Nonlinear velocity estimation: field data addendum

Jos van Trier

ABSTRACT

In SEP–51 I describe a nonlinear optimization method that estimates seismic velocities by minimizing the curvature of events in seismic data. The method is applied to common surface location (CSL) gathers after migration. The gathers are part of a field dataset from the Gulf of Mexico.

INTRODUCTION

In a previous SEP report (Van Trier, 1987) I showed a method to measure curvature of events on a seismic gather, and a nonlinear optimization scheme that minimized the curvature. I illustrated the method on NMO and shot-profile migration, and discussed how it could be extended to curvature analysis of events in the CSL gathers. Here I apply this analysis to a field dataset from the Gulf of Mexico (I presented this example at the 1987 EAEG-meeting in Belgrade).

The method requires remigration of the data at each iteration of the optimization, and, consequently, it is not efficient when many parameters have to be estimated. Therefore, I parametrize the one-dimensional velocity model in linear basis functions. Other methods that use CSL gathers are probably more efficient (Al-Yahya, 1987; Etgen, 1988). However, they rely on linearization around a reference model, and the choice of the reference model might influence the optimization.

FIELD DATA RESULTS

The field dataset consists of marine shot profiles from the Gulf of Mexico. The data have been used by several other authors; for example, see Al-Yahya (1987) for aquisition parameters. Figure 1c shows the curvature analysis for a CSL gather after migration (Figure 1b) with the starting velocity model, which has a constant velocity of 1.5 km/s. The stacked image is displayed in Figure 1a. With the exception of the shallow part, there is strong residual curvature in the events in the CSL gather. Similarly, only the shallow part of the migrated image is focused. Next, the curvature is minimized for a velocity model, consisting of a single linear gradient with depth. The resulting CSL gather and migrated image are shown in Figure 2. The curvature of events in the CSL gather starts to decrease, and the image is better focused. This velocity model is used as starting model for another optimization, where the velocity model is reparametrized in 4 linear basis functions. The basis functions are constrained to be continuous at the boundaries. The velocity in the water layer is kept constant at 1.5 km/s. Now, all the events are almost flat, and the image is well-focused (Figure 3). There is still some residual curvature; the chosen configuration of basis functions is too limited to model a velocity function that can flatten all reflectors. The velocity functions after the different optimizations are shown in Figure 4.

CONCLUSIONS

The velocity behavior in this area of the Gulf of Mexico is not very complicated: a linear velocity function is almost enough to focus the data. Also, the geology basically consists of one sedimentary sequence, and strong velocity contrasts are not likely to occur (except at the water bottom). Therefore, the choice of continuous linear basis functions does not limit the velocity inversion. However, in areas with more complex geology, a more realistic parametrization of the velocity model is necessary. In another paper (Van Trier, 1988) I describe how such a parametrization can be done.

