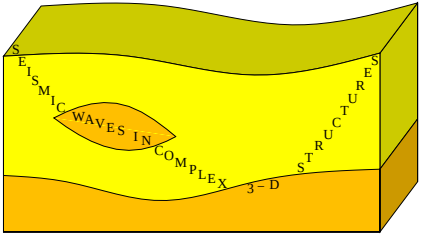
Constructing model P1I for reflection studies

Petr Bulant[1] **& Nick Martakis**[2]

[1] *Department of Geophysics, Faculty of Mathematics and Physics, Charles University,*
Ke Karlovu 3, 121 16 Praha 2, Czech Republic,
http://sw3d.cz/staff/bulant.htm,
[2] *Landtech Enterprises S.A*



http://sw3d.cz

Seismic Waves in Complex 3-D Structures, Consortium meeting, Prague, May 30-31, 2011

Data:

- the values of P-wave velocity and P/S ratio given on a 2-D grid

- (later: the positions of the structural interfaces given)

Task:

- to calculate synthetic seismograms simulating a reflection measurement in the locality.

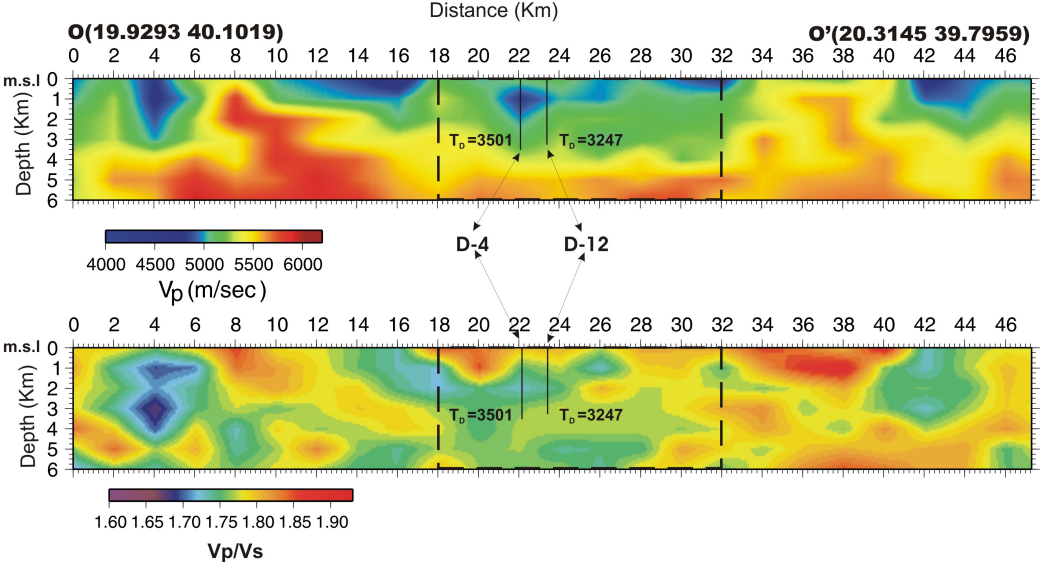
Method

Construction of a smooth one-block velocity model P1 by simultaneous least-square fitting of the discrete values of slowness and minimizing the square of the Sobolev norm composed of second derivatives of the slownesses in the model.

For model P1I with interfaces: simultaneous least-square fitting of the discrete data for interfaces and minimizing the square of the Sobolev norm composed of second derivatives, i.e. we minimize the curvature of the interfaces. In the second step fitting of slownesses.

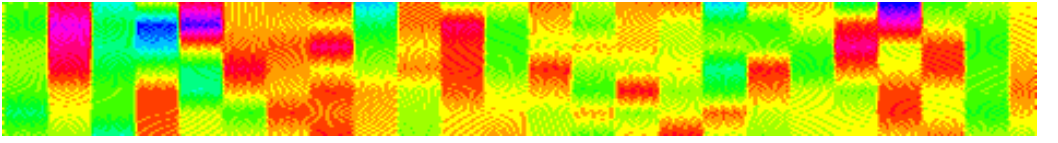
Input information for velocity model

2-D velocity profile, length of 47.3 km and depth of 6 km,
474 × 61 points with equal horizontal and vertical spacing of 0.1 km

