Poststack Driven Prestack Deconvolution (PPDEC) for Noisy Land data And Radial Trace Mixing for Signal Enhancement

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Summary

Land 3D data is historically very noisy causing various signal enhancement problems. Single trace deconvolution in particular fails to obtain a reliable estimate of the multiples on such noisy traces causing ineffectively deconvolved results. Here we introduce a method that has locally been known as "Al Burj deconvolution" (named after the project on which the method was first derived) as a way of reducing noise from input traces before deconvolution operators are designed. As post- NMO stacking is used for this procedure we call this process, more properly, a post stack driven prestack deconvolution method (abbreviated as PPDEC from here on). In this paper we describe the method and give examples of successful deconvolution applications. We also show that the Radial mixing operation (inherent in the PPDEC method) for deconvolution design can also be used as a powerful noise attenuation algorithm, which we call Radial Mix.

Introduction

Noisy land data has traditionally been difficult to interpret due to loss of resolution as well as the presence of ineffectively deconvolved multiples. It has recently been reported (Schjolberg et al, 2008) that reprocessing by using the PPDEC method has allowed successful interpretation of data from Oman leading to the discovery of oil. Here we aim to illustrate the idea behind the PPDEC method and show its application to some field data.

Field data and shot array forming via radial mix

The example data we use to illustrate the method has been recorded as part of a wide azimuth land survey leading to 8791 fold common receiver gathers. The common receiver domain provides a dense areal distribution of shots and this domain is therefore suitable for various noise reduction schemes before deconvolution. Shot x-y coordinates of part of such a common receiver gather are shown in Figure 1. An inline of shots from this gather are shown in Figure 2. In this domain, and for each input trace, (post NMO), one can find all of the traces within the neighbourhood of the trace (say within a circle of radius R, typically being less than one hundred meters) and stack them to reduce noise on them (and hence obtain a much better estimate of the primary and multiple amplitude relationship). The result of this process is shown in Figure 3. As can be expected from Figure 1 this is a shot array forming process (similar to shot arrays in the field) and is complimentary to missing or short shot arrays that are used in current land acquisition systems. Deconvolution operators can now be designed from these improved S/N ratio traces (Figure 3) instead of the noisy input data (Figure 1). The autocorrelations of the traces in Figure 3 are shown in Figure 4 and gapped deconvolution operators designed from this autocorrelation are shown in Figure 5. Application of these gapped deconvolution operators to the noise reduced traces in Figure 3 produces the record in Figure 6, whose autocorrelations are given in Figure 7. It is clear from the comparison of Figure 7 and Figure 4 that this deconvolution process is a powerful tool in suppressing the ringing on the stacked traces. During this process it is important to allow offset varying deconvolution parameters such as gap, effective operator length and white noise since NMO stretch is present on the traces before deconvolution. Applying these operators to the original data (post NMO) and removing the NMO produces the record shown in Figure 8. To summarise, the noisy traces of Figure 2 are deconvolved with clean and effective operators to produce the deconvolved traces in Figure 8.

The effect of this process on stacked sections are shown in Figures 9,11, and 13 where stacks with no deconvolution (Figure 9) are compared to stacks with single trace decon (Figure 11) and with PPDEC (Figure 13). The corresponding autocorrelations for these stacks are shown in Figures 10,12, and 14. It is clear that ringing present in the stack with no decon (Figure 9) is somewhat suppressed by single trace decon (Figure 11) but is much more effectively suppressed by PPDEC (Figure 13).

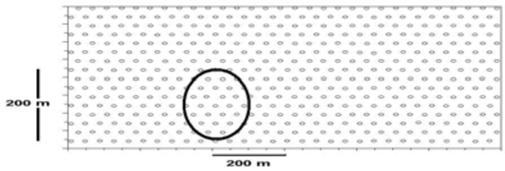

Figure 1 Distribution of shots on a common receiver gather. A small portion of an 8791-fold gather is shown.

