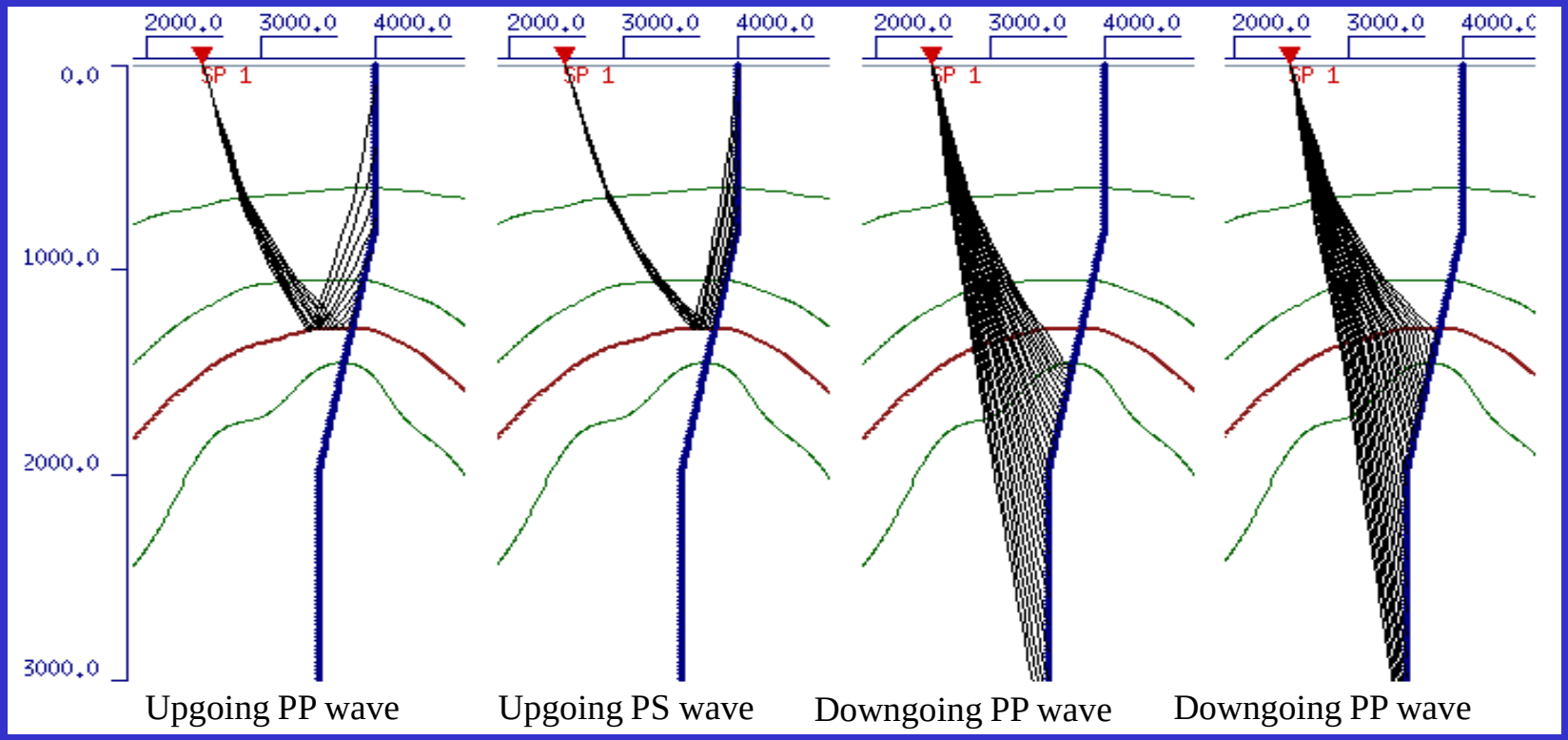
JOINT IMAGING OF THE MEDIA USING DIFFERENT TYPES OF WAVES