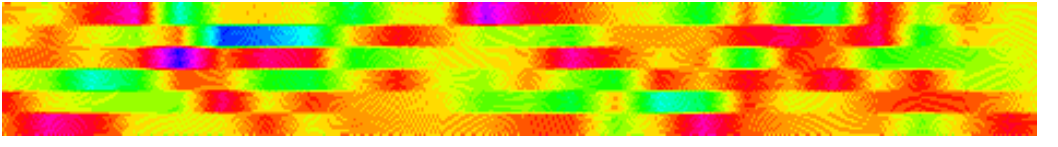


First derivatives of the P-wave velocity data

Horizontal first velocity derivatives in data grid

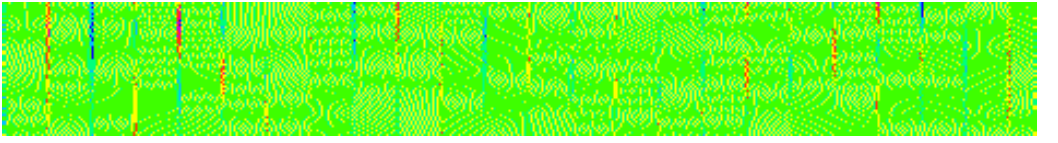


Vertical first velocity derivatives in data grid

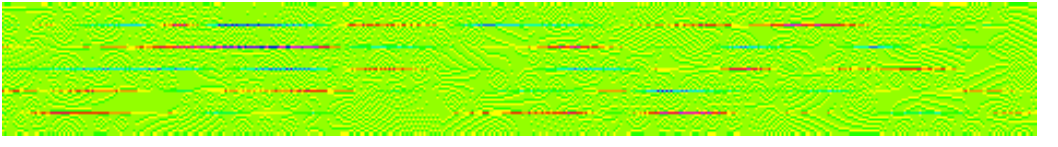


Second derivatives of the P-wave velocity data

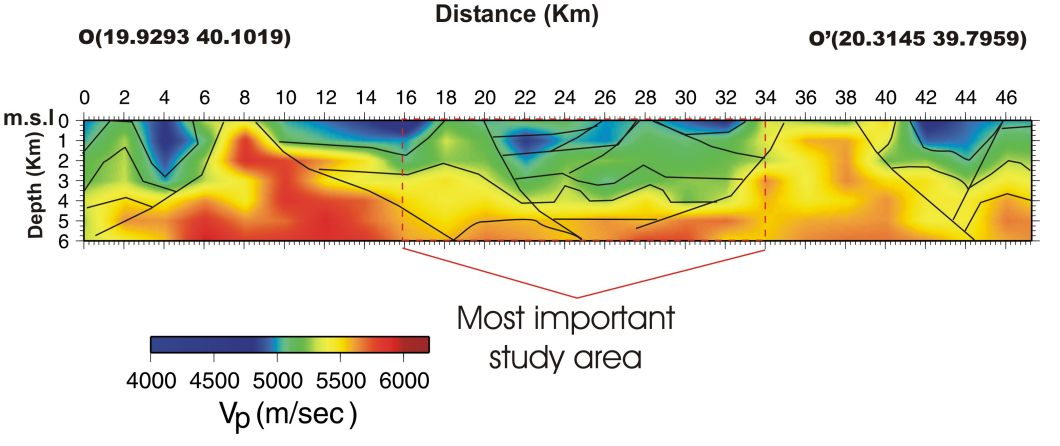
Horizontal second derivatives in data grid



Vertical second velocity derivatives in data grid



Data for the structural interfaces



Smooth one-block model P1

Model parameterization, amount of smoothing:

- both the P and S-wave velocities parameterized by 474×61 spline points located at the same positions as the velocity data points

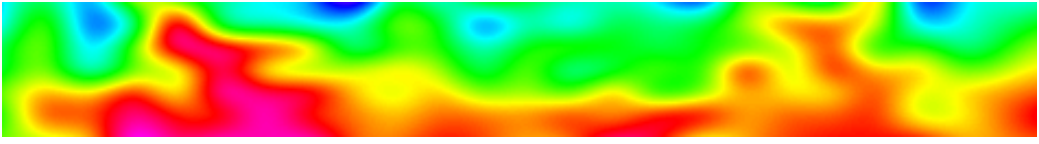
- as the data, the values of P and S-wave slowness are used

