Migration velocity analysis of field data: preliminary results

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INTRODUCTION

In Al-Yahya (1986), I showed various examples of migration velocity analysis using synthetic data. Those examples demonstrated that prestack migration can be used as a velocity analysis tool. Moreover, residual velocities can be estimated from an initial migration of the data.

In this paper, examples will be shown from marine data, kindly provided by Chevron. The results are preliminary and they are intended to show the applicability of migration velocity analysis to field data.

DISCUSSION

As mentioned in Al-Yahya (1986), two approaches are taken. In the first approach, the data is migrated once and a residual velocity is estimated. The residual migration velocity has to be converted to interval velocity. The data is then migrated with the updated velocity, and so on, until convergence is reached. In the second approach, the data is migrated with constant velocities and "migration velocities" are picked. Here also, the migration velocity has to be converted to interval velocity.

For layered media, interval velocity can be obtained by stripping which removes the effect of the top layers. However, it is in this case that migration velocity analysis is not needed! For the case of general velocity variation, a tomographic correction is one way of

distributing the residual velocity along the travel path of the ray from the source to the diffraction point and back to the receiver.

RESULTS

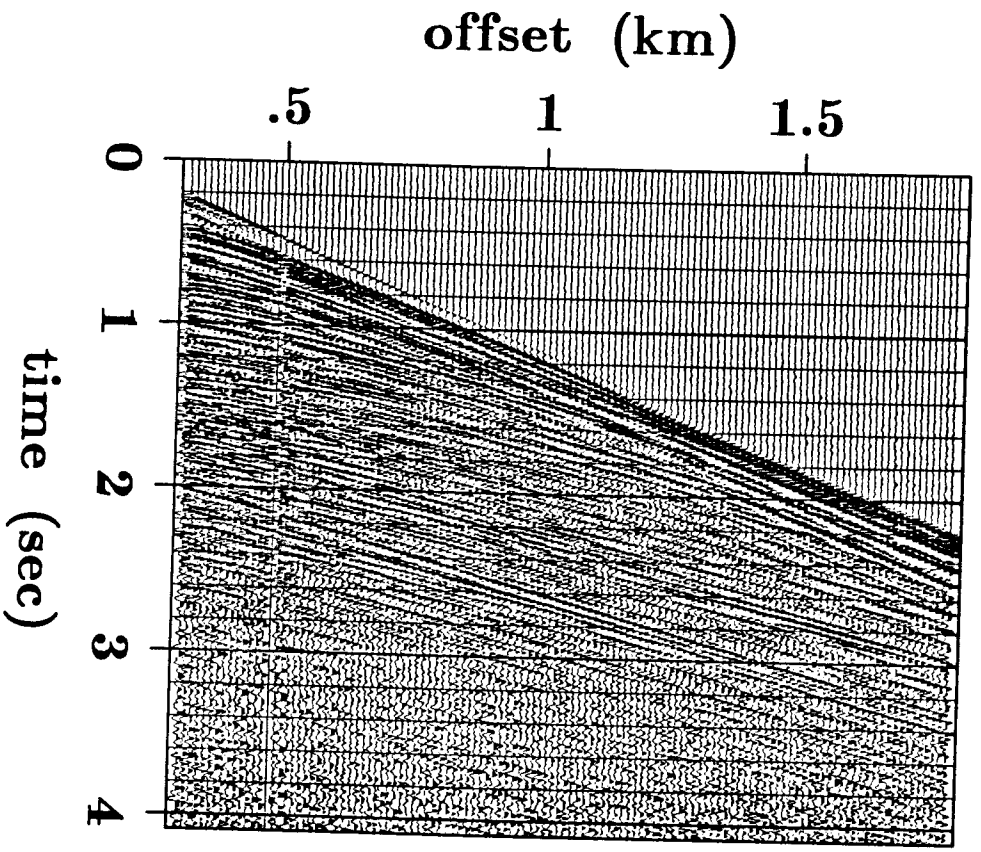

FIG. 1. A typical marine shot gather used for migration velocity analysis.

