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Multiple suppression in the image space: A Mahogany field example

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ABSTRACT

Stolt residual migration (SRM) is an effective technique for image processing after migration. It allows us to reconstruct an image corresponding to a velocity different from the original migration velocity. Furthermore, multiple attenuation in the image space (MAIS) is a powerful technique for seismic data processing after migration. Combining these two techniques makes it possible to remove multiples in the image space without accurately knowing the velocity model. The PZ section of the Mahogany field serves as a field data example to demonstrate the advantage of this combined methodology.

INTRODUCTION

Separating multiples from primaries has been a long-standing problem in exploration geophysics. Multiple reflections often destructively interfere with the primary reflections of interest (Foster and Mosher, 1992). Marine data often exhibits strong multiple-reflection problems. However, Ocean Bottom Seismic (OBS) data presents an ideal acquisition setting for removing the receiver ghost by PZ summation (Barr and Sanders, 1989; Soubaras, 1996). However, the PZ summation does not remove all the multiples, and further processing is required.

This paper combines two post-imaging processing techniques: 1) Stolt Residual Migration (SRM) (Sava, 1999, 2000), and 2) Multiple Attenuation in the Image Space (MAIS) (Sava and Guitton, 2003). Integrating these two processing techniques in one process leads to a way of eliminating multiple reflections in areas with unresolved velocity problems. Stolt Residual Migration is used in the prestack domain to obtain an image focused with a different velocity model.

Sava and Guitton (2003) discuss multiple suppression in the image space (i.e., after migration) as an alternative technique to multiple suppression in the data space (i.e., before any imaging operation). Their main assumption is that after migration with the correct velocity model, primaries are flat in angle-domain common-image gathers, while multiples present a residual curvature; therefore, primaries and multiples can be separated using the Radon transform (Foster and Mosher, 1992). However, if we yet do not have the correct velocity model, the primaries and multiples may present a similar residual moveout in the angle domain, and

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they will not be distinguishable by their curvatures using the Radon transform.

The problem we address in this paper is how to discern between primaries and multiples in the image space if the events have similar curvatures. We present a real data example, the Mahogany field, a 2-D OBS data set in the Gulf of Mexico.

METHODOLOGY

The methodology introduced in this paper targets those multiples that are not easily removed with known techniques, for example when stacking normal-moveout corrected seismic gathers does not eliminate all multiples (Foster and Mosher, 1992). In a previous report, Sava and Guitton (2003) introduce a technique to remove multiples after imaging. Their technique consists of applying the Radon analysis in the depth-angle domain instead of the standard Radon analysis done in the offset-time domain. Their main assumption is that primaries and multiples migrated with the correct velocity model for the primaries and transformed into angle domain common image gathers, map to distinctive angles, where primaries are flat and multiples present a residual curvature. Finally, the angle gathers are mapped into the Radon domain, where the multiples can be suppressed.

A potential issue with the previous methodology is the coupled problem of velocity analysis and multiple suppression. It is difficult to obtain an accurate velocity model when multiples are present. Moreover, the previous methodology relies on an accurate velocity model in order to suppress the multiples.

This paper proposes a solution for solving this problem. Our methodology combines two post-migration processing techniques. The first one, SRM, produces an intermediate image with a new velocity information given, by the ratio (ρ) between the original migration velocity and the new migration velocity; therefore, SRM induces a curvature change between primaries and multiples if ρ is significantly different than 1. The second technique, MAIS, separates the primaries and multiples into two different groups, based on their distinctive curvature induced by SRM. This allows us to model the multiples and suppress them from the final section.

Figure 1 shows the basic flow chart to eliminate multiples in the image space. The input data are our best result after processing in the data space, and after prestack migration with our best velocity model at this stage. Such processing may vary and depends on the data set under study. The next step is to perform SRM with a velocity ratio high enough to produce a difference in curvature between the primaries and the multiples (e.g., $\rho = 1.25$). The difference in curvature yields to the application of the Radon transform in the angle domain to eliminate multiples (Sava and Guitton, 2003). Finally, we apply SRM with a ratio that should be the inverse of the ratio applied before (e.g., $\rho = 0.8$).