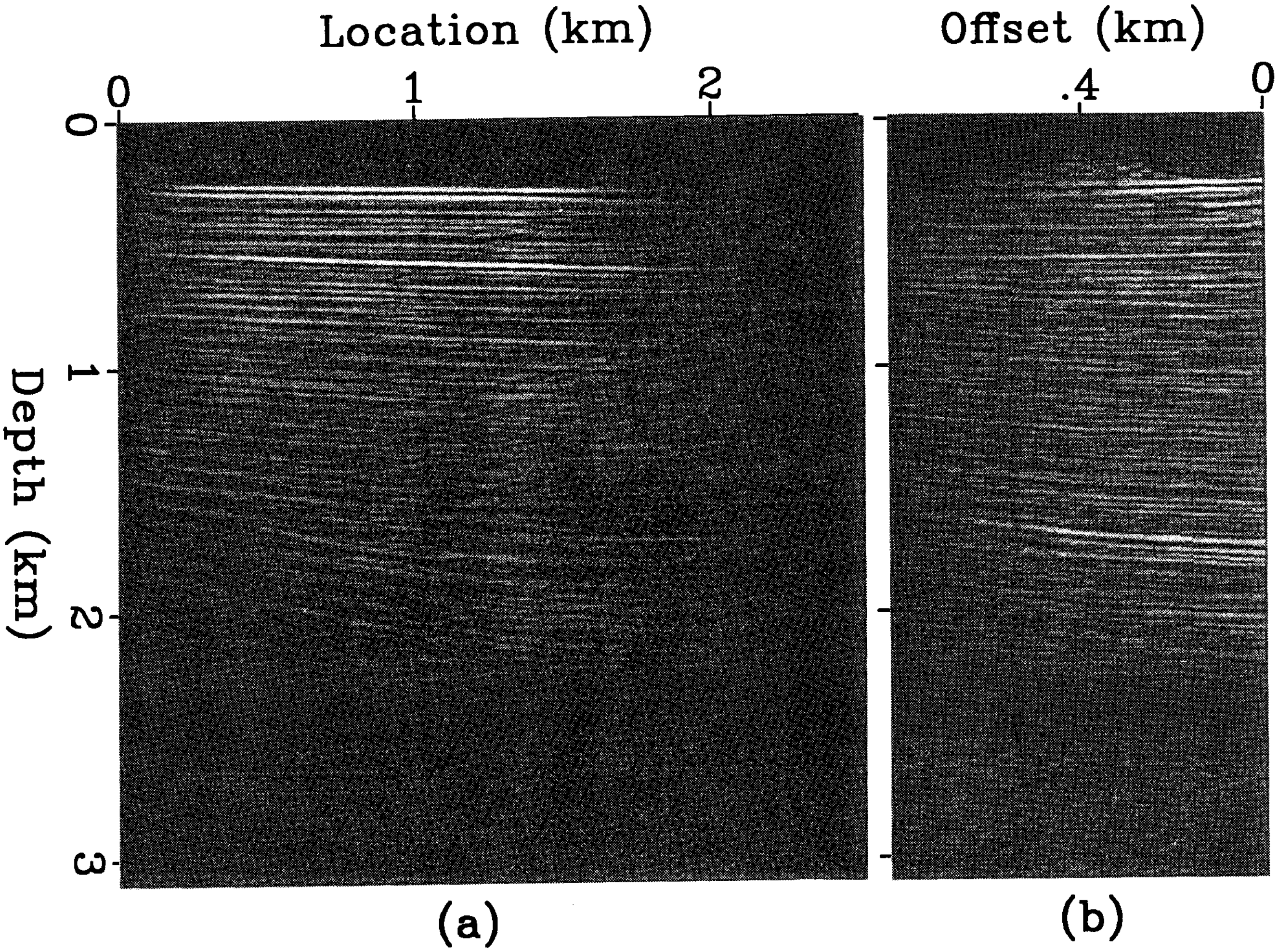
REFERENCES

Al-Yahya, K., 1987, Velocity analysis by profile migration: Ph.D. thesis, Stanford University.

Etgen, J., 1988, Velocity analysis by prestack depth migration: linear theory: SEP–**57**.

Van Trier, J., 1987, Velocity analysis by nonlinear optimization of phase-contoured shot profiles: SEP–**51**, 85–106.

Van Trier, J., 1988, Geological constraints in velocity inversion: SEP–**57**.



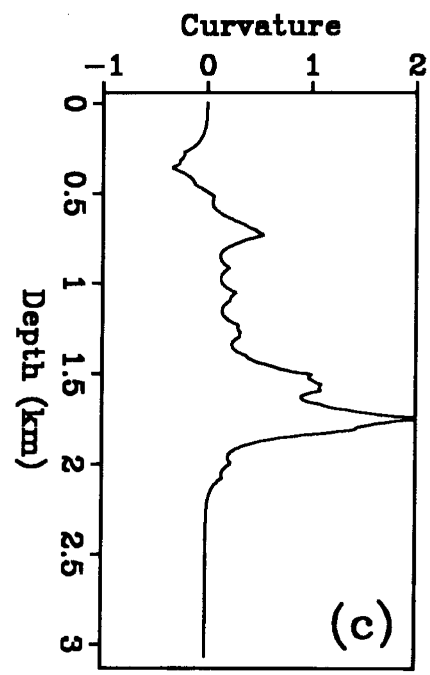


FIG. 1. Migrated image (a), CSL gather (b), and curvature analysis (c) after migration with a constant velocity of 1.5 km/s.

