KINEMATIC INVERSION OF THE FULL VECTOR VSP P-Wave Field

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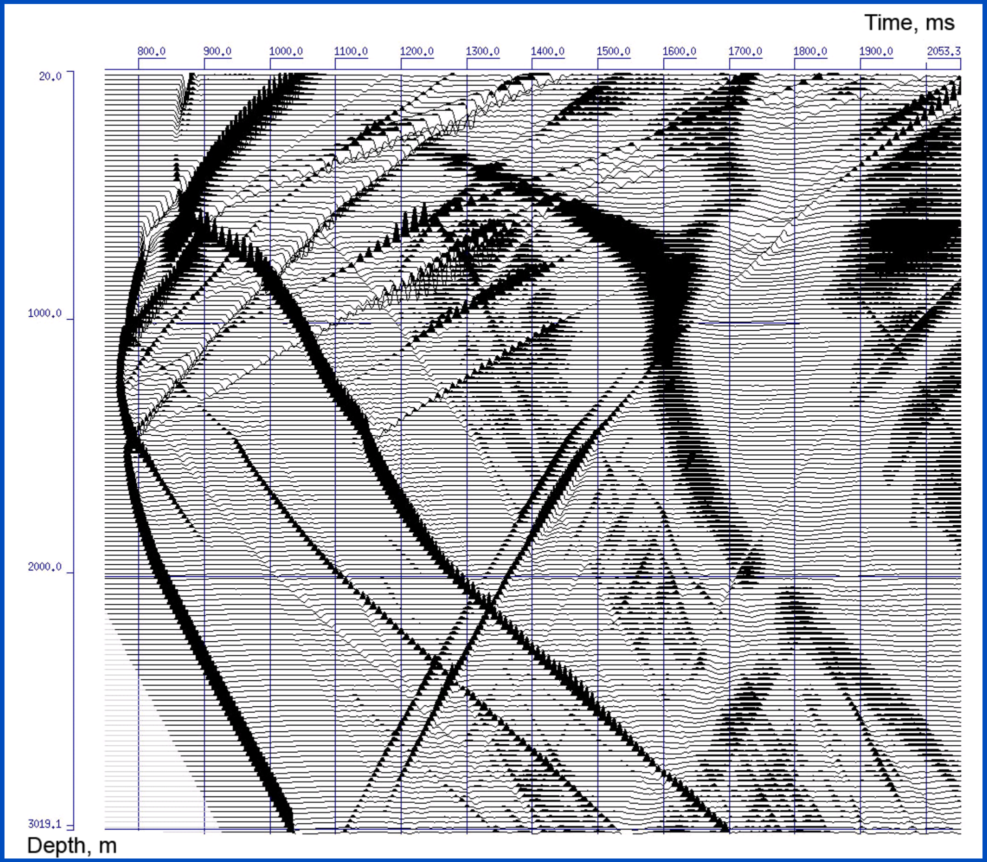
Introduction

Determination of seismic velocities and geometry of reflecting boundaries in the borehole environment is one of the essential tasks decided by VSP method.

Determination of kinematic medium characteristics using VSP data usually includes construction of an initial approximation of velocity model and a following iterative process of the hodograph optimized inversion.

As a result, such model parameters are selected to help provide the best coincidence between observed and model VSP travel times.

Inverse kinematics problem definition



Source wave field

A solution of inverse kinematics problem aimed at recovery of reflecting boundary geometry and also velocities and its vertical gradients of pressure and share waves is considered.

Reflecting boundary geometry is described by cubic splines.

In the parameters definition process well-known layers section and VSP hodographs of direct as well as all first order reflected and transferred waves were used.

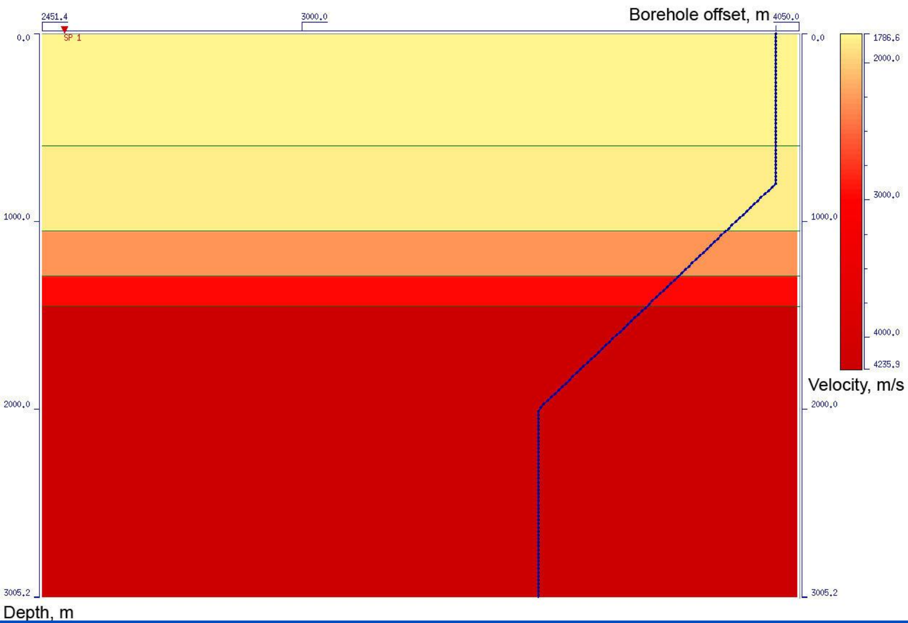
Inverse kinematics problem solution stages:

