PAPER S

ANALYSIS AND COMPARISON OF THE CLP AND CDP REFLECTION IMAGING METHODS

Nicholas Smalley

ABSTRACT

There have been two methods that have been used for crosswell reflection imaging. These are the XSP-CDP and CLP imaging methods. This paper compares the theory of the two methods, and shows final reflection images using the two methods on a data set with 2-d variation in geology and seismic velocity.

INTRODUCTION

The high frequency content of crosswell data makes it advantageous for reflection imaging. The XSP-CDP reflection imaging algorithm was adapted to the crosswell geometry from the VSP-CDP imaging algorithm. The CLP reflection imaging algorithm is based on a parallelism with surface seismic reflection imaging and sorting (Smalley, 1992, 1993, 1994). This allows us to combine the high resolution of crosswell seismic data with the well developed techniques of surface seismic reflection imaging. One of the primary advantages of the CLP imaging method is that it allows for a 2-d velocity model for the reflection mapping. This is advantageous when we have 2-d variation in velocity and wide well spacings. In this paper both of these methods are applied to a data set with a wide well spacing (1225 ft.) and 2-d variation in velocity. Figure 1 shows the geometry for this data set.

PRE-PROCESSING OF THE REFLECTION DATA

Common to the CLP and XSP-CDP imaging algorithms is the wavefield separation techniques used to remove unwanted wave modes and enhance the reflection data. Figure 2 shows a CRG at 4905 ft. of the raw data. Figure 2 also shows the same CRG gather enhanced for reflection imaging. It has had the direct arrival removed, with downgoing reflections enhanced, and an additional filter applied to remove additional noise from the data.

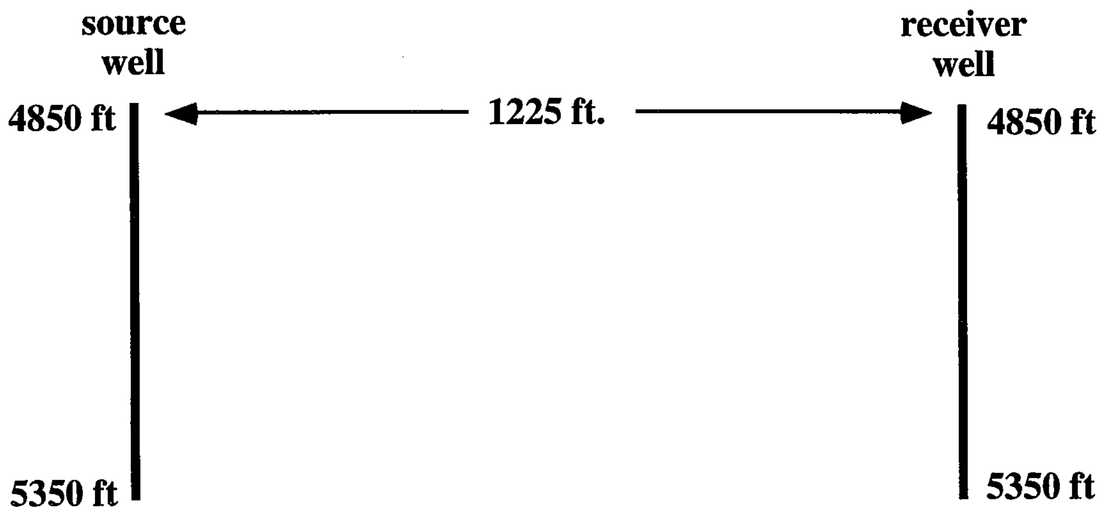

Figure 1. Data set geometry.

SORTING THE REFLECTION DATA

Reflection data has to be sorted into defined gathers to be input into the XSP-CDP and CLP imaging algorithms. The XSP-CDP imaging algorithm uses source or receiver gathers as the input to the mapping routine. The CLP imaging algorithm uses Common Reflection Point or Common Lateral Point (CLP) gathers (Smalley, 1992) as its input . Figure 3 shows four CLP gathers at reflection depth 4765 ft. and 240, 260, 280, and 300 ft. from the source well respectively.