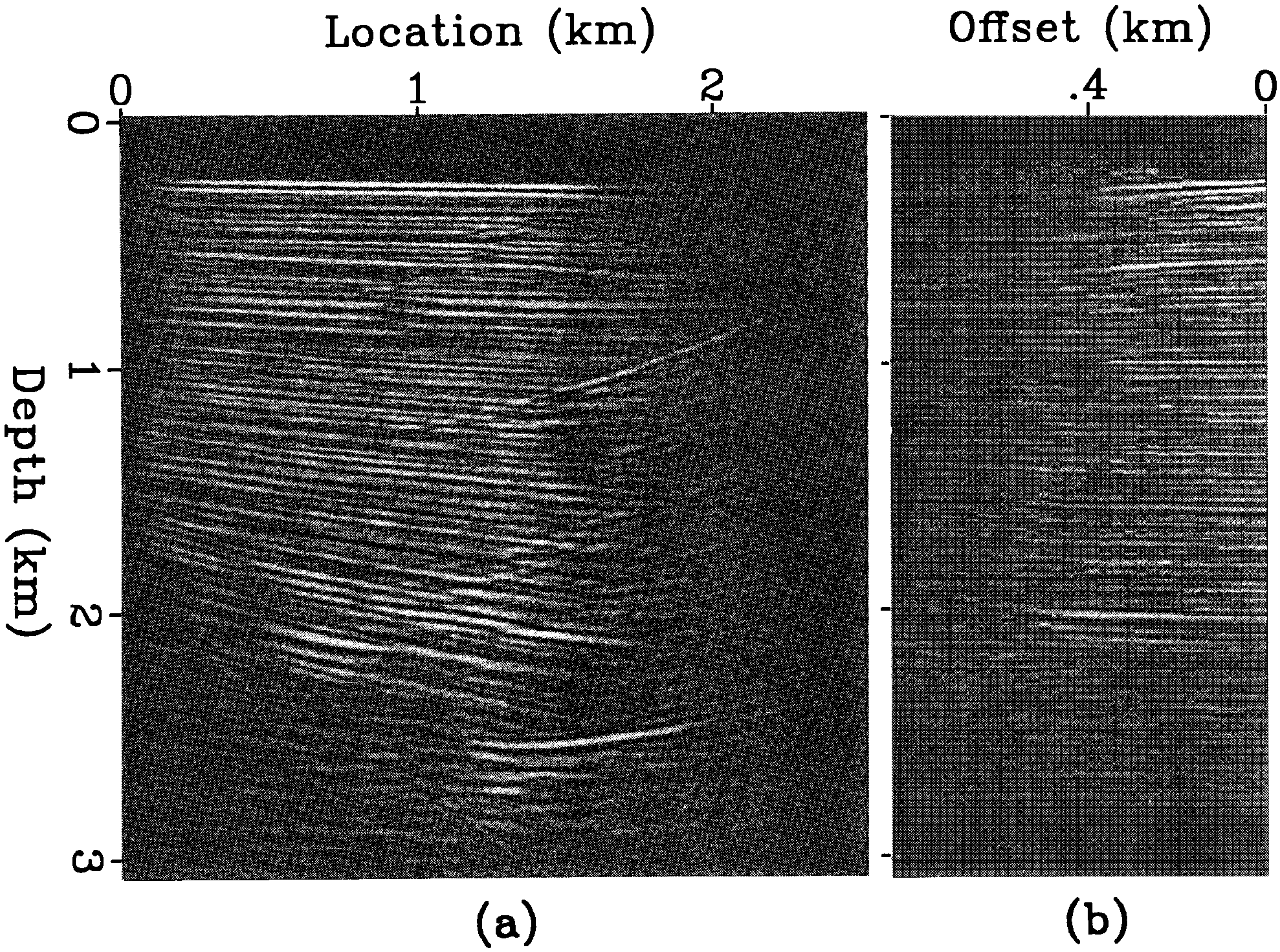
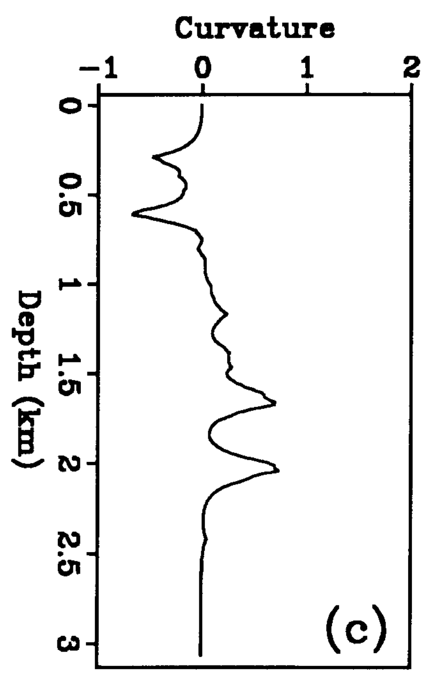