I. Zero range velocity model definition

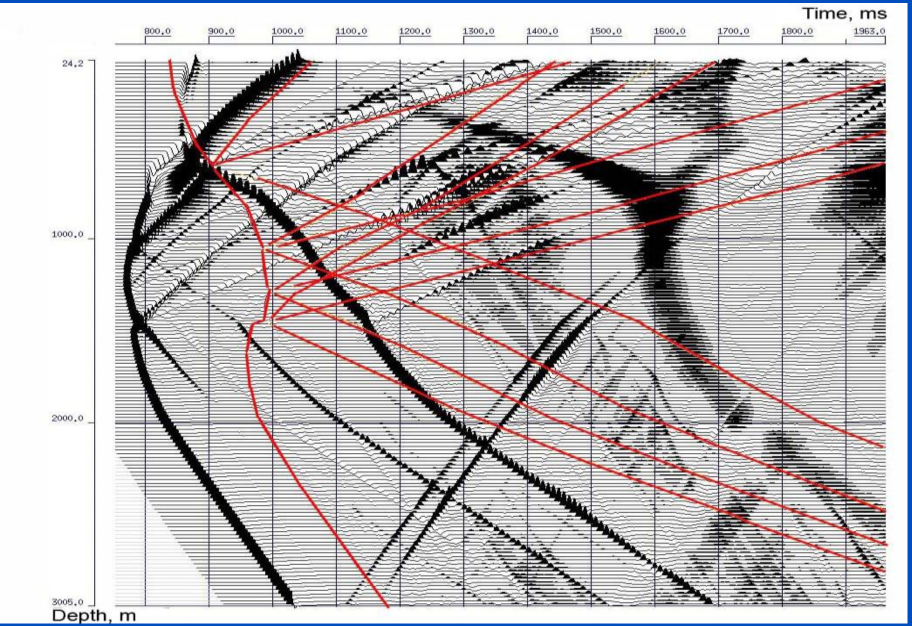
II. Polynomial boundaries velocity model construction

III. Spline boundaries velocity model construction

I. Zero range velocity model definition



Zero range velocity model



Zero range velocity model hodographs

In this phase the pressure wave velocities are reinstated in each of the layers with a certain accuracy using well-known layer section over all hodographs of the direct wave. It is considered the section boundaries to be straight.

In this way the received zero-range approximation of the complex constructed medium is represented in the form of the horizontally schistose velocity model.

II. Polynomial boundaries velocity model construction

Zero range

P-wave velocity and vertical gradient of i-1 body from direct wave

Polynomial coefficients of bound i from PPup[i] wave

P-wave velocities and gradients of i body from direct wave

S-wave velocity and vertical gradient of i-1 body from PSup[i] wave

S-wave velocity and vertical gradient of i body from PSdown[i] wave

In velocity model boundaries

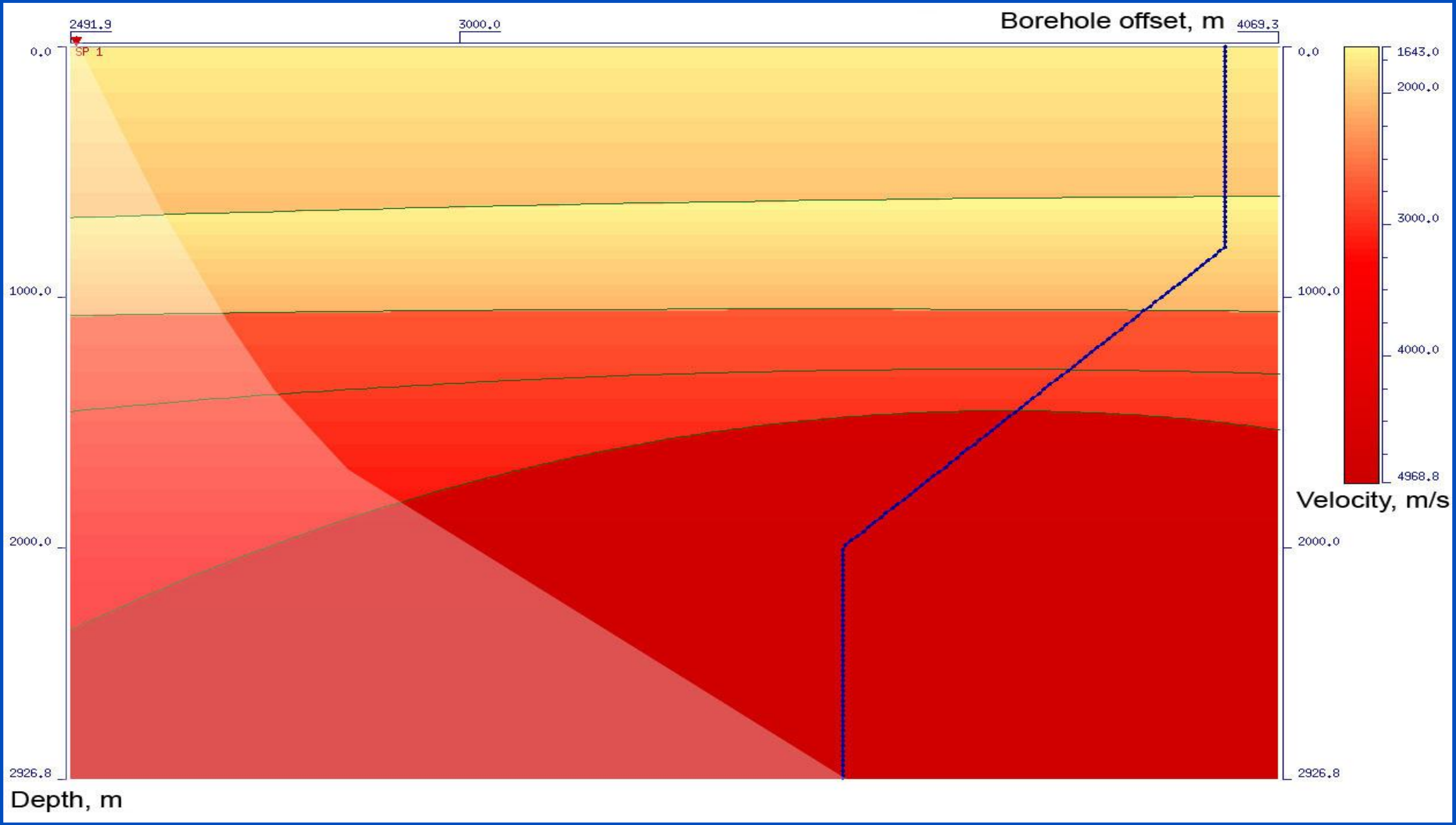
Spline boundaries velocity model construction