- in the model the slownesses are interpolated

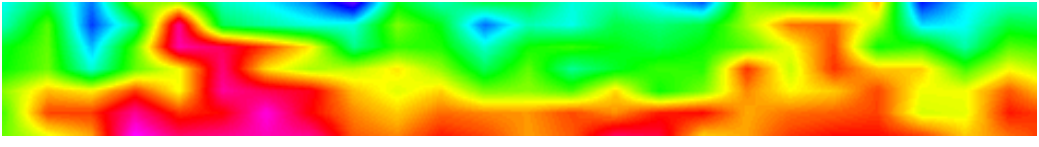
- the amount of required smoothing is relatively small

Smooth one-block model P1

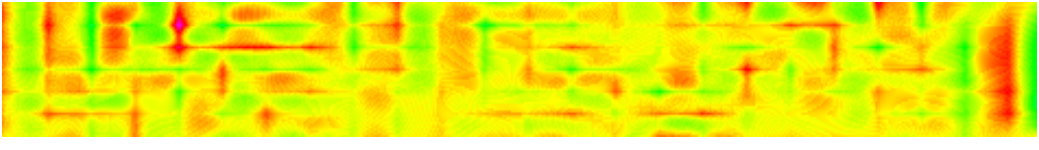
P-wave velocity in the smooth one-block model P1 (4.64 km/s – 5.93 km/s)



P-wave velocity data for the model P1 shown in the same colour scale

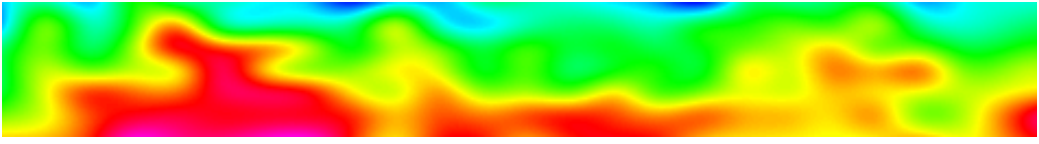


P-wave velocity differences (-0.13 km/s – 0.08 km/s)

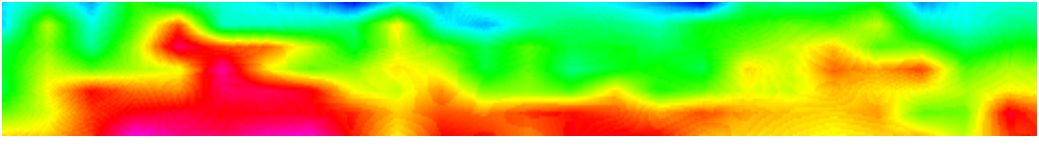


Smooth one-block model P1

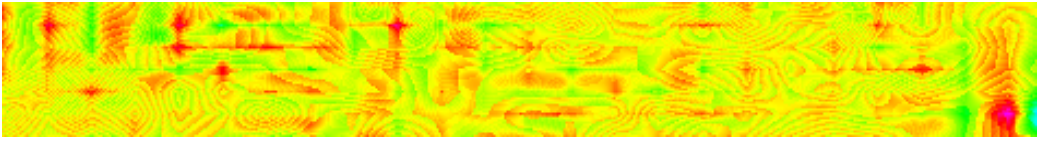
S-wave velocity in the smooth one-block model P1 (2.66 km/s – 3.35 km/s)



