Simple Approach to Detect Fractures/Faults and Dim Spot where Data Quality is Poor

Subrata Gangopadhyay, ONGC, India*

gangopadhyay_subrata@ongc.co.in

Keywords

Trace Inverse, Amplitude, Frequency

Abstract

Fault detection carried out by coherency technique gives wonderful results, when data quality is wonderful. Even coherency is also not needed to identify fault. Poor data quality in deeper part of the areas are very challenging to interpret faults or fractures due to loss of amplitude and frequency. A phase volume is not sufficient to confirm the fault/fractures in this type of data. In this paper a very simple low amplitude enhancement technique by inverse of trace method was proposed and applied in Bengal basin data which satisfactorily confirm the fractures in seismic section and found confusing by coherency method. The process is very simple and it can be done by any interpretation software by any geoscientists in no time who knows workstation little bit. This technique also helps to clearly identify dim spot rather most dimmed area among other dim areas.

Introduction

Onland seismic data of Bengal basin is not very good and mostly dominated by CLC (channel levee complex) system. Two recent gas discoveries happened in late Miocene channel sand. The gas is thermogenic in origin and middle Eocene Hooghly shale is the source rock, which is underlain by Late Eocene widespread Kalighat limestone. Charging from Hooghly shale to the younger bed is considered via carrier bed and vertical migration via faults and fractures. But faults fractures are not very clear to satisfy the management of its presence in the area due to poor quality of data **(Fig.1).** In this paper a very simple but useful technique was derived by the author, which helps to strengthen the argument of fractures availability in the area. The method can be used in any type of seismic data also to understand the dim zone in the area which generally difficult to distinguish.

Methodology

Any seismic trace is time series with different amplitude values. As signal penetrates deeper, it loses its frequency content and amplitude. A seismic trace can be written as below.

Trace = f [(t_1, a_1), (t_2, a_2), (t_3, a_3)..................)].

Here a_1, a_2, a_3 are the different amplitude values at time t_1, t_2, t_3……etc.

Now if $(\text{Trace})^{-1}$ is done, then it will be

$(\text{Trace})^{-1}$ = f [(t_1, a_1^{-1}), (t_2, a_2^{-1}), (t_3, a_3^{-1})………)].

Fig.1 Seismic section showing Bengal Onland data quality

Think a_1 is a very high value, say 10^5 then a_1^{-1} will be $10^{-5,}$ which is a very low value. Same way if a_2 is a very low value, say 10^{-4}, then a_2^{-1} will be 10^4 which is very high value. So, by having this we can see that amplitude values are flipped. Now a seismic volume is just the aggregation of traces with space variation. So,

Seismic Volume = Cluster of traces in X and Y direction.

So, in this process a new seismic volume 'A' is derived by doing

Seismic Volume 'A' = $(\text{Original Seismic Volume})^{-1}$

After that some high value integer number is multiplied to get the good amplitude range in the new volume. So, Final Volume = (Seismic Volume A)*(integer number). The high integer value is decided on the basis of amplitude availability present in the data to give an equal boost throughout the data.

Above is the simple derivation process which can be done in any interpretation software. But this produce a very interesting result. In general, any fault or fractures there are discontinuities, and there are sharp edges. In those discontinuous zones amplitude diminishes and becomes almost zero or null value or very low value. So when this process is applied it boosts up those faded zone in vertical linear fashion (if it is a fault/fractures), which is become confusing in low quality, low amplitude data and fails to be detected by coherency. It just the flipping of amplitudes in the same signal keeping the frequency and phase remain same.

Interpretation

This work is applied to one of the Bengal data to see the fractures/faults in the area. Fig.2**,** below shows, an original seismic volume of the area, where arrows shows fault/fractures through which migration took place from deeper Eocene source rock to Mio-Pliocene section. Strong reflector is the Late Eocene Limestone.

Fig.2 Original Seismic volume

The vertical migration through limestone is not explainable in the area, as this strong reflector i.e Kalighat limestone is widespread, and management is not convinced about the presence of any fault of fractures from the seismic. Phase volume was tried **(Fig.3),** but nothing satisfactory is seen.

Fig.3 Instantaneous phase of original Seismic volume

Coherency (Variance) volume was also prepared to see visualize the fault/fractures/discontinuities. But clarity was not seen. **Fig.4,** displays the Coherency (Variance), volume below.