VELOCITIES FOR MAPPING THE DATA

The CLP method uses a crosswell reflection velocity analysis procedure (Smalley, 1994, 1993) based on finding the velocities that will optimize the stack of the data. Figure 4 shows the same CLP gathers as figure 3, but after a matrix of HNMO and VLMO stacking velocities (Smalley, 1993) have been applied to maximize the semblance of the data. The XSP-CDP reflection mapping algorithm uses 1-d direct arrival travel time tomography to obtain the velocity model for mapping. Figure 5 shows the velocity model used to map this data set. Figure 6 shows the stacking velocities used to transform the data from CLP gathers (figure 3) to CLP-VLMO gathers ((figure 4) - Smalley, 1993). By changing the lateral location and reflection depth where we perform velocity analysis, we create 2-d variation in the stacking velocities. Figure 7 shows all of the CLP's or control point locations where we have done velocity analysis to generate 2-d variation in the velocity model used for CLP mapping. Figure 7 also shows the stacking velocities determined from reflection velocity analysis at certain locations.

IMAGING AND STACKING THE DATA

Figure 8 shows the final stack for the CLP imaging method and figure 9 shows the final stack for the XSP-CDP imaging method. Clearly the images are quite different, and the CLP imaging method results in a much more coherent overall stack. However, there are similarities in the type of structure indicated by the two images. The top part of both images (between 4700 - 5000 ft.) indicate flat events. The middle depth part (5150 - 5300 ft.) of both images show more complicated structure with upward dipping events toward the receiver well. As well as the overall quality of the stack, the CLP image also differs from the XSP-CDP imaging method in having much lower wave number data in the middle depth part of the image. This is due to bandpass and f-k filters applied during the velocity analysis procedure that optimized the reflection data in the CLP gathers.

CONCLUSIONS

We have performed both CLP and XSP-CDP mapping procedures on a data set with wide well spacing and 2-d variation in velocity. The CLP method produces a more coherent stack than the XSP-CDP method due to its ability to deal with 2-d variation in velocity. However, both imaging methods indicate the same general geological structure.

REFERENCES

Smalley, N., Crosswell Partial Pre-Stack Migration, 1992, STP vol. 3 No. 1 Paper M.

Smalley, N., Crosswell Reflection Velocity Analysis, 1993, STP vol. 4 No. 1 Paper G.

Smalley, N., Crosswell CLP Reflection Imaging, 1994, STP vol. 5 No. 1 Paper E.

