CFP gathers: definition, synthesis and application

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Introduction

Common Focus Point (CFP) technology has become a new paradigm in the DELPHI research program. The construction and understanding of CFP gathers has lead to significantly new insights. In this presentation CFP gathers and their application in prestack migration are summarized and illustrated with examples.

Definition

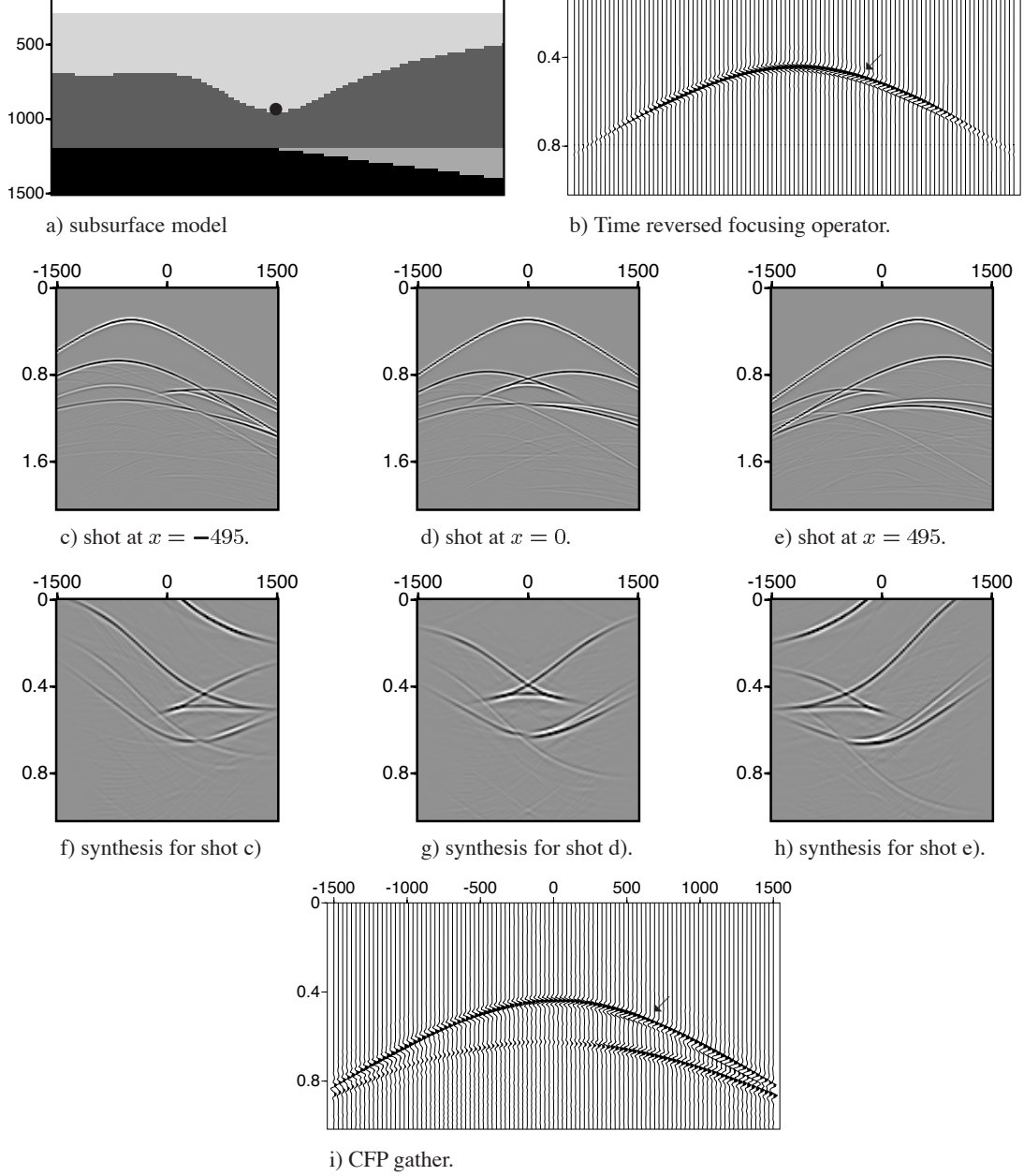
Focusing is defined by a (in phase and amplitude) weighted summation along source or receiver arrays in such a way that the synthesized wave front has a focus point, at a specific gridpoint in the subsurface. The involved synthesis operator is called the focusing operator. The principle of synthesizing (focusing) areal sources was already introduced by Berkhout (1992) for controlled illumination in prestack depth migration. Rietveld (1995) has shown many examples for the planar areal sources.