Comparison of stacks after PPDEC with the stacks after other deconvolution methods than single trace decon (e.g. as tau-p decon) also illustrated us the power of PPDEC in suppressing difficult multiples. Additionally it has been shown in many areas that the use of PPDEC provides greatly improved seismic to well matches as illustrated in Figure 15.

We show in Figures 16-18 the effect of the radial mix on steeply dipping noise. It is clear from these images that the process is signal preserving to a large degree. The effect of the process on continuity of events is clearly illustrated by comparing a stack of the data with just ground roll attenuation (Figure 19) and with ground roll attenuation followed by radial mix (Figure 20) in a structurally complex area.

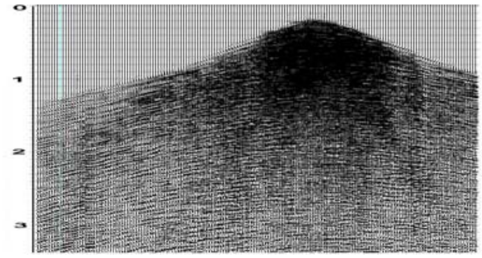

Figure 2. An inline (of shots) from one common receiver gather.

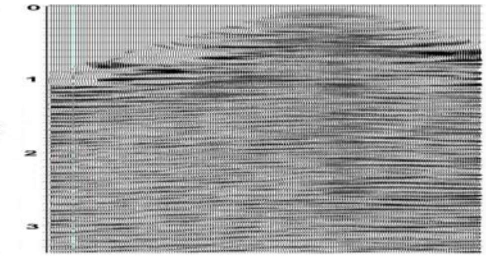

Figure 3. Post NMO radial stacking of the common receiver gather within a radius of 400m. The same inline of shots as Figure 2 is shown.

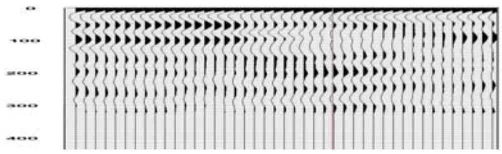

Figure 4. Autocorrelations of traces in Figure 3.

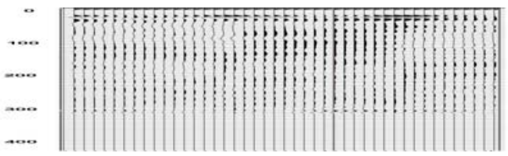

Figure 5. Gapped deconvolution operators designed from the autocorrelations in Figure 4.

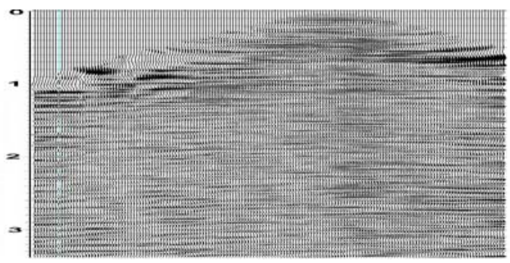

Figure 6. Record in Figure 3 after application of the gapped deconvolution operators.

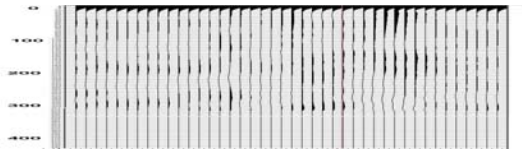

Figure 7. Autocorrelation of traces in Figure 6. Comparison of this figure with Figure 4 suggests that deconvolution application has been very successful.

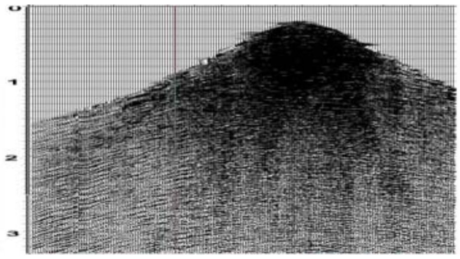

Figure 8. The result of post NMO gapped deconvolution application (PPDEC as described in Figures 3-7.) after removal of NMO.

