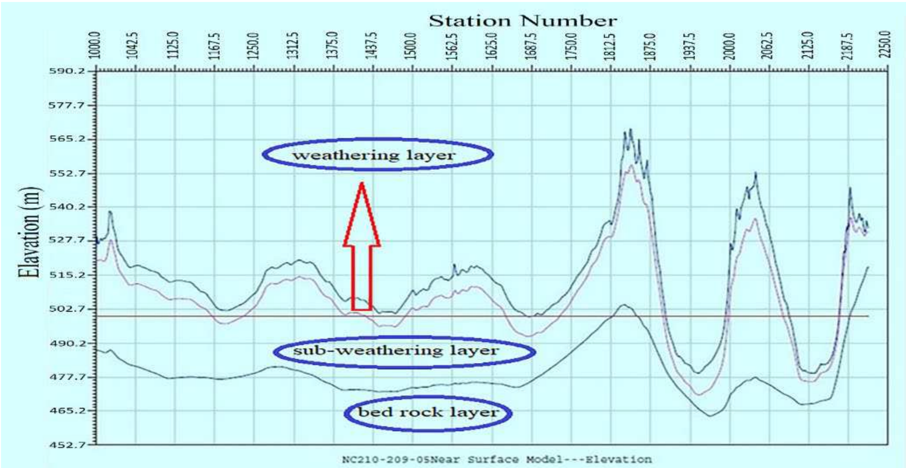

Fig. 5: Near-Surface Layer Thicknesses Along Part of Seismic Line NC210-209, Interpolated between Line Intersections and Control Points and between Control Points and Upholes, for the Conventional Method of Estimating Field Statics.

Table 1: Computation of Datum Static Corrections (Weathering and Elevation Corrections) at the Upholes Along Seismic Lines NC210-(202, 207 and 209)

Name of Uphole	009	007	008	010	002	005	032	034	001	006
Ele(m) (surface Elevation)	530.7	506.4	509.9	520	521.1	517.0	498.5	507.3	513	517.8
Datum	500	500	500	500	500	500	500	500	500	500
Z1 (Thickness layer 1)	3.9	4.9	4.8	5.7	15.4	7.4	2.6	2.8	6.4	5.5
Z2 (Thickness layer 2)	17.5	28.7	29.9	35.7	27.4	35.5	13.6	27.6	29.5	40.7
Z3 (Thickness layer3)	33.2	_	_	_	_	_	_	_	_	_
V1 (weathering velocity layer 1)	370	593	473	488	657	617	398	340	512	472
V2 (weathering velocity layer 2)	763	834	775	789	877	834	1014	792	809	880
V3 (weathering velocity layer 3)	2069	_	_	_	_	_	_	_	_	_
Vr (replacement velocity)	904	2092	2035	2105	2002	2109	2448	2065	2037	2289
Ele-(z1+z2)-Datum	-23.9	-27.3	-24.9	-21.3	-21.7	-25.8	-17.7	-23.2	-22.9	-28.3
weathering correction1 Z1/V1	10.6	8.4	10.2	11.6	23.4	11.9	6.6	8.3	12.5	11.6
weathering correction2 Z2/V2	22.9	34.4	38.7	45.2	31.3	42.6	13.4	34.9	36.5	46.3
weathering correction3 Z3/V3	16	_	_	_	_	_	_	_	_	_
Elevation correction	-26	-13	-12.2	-10	-10.8	-12.2	-7.2	-11.2	-11.3	-12.4
Datum correction	-23.1	-29.8	-36.7	-46.8	-43.8	-42.3	-12.7	-31.9	-37.7	-45.5

3.1. Gain corrections

The field tapes and observers repot for three lines were provided by Woodside company. A data set in SEG Y format is taken from tape or disk and converted to the structured file format ready for use to processing operations in order to facilitate the movement of data from one processing contractor to another. As shot fired, Waves spread as a cone in 3 dimensions.

This spreading of energy is called spherical divergence that in result decrease energy as it moves away from the source in depth. In this process, high frequencies are more rapidly to absorb than low frequencies by the rock (Rothman, 1986). So, seismic energy reflect from deep geological event will be received at geophone as weak signal, & near surface will be received as strong signal. Then the test function gain is applied to enhance these weak signals.

3.2. Test function gain

The time (in seconds) of each data sample is first raised to a user-supplied exponential value; the result is shown in Figure 6: that shows a multiplication by the amplitude of the sample at that time. Trace samples are scaled by first raising the time (in seconds) to a user-supplied exponential value, then multiplying the result by the amplitude of the sample at that time. The user supplies the exponent as the value of the GAIN EXPONENT parameter in the General Parameters parameter set:

$$Ao(t) = Ai(t)\ t^{x} \tag{5}$$

Ao(t) = Amplitude of output trace sample at time t.
Ai(t) = Amplitude of input trace sample at time t
t = Time in seconds.
x = Value of GAIN EXPONENT.
Fig (6) shows four tests have been done with different values of GAIN EXPONENT (1, 1.2, 1.8 and 2) the difference between raw data and tested data.

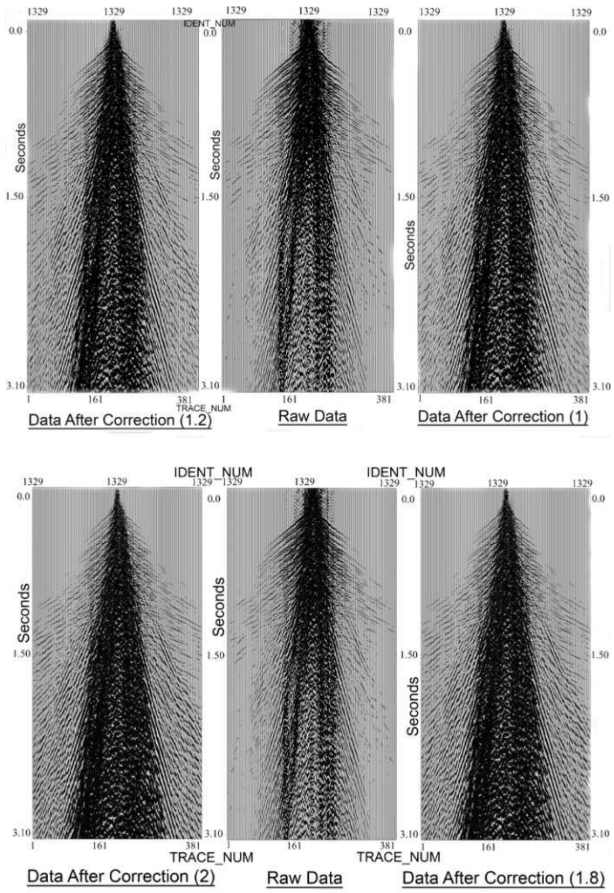

Fig. 6: Raw Data and Tested Data with Gain Exponent Values (1, 1.2, 1.8, 2).

The Geometric Spreading Amplitude Compensation

Normal or inverse geometric spreading correction is applied to seismic data. The only requirement is that the data must have geometry information in the trace headers. Absorption in rocks is believed to be related.

to the first power of frequency whereas in liquids it is related to square of the frequency (Anstey, 1977). Magnitude of absorption (friction) loss in a hard rock is liable to be much higher than that in a fluid saturated rock as friction in fluid, considered as a slushy medium, is likely to be small (Gregory, 1977).

The Geometric Spreading Amplitude Compensation for the amplitude decay is associated with a primary seismic wave propagating from a point source. Water-bottom multiples and peg-leg multiples tend to be overcompensated by this process. (Fig 7) shows a tested data with geometric spreading amplitude.

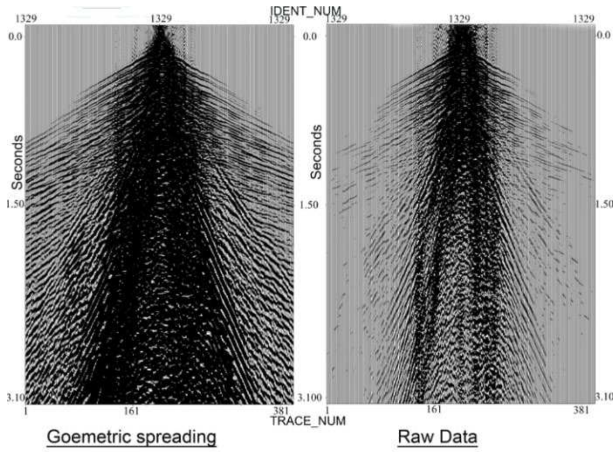

Fig. 7: Shows A Row Data and Tested Data with Geometric Spreading Amplitude.

The Residual Amplitude Analysis Compensation (RAAC)

When true-amplitude information needs to be retained in the data, the application of data dependent scaling is undesirable; yet the failure to apply scaling can result in data which is difficult to display due to the range of amplitudes (dynamic range) present. The RAAC process uses statistical means to retain anomalous amplitude information, such as bright spots, while allowing the data to be scaled. The analysis step of RAAC computes, (Fig 8) shows a raw data apply of (RAAC) for each trace, the amplitudes of multiple windows using an rms-amplitude criterion. The Residual Amplitude Compensation (RAC) value of each window is then the reciprocal of this computed amplitude.