S-wave velocity data for the model P1 shown in the same colour scale

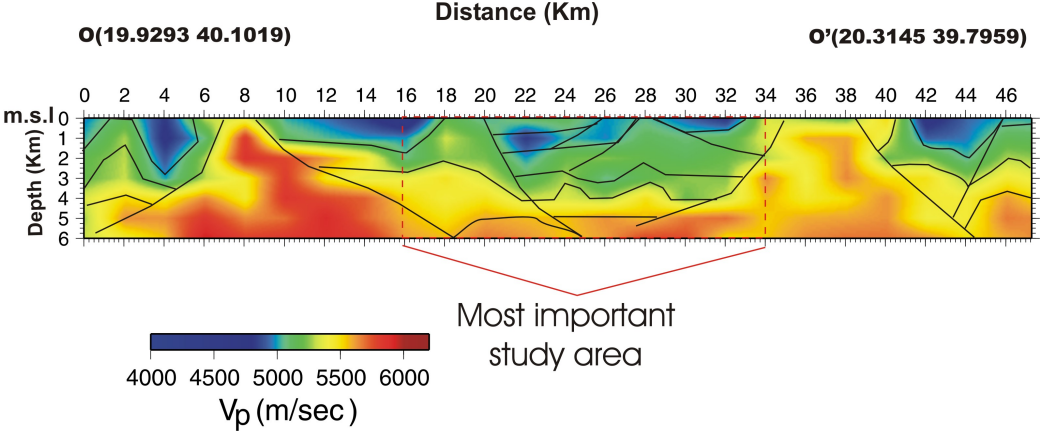


S-wave velocity differences (-0.08 km/s. – 0.08 km/s)

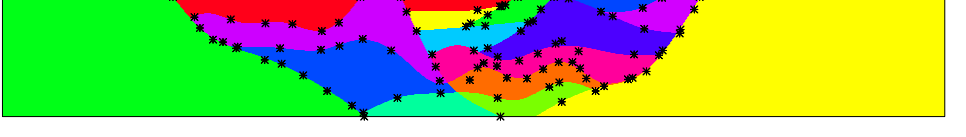


Model P1I with structural interfaces

Data for the structural interfaces

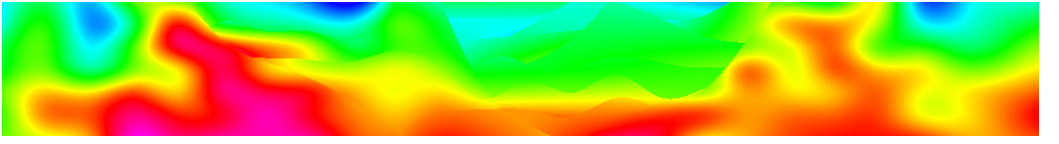


Structural interfaces and structural blocks in the model P1I

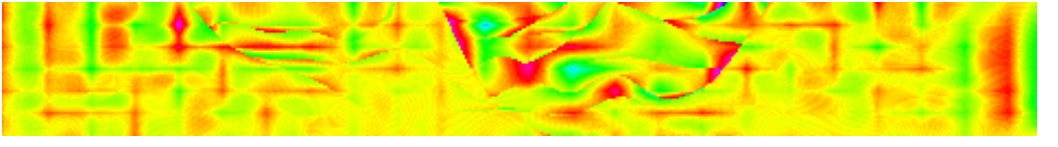


Model P1I with structural interfaces

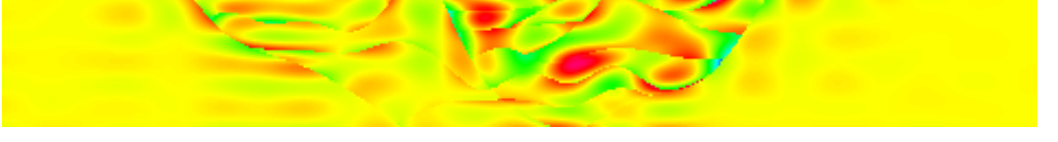
P-wave velocity in model P1I (4.66 km/s – 5.93 km/s)



P-wave velocity differences from the data (-0.21 km/s – 0.15 km/s)

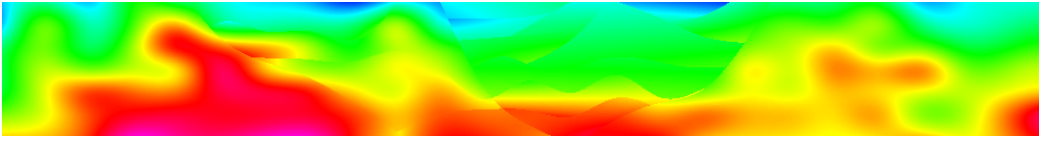


P-wave velocity differences between models P1 and P1I
(-0.10 km/s – 0.19 km/s)

