3-D ESP-Experiment of the Integrated Seismics Oberpfalz 1989

H. Wiederhold

3D-ESP - EXPERIMENT OF THE INTEGRATED SEISMICS OBERPFALZ 1989

Helga Wiederhold

ABSTRACT

The comprehensive field investigations of the Integrated Seismics Oberpfalz 1989 (ISO 89) were carried out by the DEKORP group at the German Continental Deep Drilling (KTB) Site from late July to late November 1989. A 3D-expanding-spread experiment (3D-ESP) was involved utilizing the source signals of the 3D seismic survey in such a manner that the common midpoints fall into a small area with the KTB at its centre. 189.460 seismic traces have been recorded. The source-receiver configurations comprise offsets from 0 to 24 km and azimuth angles from 0 to 180°. Thus best conditions for velocity analyses in 3 dimensions for the area around the KTB are given. The layout and the field parameters of the 3D-expanding-spread experiment are shown. The subsurface area covered ca. 40 fold has an extension of about 2650 m x 3800 m. Details of the recorded data material are demonstrated.

Niedersächsisches Landesamt für Bodenforschung
Stilleweg 2
D-3000 Hannover 51

INTRODUCTION

The 3D-expanding-spread experiment (3D-ESP) is part of the Integrated Seismics Oberpfalz 1989 (ISO 89) and is directly connected with the 3D seismic reflection survey (REHLING and STILLER, 1990). The basic idea, first suggested by the Geophysical Institute of Technical University of Clausthal, is to record all source points of the 3D seismic survey with an additional geophone spread in such a way that the subsurface reflection point is constant vertically below the KTB location. With this configuration reflections within a wide source-receiver offset and azimuth range are obtained with best chances to determine detailed average and interval velocity information in 3 dimensions for the area around the KTB and depth down to Moho. In the following an overview of the field investigations and the collected data material is given.

FIELD INVESTIGATIONS

The field investigations took place in August/September 1989. As seismic source the Vibroseis signals of the 3D seismic survey were used. The planning, preparation and realization of the 3D seismic survey is described in detail by REHLING and STILLER (1990). For the 3D-expanding-spread experiment a DFS-V recording unit with 120 channels operated by the DEKORP group was used. In order to integrate this experiment into the 3D seismics the geophone locations were chosen to be the same as used for the 3D seismics; thus no extra locations needed be surveyed. That means, the geophone spread had to be along the geophone lines of the 3D seismic survey. The spread for one shot included two parallel lines with 60 channels each, a geophone group spacing of 100 m and a distance of 400 m between both lines. A sketch of the geometry is given in Fig. 1. While, for example, the 3D seismic survey was on swath 4 the 'expanding spread' was on geophone lines 5 and 6 of swath 1, and correspondingly, while the 3D survey was on swath 3 the 'expanding spread' was on lines 15 and 16 of swath 2. The midpoints of the geophone spread and the vibrator traverse are symmetrical to the KTB. The spread has been kept fixed for one vibrator traverse (= 40 shotpoints). With the change of the vibrator traverse (800 m distance) the geophone spread moved by 8 geophone positions (= 800 m) in the opposite direction, thus the covered area remains always the same.