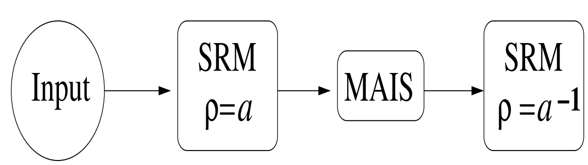

Figure 1: Flowchart for multiple suppression in the image space with no flat events in the angle domain. daniel1-flow [NR]

APPLICATION

The Mahogany field, located in the Gulf of Mexico, is dominated by a salt body structure. One of the data set acquired on this area consists on a 2-D Ocean Bottom Seismic (OBS) multicomponent line. Rosales and Guitton (2004) present the steps involved in the PZ summation that results in the P component section that is now under study. The PZ summation was successful in eliminating the receiver ghost; however, other surface-related multiples, like the source pegleg, are still present after the combination.

The remaining multiples are a problem when performing any migration-velocity-analysis technique. Therefore, we apply the methodology discussed in the previous section to eliminate the remaining multiples. Figure 2 shows three characteristic angle-domain common-image gathers, after three processes: the PZ summation described in Rosales and Guitton (2004), the downward continuation of the sources to the receiver label, and the migration with the velocity model presented in Rosales and Guitton (2004).

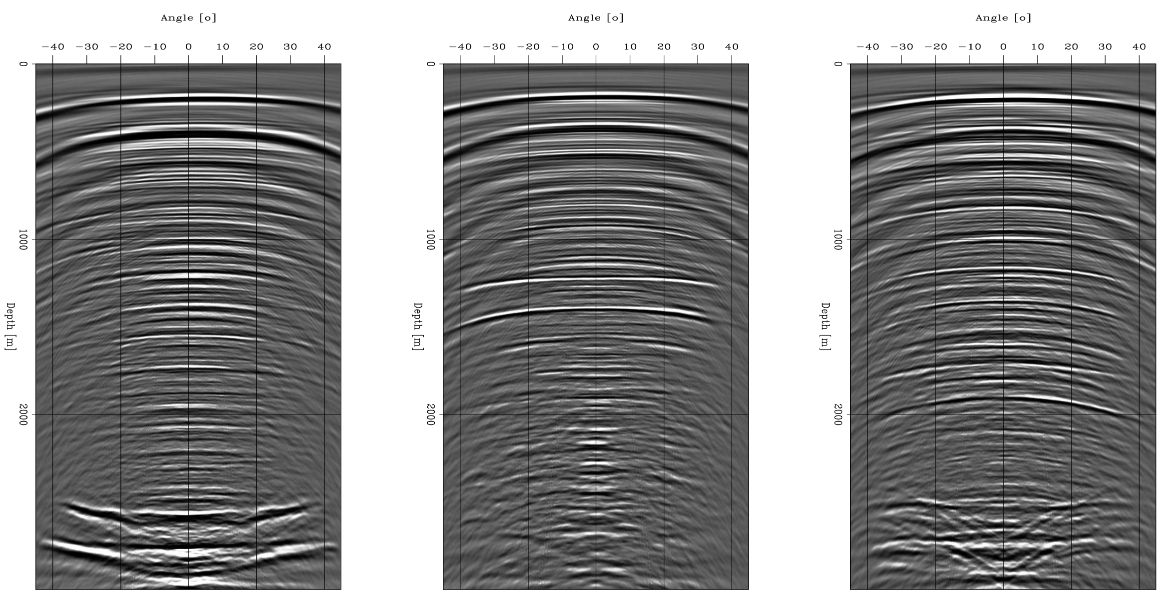

Figure 2: ADCIGS after PZ summation at three different locations. daniel1-adcigs [CR,M]

It is possible to observe a similar residual curvature for both primaries and multiples. Additionally, at this stage the primaries and multiples present a very similar moveout, since the migration velocity is still not perfect. Any migration-velocity-analysis technique done with this data will be biased with the multiple reflections still present. Additionally, Figure 3 presents the same ADCIGs as in Figure 2 but after Radon transform in the angle domain is not easy to distinguish between primaries and multiples; therefore, another process is required.