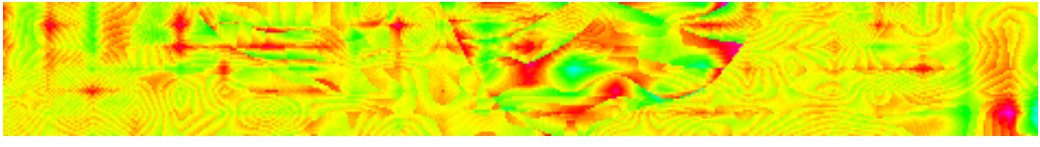


Model P1I with structural interfaces

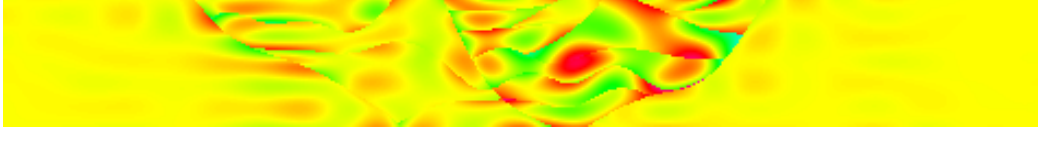
S-wave velocity in model P1I (2.69 km/s – 3.42 km/s)



S-wave velocity differences from the data (-0.08 km/s – 0.08 km/s)



S-wave velocity differences between models P1 and P1I
(-0.07 km/s – 0.08 km/s)



Synthetic seismograms in model P1I

Ray tracing:

- waves primary reflected at first to eighth interfaces plus converted waves

- point source at the surface at 25 km

- profile of 37 receivers placed from 16 km to 34 km with the step of 0.5 km

Synthetic seismograms:

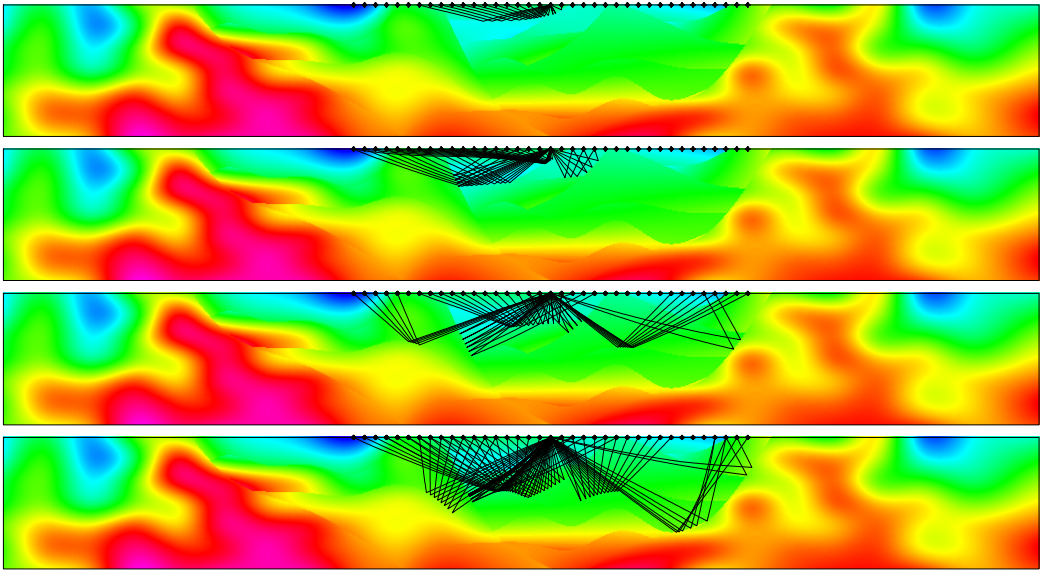
- vertical force

- Gabor signal with reference frequency 100 Hz

- seismograms are shown with no differential scaling between components and traces to see relative true amplitudes