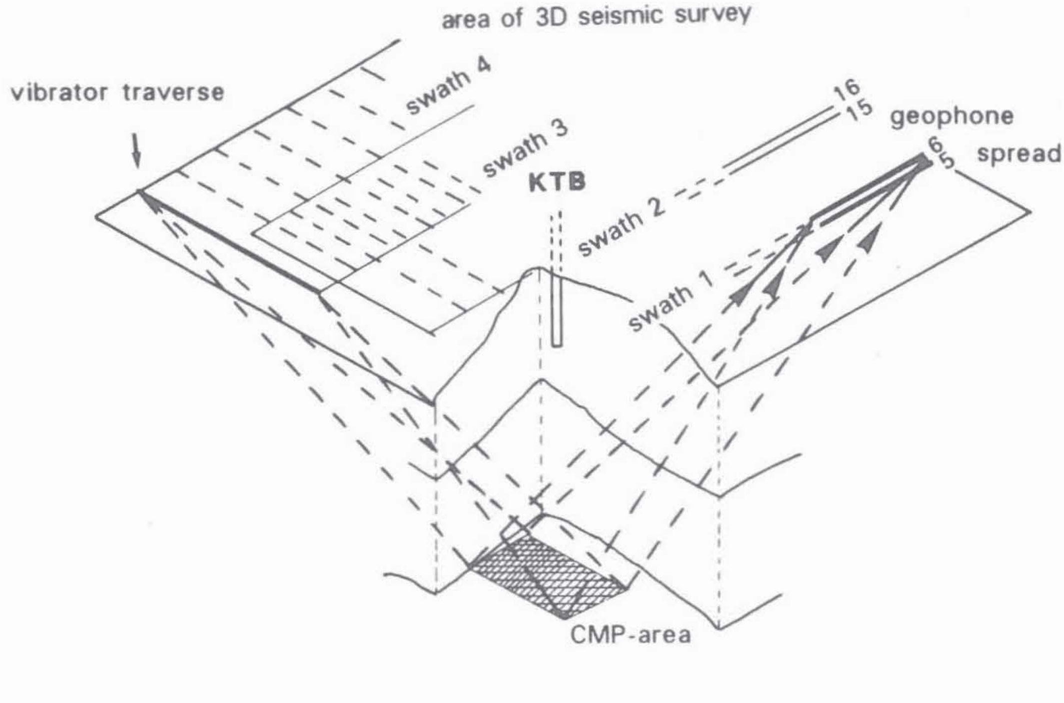

Fig. 1: Sketch of geometry of the 3D-expanding-spread experiment.

By this procedure a subsurface area is set-up with the following parameters (theoretically): The geophone spacing, 100 m at the surface, means 50 m subsurface distance. The vibrator spacing is irregular but in the mean 200 m, giving 100 m subsurface interval. With each second traverse the vibrator points are permuted and the subsurface reflection points fall in the intermediate space and we get a 10-fold, respectively 11-fold coverage with 50 m interval for the 21 traverses of one swath. By the second geophone line the coverage is dou-

bled and we get a coverage of 21. With the second swath it is doubled to 42. Due to budget restrictions only two of the 4 swaths of the 3D survey were observed in this way. So theoretically a coverage of 42 for each 50 m x 50 m bin was obtained.
The field parameters are specified in Table 1.

Method	Vibroseis
Equipment	DFS-V (DEKORP), 120 channels
sampling rate	4 ms
recording time	33.7 s
reflection time	13.7 s
source signal	upsweep 12-48 Hz, 20 s
vertical stack	5 - 8 fold
data format	SEGB, multiplexed
Receiver geometry	
layout	in a plane, 2 receiver lines with 60 geophones, 400 m line interval, 100 m receiver intervall, center of receiver spread and center of vibrator traverse are symmetrical related to KTB.
Source parameters	same as 3D-seismics
vibrators	5 VVEA (16 to)
pattern	48 m
interval	alternating: 100-200-300-200-100 m, 40 source points per traverse und receiver spread in total 21 vibrator-traverses, subdivided into 2 swaths.
Coverage	42 fold (theoretical)
CMP interval	50 m
CMP area (1 fold)	3550 m x 4150 m (theoretical) 4050 m x 4200 m (actual)
CMP area (ca. 40 fold)	2350 m x 3750 m (theoretical) 2650 m x 3800 m (actual)

Table 1: Field parameters for the 3D-expanding-spread experiment of the Integrated Seismics Oberpfalz 1989.

