The effect of variable receiver samplings on a velocity model obtained by an automatic inversion of the traveltimes from the synthetic data set distributed prior to the meeting.

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To test the effect of relatively sparse sampled receivers, and of course the inversion algorithm itself, the data set distributed prior to the meeting was analysed with a 2-D tomography algorithm.

Seismic refraction data are primarily used to obtain a velocity model including interface structures from the underground. Usually the traveltimes of the first breaks are picked and synthetic travel times are adapted to the data by forward modelling. Although there are several modelling strategies and in most cases prior information, the non-uniqueness of the problem continues to exist and will probably neither lead to the simplest model, nor will give an estimate of the possible range of models, that fit the data. Thus modelling is enhanced by using an automatic algorithm for the adaptation of synthetic traveltime data to real data in order to exclude as much as possible the influence of an interpreter. But in most cases the number of receivers is limited (e.g. the BGR owns 10 OBH/OBS stations) and the minimum number of stations, i.e. the spacing of stations along a line with a given length, necessary to resolve the critical structures in the underground using an automatic inversion algorithm is only vaguely known.

The modelling was started with the tomographic inversion of the first breaks traveltimes from 7 receivers (spacing 40 km) followed by the inversion using 13 receivers (spacing 20 km), 25 receivers (spacing 10 km) and finally the data from all available fifty receivers with 5 km spacing were included. Only the vertical components of the synthetic wide-angle dataset calculated for the (unknown) 250 km long crustal model were used in order to be able to compare the results to marine OBH data. Traces from all 2779 shots (receivers) were available for each receiver with a trace length of 40 seconds and an excellent signal to noise ratio.

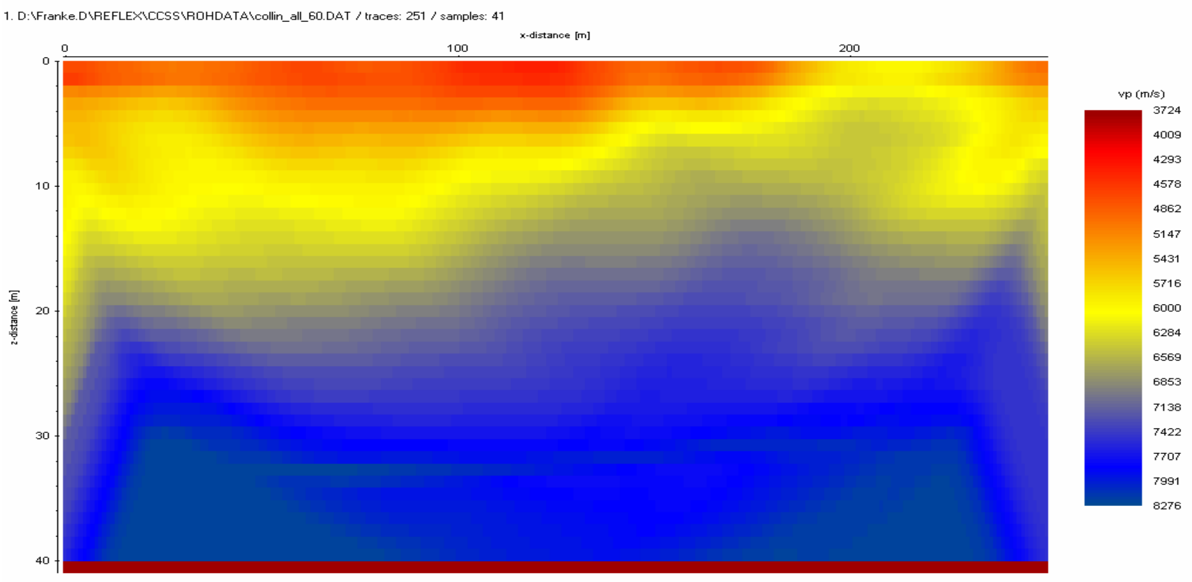
The software package used was REFLEXW by Sandmeier Scientific software (http://www.ka.shuttle.de/software/index.html). The package includes a 2D data-analysis tool that allows the complete 2-dimensional processing of single shots, zero offset lines or multi-shot gathers, and picking the onsets/first arrivals. A semi-automatic picking using a phase follower was applied with manual corrections and a pick spacing of 15 traces. The module refraction traveltime analysis contains the possibility to put together the picked traveltimes from several shots and to assign the picks to special layers. A tomographic approach based on SIRT (simultaneous iterative reconstruction technique) was used for the inversion of the traveltime data. The starting model, a laterally homogenous media with a velocity of 3000 m/s on top and a strong vertical velocity gradient ($dV/dZ = 60\ ^{m/s}/_{m}$) was identical for all inversions. The model was always rastered with a space increment of 1m.

Curved rays, based on a finite difference approximation of the eikonal equation, were used for the ray-tracing contained in the SIRT-algorithm. Traveltime residuals were not restricted to the single rays but to a range around the ray (beam). The beam width corresponds to the receiver spacing. Starting from the actual model synthetic travel times were calculated and compared to the real ones. Model changes were automatically derived from the travel time residuals. This procedure was repeated based on the changed model. The complete process stops, if distinct stopping criteria are fulfilled, e.g. if the data are fitted or the maximum number of iterations (here 20) is reached. With a supposed default data-variance of 0.15-0.17s the tomography finished after11 to 16 iterations. The adaptation of the synthetic to the measured traveltimes in the final models was checked by forward FD-Vidale raytracing. Two of the resulting models from the tomography are shown in Figures (a) and (b).

The overall shape of the resulting models from the inversions of the traveltimes from different numbers of receivers (spacing: 5km, 10km, 20km, 40km) is in general accordance (Figures (a) and (b)). There is a wave shaped velocity contrast showing a velocity of around 6000 m/s from around 10 km depth on the left to 2 km depth at 200 km offset and slightly increasing depth to the right beneath a layer with a velocity of 4500 to 5500 m/s. Decreasing receiver numbers and thus decreasing ray coverage shows of course lower resolution in the uppermost part, where no receivers are located. This problem may be overcome in reality by a joint reflection/refraction survey, where the resolution of the sedimentary packages is especially high in the reflection data. More problematic is the increasing smearing of the velocity boundaries along the individual ray paths. The most critical changes in this example take part between the models with 20 km and 40 km spacing.

Figures: Final models from the tomographic inversions. In (a) all fifty receivers with 5 km spacing were included; and in (b) only 7 receivers were inverted with a spacing of 40km. The lower left and right corners and the depth area beneath 35 km are not covered by rays and thus reflect the values from the starting model. The models are fairly in general accordance but show increasing smearing of small scale heterogeneities along the ray-paths.

(a)



(b)