Experiment "Durchschallung"

Calculation of Static Corrections from Seismic Borehole Records Using the Vibrator Signals of the 3-D Seismic Reflection Survey within ISO 89

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Jörg Albrecht and Dietmar Teichert

Abstract

During the 3D seismic reflection survey within the project Integrated Seismics Oberpfalz 1989 (ISO89) the vibroseis source signals were recorded simultaneously with five three-component geophone borehole chain SEKAN5 or a single three-component borehole geophone, respectively, in the KTB pilot hole. The aim was to measure the traveltimes of direct waves in the depth range between 3220 and 3420 m in order to deduce spatial velocity inhomogeneities between surface and recording depth from traveltime residuals in the surroundings of the KTB. These data shall be used for improved static corrections if distinct from statics obtained by short refraction lines and first arrival analysis of surface data. A short description of the method is given which is based on approximation by least square fitted planes. Data examples and preliminary results are presented.

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1. Introduction

The huge amount of source signals generated during the 3D seismic reflection survey within ISO89 was predestinated to provide additional information on spatial velocity inhomogeneities in the vicinity of the KTB drill site by observation of the direct seismic waves in the borehole in depth as great as possible. These data should enable better resolution of traveltimes than surface data due to the almost noise-free recording conditions at greater depth. The traveltime anomalies are analyzed and shall be transformed into static corrections. By comparison with the static corrections obtained by conventional methods (i.e. short refraction lines and and first arrival analysis of surface data) it will be decided whether these data will contribute to improved corrections essential for the quality of the 3D seismic results.

2. Survey Geometry

2.1 Intended Scheme

The vibrator positions used for this experiment resulted from the survey geometry of the 3D reflection seismics elaborated at the DEKORP Processing Center (DPC), TU Clausthal (REHLING and STILLER, 1990).

The survey area extends over a square of about 20 km side length with the KTB pilothole at its centre. The deployment scheme of the vibrator positions comprises 21 traverses of about 100 source points each. The interval between these points is a recurring sequence of 100m, 200m, 300m, 200m. Sixty percent of the source points, (position numbers 21 to 80) are to be used two times corresponding to a total of 3360 vibrator points, nominally. For recording of the vibrator signals a borehole chain consisting of five three-component geophones with 25m spacing (SEKAN5) should be used (1 vertical and two horizontal traces per geophone). This tool is a development of PRAKLA-SEISMOS AG, Hannover (MYLIUS et al., 1990). Since a two-fold vibroseis signal excitation was designed in the central part of each traverse it was intended to record the signals in two different depth positions of the geophone chain thus extending the observed depth range. For vibrator point numbers 1 to 60 of each traverse the depth range of 3320 to 3420m was scheduled and for numbers 21 to 100 the depth range of 3220 to 3320m.

2.2 Actual deployment

Due to technical difficulties the SEKAN5 borehole geophone chain had to be replaced several times by a single three-component borehole geophone (MYLIUS et al., 1990, and REHLING and STILLER, 1990). The recording depths of the single geophone are 3220m and 3420m, respectively. However, some data could not be recorded at the intended depths because the chain and the single geophone, respectively, could not be sinked appropriately. Table 1 presents to which extent the vibrator signals of the 3D seismics could be recorded within the pilothole.

Table 1

Depth range (m)	Geophone chain (%)	Single geophone (%)	Deficit (%)
3220-3320	18.27	60.48	21.25
3320-3420	59.05	36.19	4.76