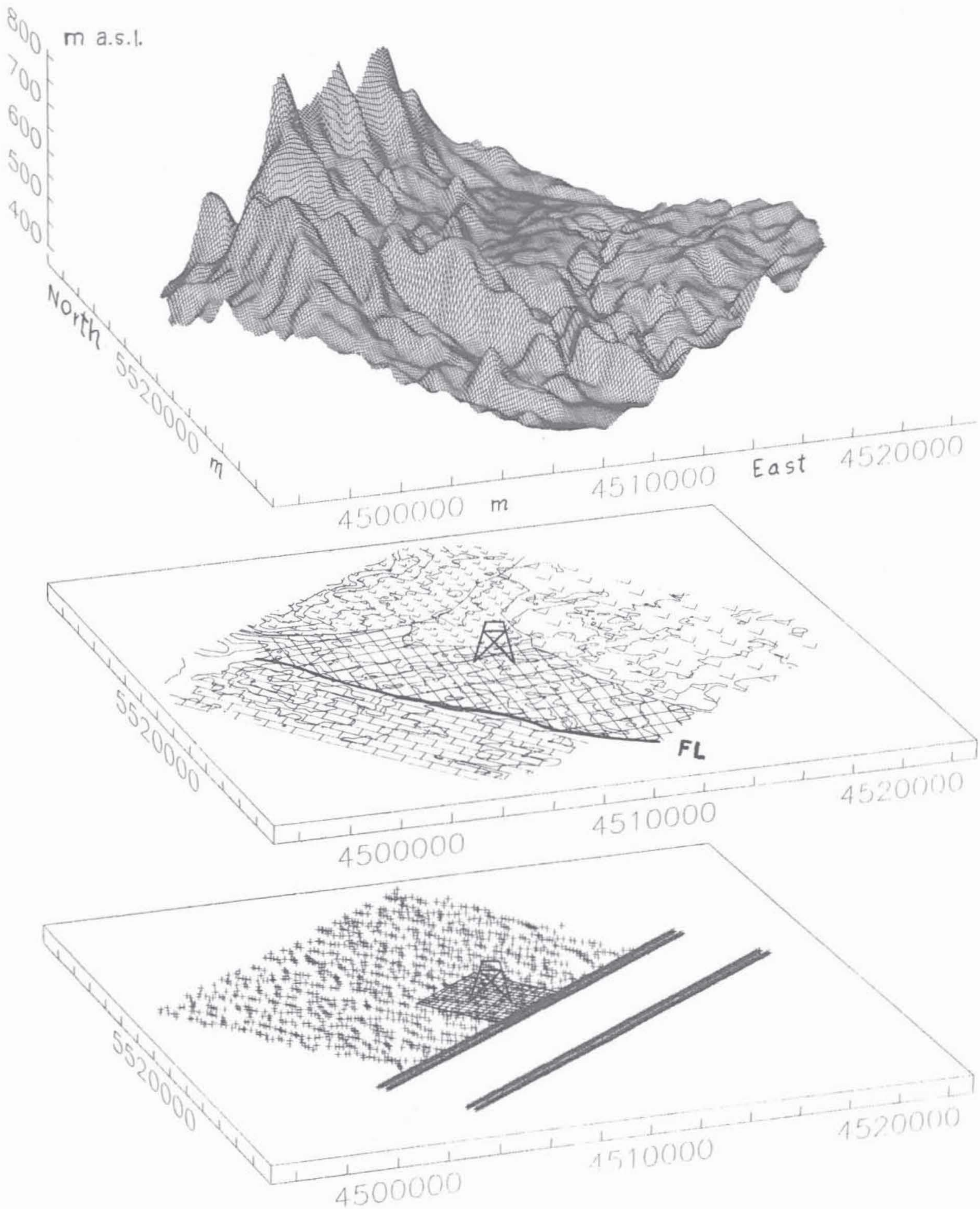

Fig. 2: Surveyed area of the Integrated Seismics Oberpfalz 1989 with the KTB drillhole in its centre. Top: Topography (vertical exaggeration: 20); centre: Contour lines and main geological units: [symbol] Steinwald granite massif, [symbol] Falkenberg/Friedenfels granite massif, [symbol] gneisses and amphibolites, [symbol] sediments. FL=Franconian Line. Bottom: Situation map of actual vibrator points (scattered) and geophone lines. The covered subsurface area is marked.

DATA MATERIAL

Fig. 2 gives an overview of the surveyed area. In the upper part the topography is shown. The Franconian Line in the foreground is striking as well as the Steinwald granite massif in the northern part with up to 800 m height above sea level. In the middle part the main geological units are sketched as there are the Variscan granites (Steinwald G., Falkenberger G., Friedenfelser G.), the ZEV (= zone of Erbendorf-Vohenstrauss) with metabasitic gneisses and amphibolites, the Franconian Line and the sediments northwest of it.