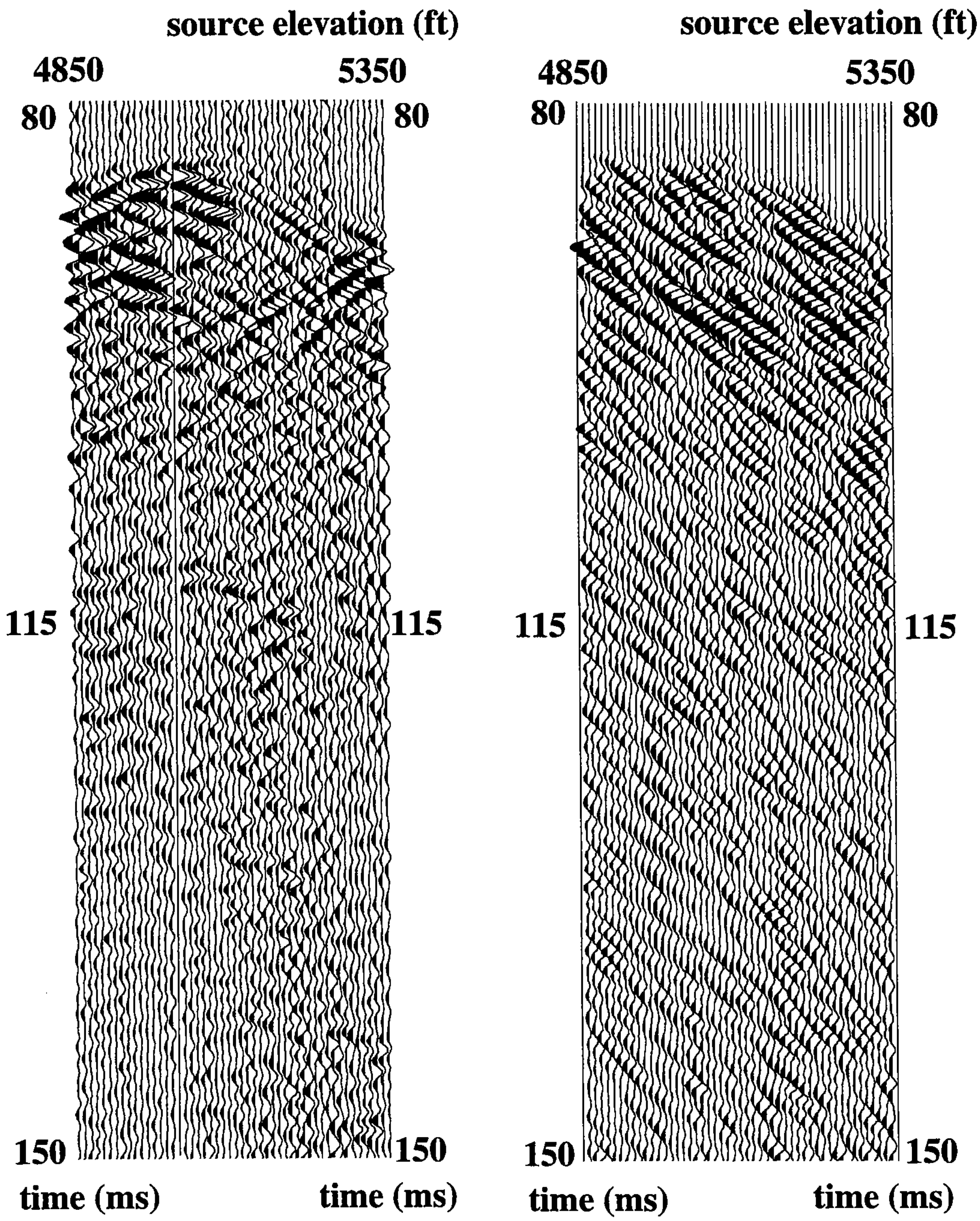

Figure 2. CRG of raw data (left) and pre-processed data (right).