PPup[i] – upgoing reflected P-wave from bound i

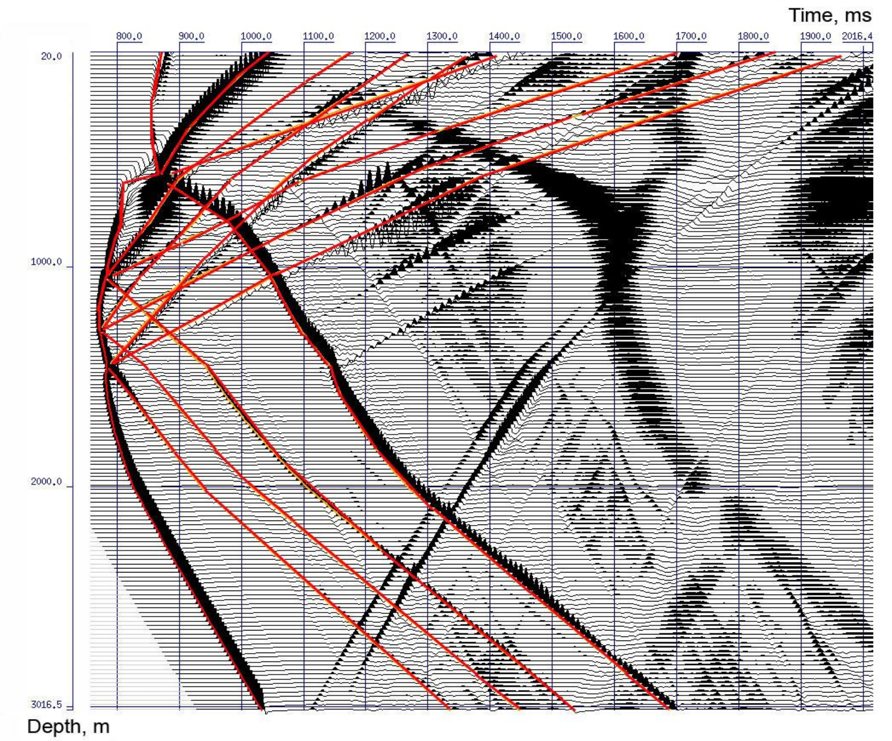
PSup[i] – upgoing reflected S-wave form bound i

PSdown[i] – downgoing transmitted S-wave from bound i

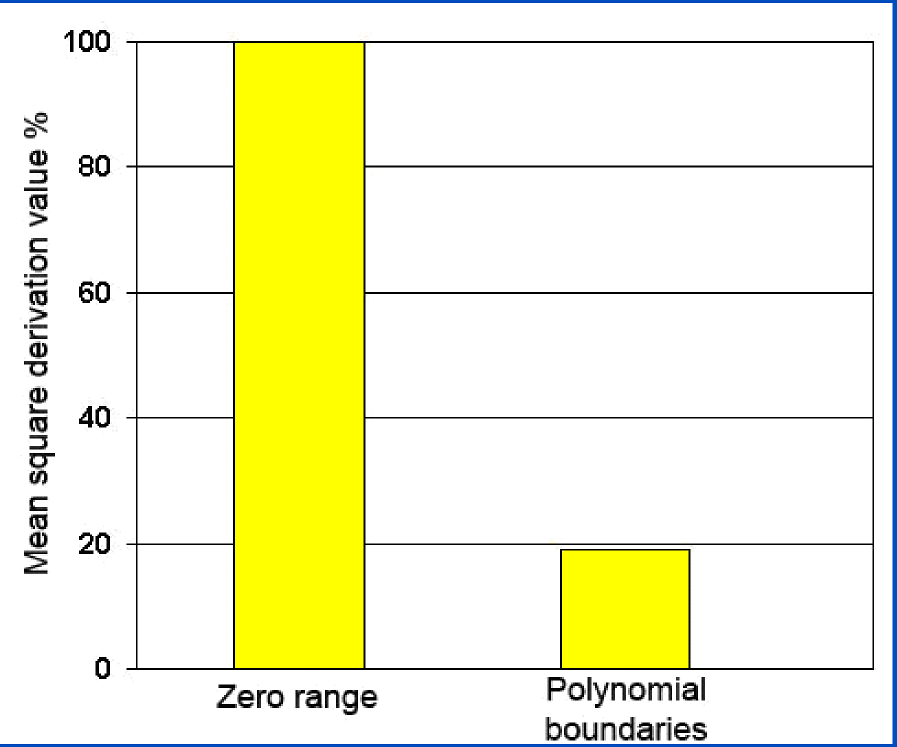
Velocity model with polynomial boundaries as a result of kinematics inversion