Figure 1 shows a typical shot gather containing 240 traces, with group interval of 12.5 m. 28 shot gathers were used in this test with shot interval of 50 m. The original shot interval was half of that, but they were resampled, because course sampling over the shot axis can be tolerated in this scheme. The resampling also saves computational time.

Figure 2 shows the result of migrating the gather of Figure 1 with a constant velocity of 1.5 km/sec, which should image the primary water-bottom reflection. Below that the velocity is higher than 1.5 km/sec, so under-migration occurs. A notable event in Figure 1 (and all the other figures) is the strong reflections at large offsets between .3 and .6 sec. These are post-critical reflections; the farthest offset is over 3 km and the water depth is less that $\frac{1}{2}$ km. No additional processing has been done to all the figures shown in this

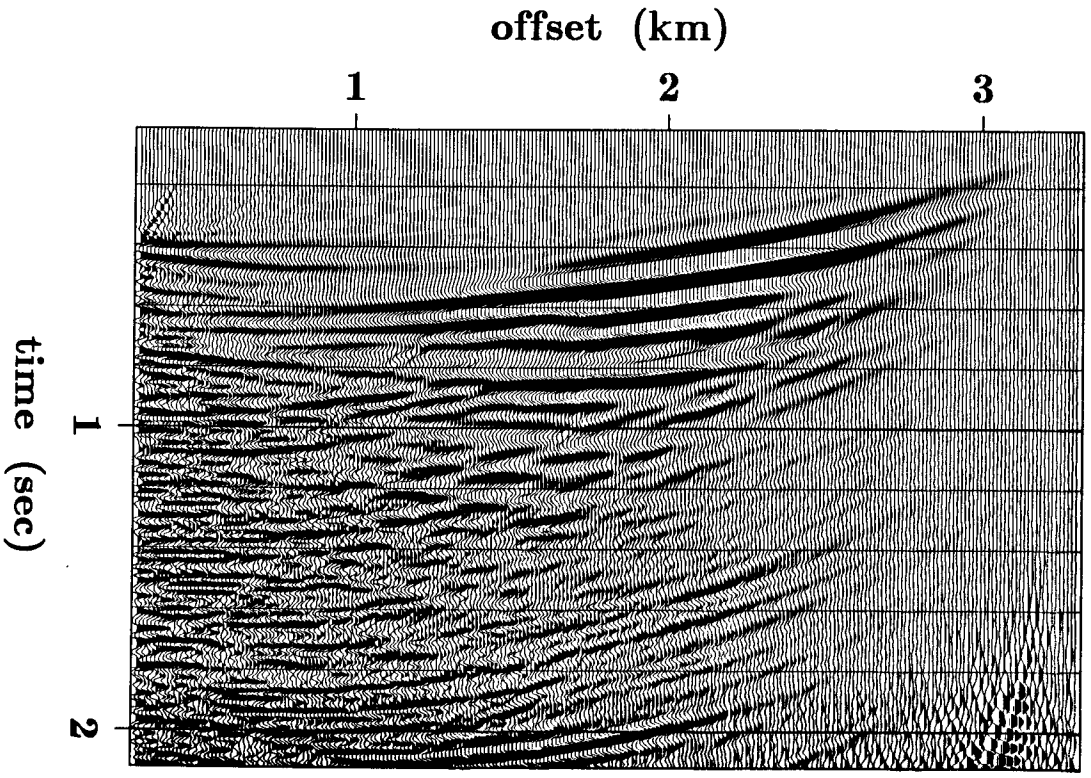

FIG. 2. The result of migrating the gather in Figure 1 with a velocity of 1.5 km/sec.

paper. In practice, we will need to borrow some of the wisdom of NMO processing like muting.

From Figure 2, we cannot tell, however, whether the velocity was correct or not. In other words, we cannot tell if the image conveys a correct or wrong structure. To examine the velocity, we look at the Common Receiver Gather (CRG). Figure 3 shows a typical migrated CRG from this data. The reflector at about .4 seconds shows a horizontal alignment implying that the migration velocity used up to the position of that reflector is correct. However, below that reflector, events are not horizontally aligned. Their upward curvature means that the velocity used in migration was low. To see how low the velocity is, we look at velocity panels, shown in Figure 4. The horizontal axis, γ is the ratio of the velocity used in migration to a constant velocity that regularly varies along the γ axis. A coherency at γ=1 means that the velocity used in migration is the correct velocity. The figure shows that only the event at about .4 sec gives γ=1. Below that, all events show γ to be less than 1 as expected.