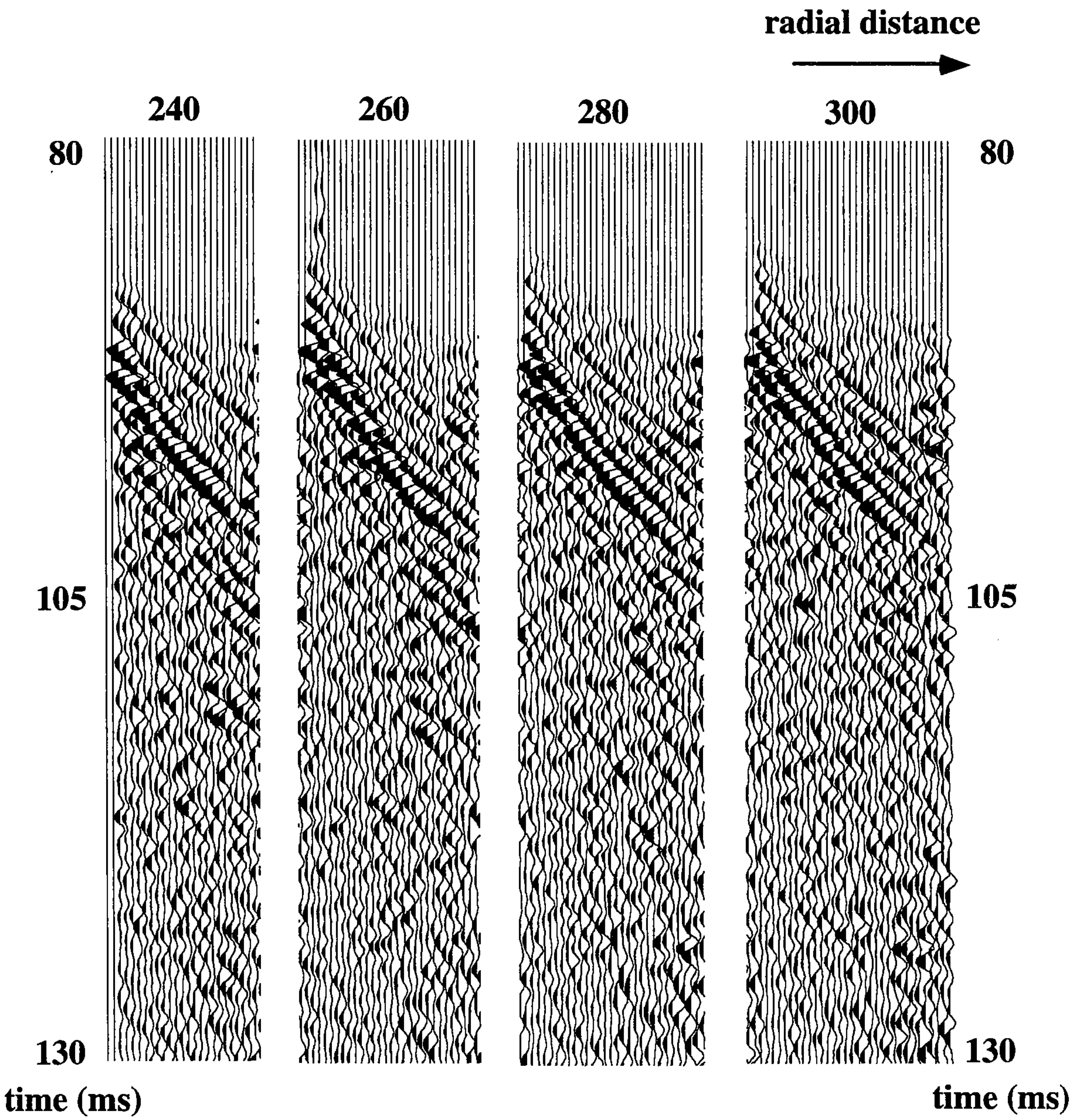

Figure 3. CLP gathers located at 240, 260, 280, and 300 ft. from the source well for reflection depth 4765 ft.