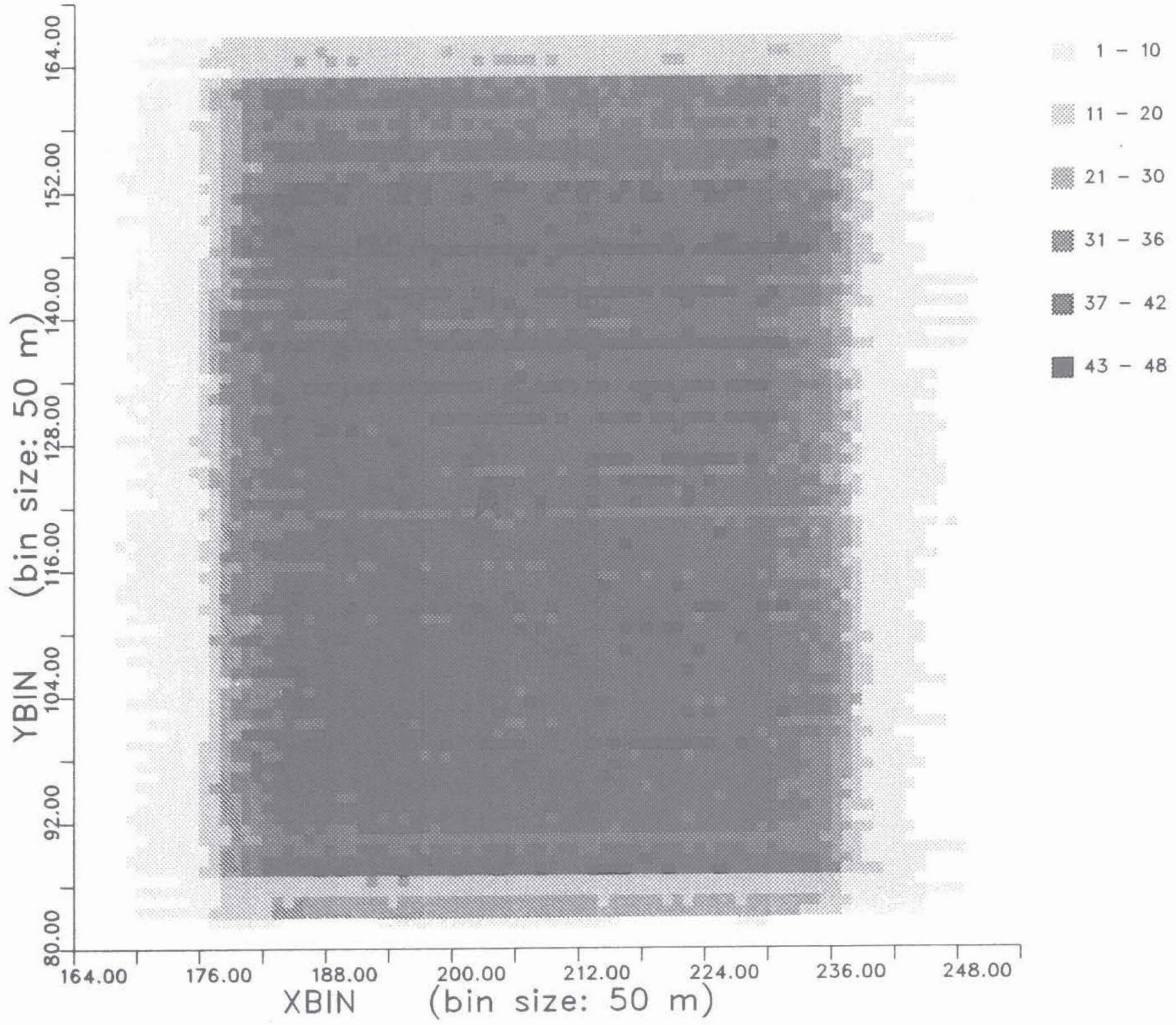

Fig. 3: Total subsurface coverage for 3D-expanding-spread experiment.

The lowest part of Fig. 2 shows the actual vibrator points and geophone locations. A total number of 189.460 seismic traces has been recorded. The area covered in the subsurface is marked. It has an extension of 4050 m x 4200 m. Fig. 3 shows the actual total coverage. The direction of XBIN corresponds to the direction of the geophone lines and YBIN to the vibrator traverses. A maximum coverage of 48 has been achieved, the mean coverage is 37 to 42-fold per 50 m x 50 m bin. The border zone with poorer coverage is caused by the fact that with the first and last vibrator traverse the geophone spread could not be shifted by 8 geophones necessary