If the gathers were migrated with a different velocity, different features of the CRG

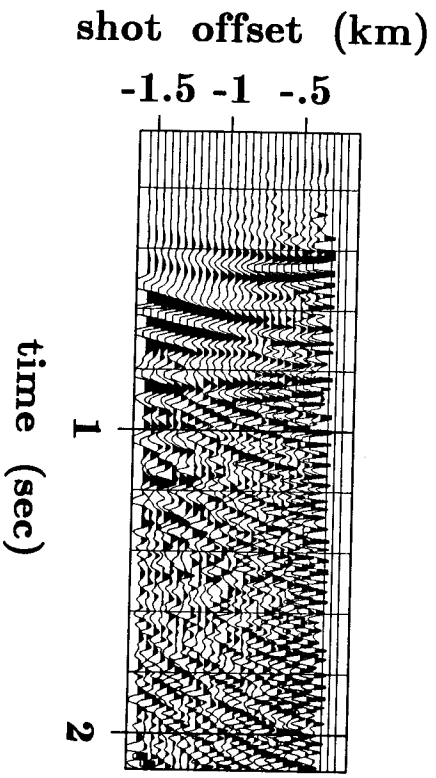

FIG. 3. A Common Receiver Gather (CRG) obtained from shot gathers migrated at 1.5 km/sec.

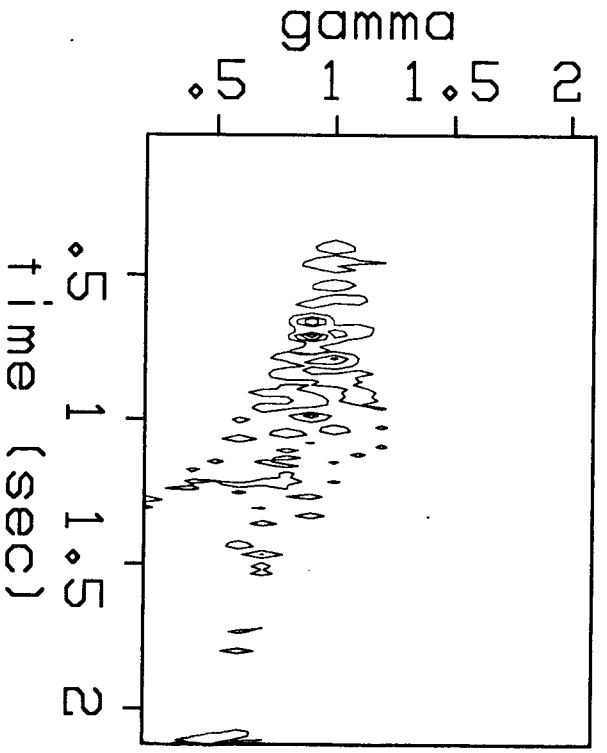

FIG. 4. A velocity panel showing coherency as a function of γ and travel-time depth for a migration velocity of 1.5 km/sec.

and the residual velocity panel would result. Figure 5 shows the result of migrating the data at both a lower and a higher velocity. Figures 6 and 7 show the corresponding CRG's and residual velocity panels, respectively. We see that when the velocity is 1.4 km/sec, all γ values are below 1, since the velocity is too low for all events. When the velocity is 1.6 km/sec, γ is at first higher than 1, briefly crossing 1, and staying less than 1 for the rest of the section.

The residual velocity panels shown were obtained by searching for residual velocities that would give the best coherence. This entails searching for various curvatures in the CRG. Instead of looking for *curvatures*, we can look for non-curvature, namely *alignment.* This means that we take horizontally aligned events to mean that the migration velocity was correct. This search is easier because alignment can be measured by stacking each CRG at each depth. However, it also means that we cannot tell what the correct velocity is until we try it (or try a velocity close to it so that we can interpolate). This approach implies that the data needs to be migrated with many velocities, making it more expensive.