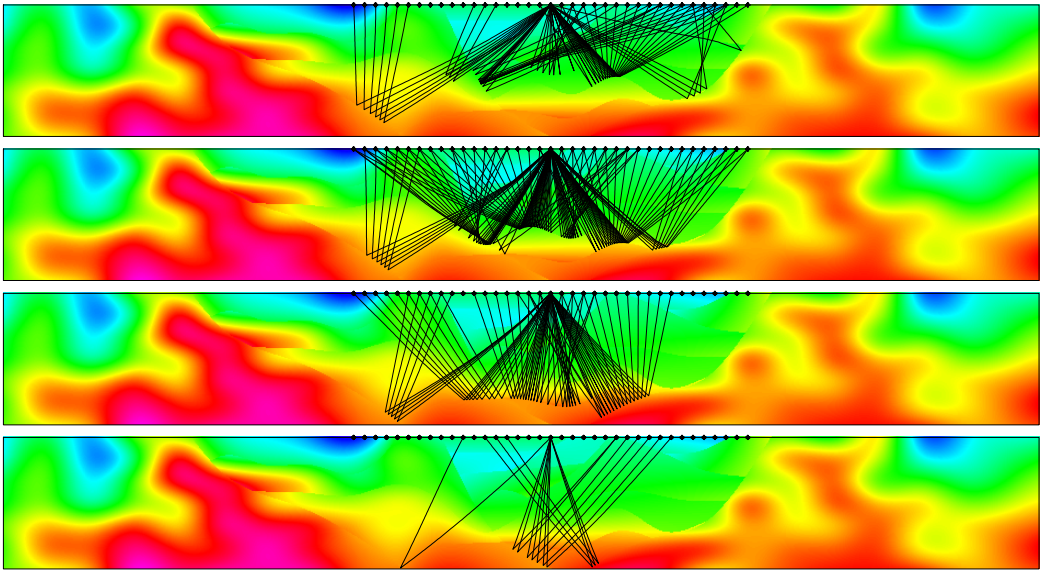
Synthetic seismograms in model P1I

Ray tracing - wave reflected at first, second, third and fourth interface

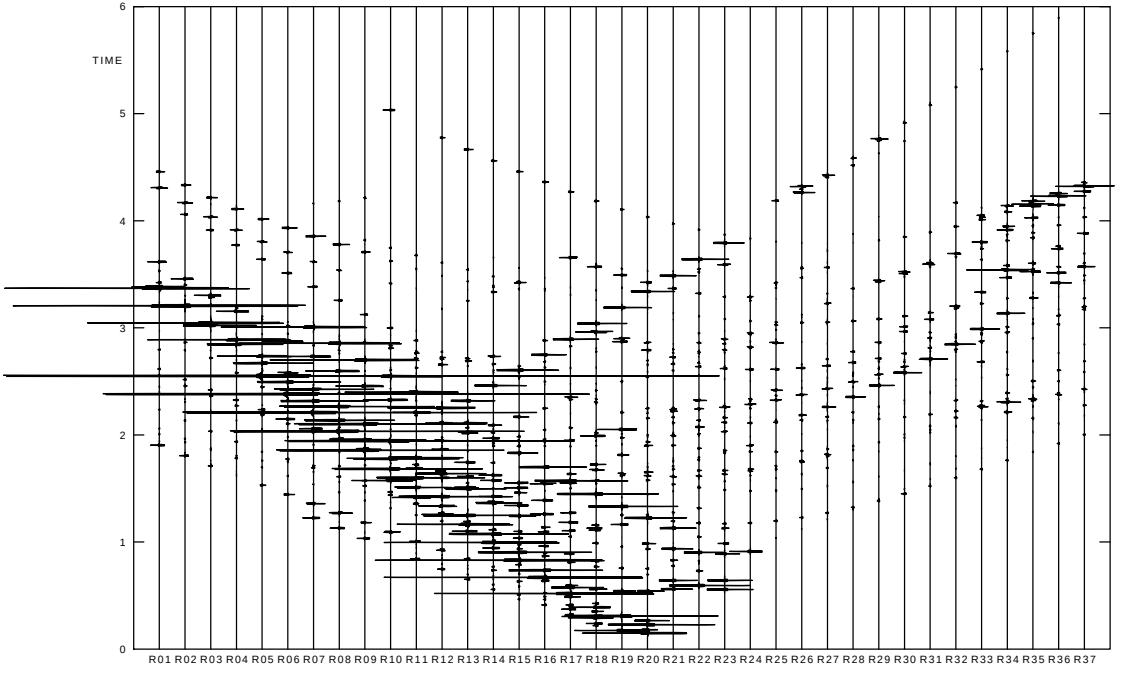


Synthetic seismograms in model P1I

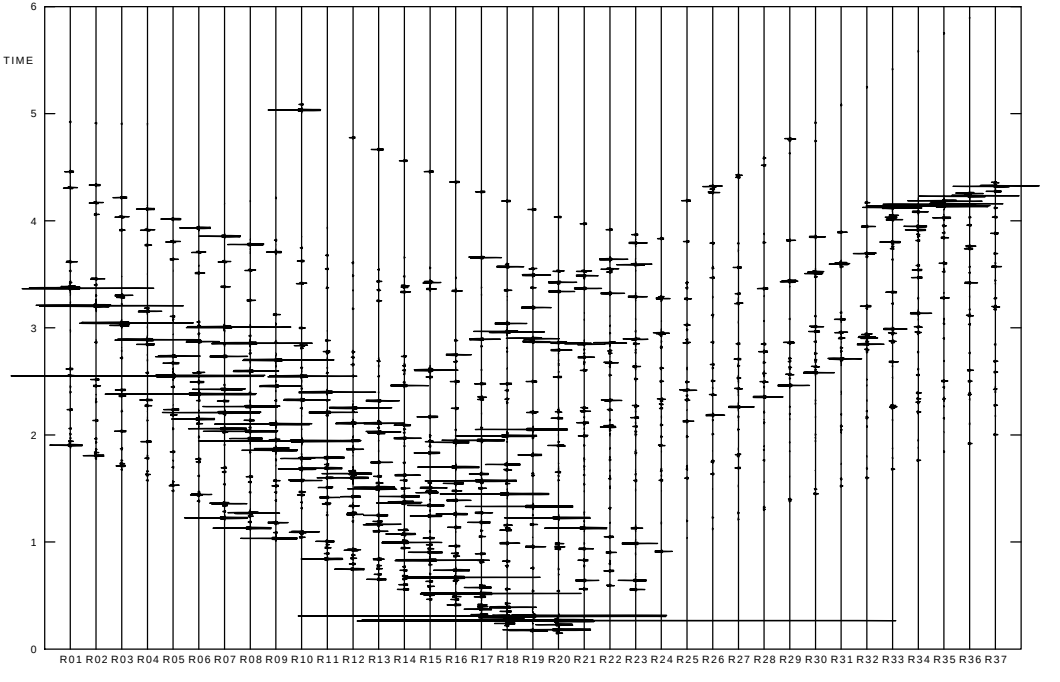
Ray tracing - wave reflected at fifth to eighth interfaces



Synthetic seismograms in model P1I - vertical component



Synthetic seismograms in model P1I - radial component



Conclusions

- The given P and S-wave velocity data are relatively smooth. The amount of smoothing required to create a smooth one-block model P1 was relatively small, and the relative differences between the smooth model and the given data are in the order of $(0.1\,\mathrm{km\,s^{-1}}/5\,\mathrm{km\,s^{-1}}) = 2\%$.

- The data given for the structural interfaces allow to construct the model P1I with interfaces, which is suitable for ray tracing. The relative differences between the model P1I with interfaces and the data are again relatively small, they remain in the order of $(0.2\,\mathrm{km\,s^{-1}}/5\,\mathrm{km\,s^{-1}}) = 4\%$.

- The calculation of P and S waves primary reflected at the interfaces provides synthetic seismograms which simulate a reflection study along the given profile.

Acknowledgements

- Stream Oil & Gas Ltd for the permission to use the velocity data

- Luděk Klimeš for his kind guidance of the presented work

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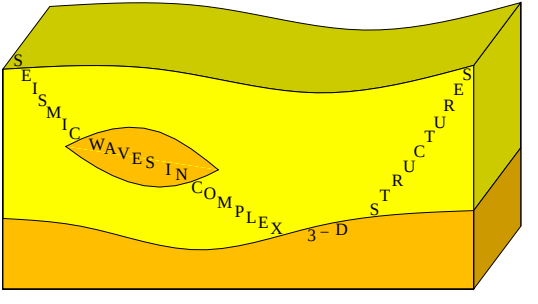

(see "http://sw3d.cz").