A New Method of Multiple Attenuation: Multiple Identification and Subtraction (II)

Wen-Jing Wu*
Apoterra Seismic Processing Ltd., Calgary, Alberta, Canada
wjwu@apoterra.com

Summary

The conventional multiple attenuation procedure would damage AVO signal, since the patterns used in the procedure exclude AVO signal. We find that the multiple identification and subtraction (MIDAS, Wu, 2008) based on pattern identification, damages AVO signal much less than Radon transformation methods, which is solved by the best fitting of input data. To preserve AVO signal from multiple attenuation a simple AVO representation is included in primary patterns. The new method of MIDAS with AVO preservation presented in this paper improves AVO signal preservation significantly.

Introduction

We found that the noise, random and/or coherent, interferes with multiple attenuation in MIDAS less than in Radon transformation method. Figure 1(a) is a CMP gather of a real data set. Obviously, the signal is damaged by the noise in near offset traces. Multiple-attenuation by Radon transformation smears the primaries into the near offset traces (Figure 1(b)), and MIDAS does less (Figure 1(c)). The efforts to preserve amplitude from multiple-attenuation can be found in the literature (e.g. Hu *et al.* 2002). It is well known and it is not difficult to understand that the conventional multiple-attenuation would hurt AVO signal more or less at least for most of real data cases. The reason is that the patterns of primaries exclude AVO signal in the conventional multiple-attenuation procedure. From synthetic data and real data tests we found that MIDAS method hurts AVO signal significantly less than Radon transformation method, which I will explain in the section examples. We also found that the high-resolution Radon does not preserve AVO signal better than normal Radon method. However it is important to preserve AVO signal from multiple attenuation, if AVO analysis is required. For this purpose I would like to present a new method of MIDAS with AVO signal preservation.

Method

The amplitude of a component (or pattern) in the conventional multiple-attenuation is constant, i. e. the amplitude is a function of t_0 and v (or equivalents) only in Radon domain, here t_0 is the time at offset $x=0$ and v is velocity. It is not a function of offset. The AVO signal would not be preserved as a primary and be treated as coherent noise in conventional multiple-attenuation. In both Radon and MIDAS, the amplitudes of one pattern are constant, which excludes AVO signal. To preserve AVO signal from multiple-attenuation, the amplitudes of one pattern must change with offsets. It means that the Radon domain is no longer a two-dimensional space ($t0$, v); it is a three-dimensional space (t_0, v, x). General speaking, a model with more parameters would have the ability to describe input data more accurately, but it reduces the stability of processing. Here I use most simple formula to describe AVO signal:

$$A + Bx^2 \quad (1)$$

or

$$A + B sin^2 \theta \quad (2)$$

where A and B are two parameters, x is offset and θ is injection angle. If using (2), a velocity model is required to determine θ by ray tracing. In order to preserve AVO signal from multiple-attenuation two parameters A and B are used for one pattern instead of a constant A only, but it is only restricted to primaries for which we want to preserve AVO signal. In the new method we identify and preserve primaries with AVO signal based on above representations and identify and remove multiples as the normal MIDAS.