The center of each time window defines the position of its associated RAC value. Knowing the X-Y location and time of each RAC value allows both spatial and temporal smoothing to be applied to the RAC values. The application step of RAAC takes the smoothed RAC values, interpolates to every sample, and applies the resulting scalars to the input traces.

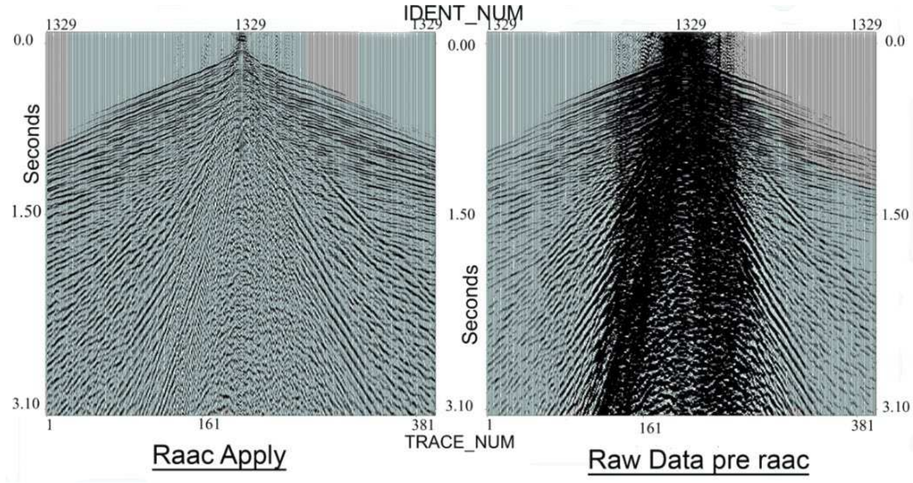

Fig. 8: Shows A Raw Data before RAAC and Data after RAAC Apply.

3.3. Seismic data processing

Three seismic lines have been processed in Western-Geco (WG) using the omega package. A good result has been achieved for removing the random noise using Anomalous Amplitude Attenuation (AAA) filter. While the ground rolls, airwave, and cable jerk have been eliminated using FK filter with velocity of 1500m/s. For the deconvolution parameters, the operator length and the gab have been selected as 240 MS, and 32 MS, respectively.

The term common depth point (CDP) gathers in subsurface is equivalent to a common mid-point (CMP) gather on the surface, only when reflections are horizontal, and velocities do not vary horizontally. However, for random stratification with beds having varying dips, only CMP trace arrays may be used for RMS velocities calculations to achieve a good degree of accuracy (see, for example, Levin 1971). Therefore, when there are dipping reflectors in the subsurface, these two gathers are not equivalent and only the term CMP gather should be used. The CDP gather should be moved in up dip direction to make it an equal lent of CMP by the process of migration. CMP stacking is a crucial step in conventional seismic reflection work because it improves the S/N ratio (attenuates random noise, and also both coherent noise and multiples provided that their move out is different from the primary reflection events). For lines 202, 207 and 209, the geophone station interval is the same as the shot point interval, so the maximum fold cover is 200 with 400 recording channels.

3.4. Velocity analysis

Stacking velocity is the parameter that controls the stack quality. The stacking velocities are used to correct for Normal Move out (NMO) Correction to align the reflections in Common Mid-Point (CMP) gather before stacking. There are two methods that can be used to estimate the stacking velocity (Fig 9). The first method is Constant Velocity Stack (CVS), by choosing the velocity that yields the best stack response at a selected (CMP) event time. By proceeding in this way, one can build up a velocity function that is appropriate for applying Normal Move out Corrections (Al-yahya, 1989). This method is applied for each reflector one by one and finally the NMO velocities are applied at the same time for each reflector to get a linear trend.

The second method is the velocity spectrum. By picking the semblance peaks at (CMP) panel one can get the best stack velocity. The velocity spectrum method is more suitable for data with multiple reflections and somewhat less suitable for complex structure. The two methods mainly used for seismic lines NC210-202, 207 and 209.

3.5. Application to a seismic line crossing sand dunes

The stacked section of seismic line 209 is shown in Fig 9, where we can note that its crossing sand dunes, with increases of travel time of reflected events in seismic data, procuring false structures, this problem is caused by residual static errors (Steeples et al., 1990).

The conventional method is shown in Fig 10. Processing includes (RAAC) gain corrections and f-k filtering of common shot gathers, predictive deconvolution before stack, normal move out correction in common midpoint gathers, and stacking (Cox, 1999). False structures are evident beneath the sand dunes, where the data also have poor signal-to-noise ratio. The surface elevation along the line and the field statics is calculated using the conventional method.

For direct comparison, the same seismic line 209, Fig 11 shows seismic stack section after applying the uphole statics (Datum statics) with exactly the same processing sequence used earlier that shows false structures beneath sand dunes have mostly been removed, but the signal-to-noise ratio beneath the sand dunes is still poor. The use of automatic statics programs improves the signal-to-noise ratio considerably and velocity analysis is applied, followed by CMP trim statics. In processing the data with conventional field statics, automatic static programs were unable to remove the false structures in Fig 10, that are now better resolved (Wenxi and Chunyan, 2007) in Fig 10.

After applying the uphole static correction (Datum statics) on seismic lines NC210-(202, 207, 209), the intersection between final correction to seismic lines Fig 12 with quick interpretation notes in seismic line 202 clearly indicate a vertical offset in the refractor across the fault.

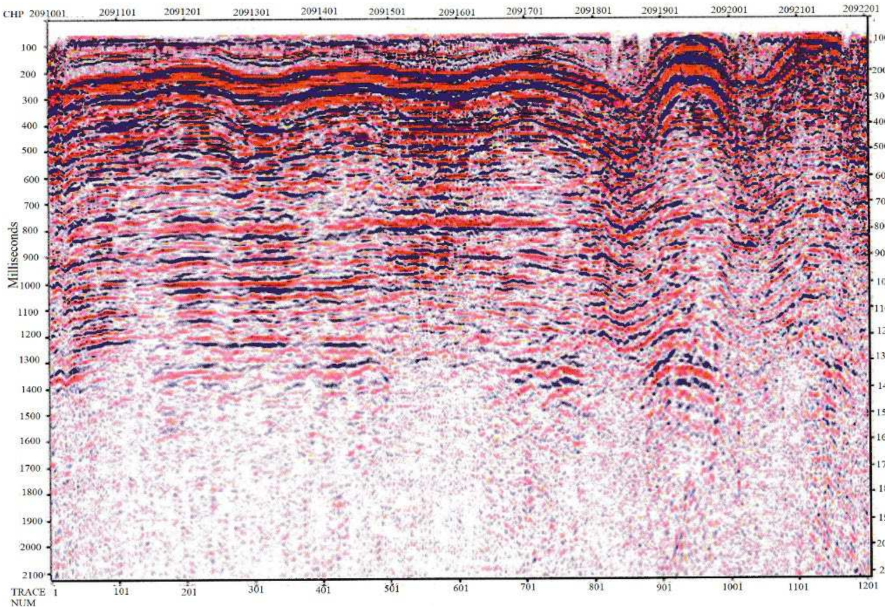

Fig. 9: Shows Stack Section to Seismic Line 209.

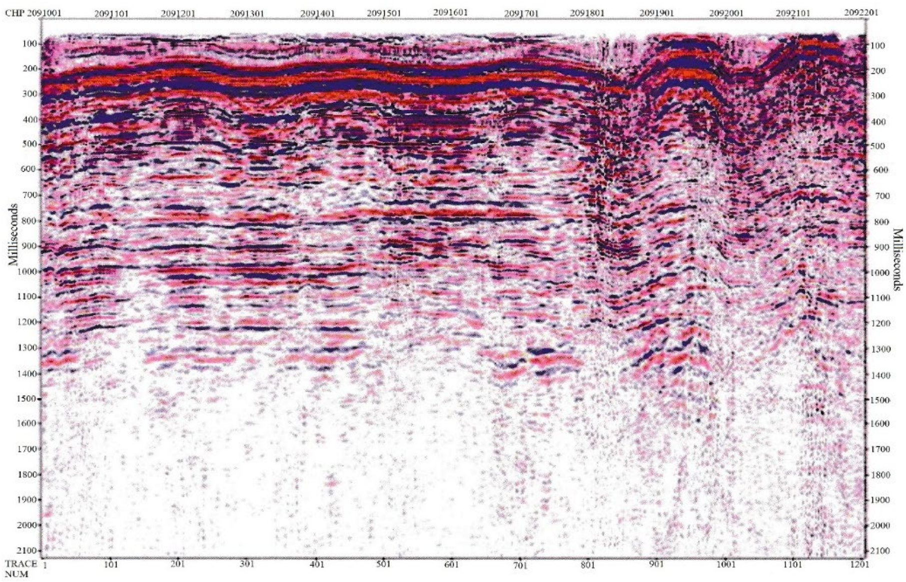

Fig. 10: Shows Elevation Static Correction to Seismic Line 209.