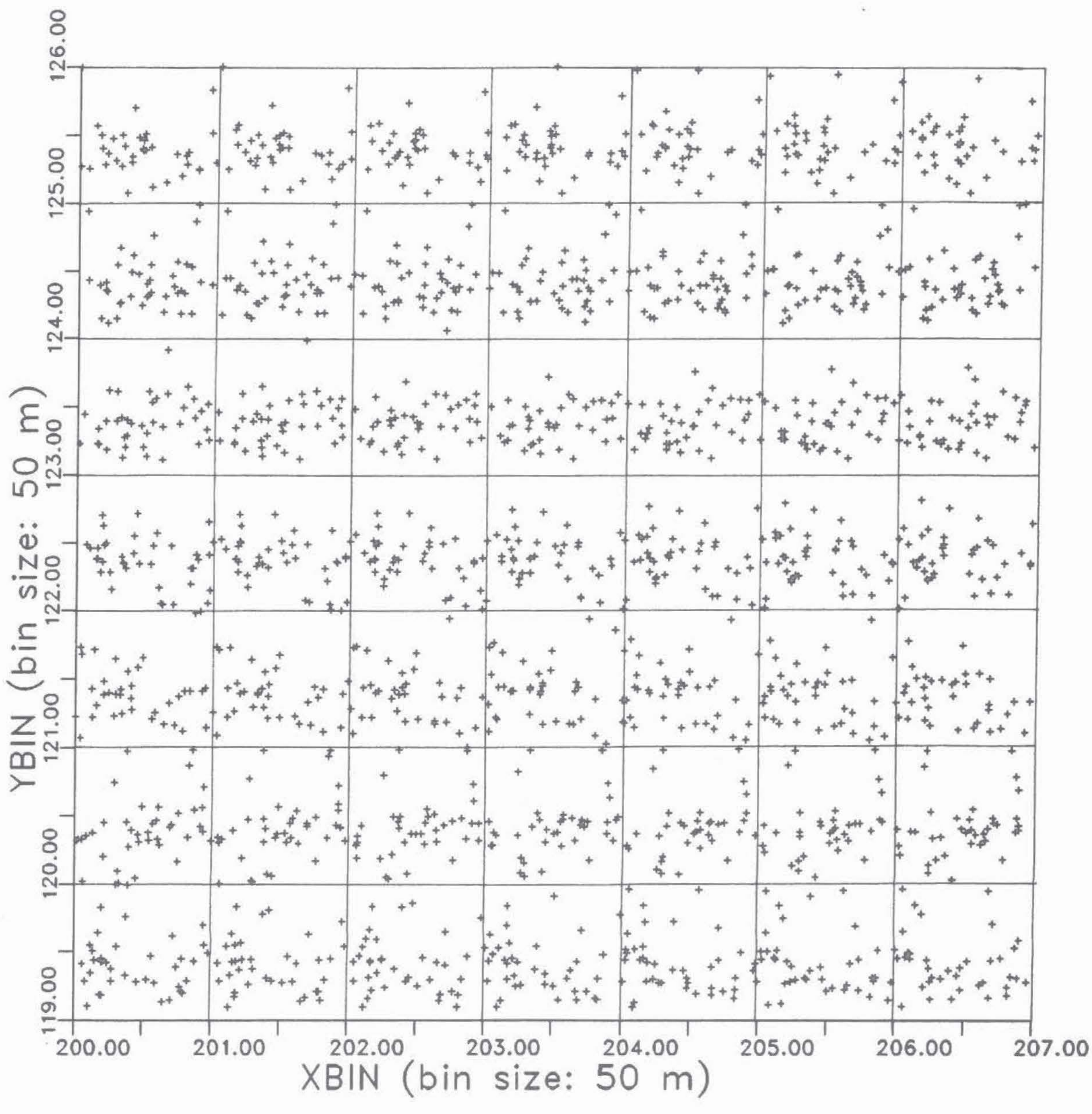

Fig. 4: Common midpoint distribution within several bins (bin size: 50 m x 50 m).

for symmetry, because the geophone lines had been surveyed for the 48 traces of the 3D survey. Dead traces are not considered up to now.

An example of the common midpoint distribution in single bins is shown in Fig. 4. Fig. 5 gives examples for the azimuth and offset distribution in single bins. Taking all subsurface points together we get the offset distribution shown in Fig. 6: Offsets from 0 to 24 km are achieved, offsets in the range 2 km to 22 km 160-fold, the range 7 km to 18 km ca. 800-fold and offsets of about 15 km about 1600-fold. Compared with the 3D seismic survey itself with a maximum offset of 6.5 km we have good conditions for velocity analyses. But we