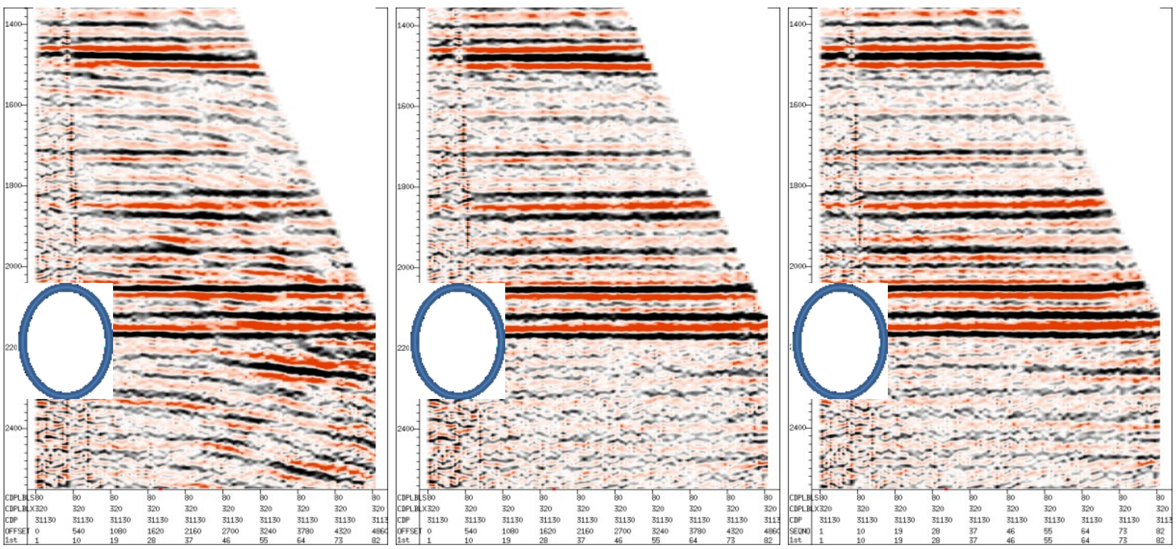

Figure 1: (a) A CMP gather of a real data set; (b) after MIDAS; (c) after Radon.

Examples

We found that the general MIDAS reported last year damages AVO signal less than the Radon transformation method. Figue 1, a real data example shown in the CSEG annual meeting presentation last year, indicates that noise influences the multiple-attenuation in MIDAS less than in Radon transformation method, as discussed above. The reason might be that the Radon transformation method, based on the best fit to input data by least-squares sense, treats signal and noise equally, and MIDAS, based on pattern identification, does not. A simple synthetic model was created to investigate the effect of multiple-attenuation on AVO signal (Figure 2a). The results of the multiple-attenuation, Radon, high-resolution Radon, and MIDAS are shown in Figure 2(b)-(d) and 2(f)-(h), respectively. From Figure 2, we find in this example that the results are improved by the high-resolution Radon over Radon only for primary with no AVO signal, and the high-resolution Radon damages the AVO signals more than Radon. The general MIDAS did better job than Radon transformation method. Figure 2(e) and (i) show that the new method, MIDAS with AVO signal preservation, does almost perfect job to preserve AVO signal from multiple-attenuation. More complicated synthetic models are created for further testing this new procedure. The models include the multiples extracted from a real data set and primaries with different AVO types (see Figure 3) The results of multiple-attenuation by Radon, high-resolution Radon, MIDAS and MIDAS with AVO preservation are investigated. We find that the results with MIDAS with AVO preservation are the best and MIDAS is better than Radon, and high-resolution Radon does not preserve AVO signal better than normal Radon. The input model and the results of one gather are shown in Figure 3 and Figure 4 respectively.

