A002 SEISMIC IMAGING BY MEANS OF TWO SEPARATE FOCUSING STEPS, PART II - MIGRATION OF MULTI COMPONENT DATA

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The WRW model for multi-component data

It has been shown that the WRW-model for compressional waves (Berkhout, 1985) can be logically extended to converted and shear waves (Wapenaar and Berkhout, 1989):

a. *Potentials:*

$$\begin{pmatrix} \mathbf{P}_{pp} & \mathbf{P}_{ps} \\ \mathbf{P}_{sp} & \mathbf{P}_{ss} \end{pmatrix} = \begin{pmatrix} \mathbf{W}_{pp} & \mathbf{W}_{ps} \\ \mathbf{W}_{sp} & \mathbf{W}_{ss} \end{pmatrix} \begin{pmatrix} \mathbf{R}_{pp} & \mathbf{R}_{ps} \\ \mathbf{R}_{sp} & \mathbf{R}_{ss} \end{pmatrix} \begin{pmatrix} \mathbf{W}_{pp} & \mathbf{W}_{ps} \\ \mathbf{W}_{sp} & \mathbf{W}_{ss} \end{pmatrix} \begin{pmatrix} \mathbf{S}_{p} & 0 \\ 0 & \mathbf{S}_{s} \end{pmatrix} \tag{1a}$$

b. *Particle velocity:*

$$\mathbf{V} = \mathbf{D}^{-}\mathbf{P}\mathbf{D}^{+}. \tag{1b}$$

If the conversion during propagation is ignored, then equation (1a) decomposes into 4 independent equations:

$$\mathbf{P}_{pp} = \left[\mathbf{W}_{pp}\mathbf{R}_{pp}\mathbf{W}_{pp}\right]\mathbf{S}_{p}; \qquad \mathbf{P}_{ps} = \left[\mathbf{W}_{ss}\mathbf{R}_{sp}\mathbf{W}_{pp}\right]\mathbf{S}_{p} \tag{2a,b}$$

$$\mathbf{P}_{ps} = \left[\mathbf{W}_{pp}\mathbf{R}_{ps}\mathbf{W}_{ss}\right]\mathbf{S}_{s}; \qquad \mathbf{P}_{ss} = \left[\mathbf{W}_{ss}\mathbf{R}_{ss}\mathbf{W}_{ss}\right]\mathbf{S}_{s} \tag{3a,b}$$

Note that in each equation mode conversion occurs during the *reflection* process.

The double focusing process for multi-component data

Each of the 4 independent equations, 2a,b and 3a,b, can be treated with the double focusing process (see part I of this paper). Considering equations 2a,b only (source energy is compressional), we may write for

PP-data:

$$P_{pp}(\vec{x}_j, z_m) = \vec{F}^{\dagger}_{p,j}(z_m, z_o)\mathbf{P}_{pp}(z_o)\vec{F}_{p,j}(z_o, z_m) \tag{4a}$$

$$R_{pp}(\vec{x}_j, z_m) = E\left\{P_{pp}(\vec{x}_j, z_m)\right\}. \tag{4b}$$

SP-data:

$$P_{sp}(\vec{x}_j, z_m) = \vec{F}^{\dagger}_{s,j}(z_m, z_o)\mathbf{P}_{sp}(z_o)\vec{F}_{p,j}(z_o, z_m) \tag{5a}$$

$$R_{sp}(\vec{x}_j, z_m) = E\left\{P_{sp}(\vec{x}_j, z_m)\right\}. \tag{5b}$$

Note that in equation 5a $\vec{F}_{p,j}$ represents the source-related focusing operator (column vector) for downward travelling compressional waves and $\vec{F}^{\dagger}_{s,j}$ represents the detector-related focusing operator (row vector) for upward travelling shear waves, both for focus point $(\vec{x}_j, z_m)$.

Methodology

Migration of multi-component measurements, based on equations 4a,b and 5a,b, may be summarized by the following processing scheme:

1. Decompose the multi-component particle *velocity* data **V** into *potential* data **P**. In its simplest version, a scaled version of the vertical components is used as compressional potentials, and a scaled version of the horizontal components is used as shear potentials.

2. Apply CFP imaging for $\mathbf{P}_{pp}$, including determination of the focusing operators $\vec{F}_p$ by applying 'the principle of equal traveltime' in the CFP-gathers $\vec{P}_p(z_m, z_o)$.

3. Apply CFP imaging for $\mathbf{P}_{sp}$, including determination of the focusing operators $\vec{F}^{\dagger}_s$ by applying 'the principle of equal traveltime' in the CFP gathers $\vec{P}^{\dagger}_s(z_o, z_m)$.

During the presentation of this paper field data examples will be shown to illustrate the large potential of the CFP approach to multi component migration.

Conclusions

CFP technology allows an alternative approach to multi-component seismic imaging. By applying and updating the focusing operators for different wavetypes, any mode-converted reflection can be properly migrated.

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References

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