A residual curvature process will help to separate primaries and multiples in the Radon domain. The advantage of using residual migration (as discussed on the methodology) over residual moveout is that residual migration reduces the effects of image-point dispersal between events imaged at the same physical location but with different aperture angle (Biondi, 2004). Performing SRM with a value of ρ different than 1 (e.g., $\rho = 2.0$) produces a distinct

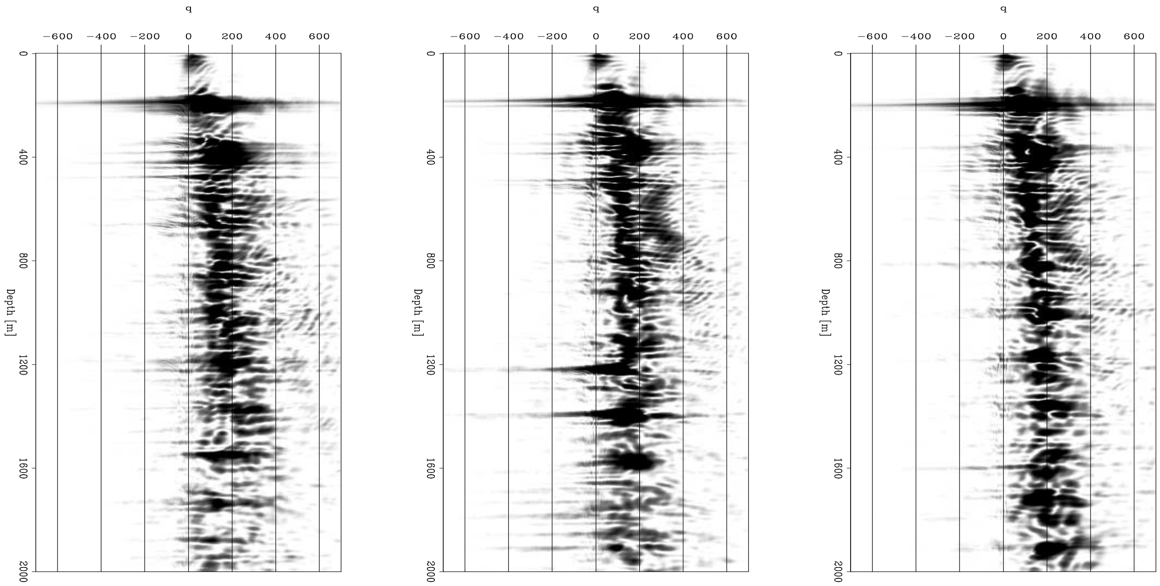

Figure 3: ADCIGs in the Radon domain, before any residual curvature process. daniel1-adcigs.art [CR]

difference between the residual moveouts of the primaries and multiples. Figure 4 shows the same ADCIGs as in Figure 2 after SRM with $\rho = 2.0$. It is now easy to distinguish between primaries and multiples through their distinctive curvatures.

Applying the Radon transform splits the image into two different curvatures; therefore, it is possible to distinguish between primaries (positive curvature) and multiples (negative curvature); additionally, it is possible to apply principles and techniques similar to those discussed by Sava and Guitton (2003) or Alvarez et al. (2004). Figure 5 shows the ADCIGs in the Radon domain. After SRM is possible to distinguish between primaries and multiples, compare the results on Figures 5 and 3. Figure 6 presents the result after eliminating the multiples and applying SRM with a ρ value of $\rho = 0.75$; this result shows a satisfactory elimination of multiples.