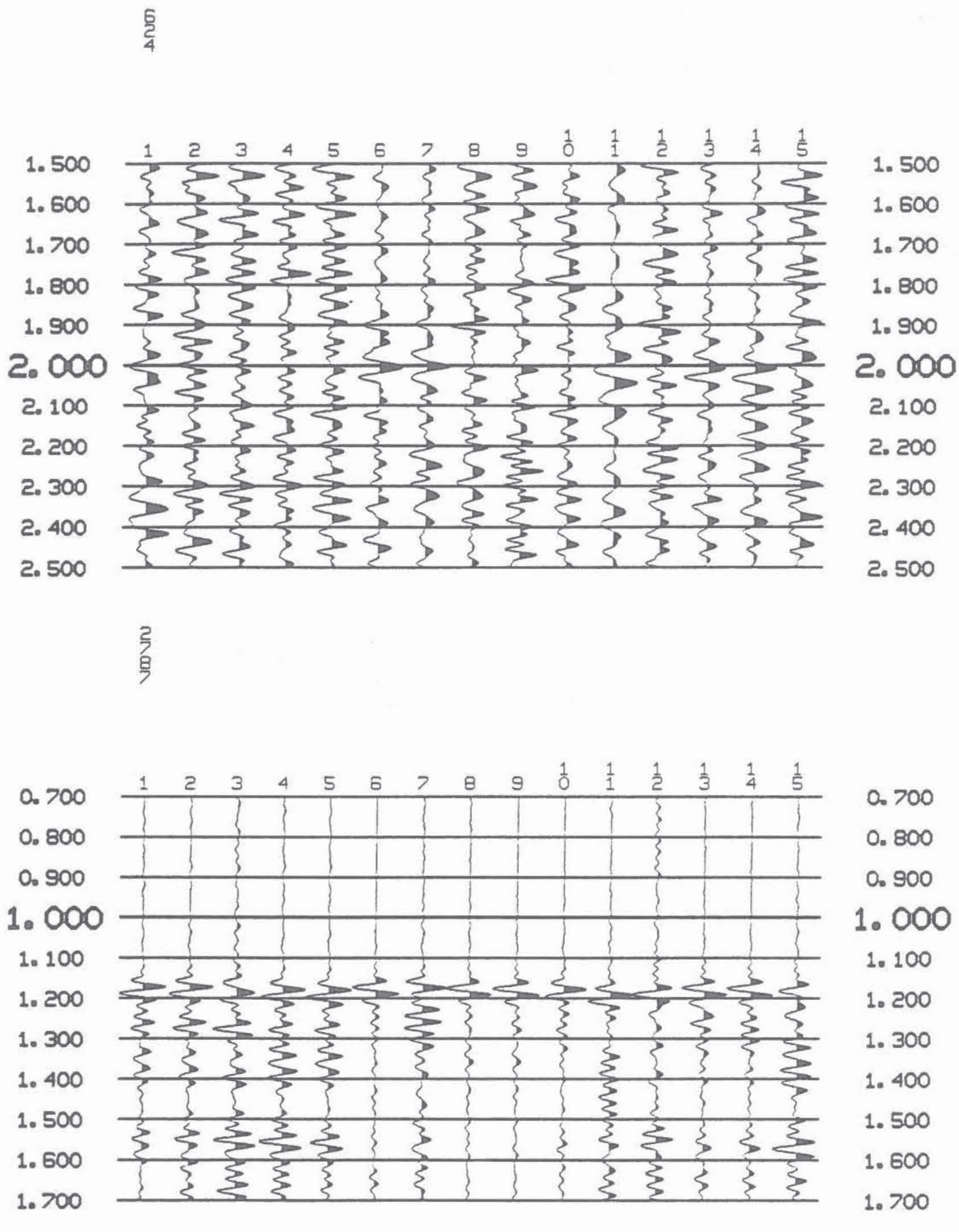

Fig. 1

Record no. 624 (upper panel) and no. 2787 (lower panel)
Traces 1 to 5: vertical components
Traces 6 to 10: 1. horizontal component
Traces 11 to 15: 2. horizontal component
Vertical scale: traveltime in seconds

3. Data base and processing

In order to deduce static corrections from the observed data the picking of direct traveltimes in the records with reference to a particular depth is necessary. Fig. 1 shows two selected records of the geophone chain at 3220 to 3320m and 3195 to 3295m depth, respectively. For the initial processing steps a reference depth of 3220 m was selected corresponding to traces 1, 6 and 11 for record number 624 and to traces 2, 7 and 12 for record number 2787 in fig. 1.

In order to obtain exact traveltimes even if the signal to noise ratio is strongly decreased (e.g. record number 624) the three components of the identical recording depth were scaled, squared and summed within the time window from 0 to 3.5 s (fig. 2). The subsequent picking of first arrivals was carried out with an appropriate computer programme developed at DPC. The output consists of a total of 1296 traveltimes for the reference depth of 3220m corresponding to about 98% of the data recorded at that depth.