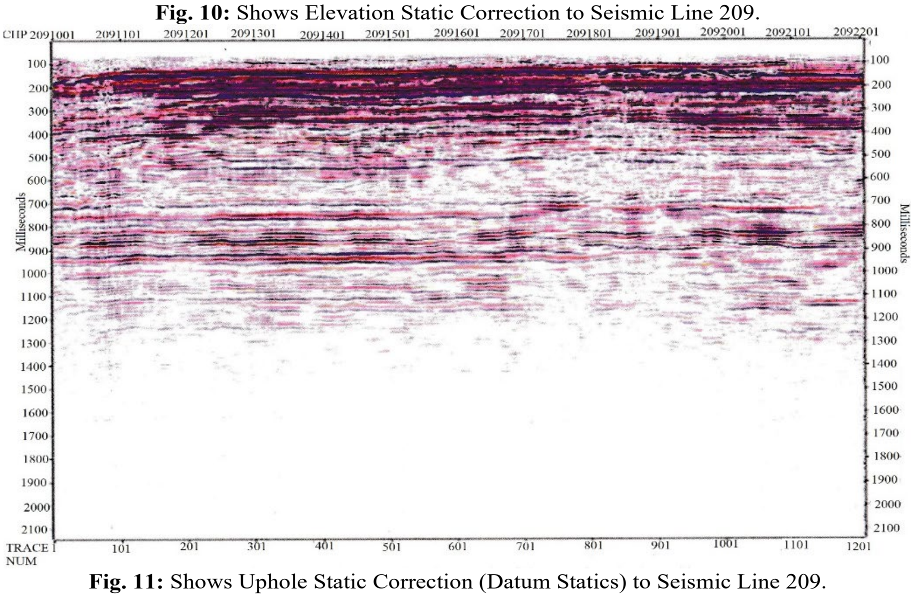

Fig. 11: Shows Uphole Static Correction (Datum Statics) to Seismic Line 209.

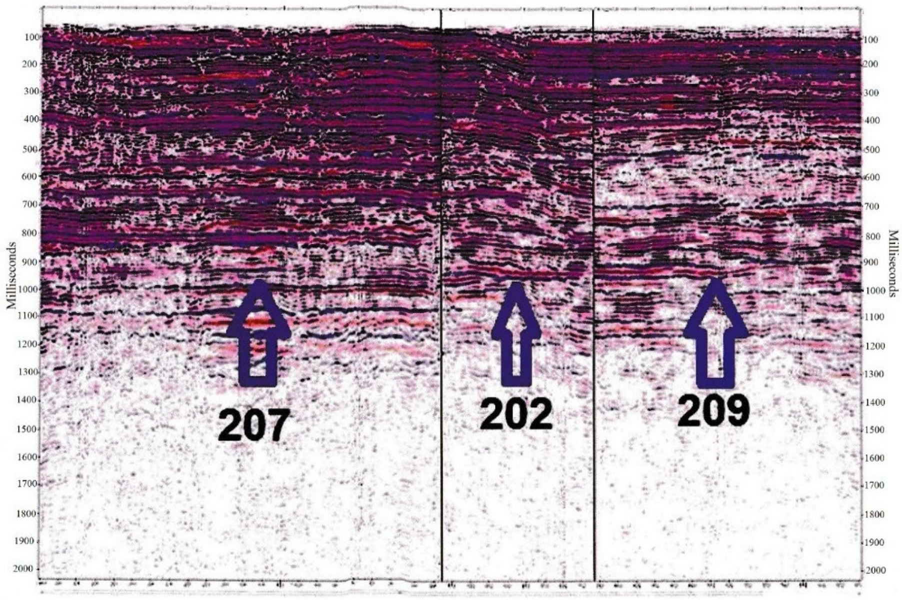

Fig. 12: Show Intersection Between Final Correction to Seismic Lines (202,207,209).

4. Conclusion

This research deals with static problems on seismic reflection profiles over sand dunes is concession N210 in western Libya. The method of computing field statics is uphole statics. Three seismic lines of about 38 km total in length are taken that cross-sand dunes that were processed by Western Geco company using omega software for each set of field statics.
In calculating the vertical uphole times, the measured travel times for the slant travel paths. Each uphole has been interpreted as a three-layer case with the thicknesses of the top two layers determined and the interval velocities of all three layers with datum of 500M. Datum static corrections (weathering and elevation corrections) are calculated for all upholes in the three lines .
All the gain corrections were tested using real data from NC210, the time function domain testing shows unsatisfactory result and will not be able to resolve real structure, effectively, After Geometric Spreading Amplitude Compensation, the horizontal Data is good enough to accept as the noise that diminishes the signal is small. However, we can see this noise in the data, in this case too, from the result of the previous test. Notice that the effect of (RAAC) on the raw data is clearly found good on clearance of noise, horizontal data set due to the correction of amplitude shows RAAC is the best method to correct the amplitude.
A good result has been achieved for removing the random noise using Anomalous Amplitude Attenuation (AAA) filter, where the ground roll, airwave, and cable jerk have been eliminated.
There are two methods that used to estimate the stacking velocity, the first method is the constant velocity stack (CVS), the second method is the velocity spectrum by picking the semblance peaks at Common Mid-Point (CMP) panel, one can get the best stack velocity. The velocity spectrum is more suitable for data with multiple reflections and somewhat less suitable for complex structure.
There are many methods of static corrections used for enhancement of seismic stack sections. One of these methods is uphole static whose application will yield better results over elevation statics corrections especially in sand dune areas (Jiang, 2008). The results from processing seismic lines crossing the sand dunes show that the datum static method gives much better results than the conventional field static method (Yoo and Haug, 1986). No faults were present on the line crossing the sand dunes, but there was a fault on the line 202 located between sand dunes.
Similar care will have to be taken around fault locations when processing seismic lines that cross over sand dunes with the uphole statics (datum statics) method.

5. Highlights

- The existence of sand dunes creates logistical and technical difficulties for seismic reflection exploration.
- static corrections are corrections applied to seismic data to compensate for the effects of variations in elevation, weathering thickness, weathering velocity, or reference to a datum.
- Comparison of the results of each method to solve problems caused by sand dunes, In the southwestern region of Libya.
- The results from processing seismic lines crossing the sand dunes show that the datum static method gives much better results than the conventional field static method.

On behalf of all the co-authors, the corresponding author states that there is no conflict of interest.