Hodographs and mean square derivations for velocity model with polynomial boundaries

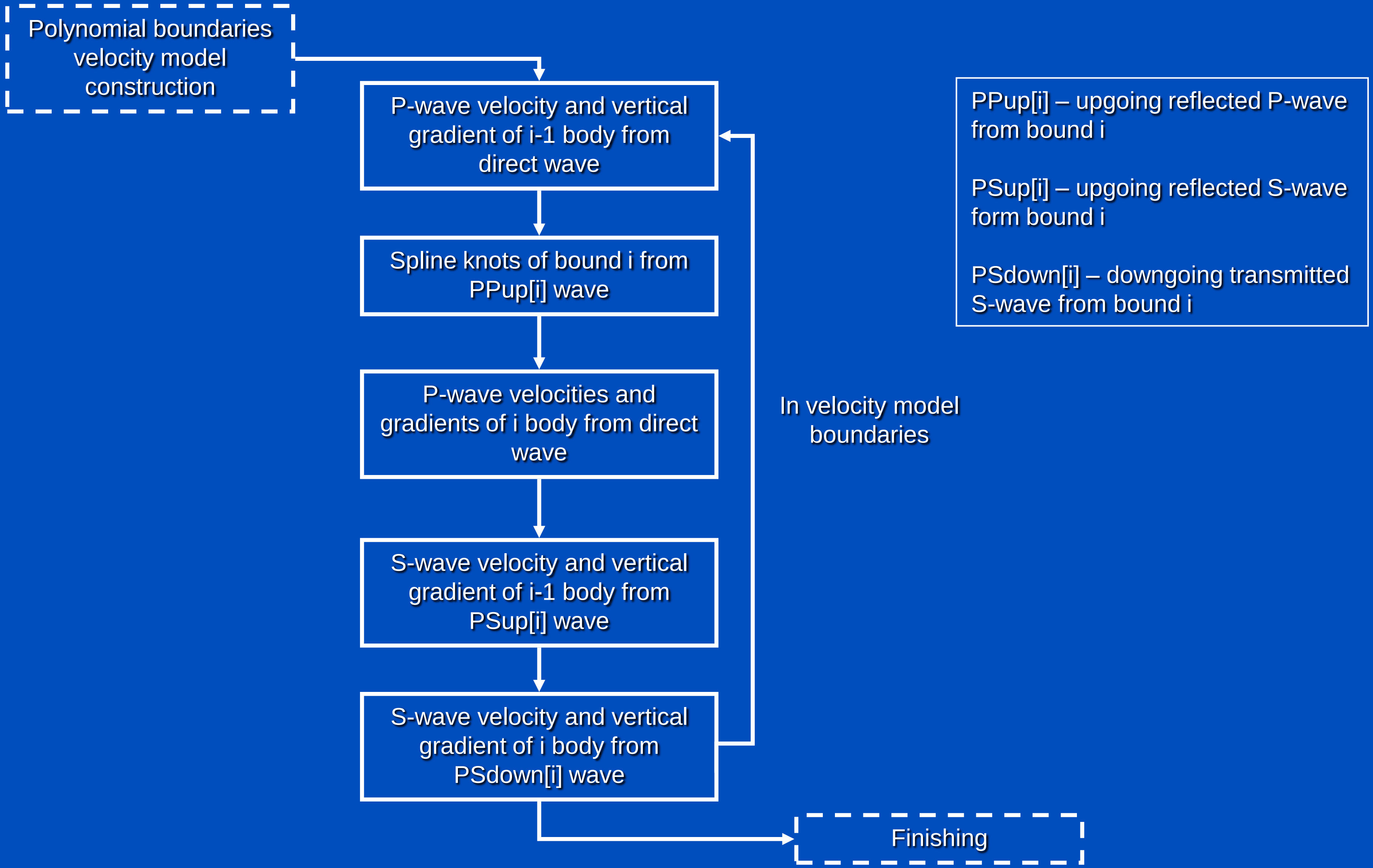


Derived from velocity model with polynomial boundaries hodographs

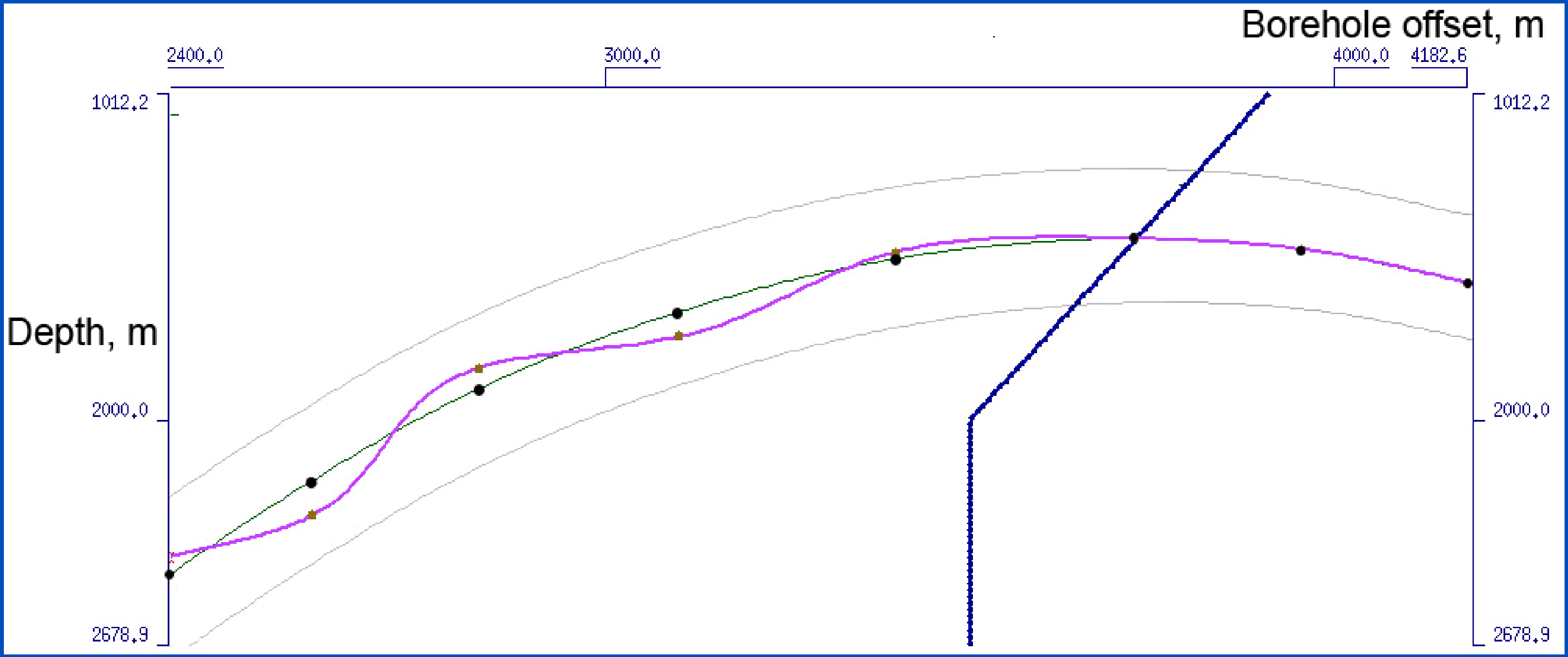