4. Methodological approach and initial results

In order to take into account large-scale inhomogeneities in the space under study the spatial traveltime plane of the first arrivals was approximated segmentially through 2nd-order planes described by the equation:

$$a_{11}x^2+a_{22}y^2+a_{33}z^2+2a_{12}xy+2a_{23}yz+2a_{31}zx+2a_{14}x+2a_{24}y+2a_{34}z+a_{44}=0$$

Its coefficients were calculated by least square fitting. Figure 3 shows the picked traveltimes along three neighbouring traverses indicated by vertical bars and the traveltimes from the least square fitted plane indicated by continuous lines. The residuals between the observed and the fitted traveltimes

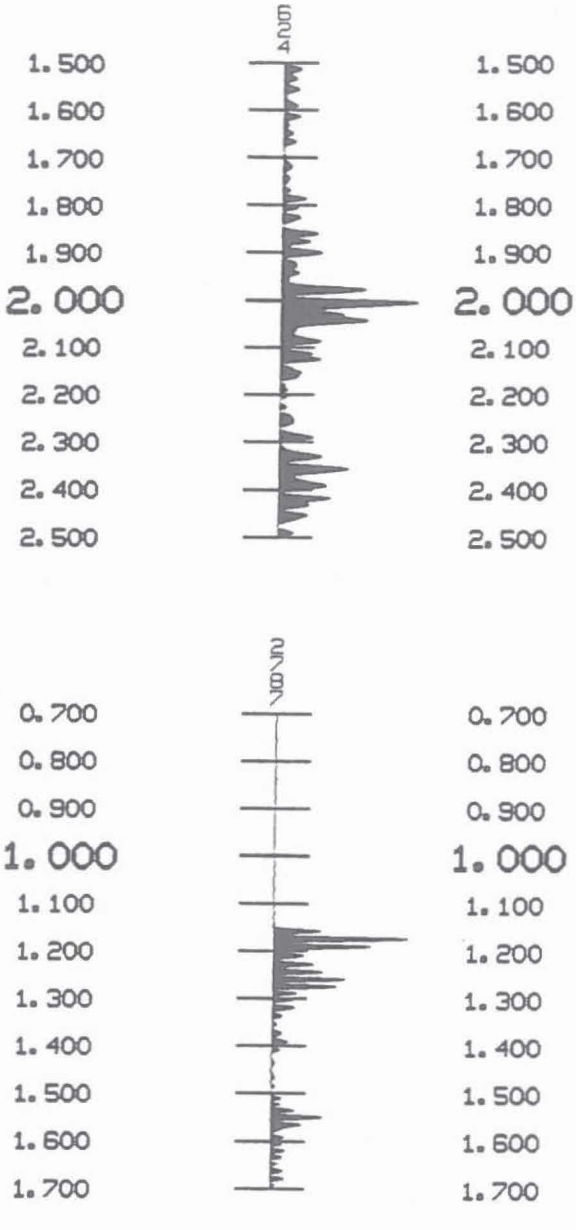

Fig. 2

Traces at 3220 m depth after pre-processing of the corresponding traces of figure 1. Note that the signal to noise ratio of record no. 624 has been improved considerably. For further explanation see text.