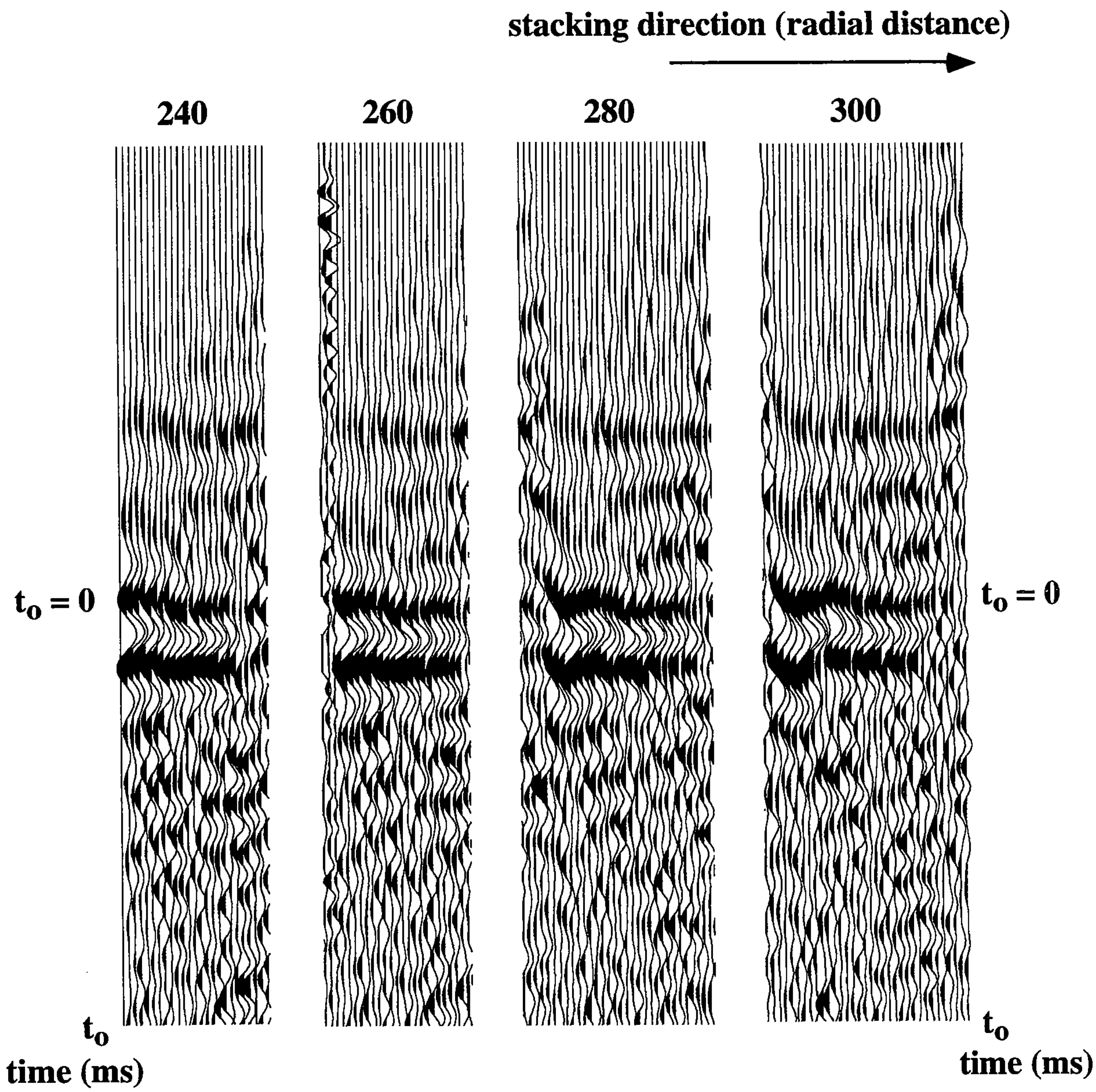

Figure 4. CLP gathers after the VLMO correction located at 240, 260, 280, and 300 ft. from the source well for reflection depth 4765 ft.

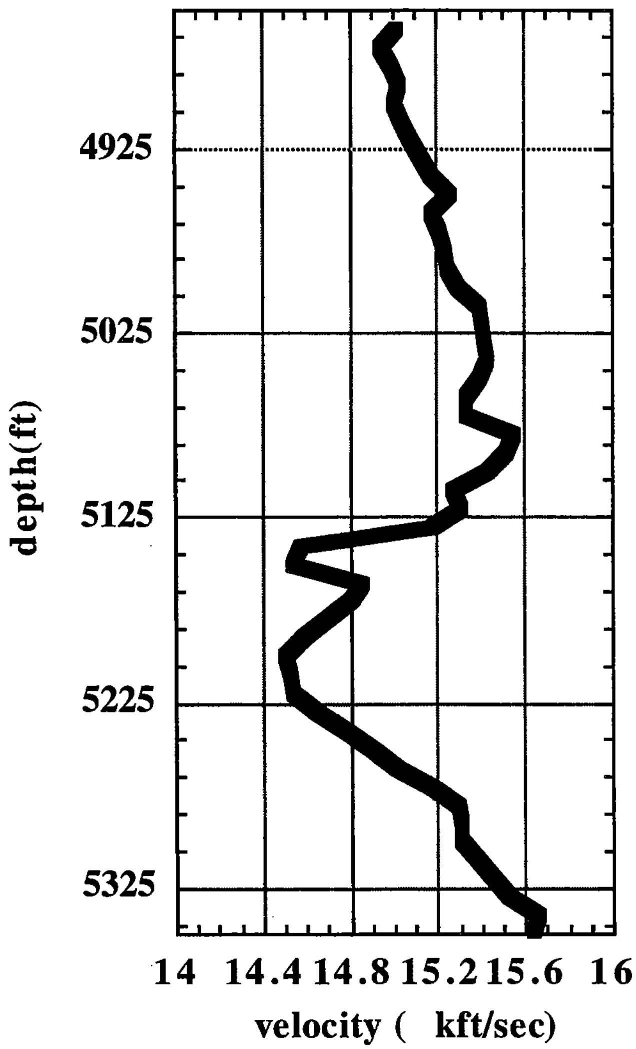

Figure 5. 1-d velocity model used for XSP-CDP reflection imaging.