Conclusions

Multiples on noisy wide azimuth land data can be more accurately modelled and suppressed when deconvolution operators are designed from noise reduced versions of the original input traces but then applied to the original traces. Application of such a method has been proven on many occasions to effectively suppress multiples and provide greatly improved seismic to well matches. The radial mixing operation that produces these noise reduced traces also seems to be a powerful method for attenuating steeply dipping noise which otherwise leaks into stack volumes. With further refinement to the method it will become standard practice on modern wide azimuth surveys which have an excellent aerial coverage of source locations. As the method is both offset and azimuth preserving it is particularly suited for this purpose. The improvement in S/N ratio of the elementary traces also opens possibilities of improved results from deconvolution methods other than PPDEC e.g. surface consistent deconvolution.

Acknowledgments

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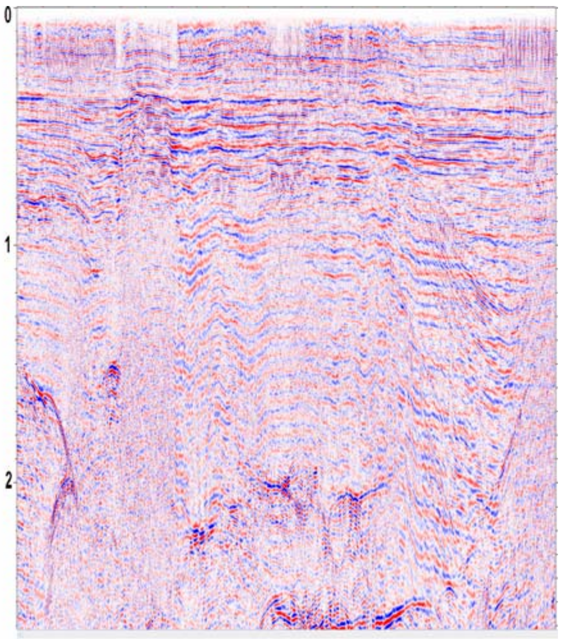

Figure 9. Stack with no deconvolution.

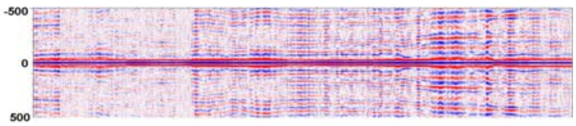

Figure 10. Autocorrelations from stacked traces with no deconvolution in Figure 9.

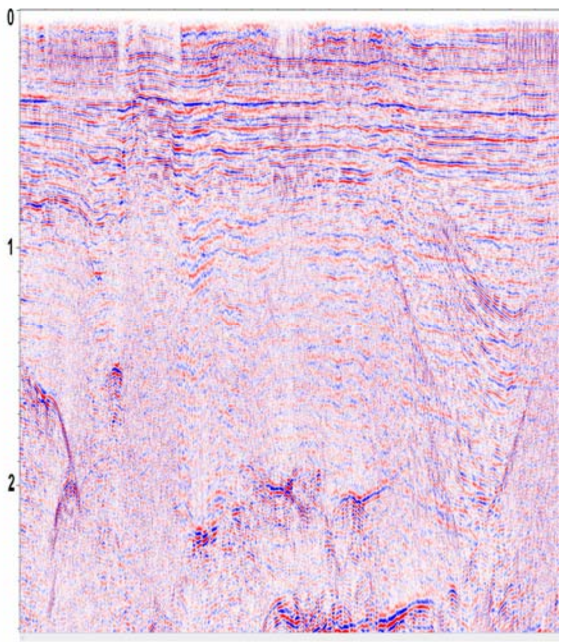

Figure 11. Stack with single trace gapped deconvolution.

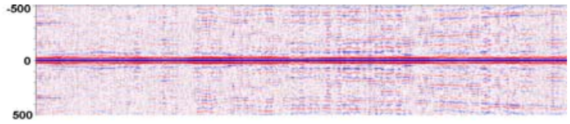

Figure 12. Autocorrelations from the stack of single trace gapped deconvolution in Figure 11.