Mean square derivation values

III. Spline boundaries velocity model construction

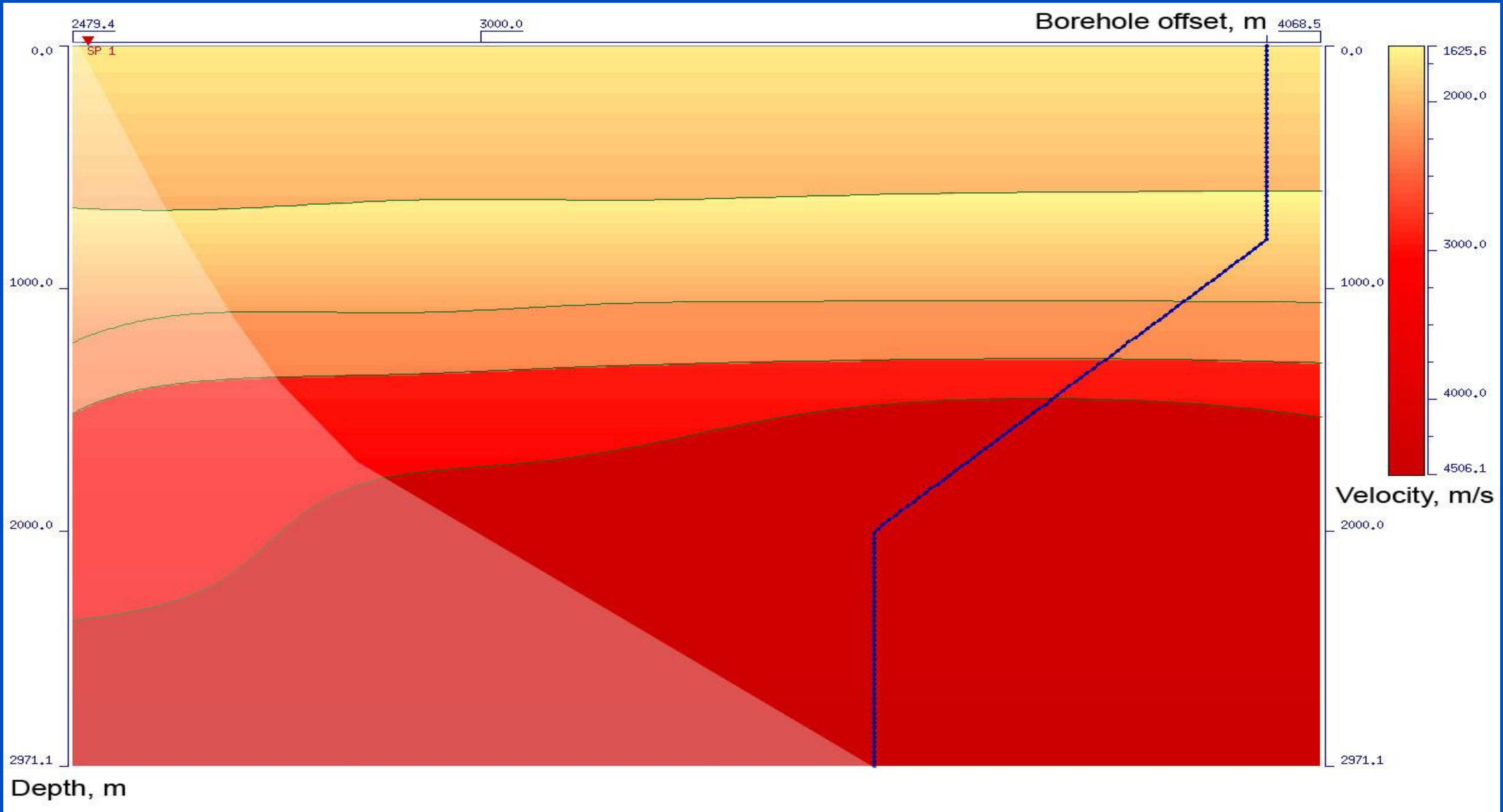


Spline knots position selection

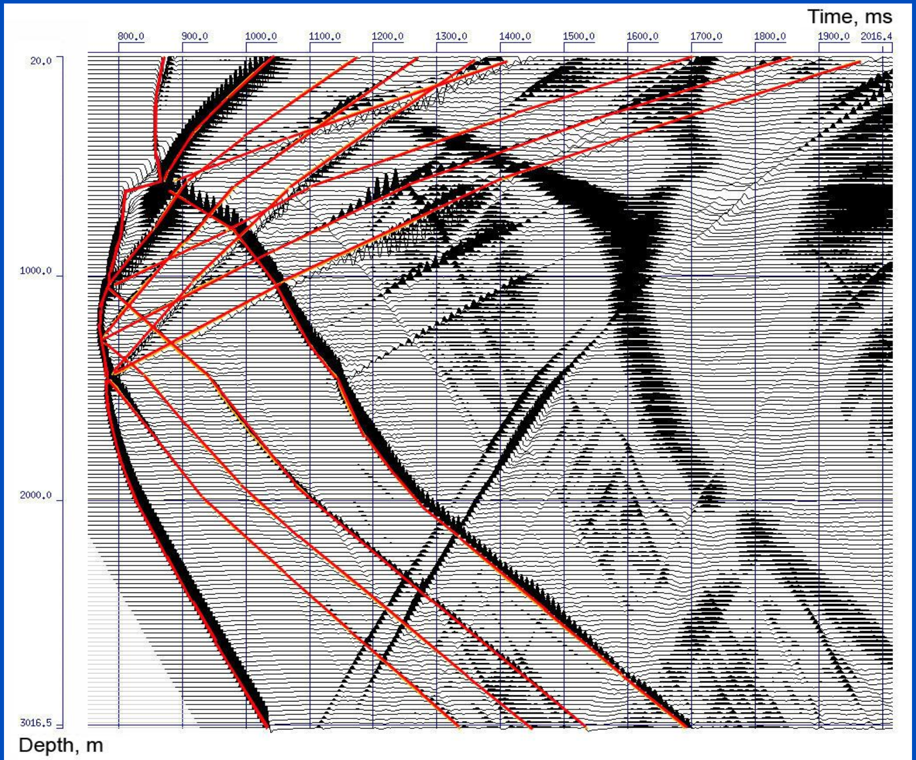