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Figures

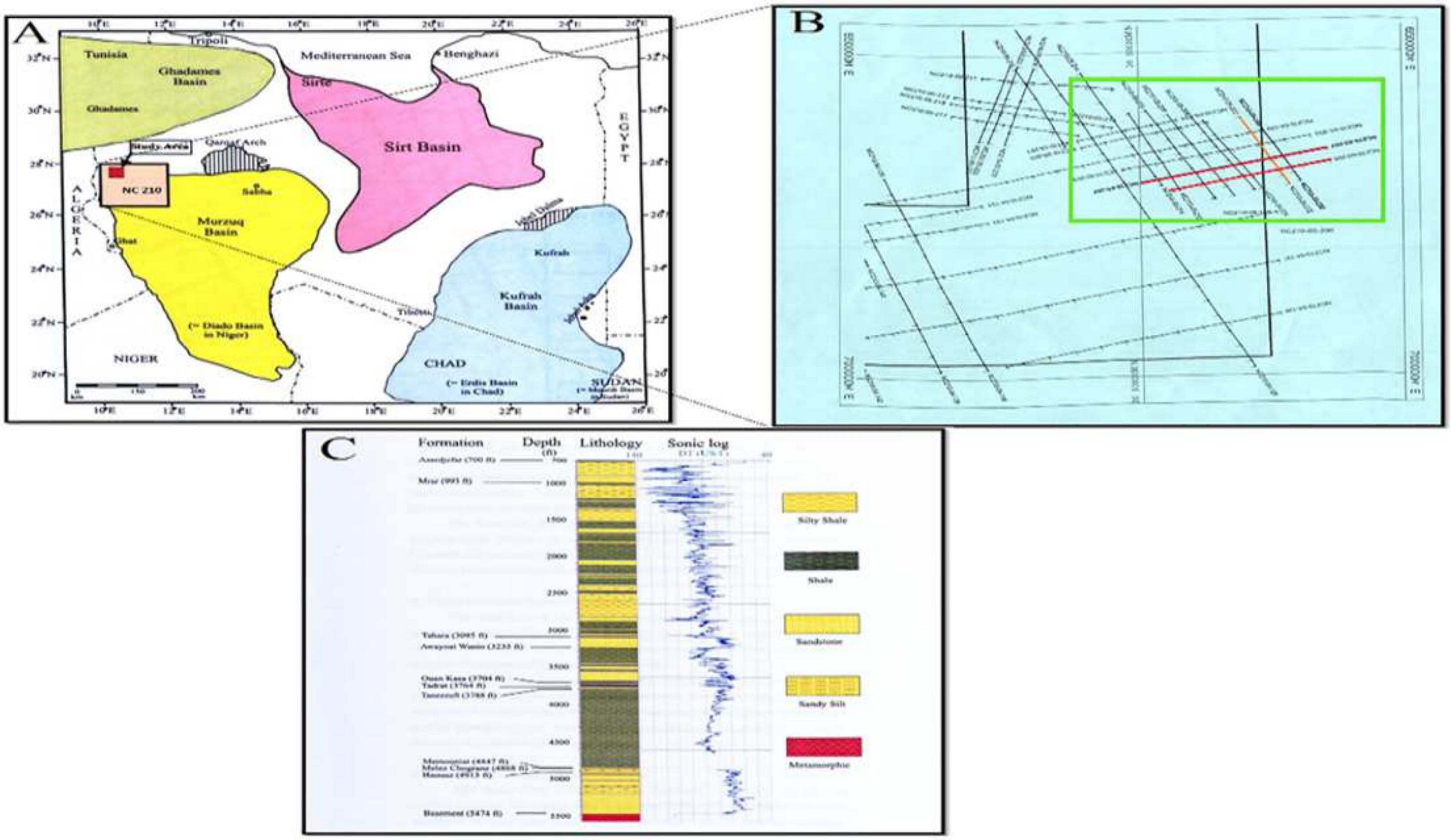

Figure 1

Generalized Location Map of the Sedimentary Basins Showing the Study Area in Concession N 210 (A) the Seismic Lines (B) Lithological Sequence and Sonic Log Recorded in Well F 1-NC 210 (C).

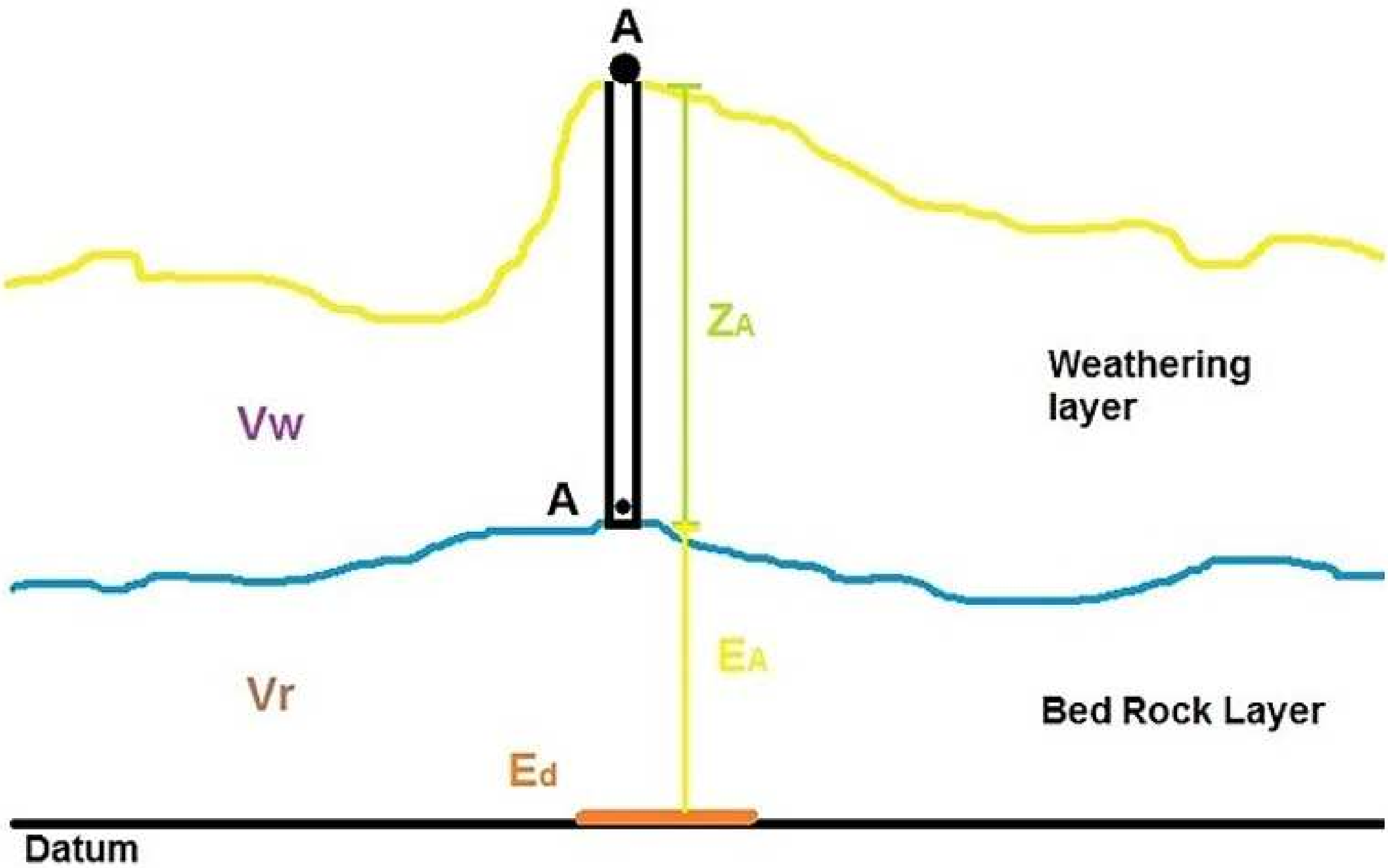

Figure 2

Computation of Datum Static Corrections with the Source or Receiver at the Surface.

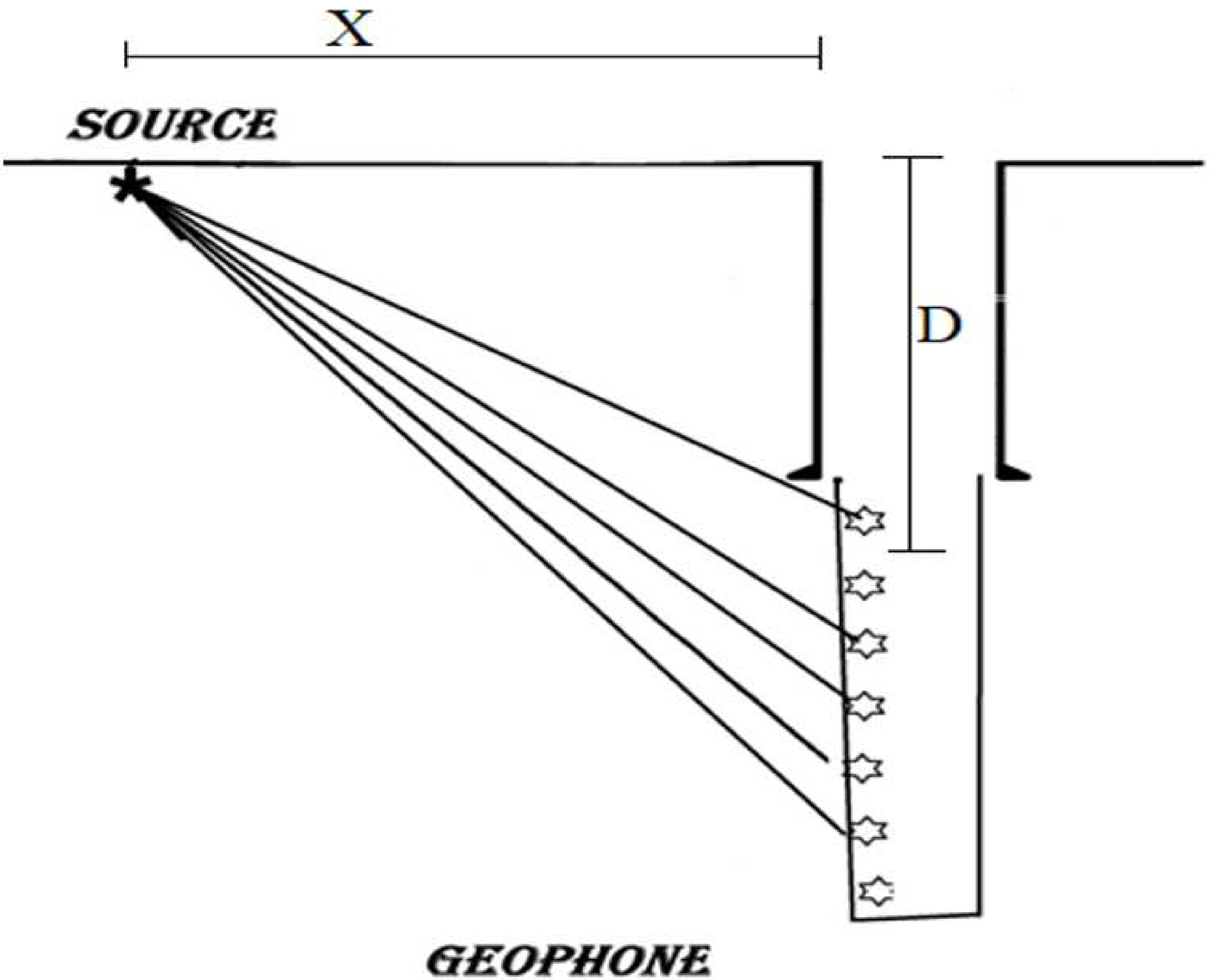

Figure 3

Shows Uphole Survey.