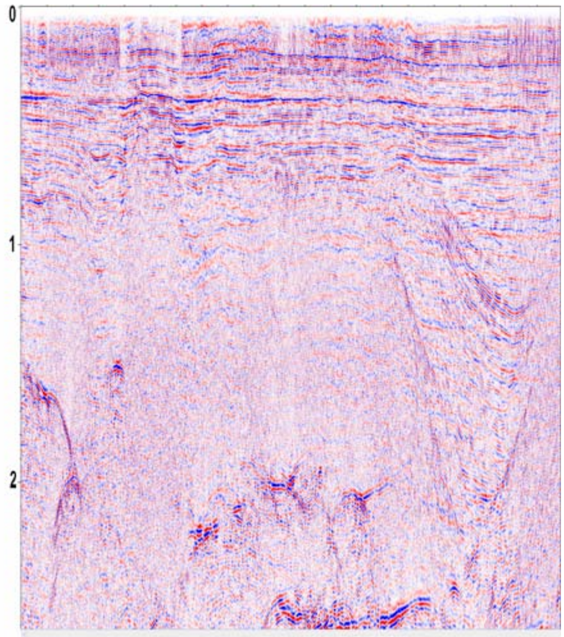

Figure 13. Stack after PPDEC.

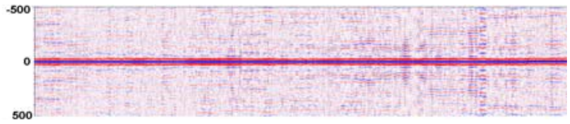

Figure 14. Autocorrelations of stacked traces after PPDEC in Figure 13.

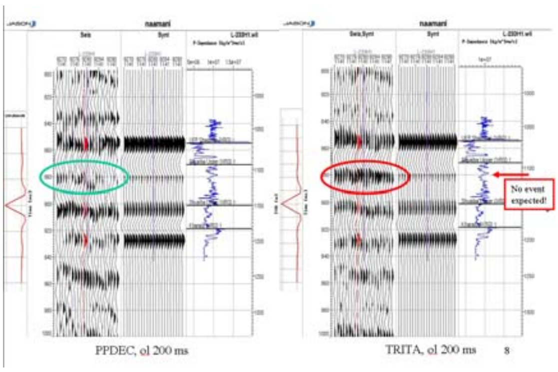

Figure 15. Improved seismic to well match provided by PPDEC (left) versus single trace deconvolution (right).

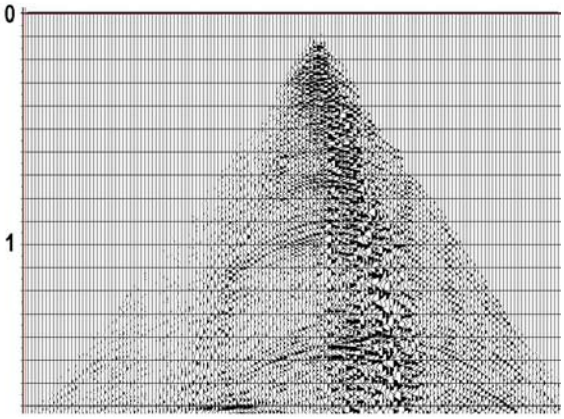

Figure 16. An input record after ground roll suppression.

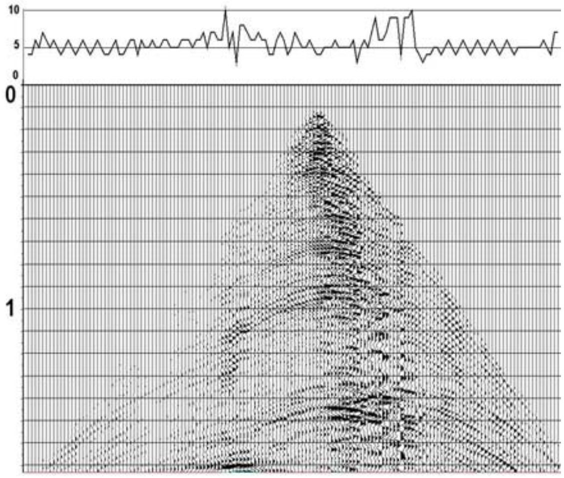

Figure 17. The same record as Figure 16, but after radial mix. The head-plot shows the fold of the radial mix. Irregularities in the fold are caused by irregularities in the surface distribution of shot locations.