Reflecting boundary geometry is described by cubic splines by means of knots points addition and its optimal position selecting.

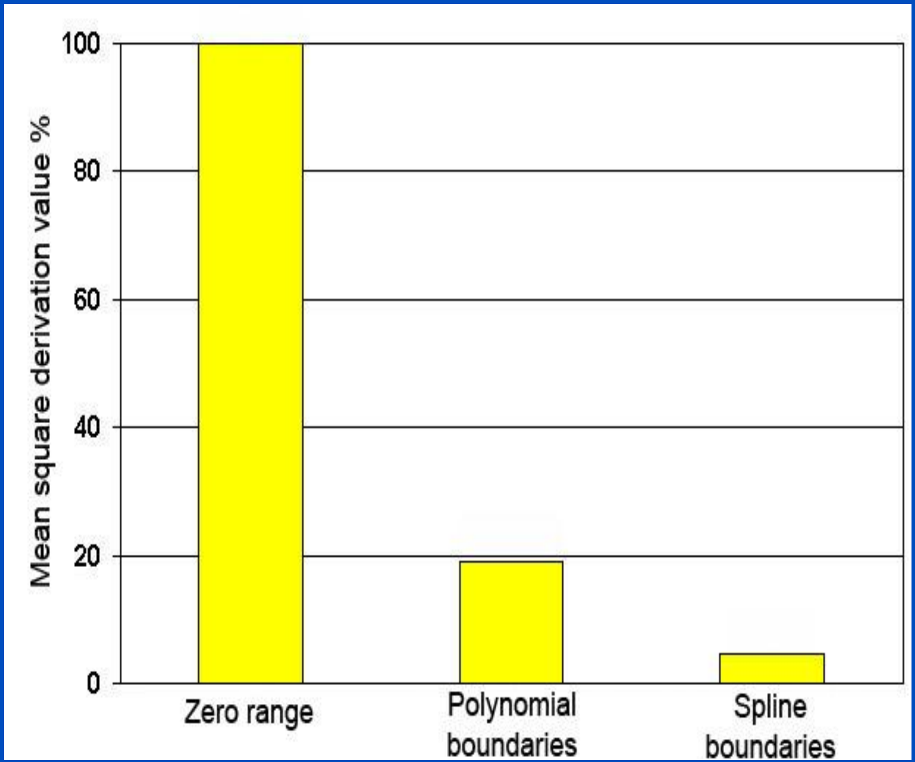
Velocity model with spline boundaries as a result of kinematics inversion