Fig.4 Coherency (Variance) volume

Finally, by using above methodology, a fresh in-house volume was prepared, which is shown in **Fig.5.** In this volume linear vertical striations are

Fig.5 Prepared Volume

Seen very clearly which was not found in Fig.2, Fig.3 and Fig.4.

In the prepared volume, it is easy to see the differences from original seismic volume. In the prepared volume high amplitude signal is suppressed and low amplitude signals are boosted up. Zero line is also highlighted, which helps to identify bed edges very clearly. Moreover, in that same logic if any low amplitude gas sand (Dim spot) is present, it will also be heightened up, hence it will help to identify the best dim spots, among other low amplitude areas.

Below are few figures which will help to do comparison between various volumes, prepared during studies on same data, and establish the claim of the author in this paper. This process helps to explain the charging model in the area via vertical migration through faults/cracks etc.

Fig.6 Different Volumes Comparison

Fig.7 Different Volumes Comparison with fault/cracks interpretation

Fig.8 Seismic Volume and Prepared Volume

Fig.9 Prepared Volume (Interpreted and un-interpreted)

Above described procedures, is designed by the author and shows the data amplitude improvement in low amplitude zones. It is clear from the study that faults/fractures/Cracks are many times masked by the poor data quality and low amplitude level, which may be caused due to various reasons, including the inherent geology of the area, and the present prepared volume is helpful to see those hidden cracks in the data. In the present study onland seismic data is taken from Bengal basin, India, and procedure is applied on it. Initially in the Fig.1, general data is shown of the basin, where different time levels are marked. This basin shows the gradual monocline dip, with constant sedimentation rate. Most of the sections are almost low amplitude level. No faults or cracks are clearly visible in the section, by which any interpreter can claim the vertical migration pathway through the strong reflector of limestone. Fig.2 is original seismic volume, Fig.3 is the instantaneous phase volume Fig.4 is the coherency volume of the same data of a seismic line, within a same time window. In those figures some arrows are shown, where some discontinuities in the area are tried to be interpreted. Fig.6 and Fig.7 are shown three volumes side by side of same time zone. An area is identified by an ellipsoidal ring where main focus is given. In Fig.6 arrows are shown as probable faults, where those are interpreted in Fig.7 as faults. These two figures are put one after another to show the comparison between interpreted and un-interpreted sections, which readers can have their own opinions, about the claim made by the author in this paper. Fig.8 to Fig.9, more examples are added, which clearly supports the author's idea on newly prepared volume. Coming to the detection of dim spot rather dimmest spot, within dim zone, same technique can be used as it heightened the low amplitude. And within the heightened amplitude it is easily can be seen that which one is the most heightened, because most heightened means maximum dim amplitude within dim area in the original volume. Finally conclusions about this new technique can be jotted down below.

Conclusions

1) This technique is very simple and unique, cost and time effective and can be carried out by any interpretation software.

2) Vertical lineation in the poor data quality area can be confirmed as fault by this process by interpreter, which was previously doubtful.

3) As low amplitude is increased and high amplitude is supressed, identifying maximum Dim area is very easy, because in original data all Dim areas are generally same colour as white. Different colour scheme also can be used to identify those zones.

4) This technique is applied in one of the 3D data of an Indian basin, where after acquiring 3D data recently, same problem of cracks identification is not resolved. So, this process can also be a first-hand information, about the cracks and faults in the area before going to a costly 3D acquisition. Applying this process it was found easy to convince management about the probable presence of cracks/fractures by some visual means in the area, which was previously couldn't be solved by available technology in the market.

References

1. Biswas, B. (1963): Geology of the Bengal Basin with special reference to stratigraphy (unpublished ISPP report).

Acknowledgement

Author is indebted to ONGC, and ED, Basin Manager, MBA Basin, Sri D. C. Pant sir, for his permission to publish this paper in the technical forum. I also express my gratitude to block manager Andaman, Sri Sanjoy Goswami, GGM, who always trusts me about my technical knowledge. Special thanks to Madam, Sayani Mondal, CG, who has helped me provide the data on which work has been carried out. Last but not the least I also express my thanks to Arijit Sahu, SG, who at the last moment had inspired me to write this paper.

Conflict of Interest

The views expressed in the present paper is solely the author's view, and not the view of the company. Author declares that there is no conflict of interest.