A.V. Reshetnikov*
Yu.A. Stepchenkov*
A.A. Tabakov**
V.L. Eliseev**

* SPbSU, St-Petersburg, ** "GEOVERS" Ltd, Moscow

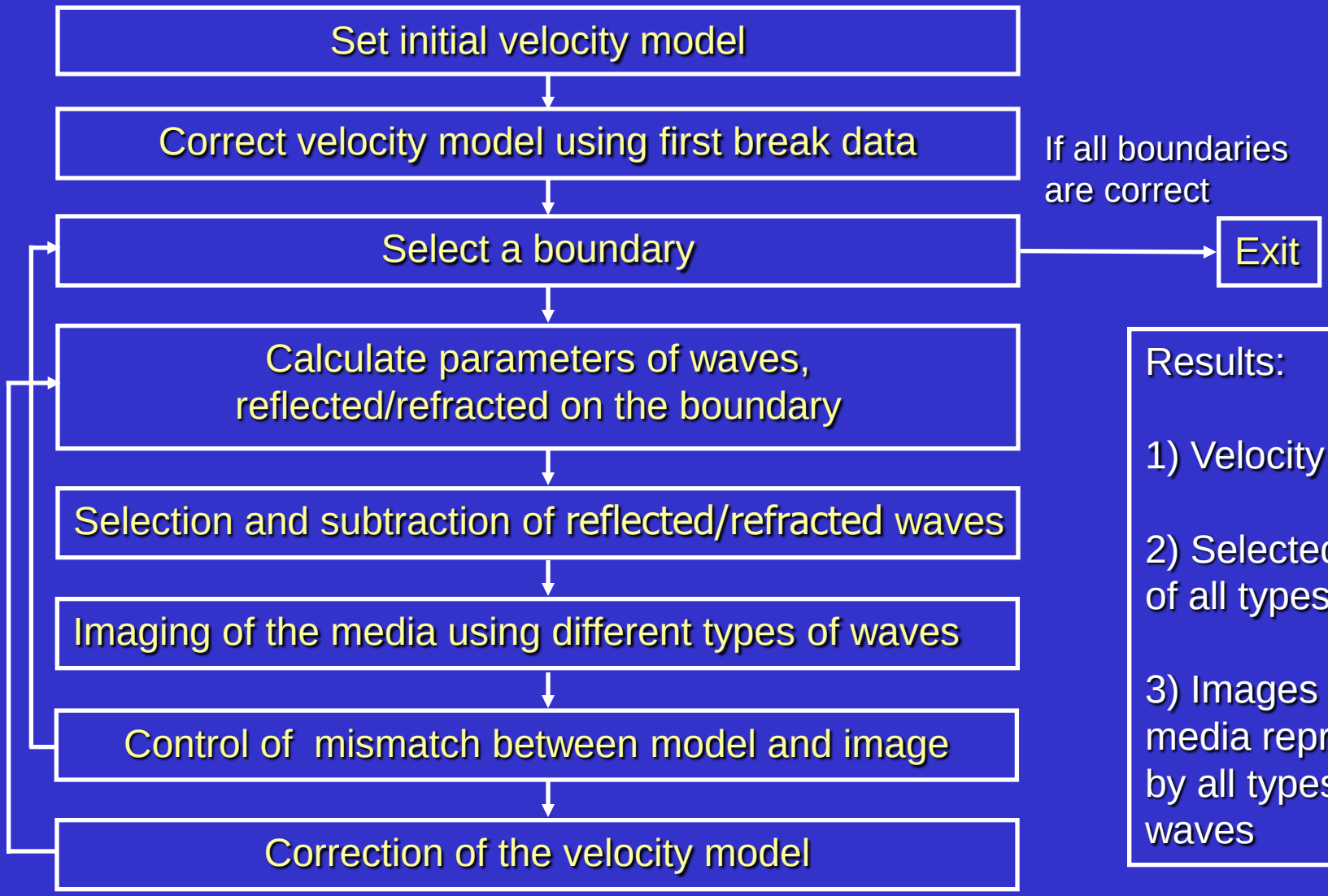
Introduction

Depending on boundaries configuration, different parts of interfaces can be exposed by one or more type of waves. Obviously, all types of waves contain information about properties of the media. It means that in process of imaging of the media all available information should be used. It is also necessary for the derived solution to particularly include "one-wave exposure" case.