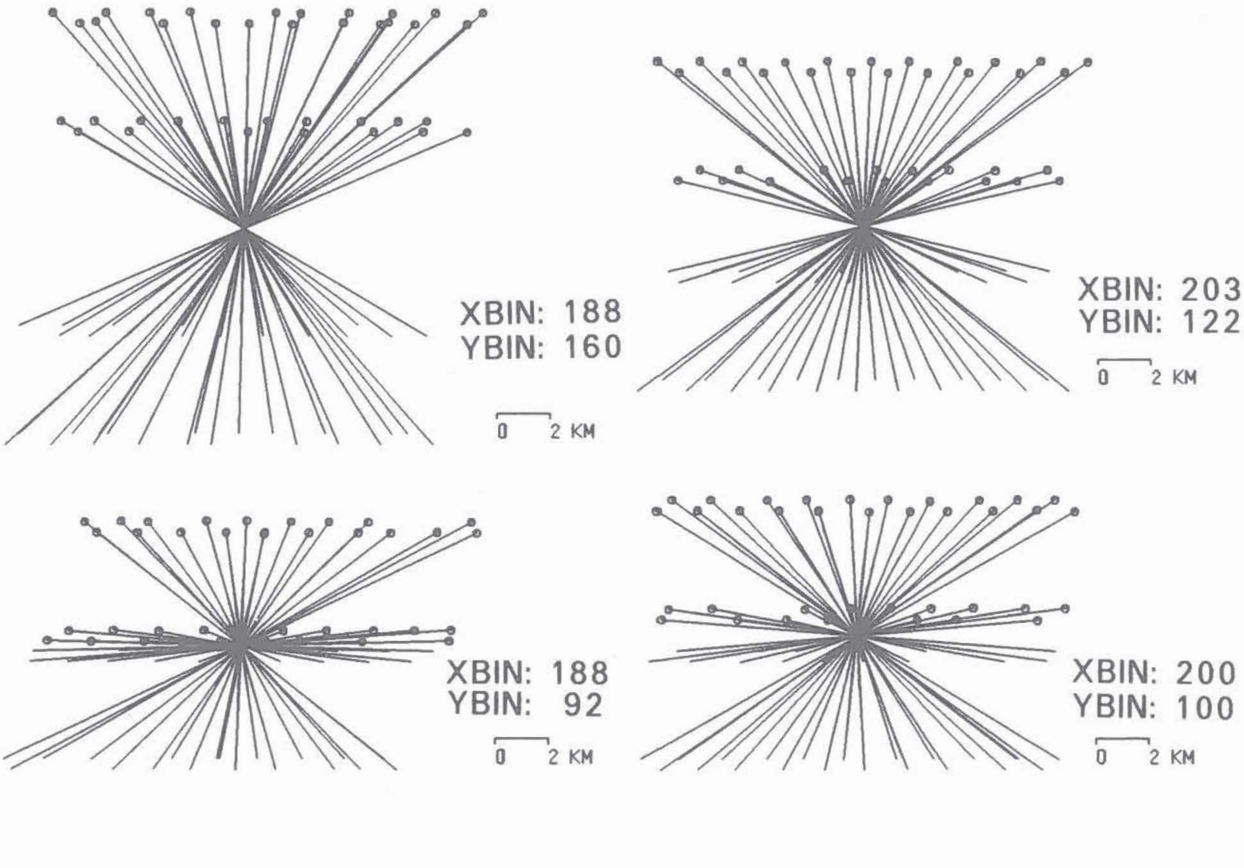

Fig. 5: Source-receiver geometry for single bins; o = source point.