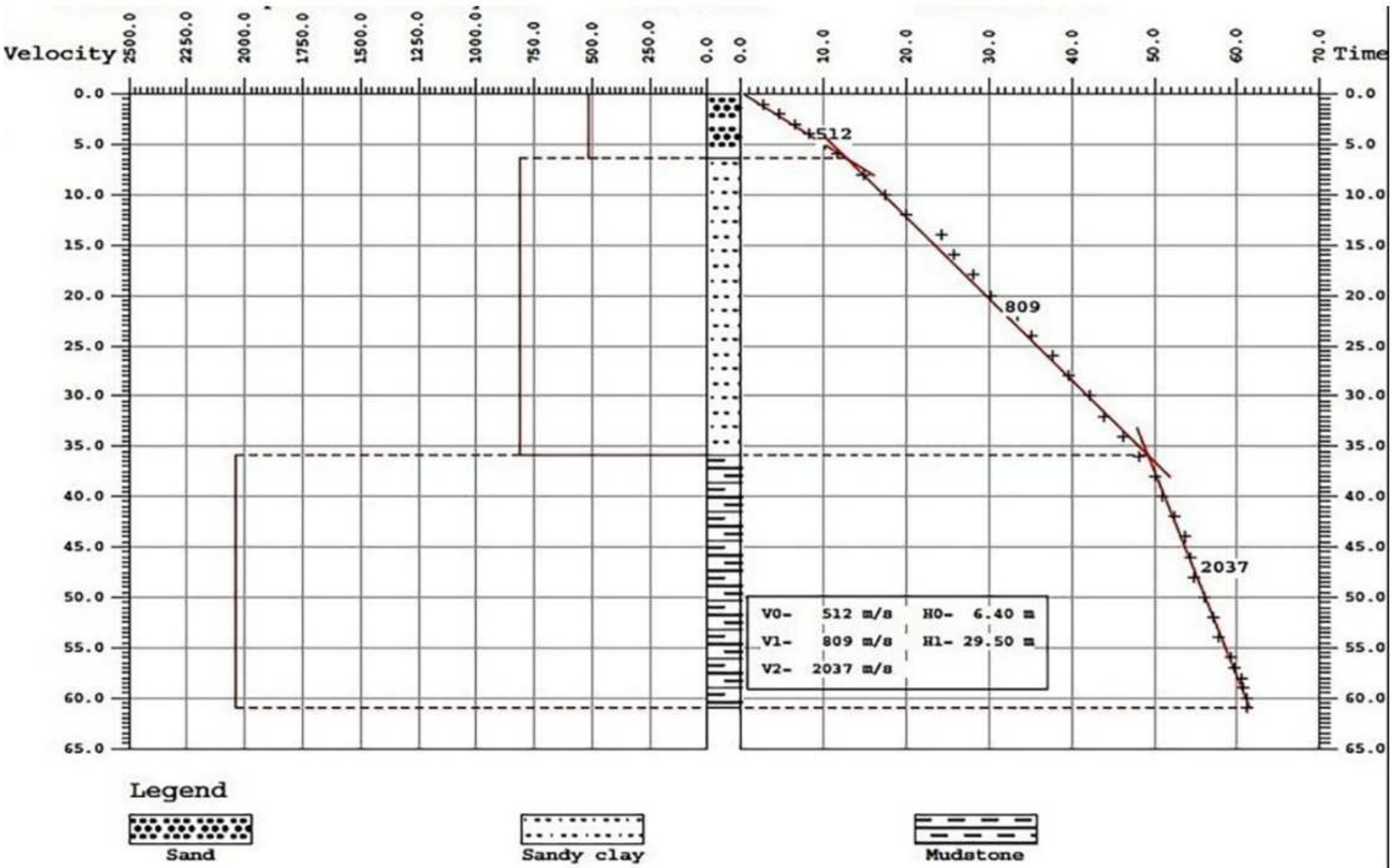

Figure 4

Interpretation of Uphole (UH05_001_209) Survey Data Depicting Three Geologic Layers.

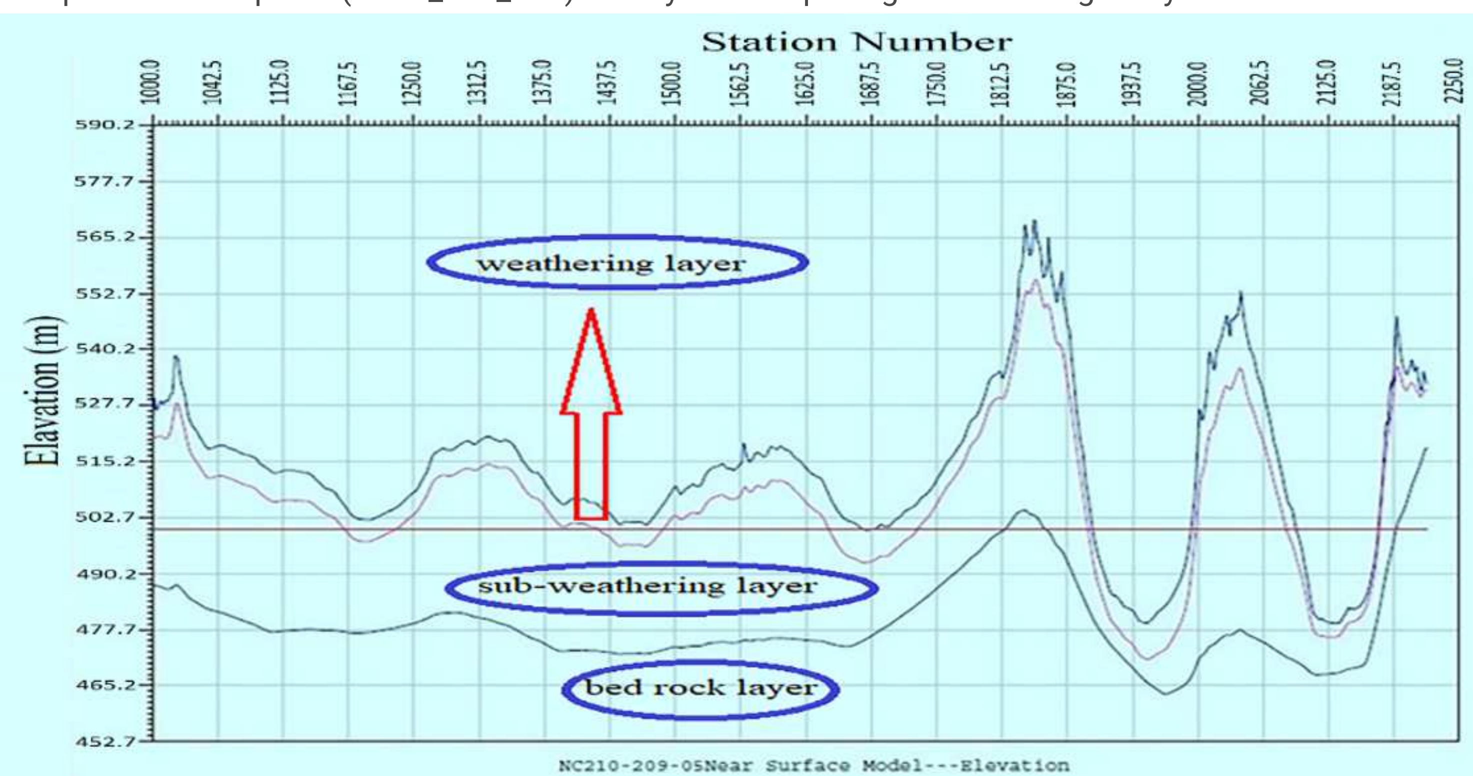

Figure 5

Near-Surface Layer Thicknesses Along Part of Seismic Line NC210-209, Interpolated between Line Intersections and Control Points and between Control Points and Upholes, for the Conventional Method of Estimating Field Statics.