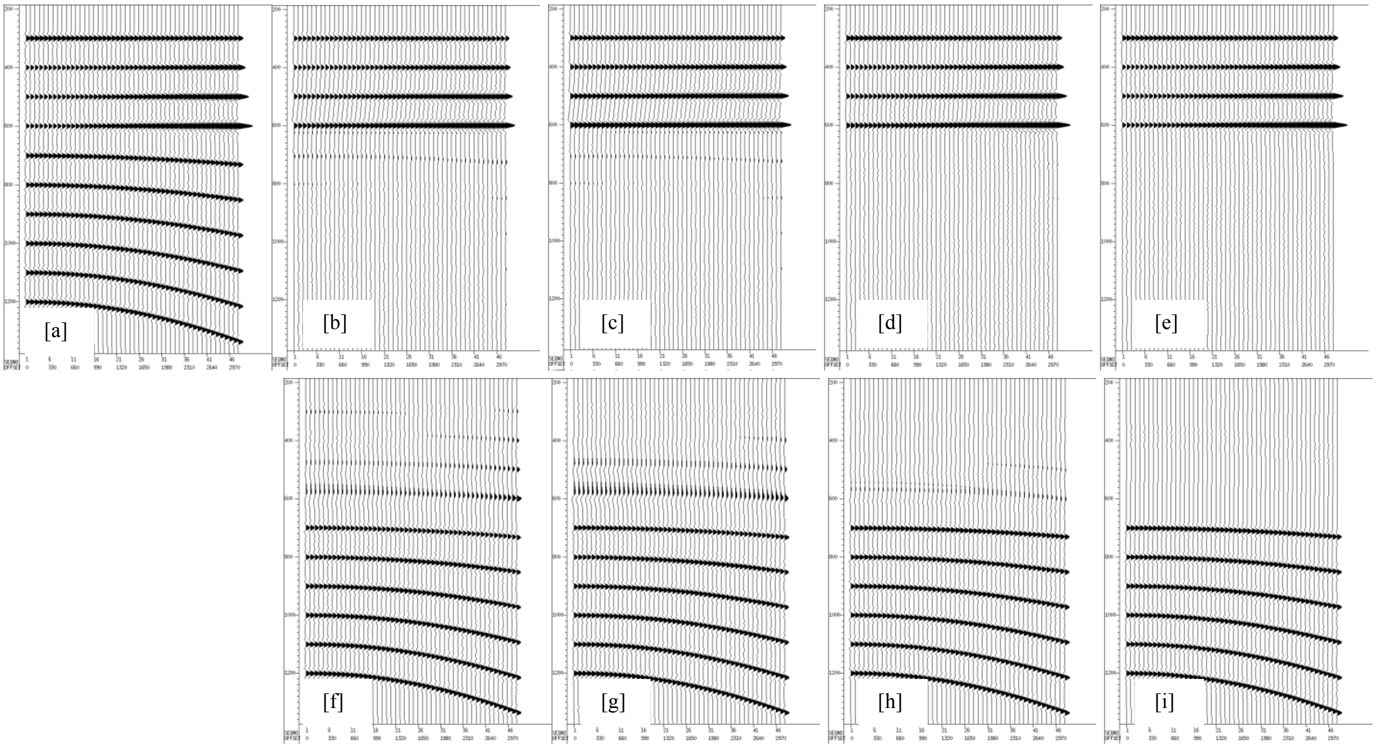

Figure 2: A simple synthetic data example: input gather (a) includes four primaries and six multiples, the first (from top) is primary with constant amplitude, the second to fourth are primaries with AVO signals from weak to strong, and the fifth to tenth are multiples with offsets at maximum offset from 30ms to 120ms. The results of multiple attenuation are shown in (b) normal Radon, (c) high-resolution Radon, (d) MIDAS and (e) MIDAS with AVO preservation. Corresponding removed multiples are shown in (f), (g), (h) and (i) respectively.

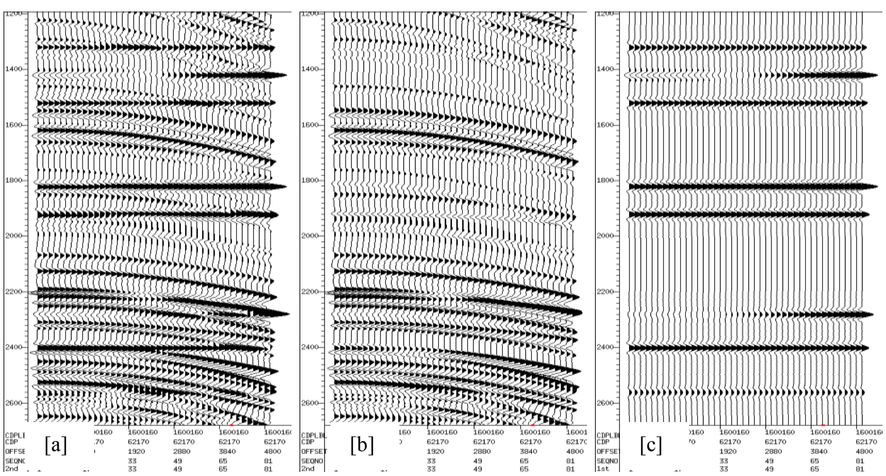

Figure 3: A synthetic data example. An input CMP gather (a) combines the multiples extracted from a real data set (b) and eight primaries (c). The second and sixth primaries (from top) contain AVO signal with phase change, and fourth contains AVO signal without phase change.

Conclusions

The conventional multiple-attenuation would damage AVO signal, sometimes seriously. It is important to preserve AVO signal from multiple attenuation, if AVO analysis is required. The MIDAS I reported at last year's CSEG convention is further developed to preserve AVO signal. A simple representation of AVO signal is used in primary patterns, which would be identified and preserved in multiple-attenuation procedures. Generally speaking, MIDAS based on pattern identification is better than Radon or high-resolution Radon transformation method, which is based on the best fitting of input data. MIDAS with AVO signal preservation much improves AVO signal preservation from multiple-attenuation.