Hodographs and mean square derivations for velocity model with spline boundaries

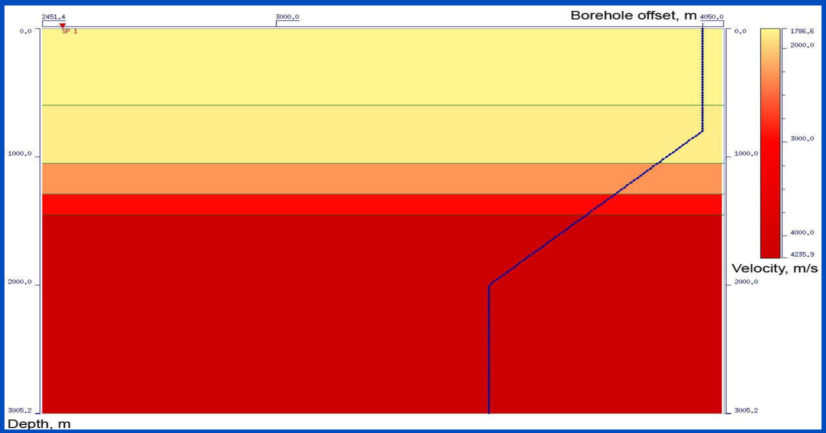


Derived from velocity model with spline boundaries hodographs

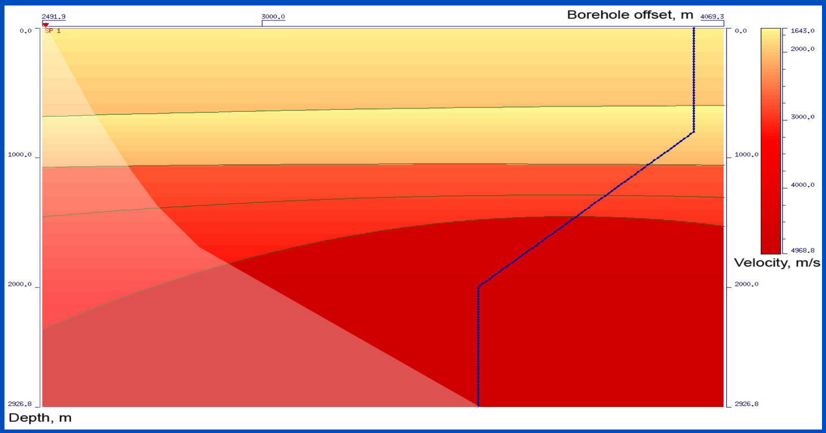


Mean square derivation values

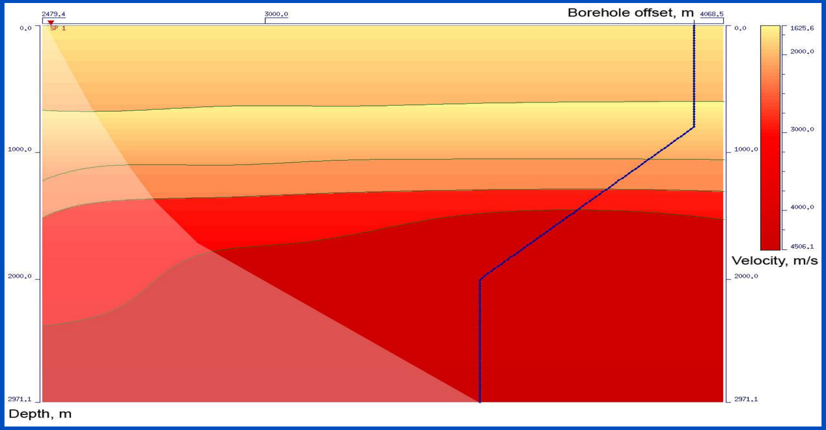
Results



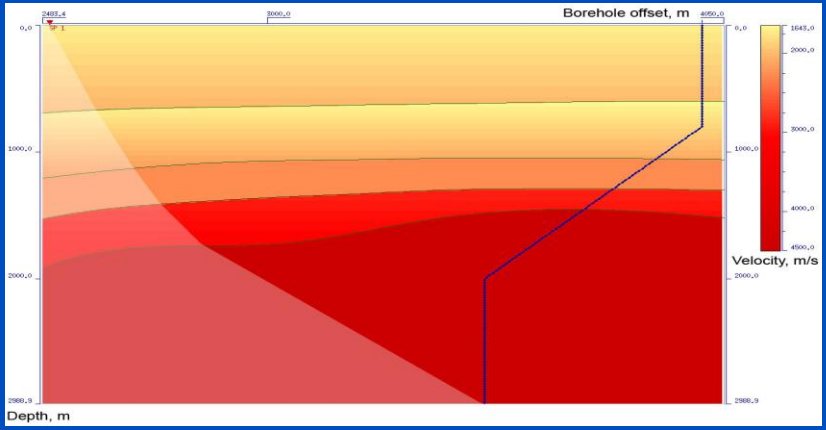
1. Zero range velocity model



2. Velocity model with polynomial boundaries

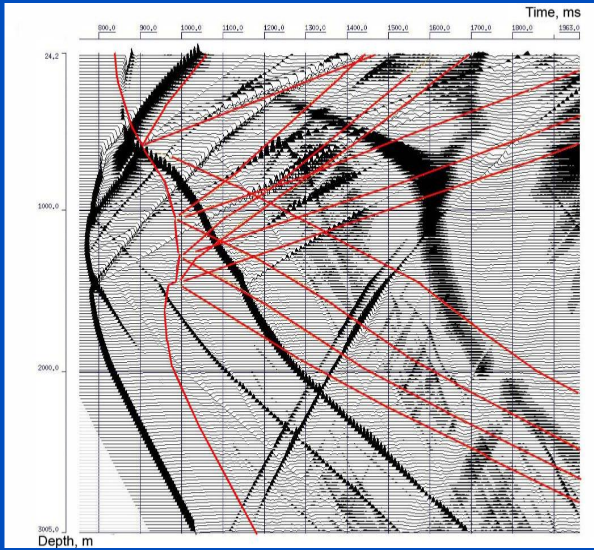


3. Velocity model with spline boundaries

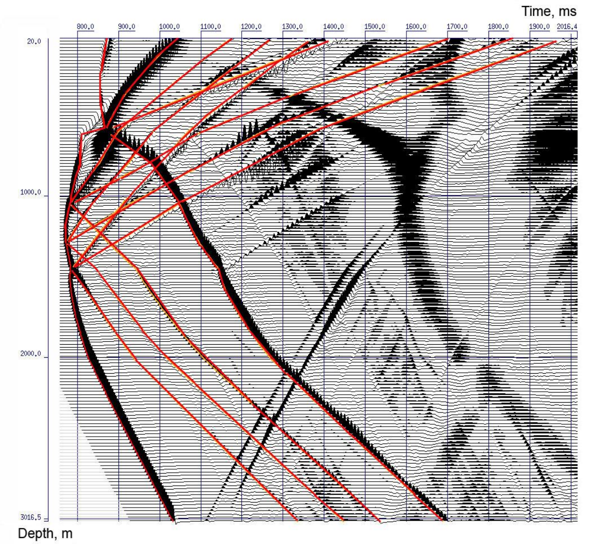


4. Exact velocity model

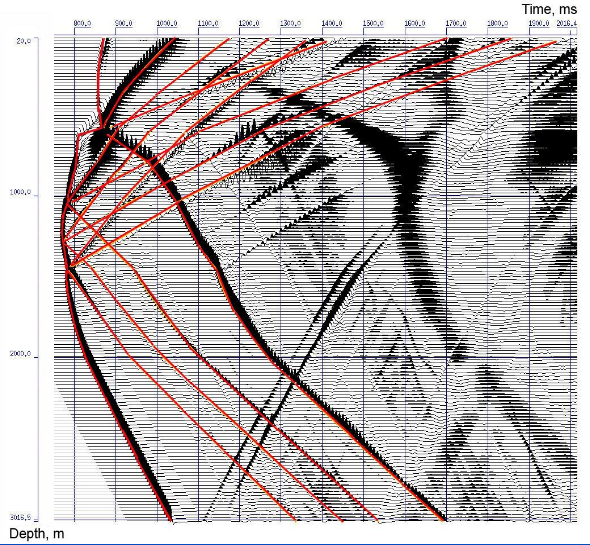