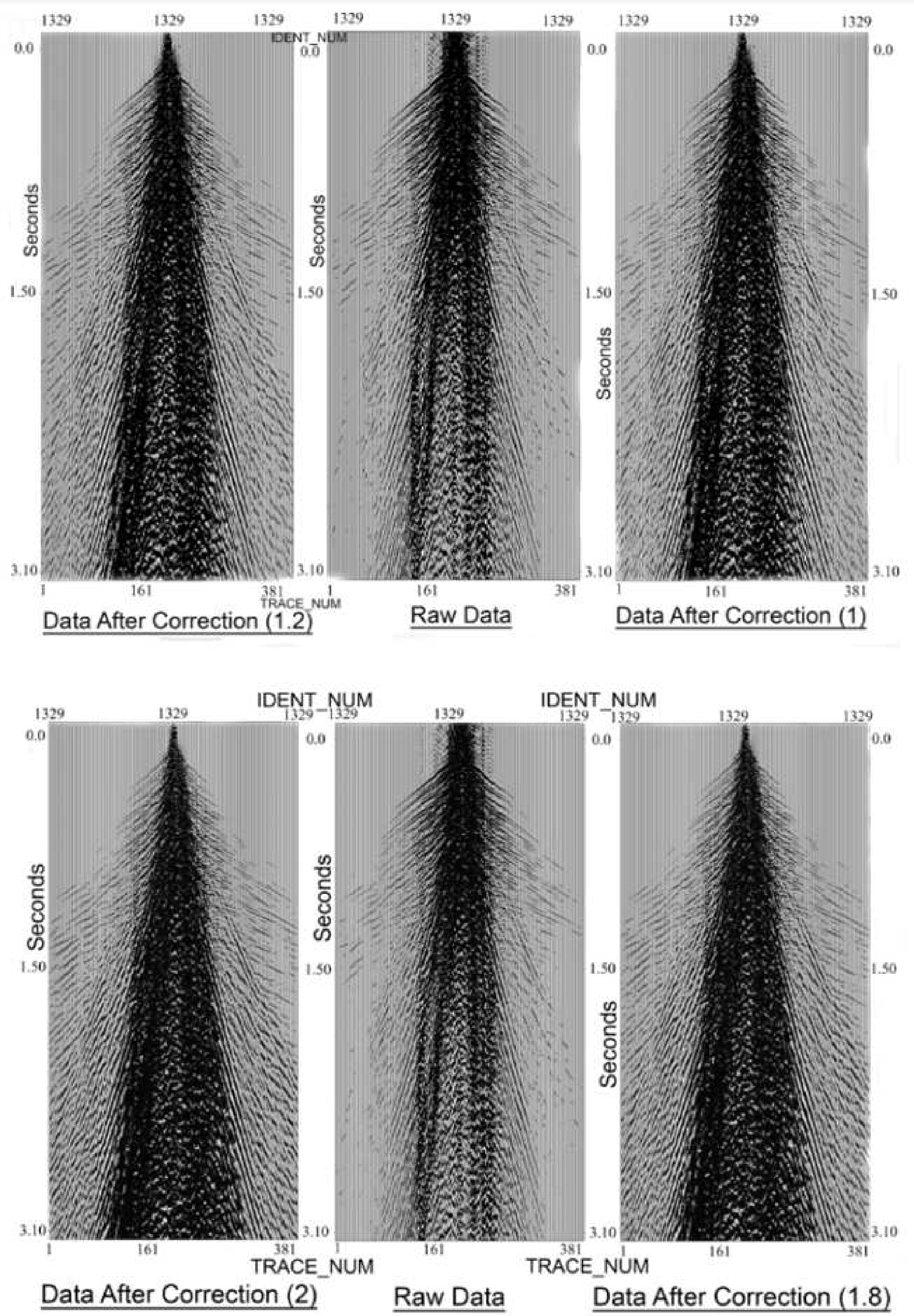

Figure 6

Raw Data and Tested Data with Gain Exponent Values (1, 1.2, 1.8, 2).

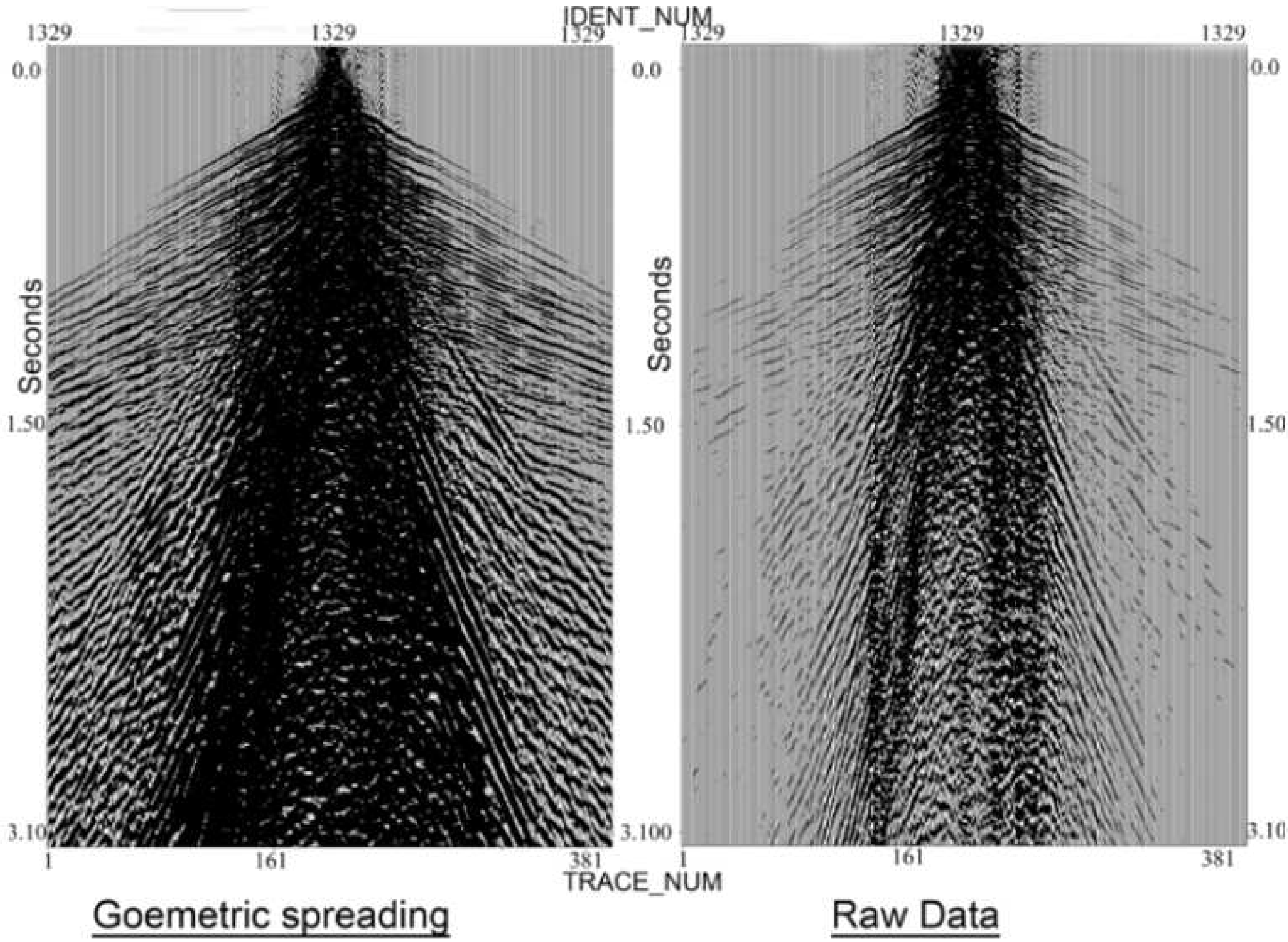

Figure 7

Shows A Row Data and Tested Data with Geometric Spreading Amplitude.