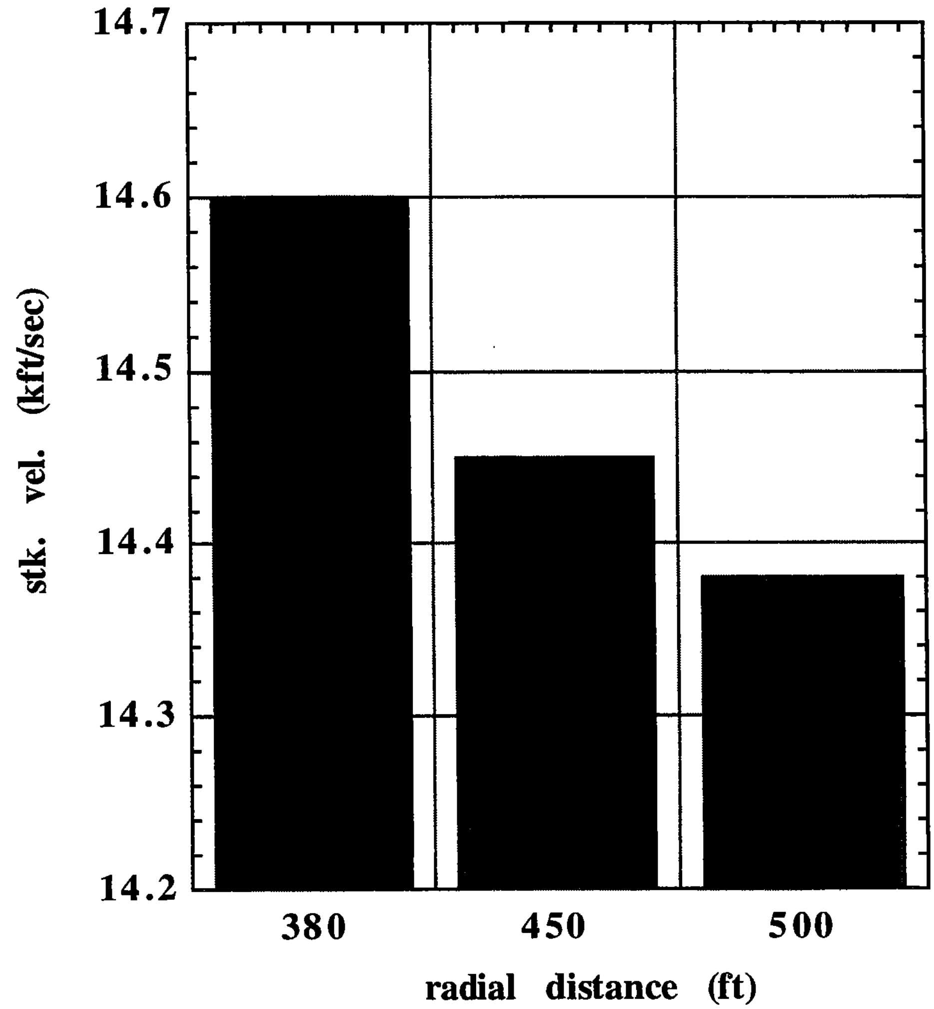

Figure 6. HNMO and VLMO stacking velocities at the CLP depth 4765 ft., 270 ft. from the source well.