Area and boundaries, exposed by waves of different types

Description of DDR Technology (Dynamic Decomposition of the wave-field and Reconstruction of the media)



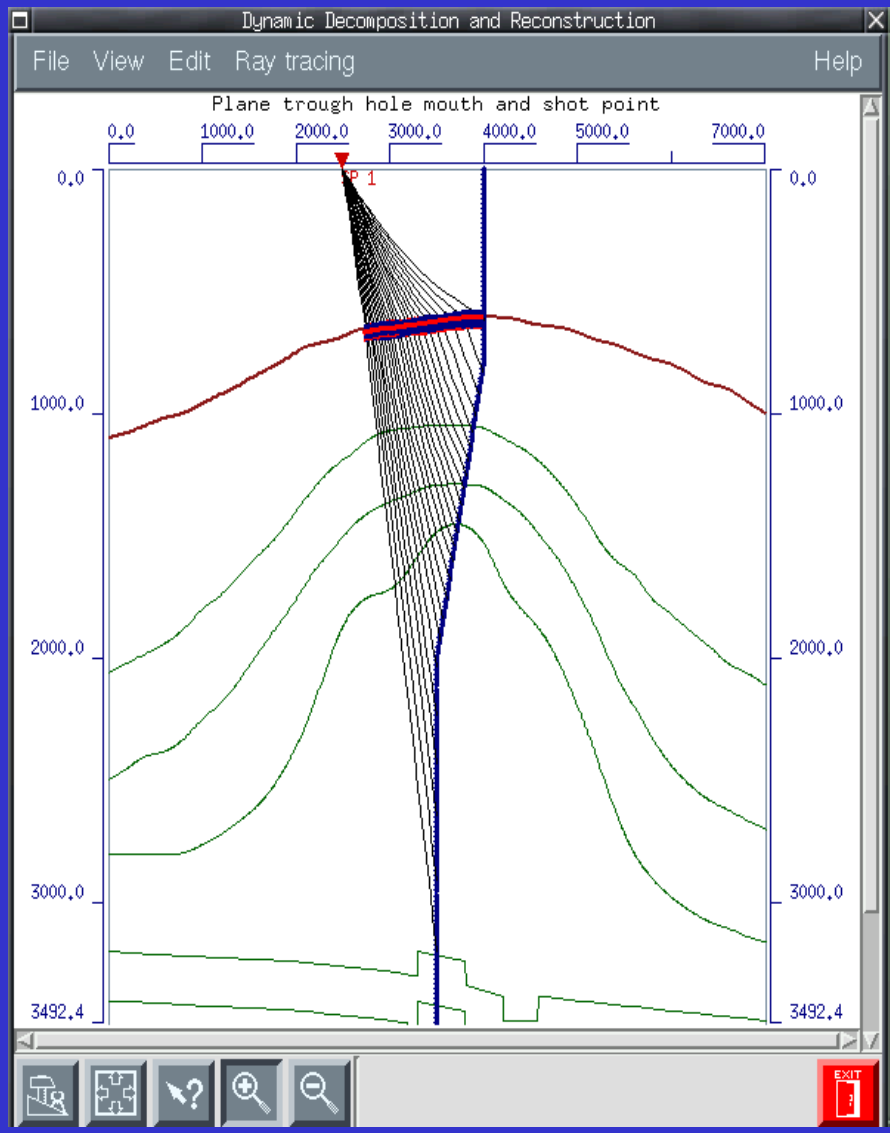
Results:

1) Velocity model

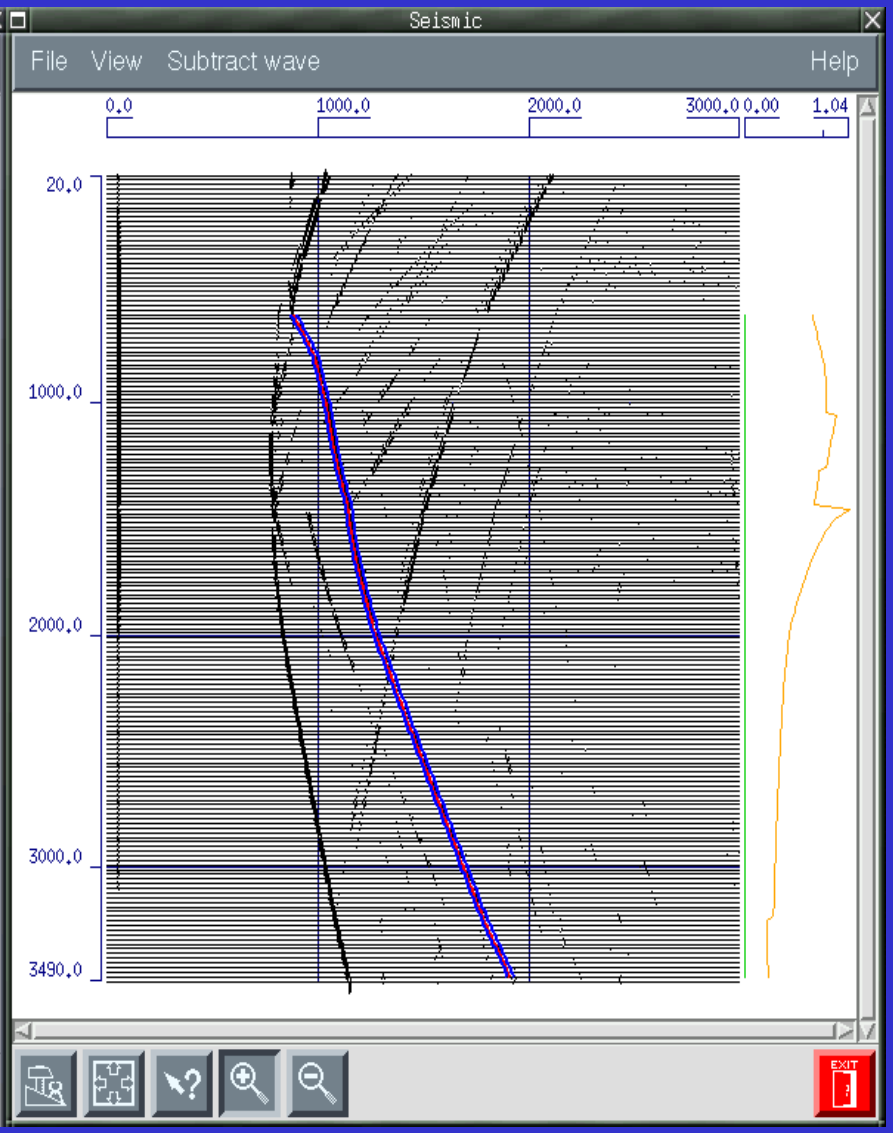
2) Selected waves of all types

3) Images of the media represented by all types of waves

DDR interface concept



Model, ray paths and image



Wave-field and wave parameters

Joint imaging

The way to calculate joint image is summing of the images from all types of waves. It is important to remember that all images dynamically correspond to different physical measures. Therefore images must be normalized before stacking. Resulting measure can be selected as value of P-waves reflection coefficient along normal to the boundary. Then normalization coefficient can be evaluated as

$$\gamma = \frac{1}{N} \frac{K_P^o}{K}$$

where

K – reflection coefficient, calculated using reference model;

K_P^o – normalized measure;

N – number of summed images.

Thus, for all boundaries of the model joint images can be calculated using all types of waves.

These images can be composed into one seismic section.

In this section amplitudes correspond to the reflection characteristic of the media.

Calculation of reflection/refraction coefficients for different types of waves

To calculate reflection/refraction coefficients in the boundary point the following system is used:

$$\begin{cases} -A_{PP}\sin\alpha_P + A_{PS}\cos\alpha_S - B_{PP}\sin\beta_P - B_{PS}\sin\beta_S = -\sin\alpha_S \\ -A_{PP}\cos\alpha_P + A_{PS}\sin\alpha_S - B_{PP}\cos\beta_P - B_{PS}\sin\beta_S = \cos\alpha_P \\ -A_{PP}\sin 2\alpha_P + A_{PS}\dfrac{v_{P_1}}{v_{S_1}}\cos 2\alpha_S - B_{PP}\dfrac{\rho_2}{\rho_1}\dfrac{v_{P_1}^2}{v_{S_1}^2}\dfrac{v_{P_1}}{v_{P_2}}\sin 2\beta_P + B_{PS}\dfrac{\rho_2}{\rho_1}\dfrac{v_{P_1}v_{S_2}}{v_{S_1}^2}\cos 2\beta_S = \sin 2\alpha_P \\ -A_{PP}\sin 2\alpha_S - A_{PS}\dfrac{v_{S_1}}{v_{P_1}}\sin 2\alpha_S - B_{PP}\dfrac{\rho_2}{\rho_1}\dfrac{v_{P_2}}{v_{P_1}}\sin 2\beta_S + B_{PS}\dfrac{\rho_2}{\rho_1}\dfrac{v_{S_2}}{v_{P_2}}\sin 2\beta_S = -\cos 2\alpha_S \end{cases}$$