Resulting hodographs and mean square derivation values



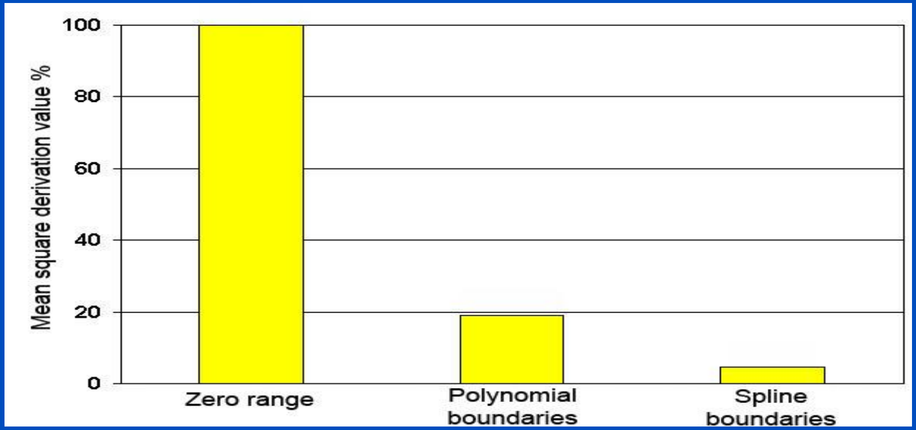
Derived from zero range velocity model hodographs



Derived from velocity model with polynomial boundaries hodographs



Derived from velocity model with spline boundaries hodographs



Mean square values of discrepancy over travel times of all used waves.

Conclusions

To get more precise result of VSP kinematics inversion for detailed construction of complex medium one may:

- using information about all hodographs of direct wave as well as all monotype and converted primaries.

- accurating reflecting boundaries geometry by means of splines.