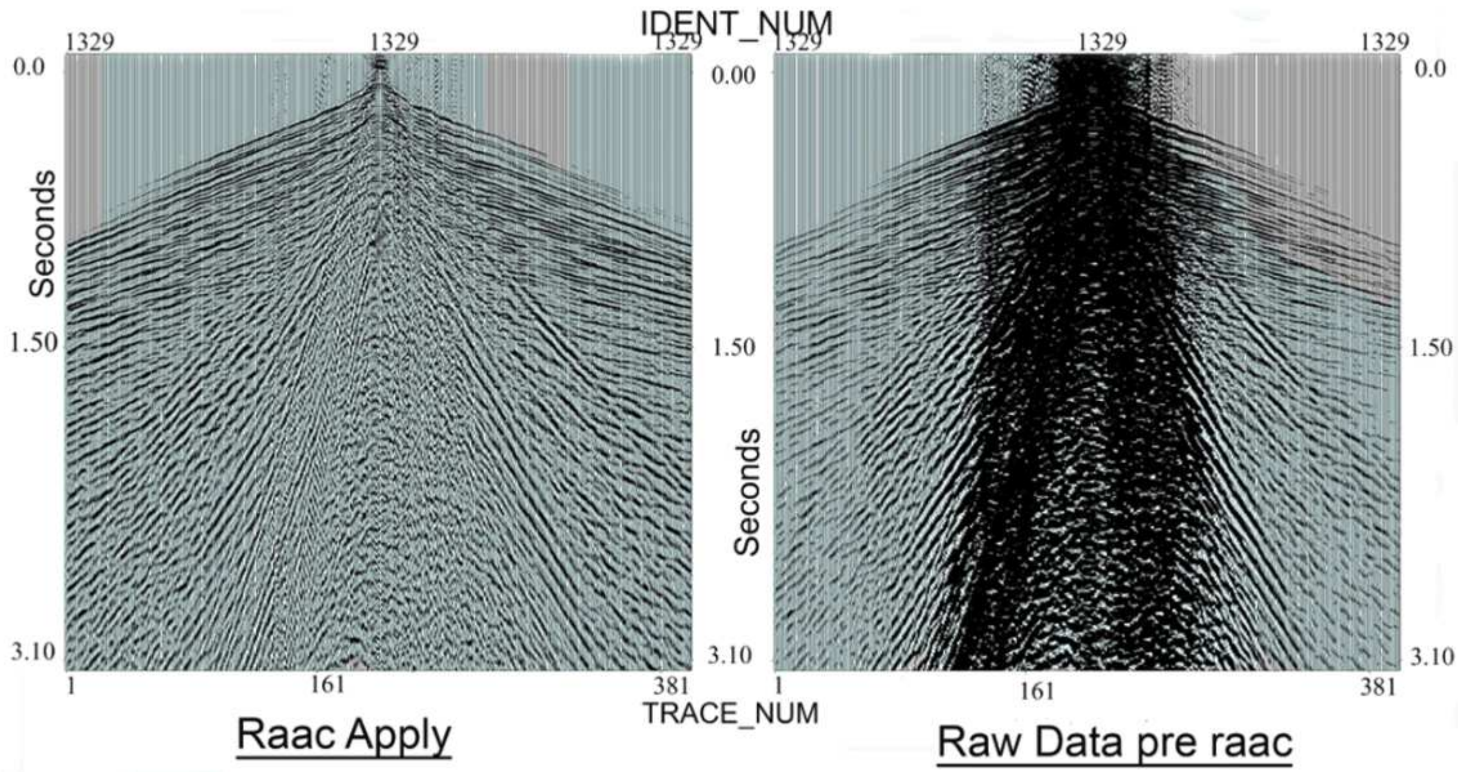

Figure 8

Shows A Raw Data before RAAC and Data after RAAC Apply.

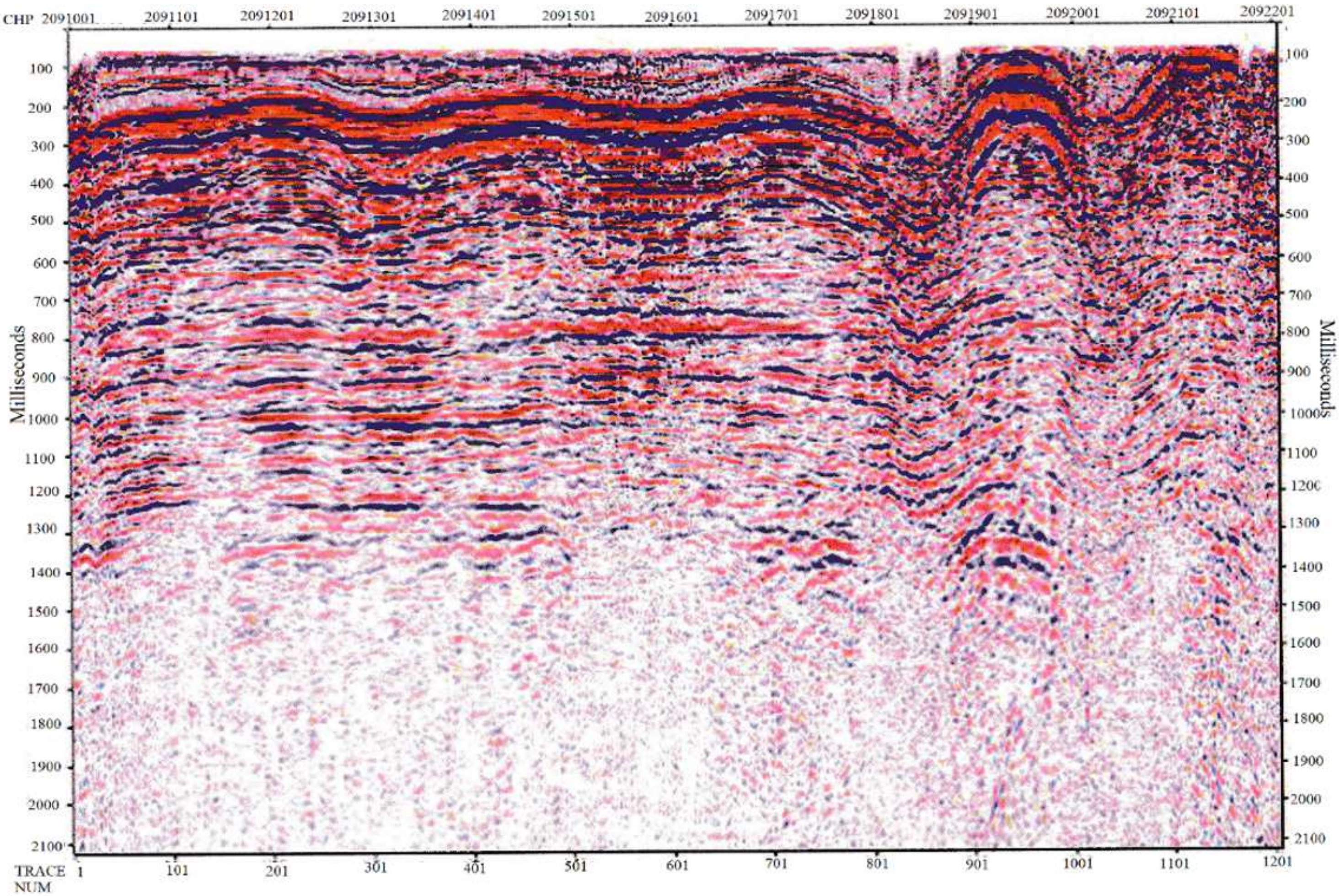

Figure 9

Shows Stack Section to Seismic Line 209.

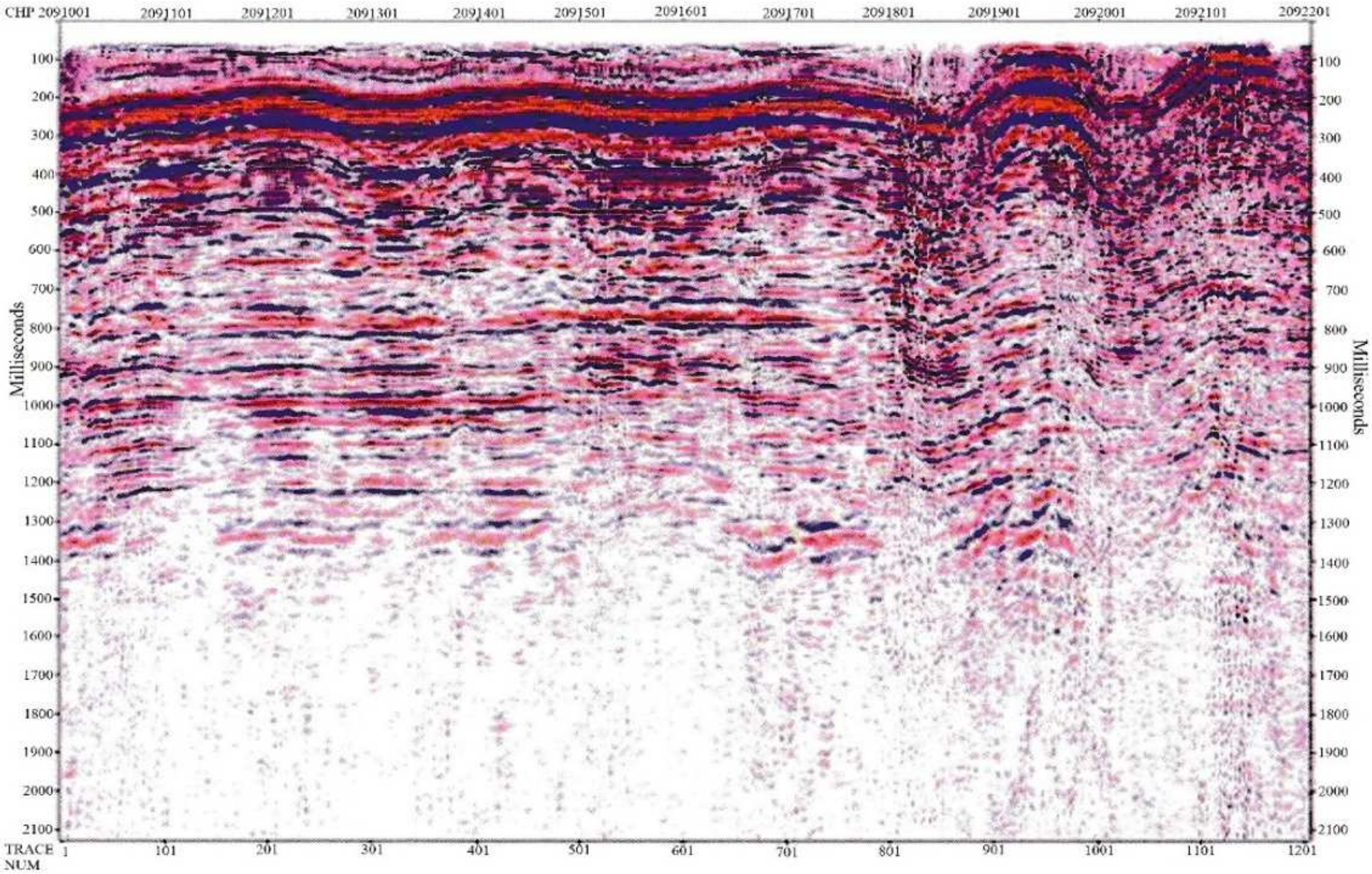

Figure 10

Shows Elevation Static Correction to Seismic Line 209.