where

a - amplitude of downgoing wave

α_P, α_S - reflection angles of monotype and converted wave,

β_P, β_S - refraction angles of monotype and converted wave,

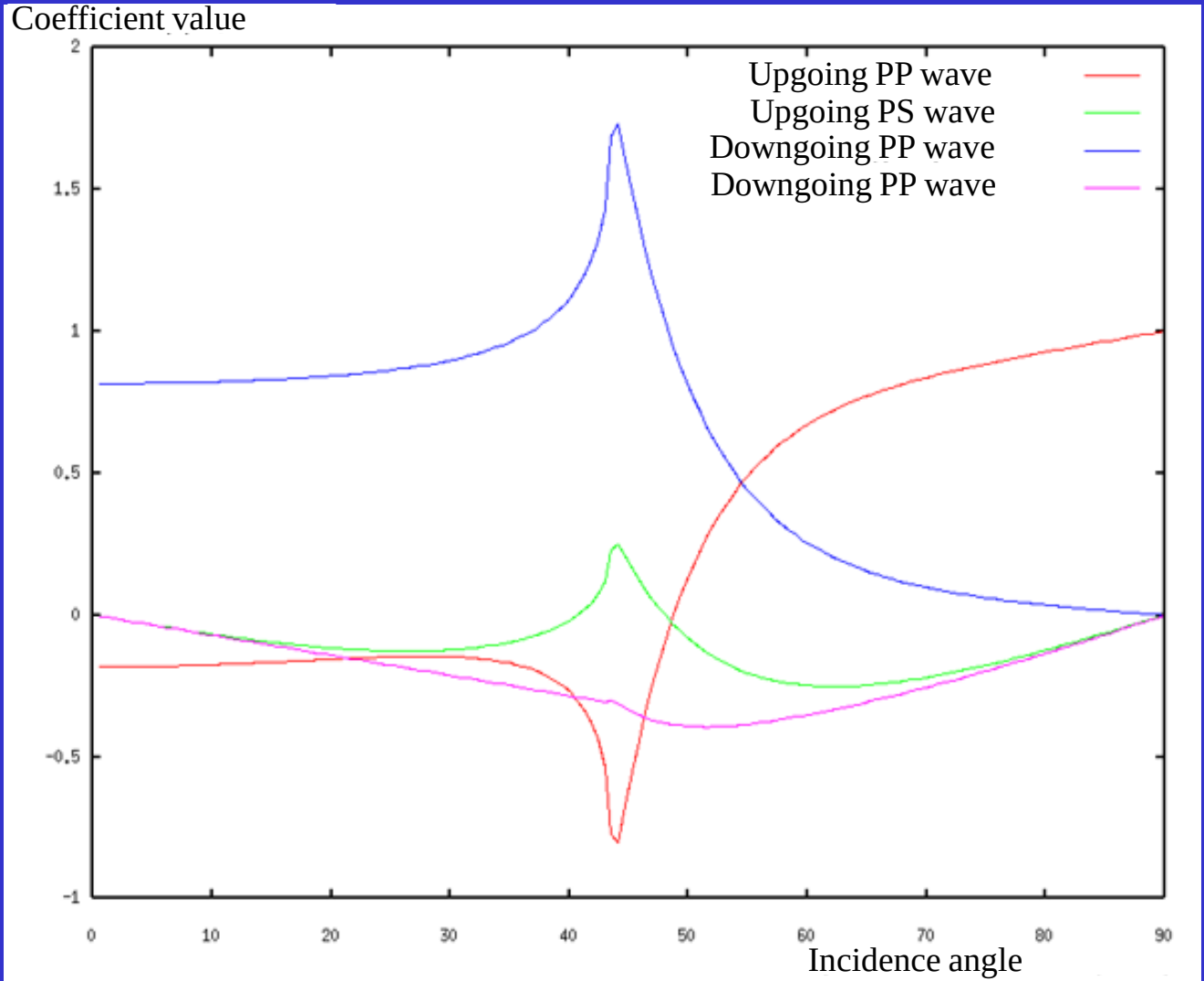
v_{P_1}, v_{S_1} v_{P_2}, v_{S_2} - P and S waves velocities