To see the effect of stacking migrated profiles, some stacks were obtained (the stacking was done along the shot-axis). Figure 8 shows some of these stacks. Note that all of these stacks were obtained with constant velocities.

The stacks show, as expected, that different regions are imaged at different velocities. This is a direct analogue to the conventional processing where normal move-out (NMO) produces coherent stacks for different horizons at different move-out velocities. In fact, when many stacks of migrated profiles are placed next to each other, we have velocity-depth panels similar to those obtained in conventional velocity analysis, in which velocities can be picked (see Al-Yahya 1986, Figure 15). In this scheme, NMO is replaced by migration and the CMP gather is replaced by the CRG.

In Figure 8(a), where the velocity is 1.4 km/sec, no reflector is correctly imaged, because the velocity is low for all regions of the subsurface. In Figure 8(b), only the water-bottom is imaged correctly, and in Figures 8(c,d), deeper reflectors are imaged, where fault plain reflections are very clear in Figure 8(d).

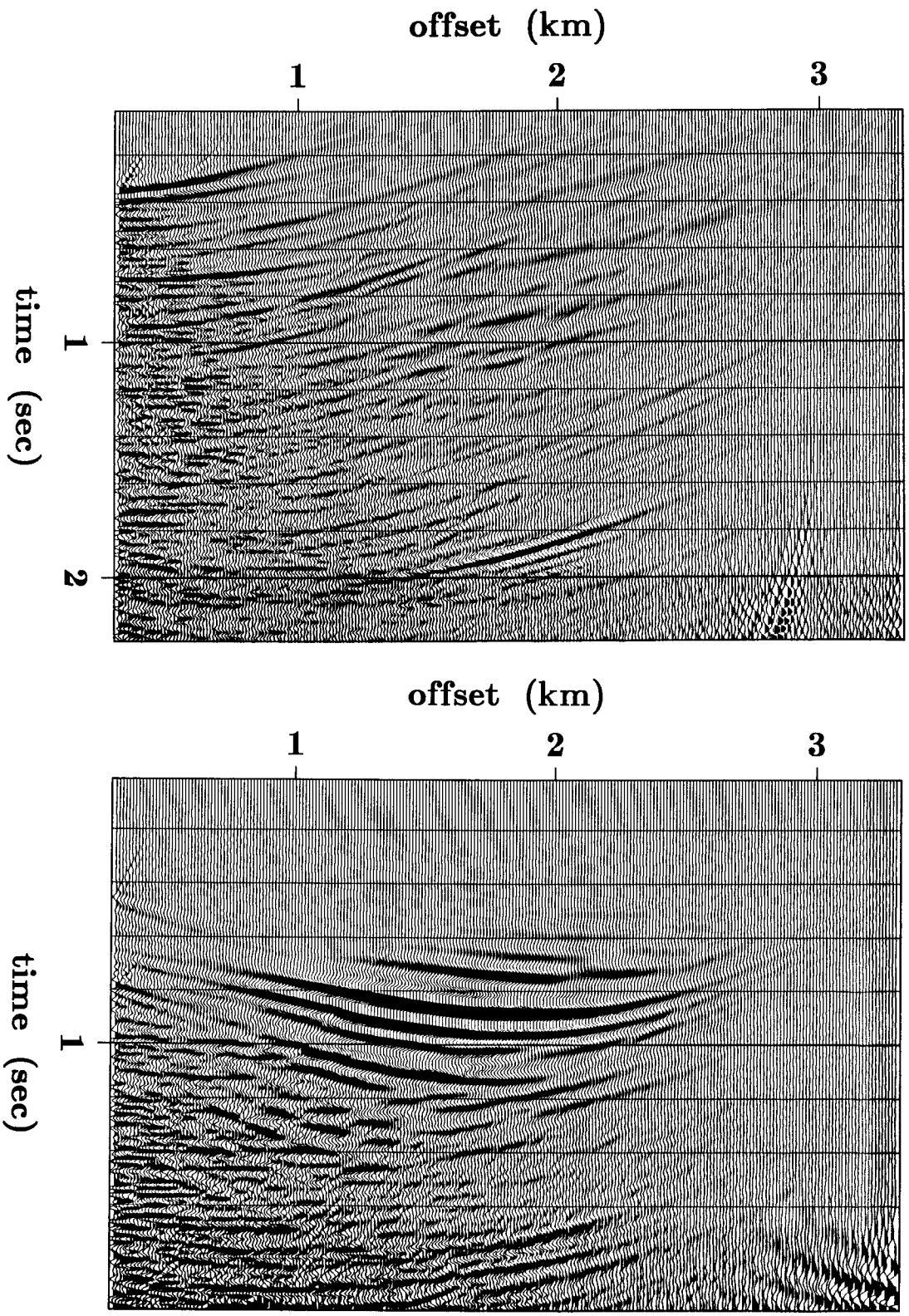

FIG. 5. The result of migrating the gather in Figure 1 with a velocity of 1.4 km/sec (top) and 1.6 km/sec (bottom).

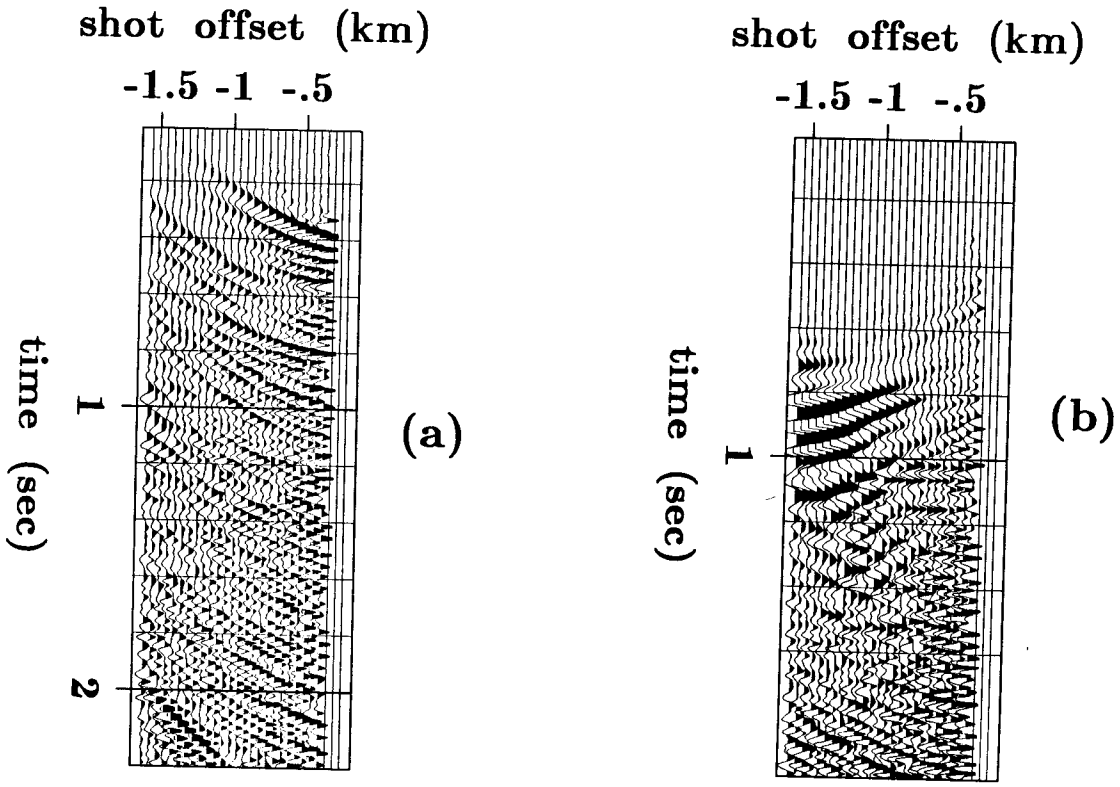

FIG. 6. (a) A CRG obtained at migration velocity of 1.4 km/sec. (b) A CRG obtained at migration velocity of 1.6 km/sec.