CONCLUSIONS AND FUTURE WORK

We have introduced a technique that addressees an important problem in seismic processing: the elimination of multiples in the image space with a not-yet-perfect initial velocity model. The combination of SRM and MAIS yields a procedure that can safely clean multiples from the data before performing any migration-velocity-analysis technique.

This technique yielded satisfactory results when applied to a 2-D line of the Mahogany field. The multiples were separated and eliminated from the primaries in the image domain, while our velocity analysis model was still incorrect.

Because both SRM and MAIS work separately on 3-D data, this technique might be useful

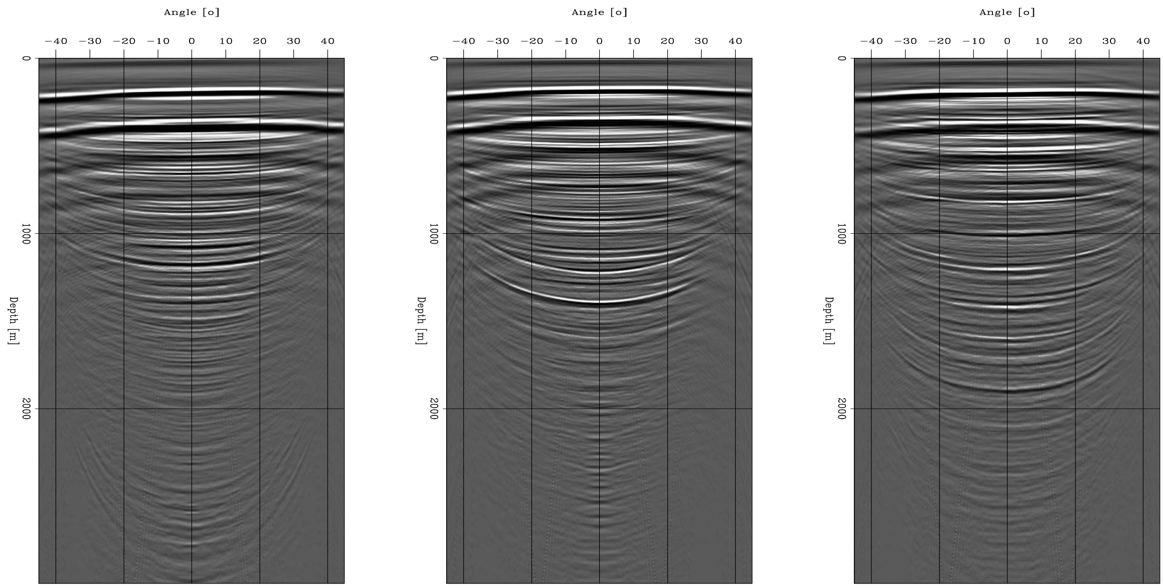

Figure 4: ADCIGs after SRM with $\rho = 2.0$. daniel1-adcigs.srm [CR,M]