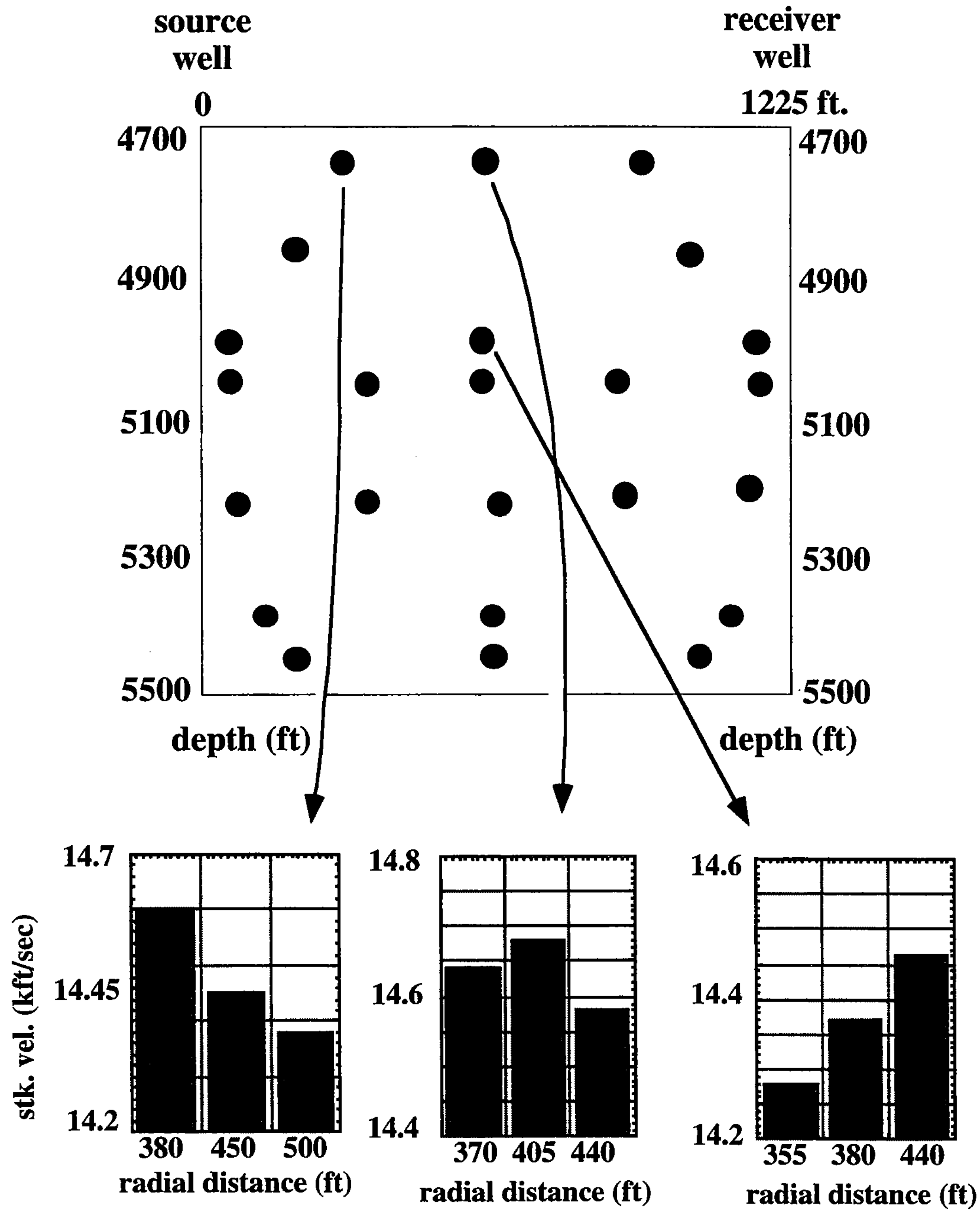

Figure 7. Velocity Analysis control point locations and stacking velocities at certain CLP locations.