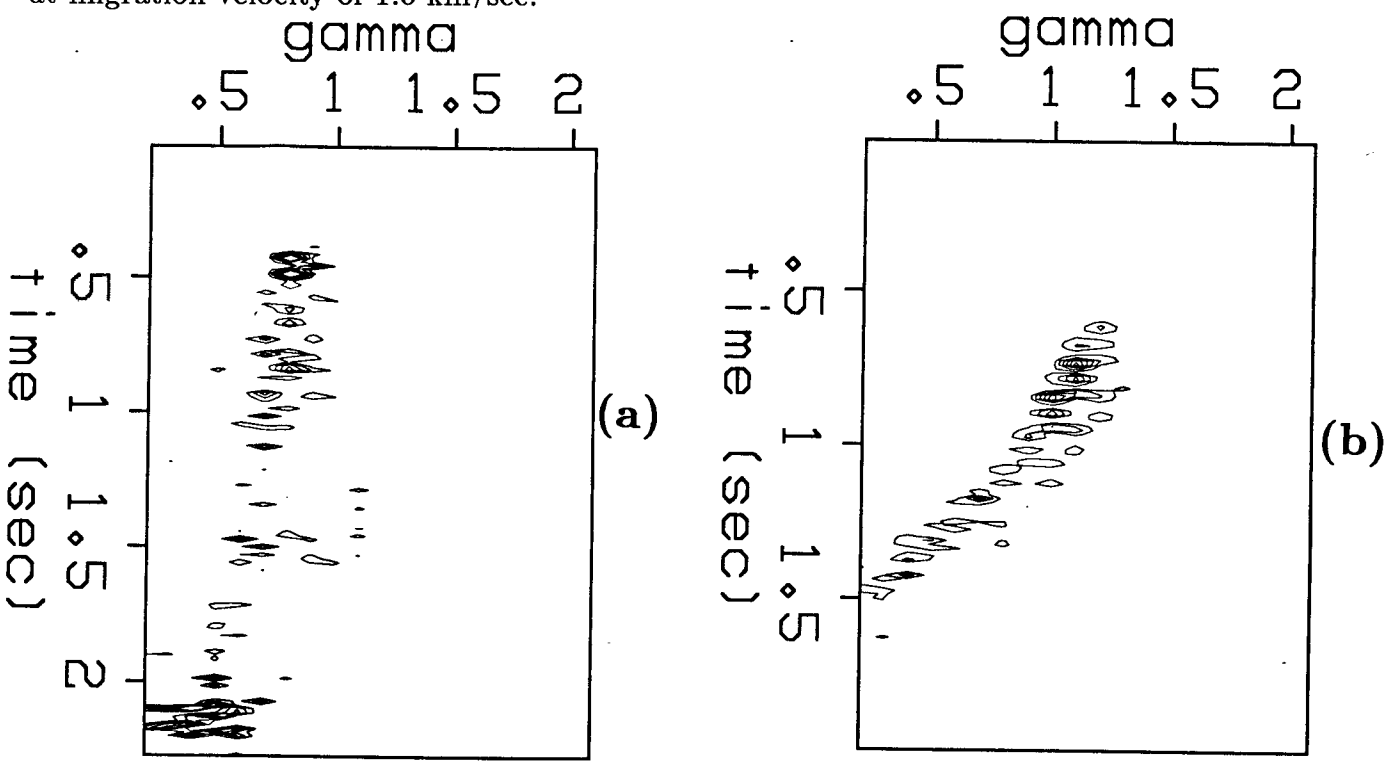

FIG. 7. Velocity panels showing coherency as function of γ and travel-time depth. (a) Migration velocity=1.4 km/sec. (b) Migration velocity=1.6 km/sec.