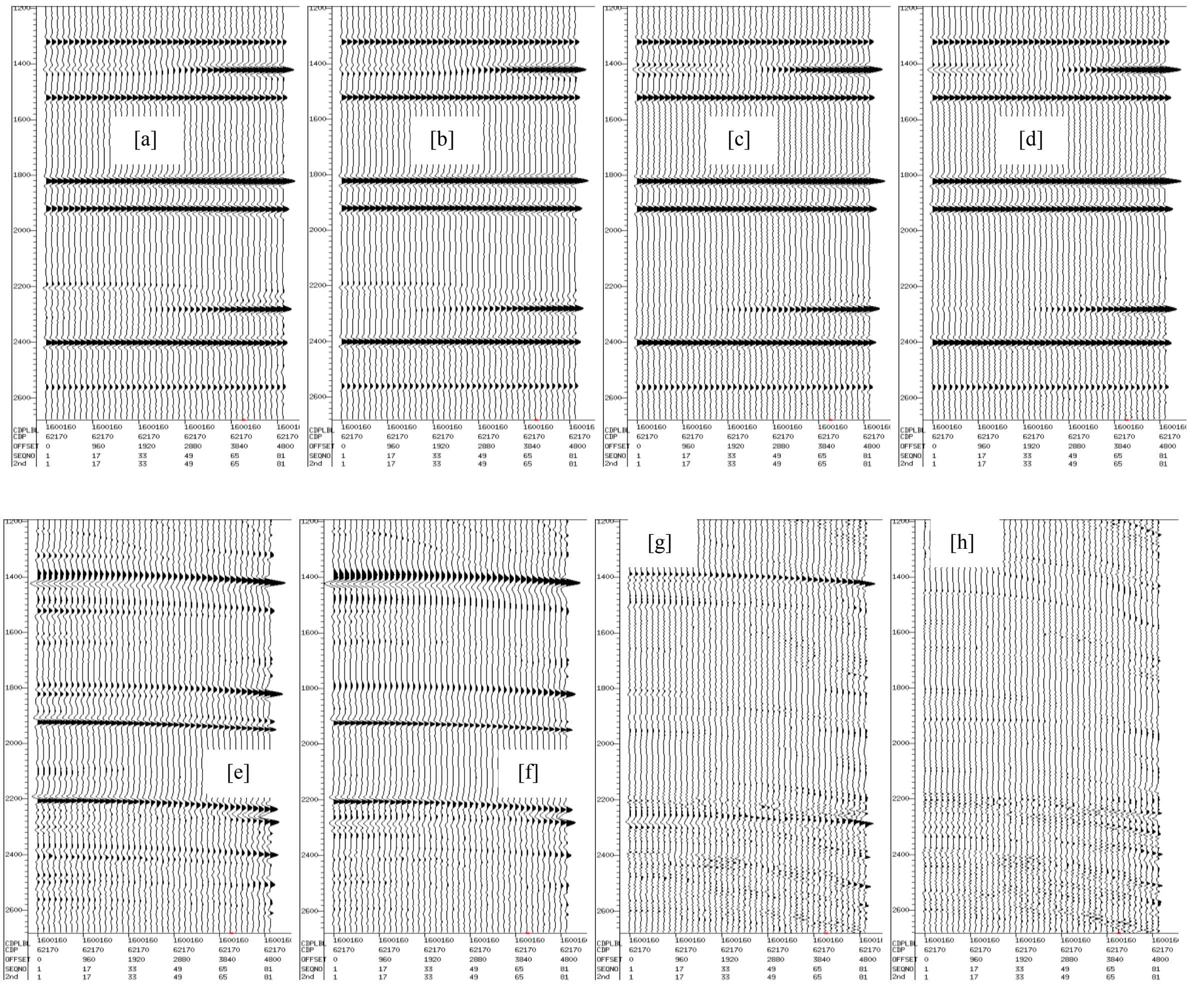

Figure 4: The results of multiple attenuation of the model in Figure 3 by Radon, high-resolution Radon, MIDAS, and MIDAS with AVO preservation are shown in (a), (b), (c) and (d). The differences (the amplitude is magnified by three times) between the results and the input primaries (Figure 3(c)) are shown in (e), (f), (g) and (h) respectively.

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References

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