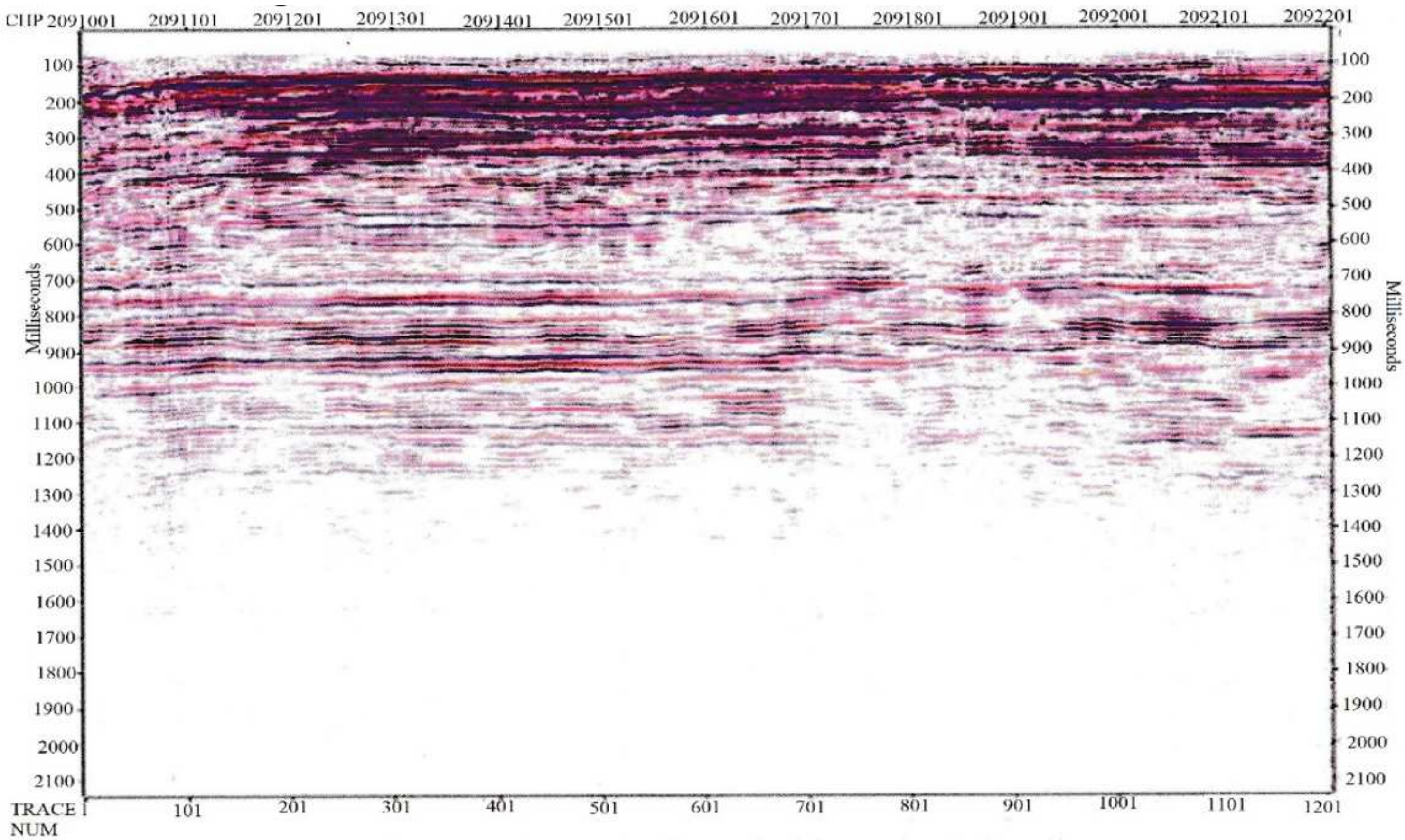

Figure 11

Shows Uphole Static Correction (Datum Statics) to Seismic Line 209.

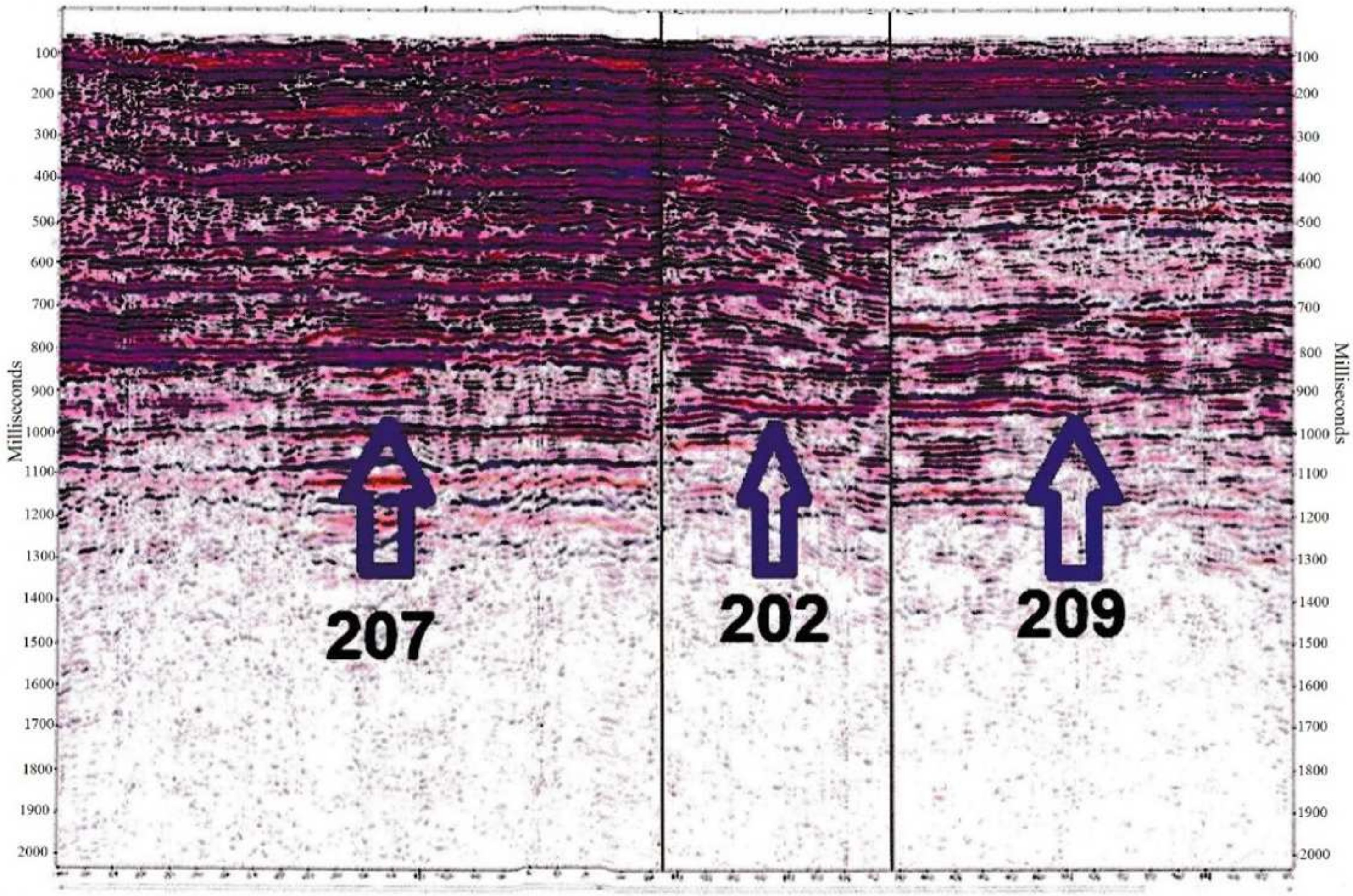

Figure 12

Show Intersection Between Final Correction to Seismic Lines (202,207,209).