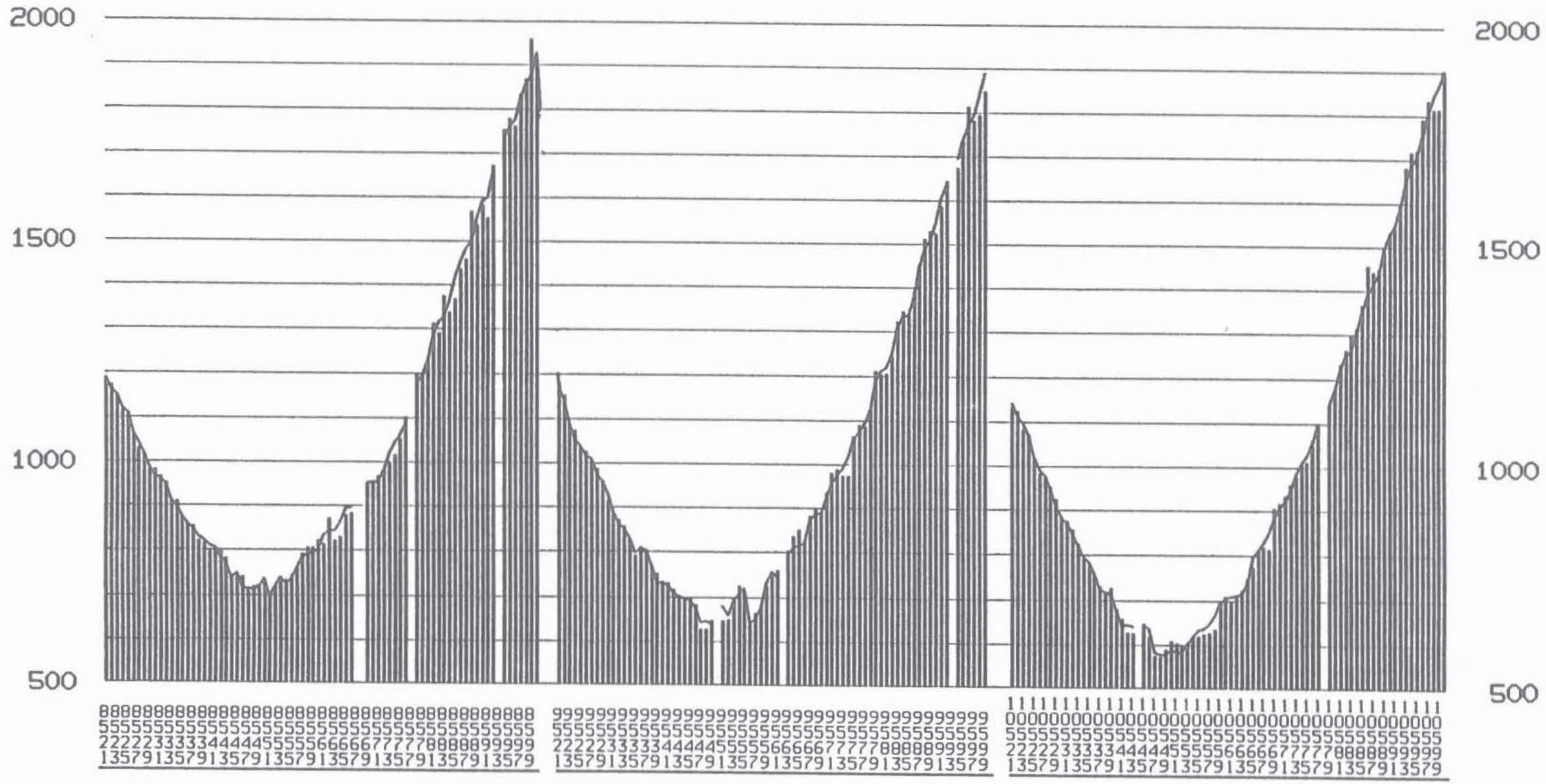

Fig. 3

Observed traveltimes (vertical bars) and least-square fitted traveltimes (continuous lines) for vibrator positions 21 to 100 of the three vibrator traverses no's 8 to 10 (from left to right). The vertical axis denotes milliseconds. Note that the crooked course of the traverses brings about a wavy-line effect on the traveltimes.

contain the effect of small-scale inhomogeneities in the space under study and, of course, the influence of the respective elevations at the source points. The residuals will be used for the calculation of static corrections for reflectors below the recording depth of 3220m, in this case (fig. 3).

During the next processing steps which are not terminated, yet, the static corrections (concerning elevation and thickness of the weathering zone) calculated conventionally thus far shall be compared with the results obtained by our method. If differences can be recognized they must be related to inhomogeneities below the reference level of the conventional static corrections. Then, the application of the respective residual static corrections should provide better stacking results of the 3D seismic data. Moreover, the results are expected to indicate lithological variations in specific domains.

Further data evaluation, e.g. the calculation of the remaining partial plane coefficients is still in process, and therefore must be reserved for future publications.

References

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