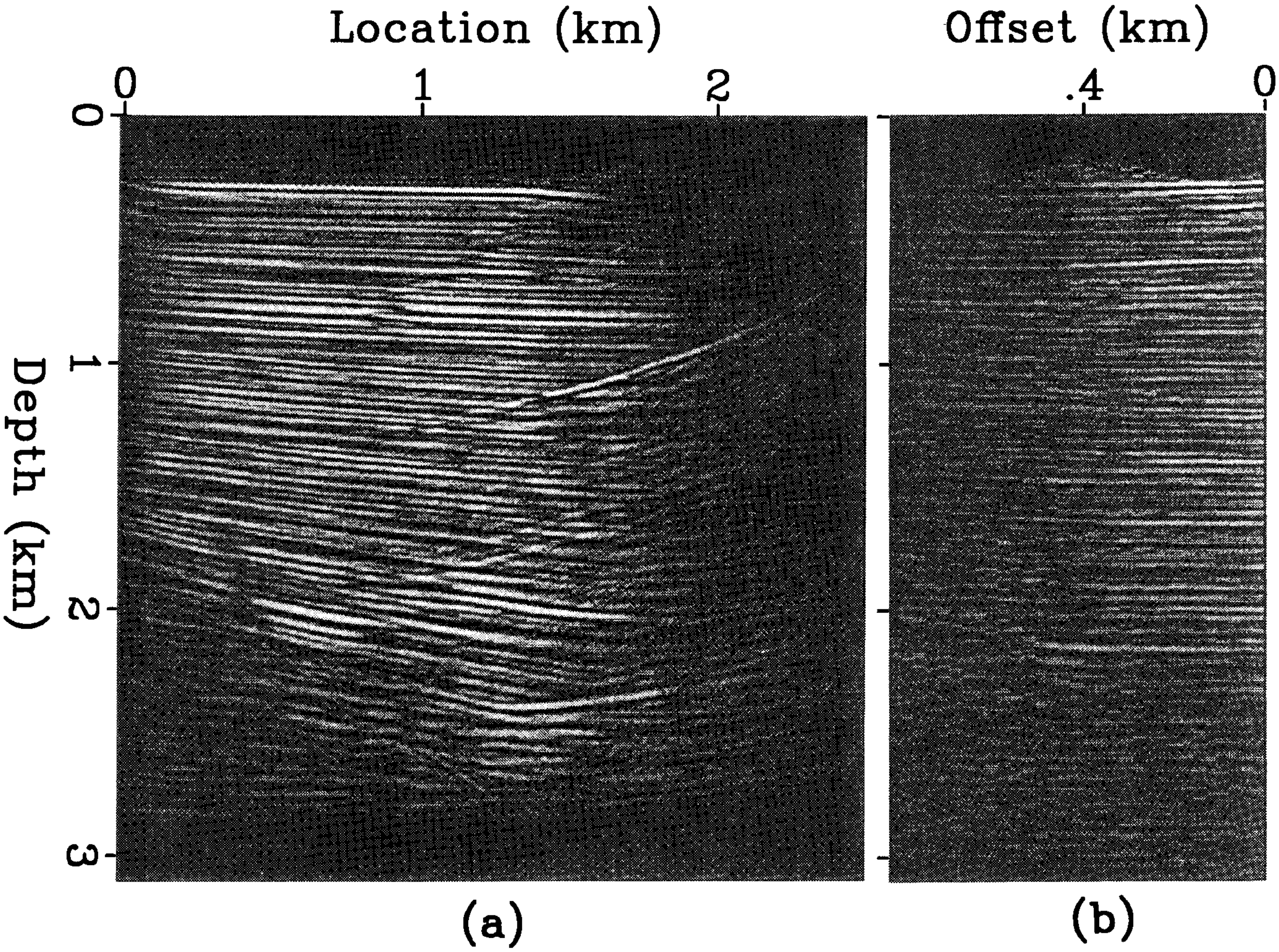