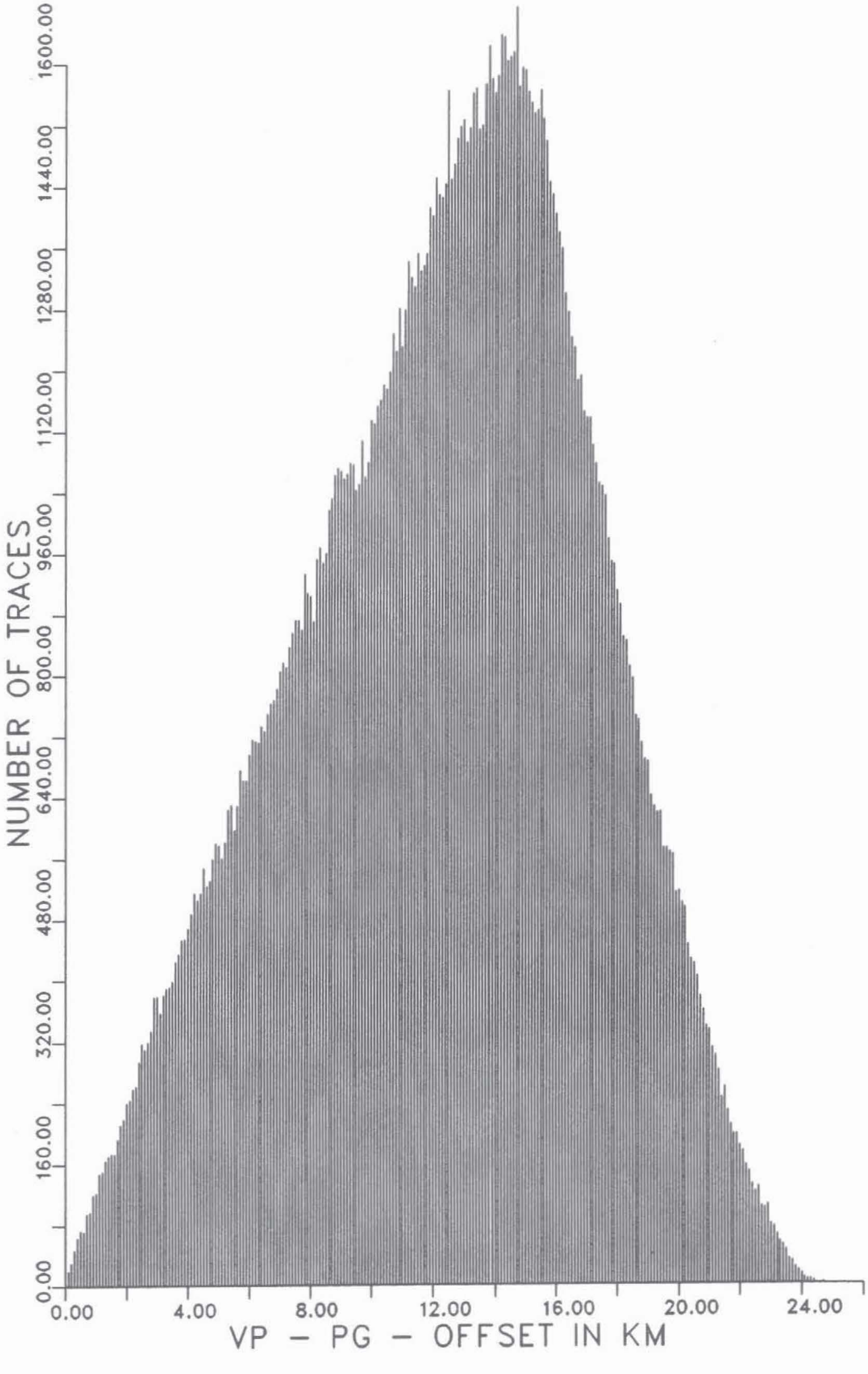

Fig. 6: Offset distribution including all traces.

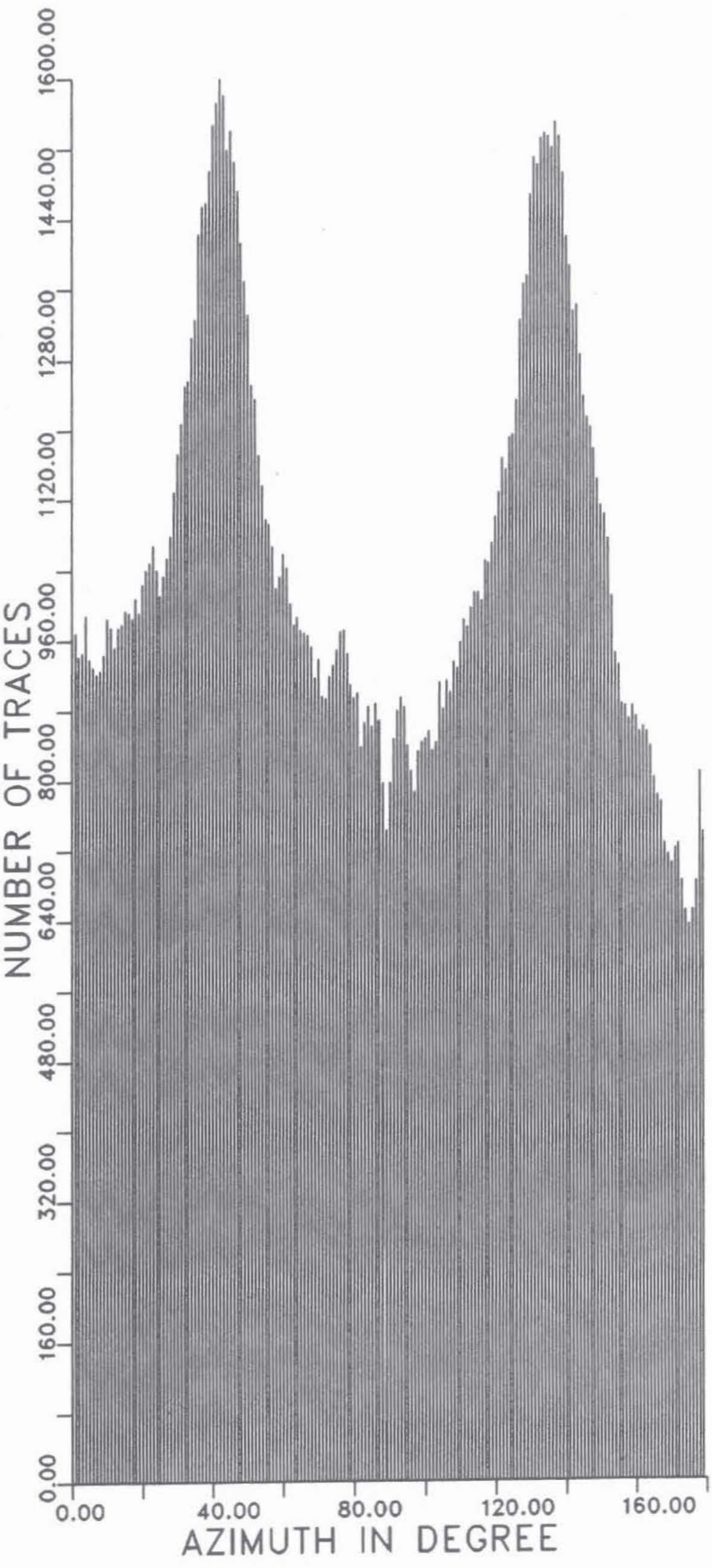

Fig. 7: Azimuth distribution including all traces.