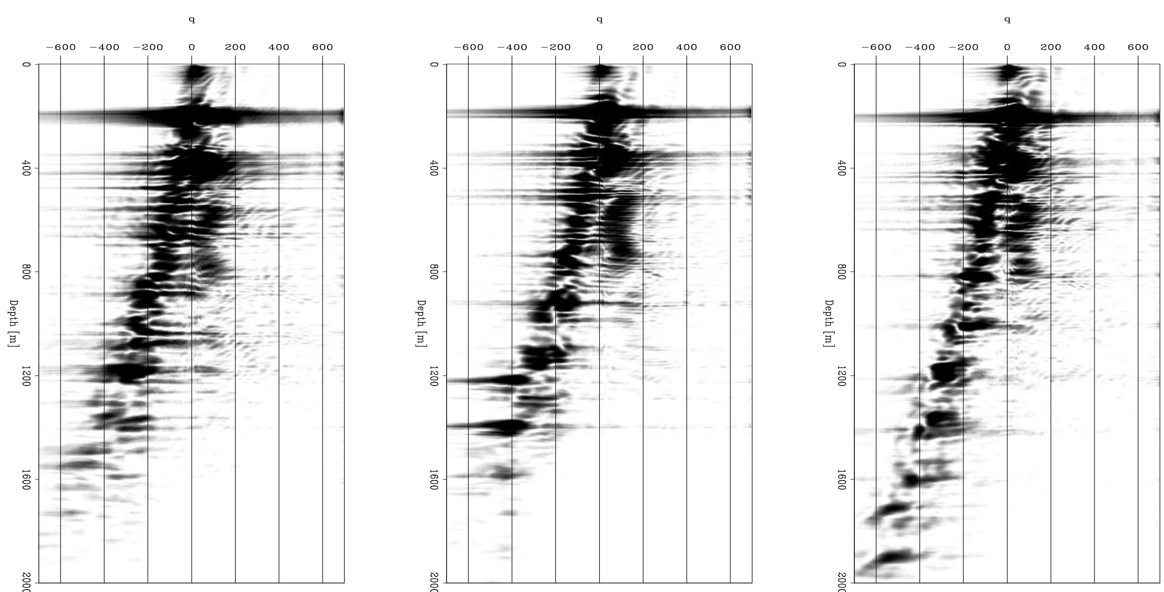

Figure 5: ADCIGs after SRM in the Radon domain. Compare with the ADCIGs in Figure 3 and note how multiples and primaries are split into two different trends. daniel1-adcigs.srm.art [CR,M]

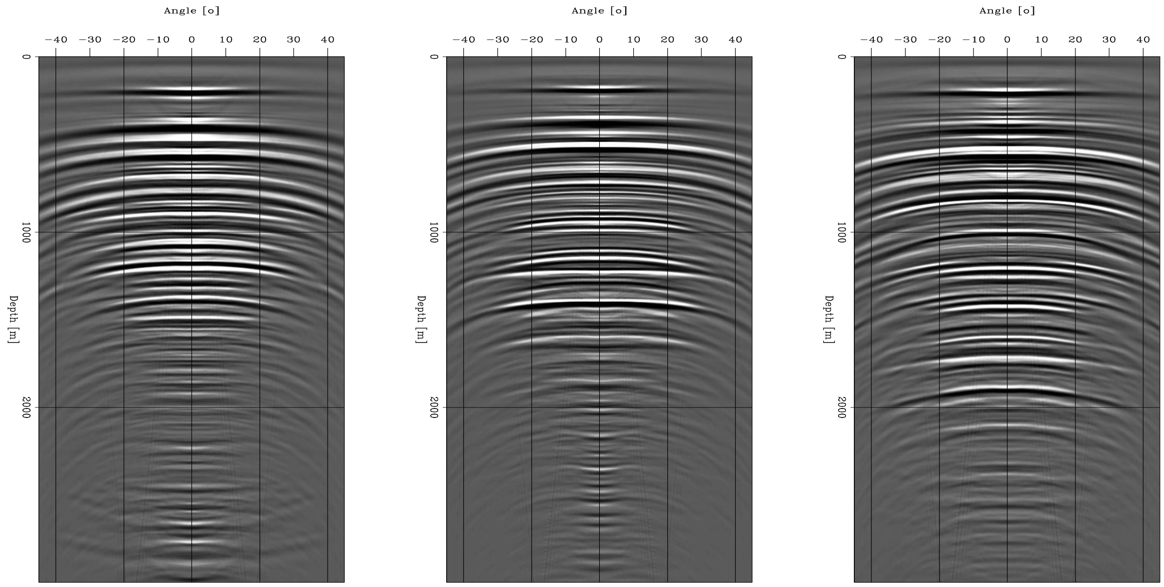

Figure 6: ADCIGS after multiple suppression. daniel1-adcigs.srm.art.isrm [CR,M]

in 3-D for eliminating multiples in the image space, in parallel with estimating a suitable migration velocity model.

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