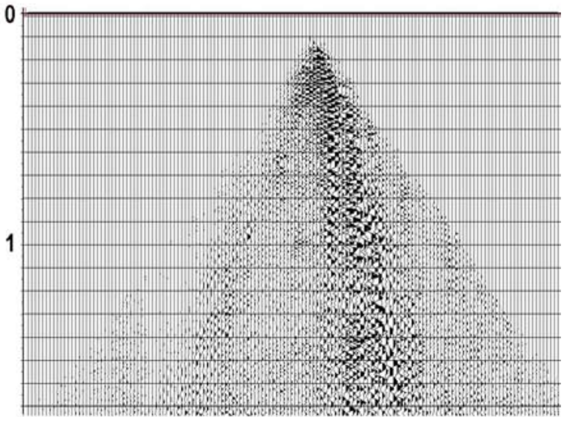

Figure 18. The difference between Figures 16 & 17, before and after radial mix.

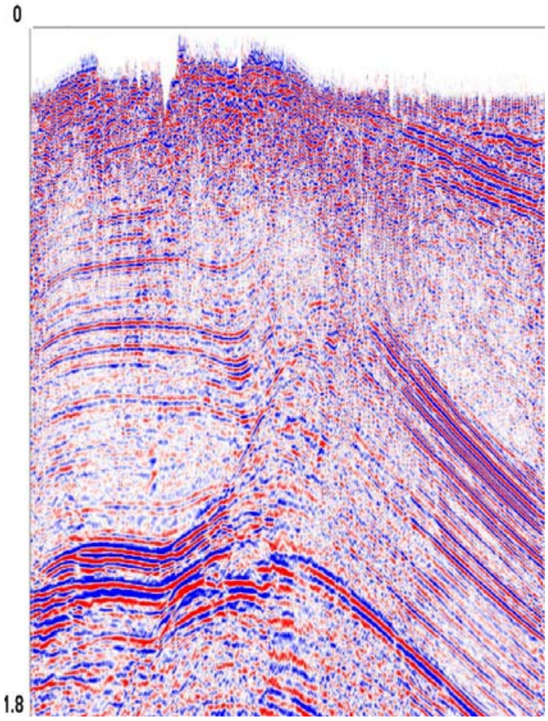

Figure 19. Stack from a structurally complex area (after ground roll attenuation).

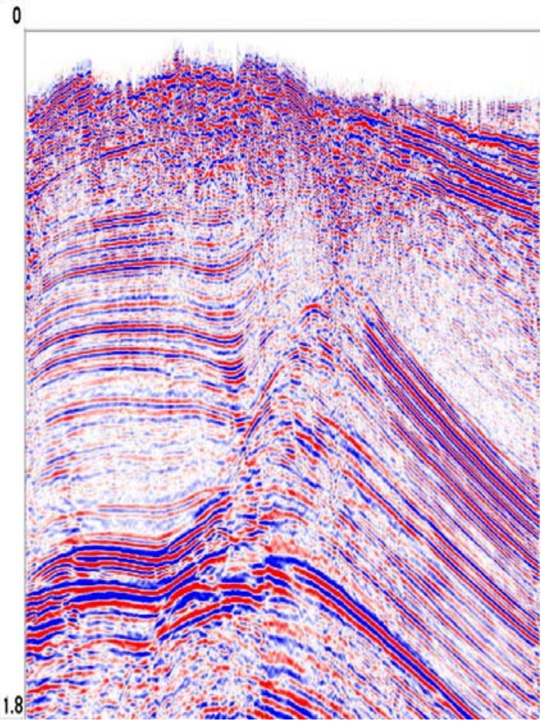

Figure 20. Stack after ground roll attenuation and radial mix.

EDITED REFERENCES
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