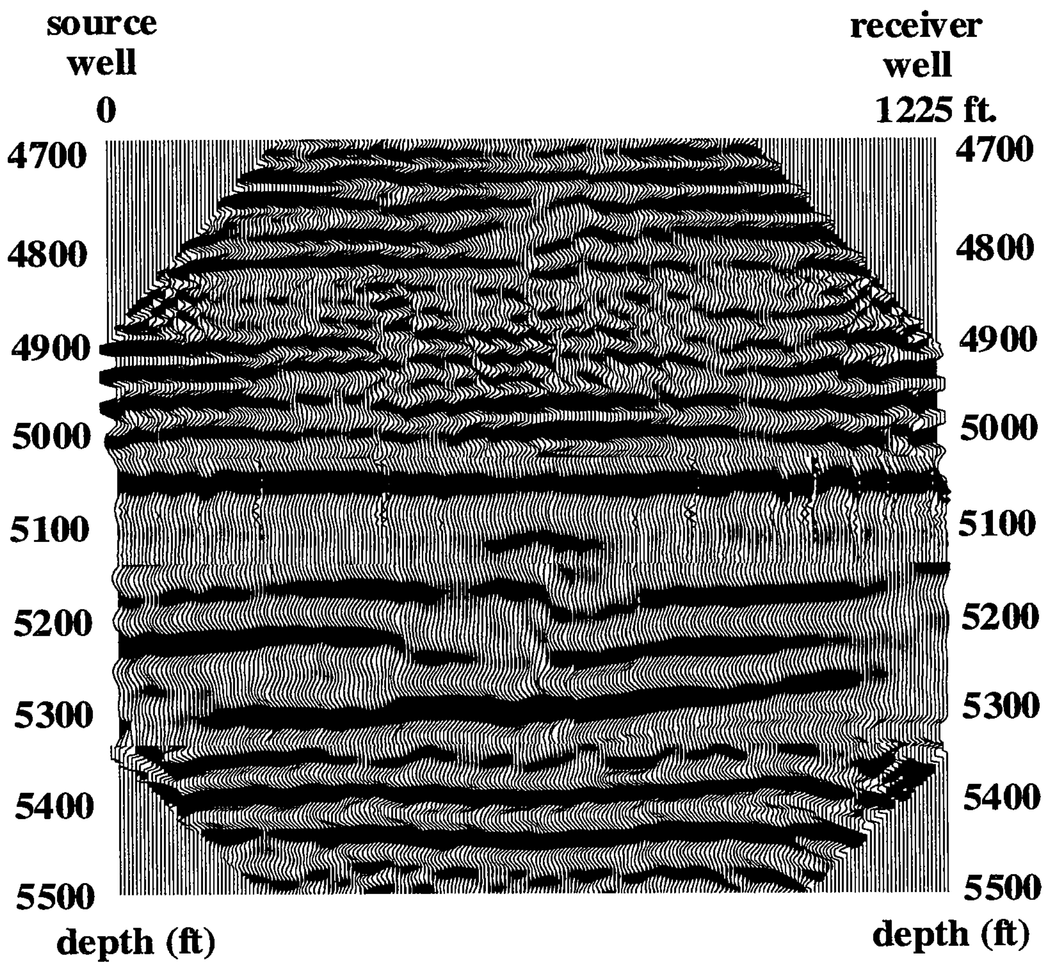

Figure 8. Final Reflection Stack using CLP reflection imaging.

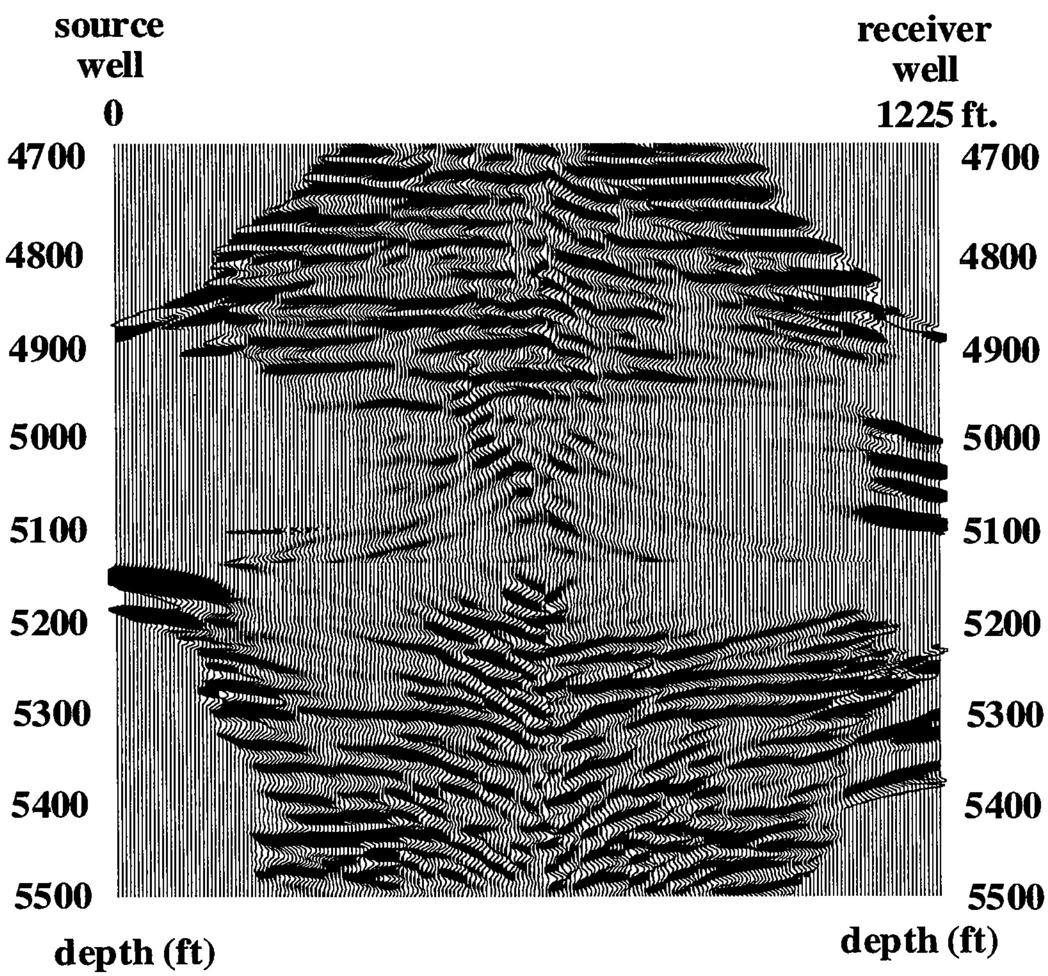

Figure 9. Final Reflection Stack using XSP-CDP reflection imaging.