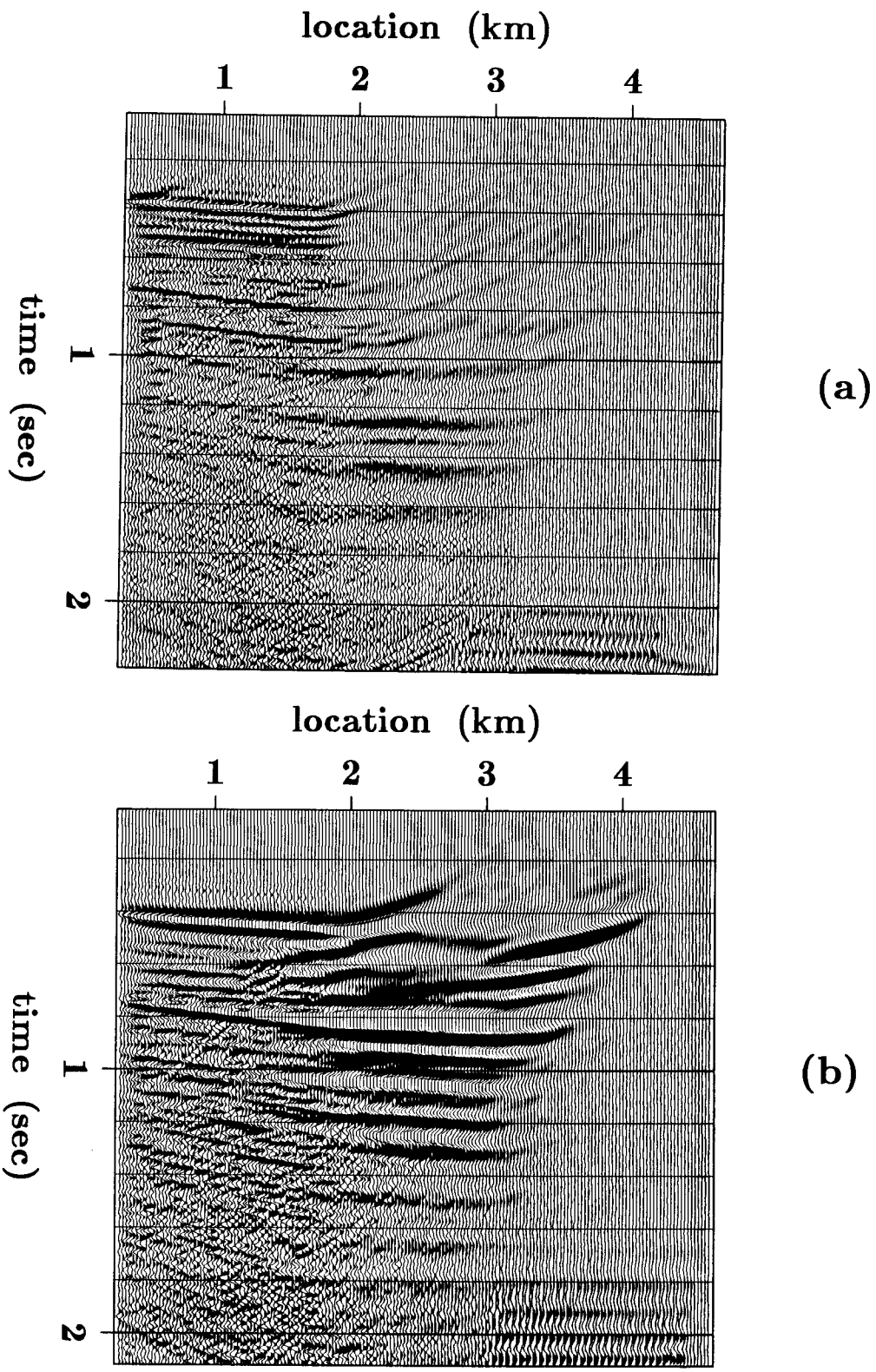

FIG. 8. Stacks of migrated profiles. (a) Migration velocity=1.4 km/sec. (b) Migration velocity=1.5 km/sec.