FIG. 2. Migrated image (a), CSL gather (b), and curvature analysis (c) after optimization with a velocity model modeled by one basis function: a single linear gradient.





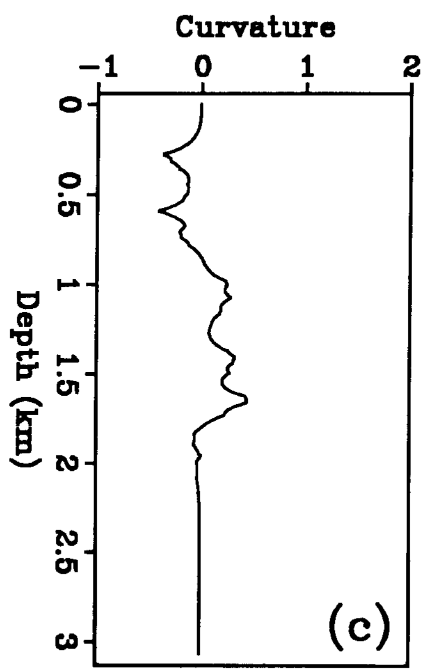


FIG. 3. Migrated image (a), CSL gather (b), and curvature analysis (c) after optimization with a velocity model consisting of 4 continuous linear basis functions. The velocity in the water layer is set to 1.5 km/s.

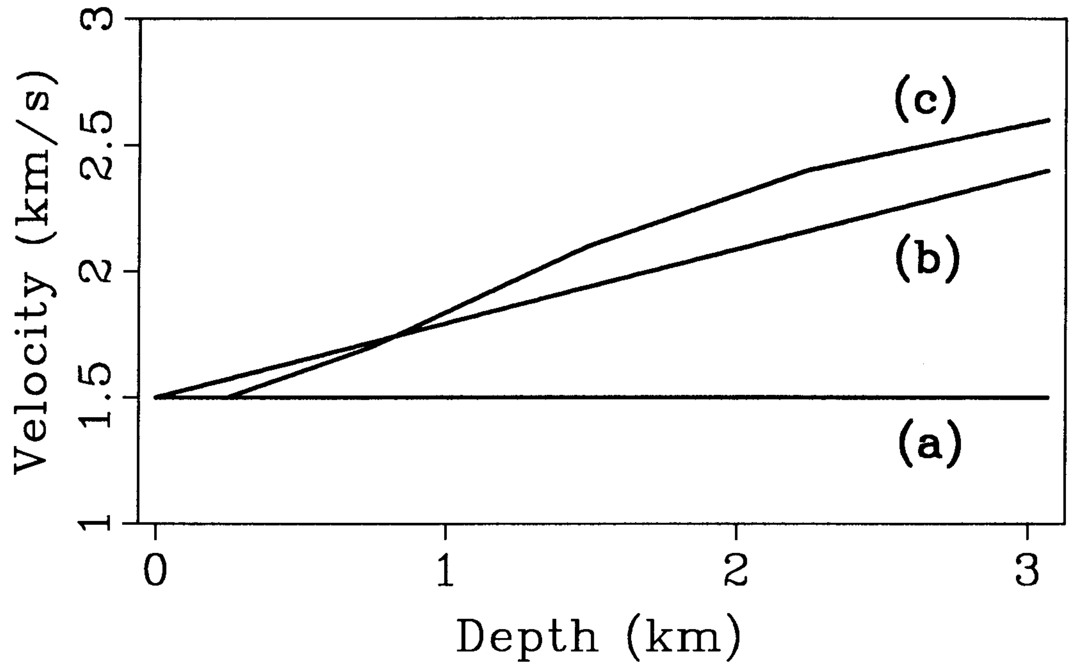


FIG. 4. Interval velocities: (a) starting model; (b) after one parameter optimization; (c) after four parameter optimization.