ρ_1, ρ_2 - densities

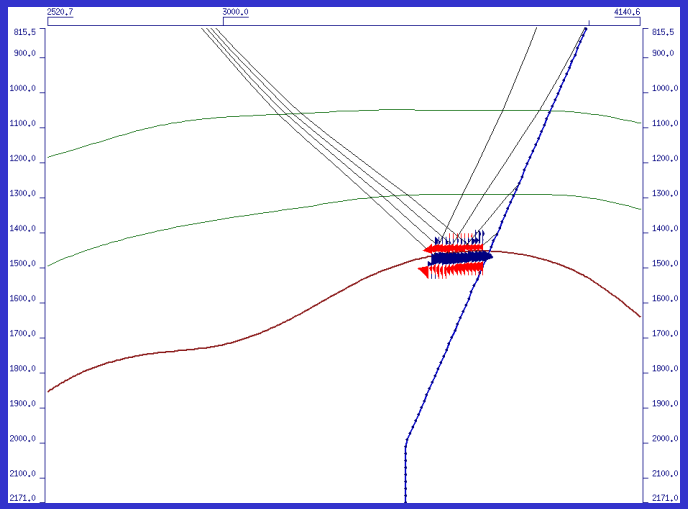
$A_{PP} = \dfrac{a_{PP}}{a}$ $A_{PS} = \dfrac{a_{PS}}{a}$ - reflection coefficients

$B_{PP} = \dfrac{b_{PP}}{a}$ $B_{PS} = \dfrac{b_{PS}}{a}$ - refraction coefficients

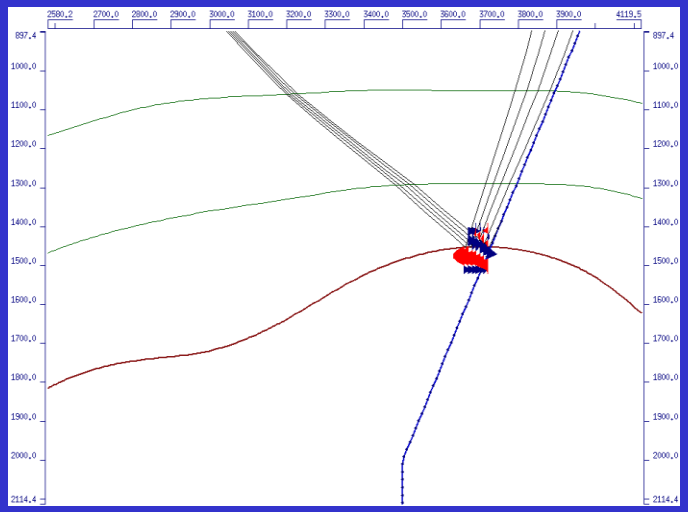
Function of reflection/refraction coefficients vs. incidence angle