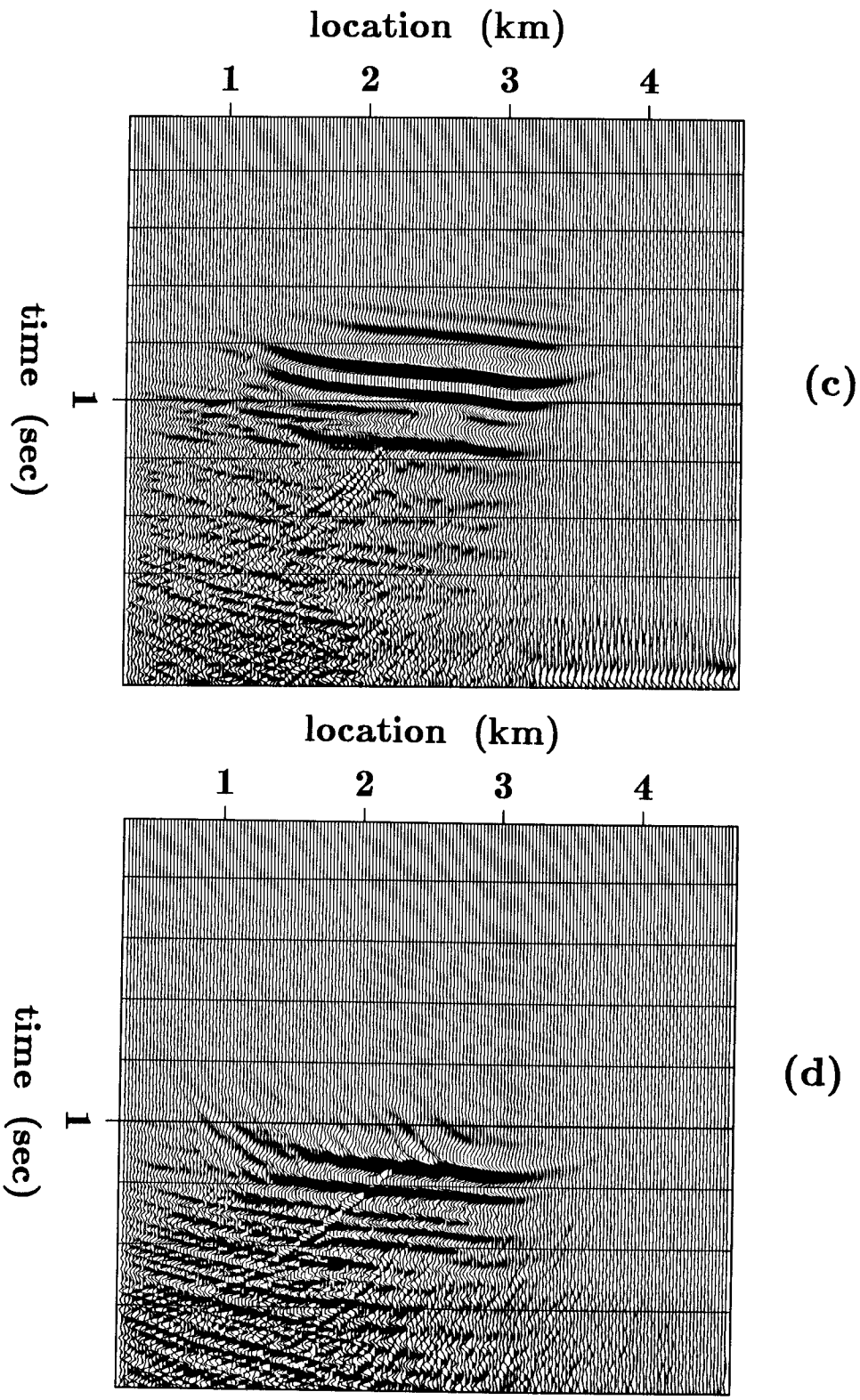

FIG. 8 (continued). Stacks of migrated profiles. (c) Migration velocity=1.6 km/sec. (d) Migration velocity=1.7 km/sec.

CONCLUSIONS

The examples shown here confirm the result previously obtained from synthetic data that migration can be used as a velocity analysis tool. The particular field data that was tested did not need any special processing like migration velocity analysis, since it had no complex structure. It is expected that migration velocity analysis will give better results when the structure is complex, and especially when there are diffractors.

ACKNOWLEDGMENT

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REFERENCES

Al-Yahya, K., 1986, Velocity analysis by prestack migration, SEP–48, p. 45-63.