Synthesis

The Common Focus Point (CFP) gather is the response of a focusing areal source or detector. Hence a CFP gather is an areal shot record. To construct the CFP-gather from the data an initial focusing operator is needed. This initial operator can be based on stacking velocities or an initial macro model. The initial focusing operator is calculated by positioning a point source at the focus point followed by forward modeling to calculate the source response at the surface. Measuring its response at the detector positions defines an operator for focusing in detection and measuring its response at the source positions defines an operator for focusing in emission. If the focusing operator at the detector positions is applied to all traces in the record then one trace of the CFP gather for focusing in detection is obtained. After the construction of the complete CFP gather the operator can be compared with the focus point response in the CFP gather and optionally the model and/or the operator can be updated. Note that the operator must be coincident in time with the corresponding event in the CFP gather (principle of equal traveltime).

The synthesis of a CFP gather is illustrated by using numerical data, based on the model shown in figure 1a. The synthesis process for a focusing receiver with a focus point defined at the synclinal interface at $x = 0$ and $z = 950m$ (the focus point is indicated in figure 1a) is shown in detail in figure 1. The time reversed focusing operator for the focus point is shown in figure 1b. This operator is applied to all common shot gathers available. Three different common shot gathers with source positions at $x = -495, z = 0$ and $x = 495$ are shown in figure 1c, d and e respectively. Convolution along the time axis of the traces in the shot gathers with the traces in the focusing operator gives the intermediate synthesis results shown in figure 1f, g and h. Summation over all the traces in the intermediate synthesis result gives one trace of the CFP gather. The summed trace is placed in the CFP gather at the position of the source. By carrying out the convolution and integration along the traces in the gather for all shot gathers the complete CFP gather for focusing in detection is constructed.

The events which are present in the shot record are also present in the intermediate synthesis result in figure 1f, g and h. In figure 1f four events are observed, the top event originates from the first reflector and should be regarded as a non-causal event because the focus point is positioned below the first reflector. The event with the triplication originates from the synclinal boundary, the weak S-shaped event originates from a diffraction point and the last event originates from the deepest boundary. In the CFP gather shown in figure 1i, the reflection from the syncline and the deeper boundary are clearly visible. The response of the first reflector is moved outside the time window. Note that the bow-tie event in the shot record (figure 1d) is focused in the CFP gather (figure 1i) which is much simpler to interpret. The CFP gather is input to the next focusing process, yielding the image of the gridpoint.



a) subsurface model

b) Time reversed focusing operator.

c) shot at $x = -495$.

d) shot at $x = 0$.

e) shot at $x = 495$.

f) synthesis for shot c)

g) synthesis for shot d).

h) synthesis for shot e).

i) CFP gather.

Figure 1: *Construction of a CFP gather for focusing in detection. Every shot record yields one CFP trace, positioned at the related source position. Note the contribution of the Fresnel zones in figure 1f,g and h to figure 1i. The time reversed focusing operator and the related focus point response have been indicated with an arrow. Note the relative simplicity of the CFP gather.*

Application

In the CFP-based imaging process there are two focusing steps involved; the first focusing step defines focusing in detection and the second focusing step defines focusing in emission. Between the two focusing steps the time-reversed focusing operator is compared with the focus point response in the CFP gather.

Conclusion

In CFP technology shot records are transformed to CFP gathers. CFP gathers are preeminently suited as input for seismic pre-processing and velocity analysis. In the last step in CFP technology processed CFP gathers are stacked.

References

Berkhout, A. J., 1992, Areal shot record technology: Journal of Seismic Exploration, **1**, no. 2, 251–264.

Rietveld, W. E. A., 1995, Controlled illumination in prestack seismic migration: Ph.D. thesis, Delft University of Technology.