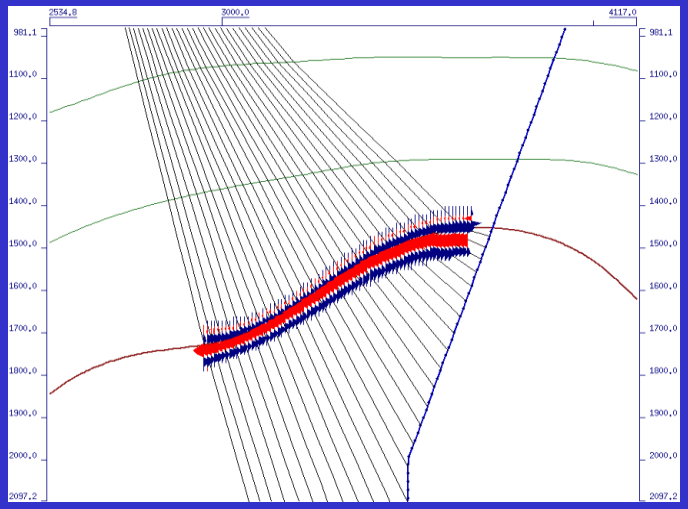
Images for different type of waves



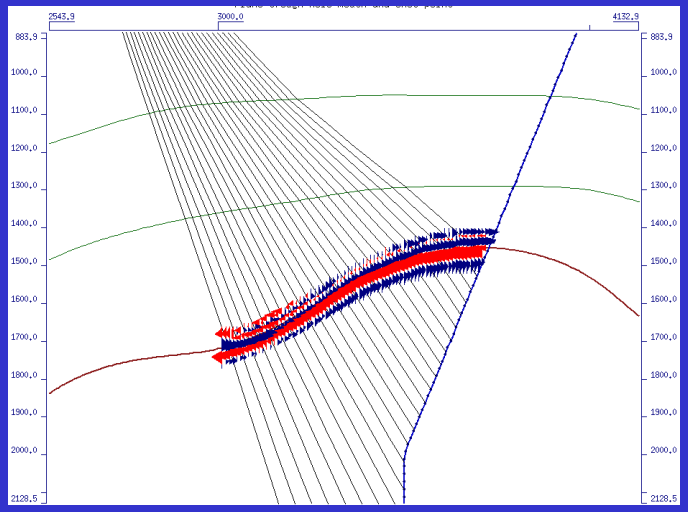
Reflected PP wave



Reflected PS wave

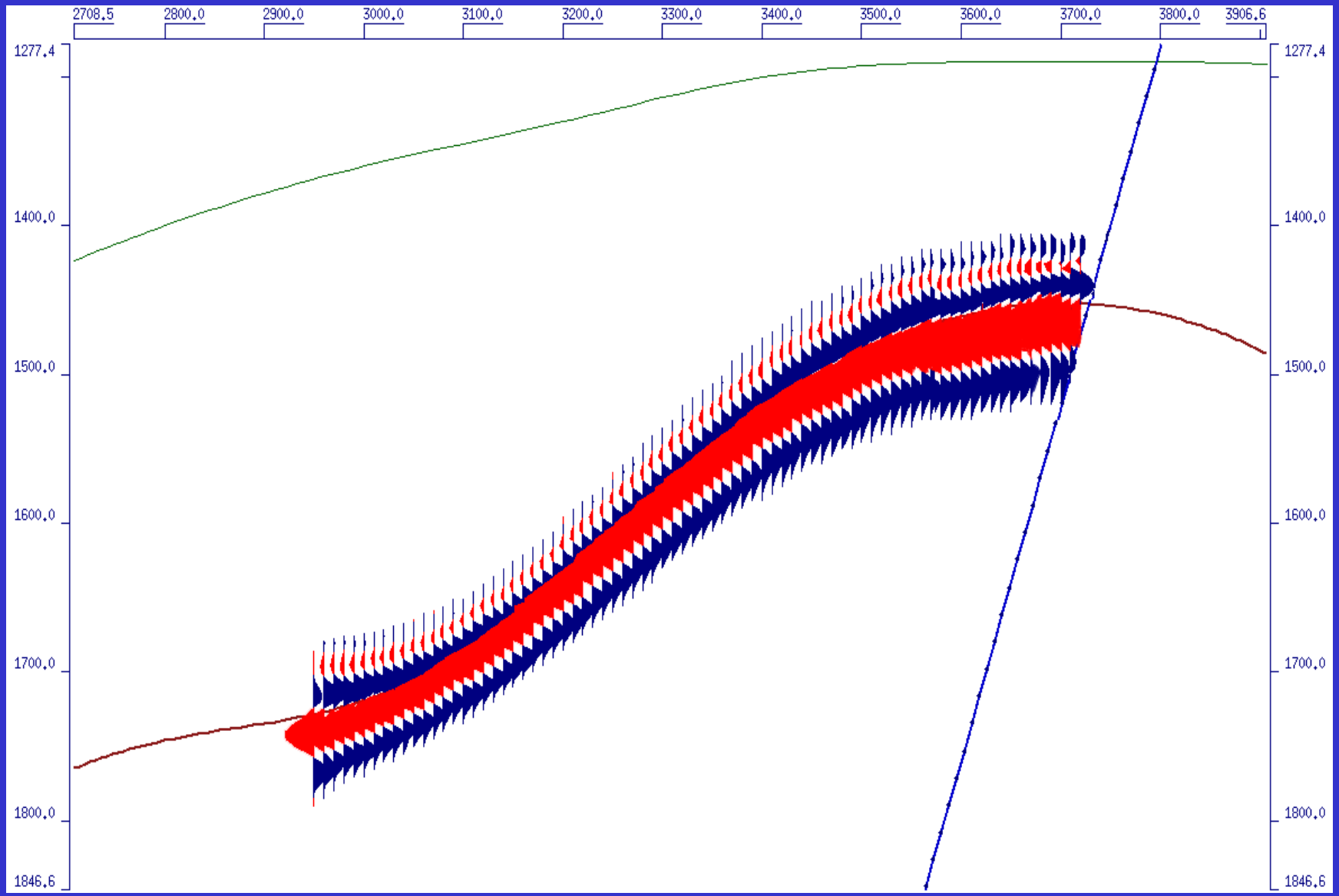


Refracted PP wave

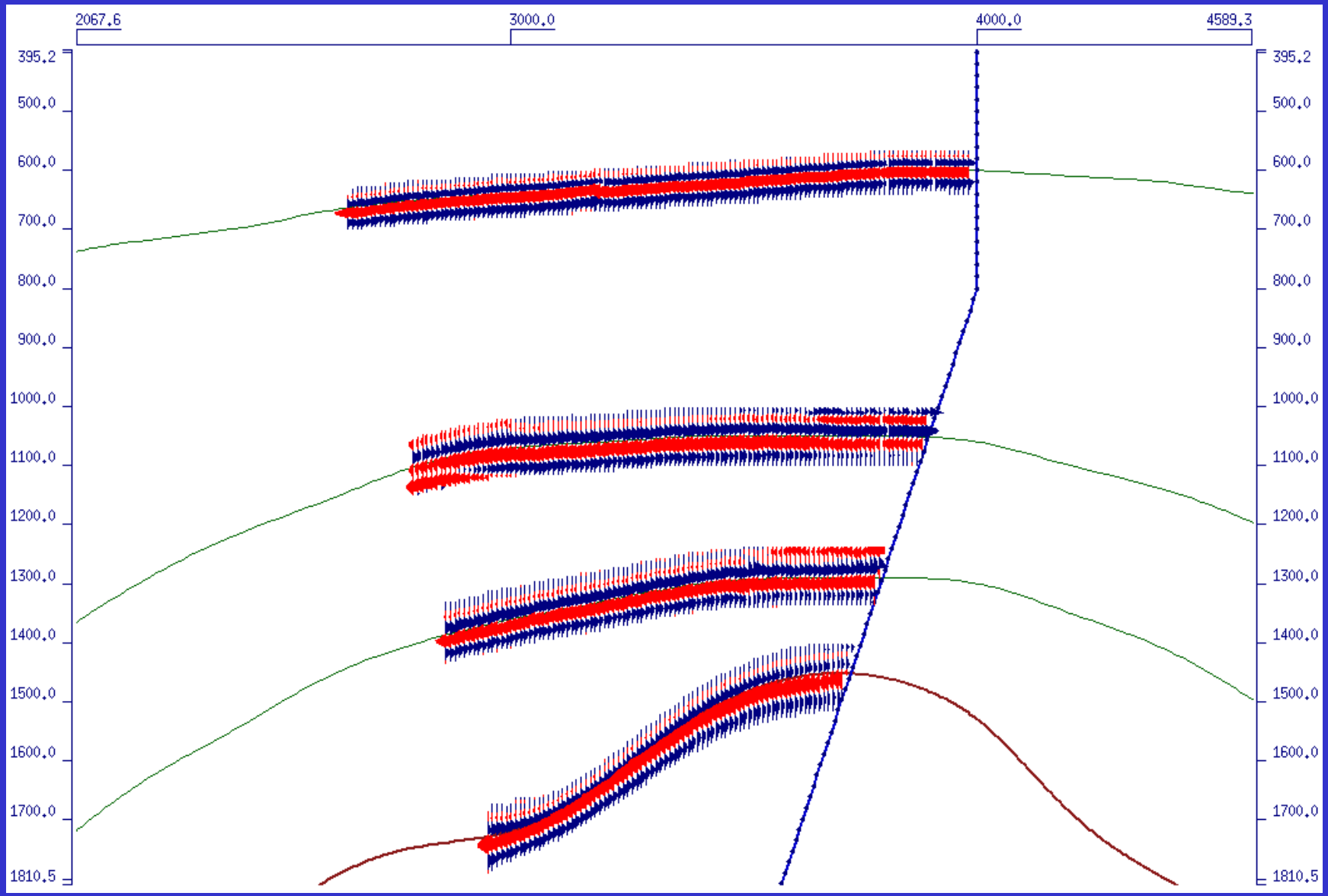


Refracted PS wave

Joint image of the boundary



Joint image of the several boundaries



Conclusion

This method allows constructing of full seismic image which represents the media as values of true reflection coefficient along normal to the boundaries.

DDR technology provide a practical possibility to build joint image of the complicated media by all available types of waves.