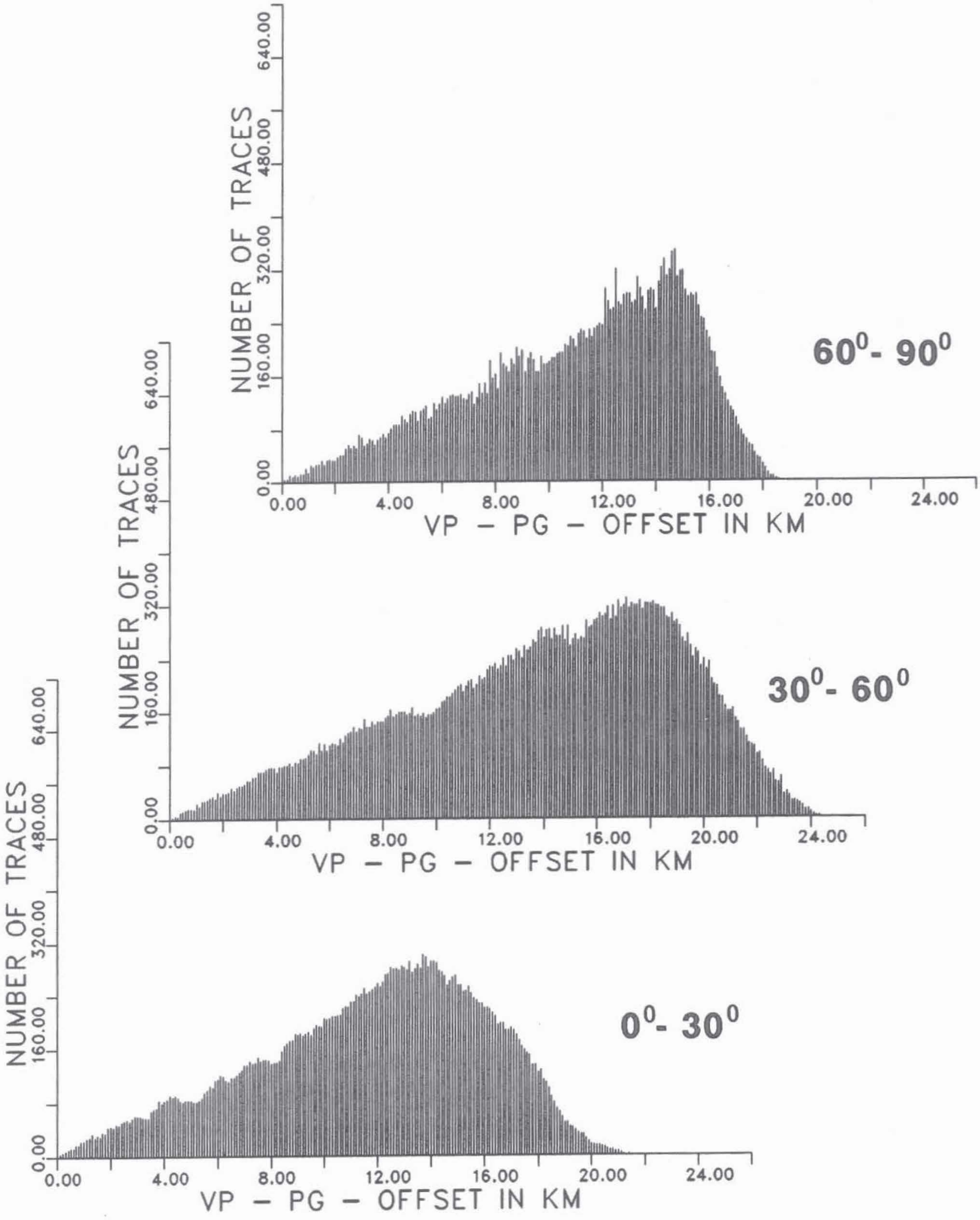

Fig. 8: Offset distribution for 30^0 azimuth ranges. The range 90^0 - 180^0 is covered in an analogous manner.

must be aware that this distribution includes all source-receiver azimuths (0^0 - 180^0), so a velocity analysis based on this data set would lead to an average velocity only without considering seismic anisotropy. The coverage for the whole azimuth range is shown in Fig. 7. An azimuth of 0^0 respectively 180^0 corresponds to the direction of the geophone lines. A mean coverage of 800 is achieved for the whole range, maximum coverages of 1600-fold are obtained for angles of 45^0 and 135^0. The offset distributions for single azimuth ranges, in 30^0 steps, are shown in Fig. 8 and listed below:

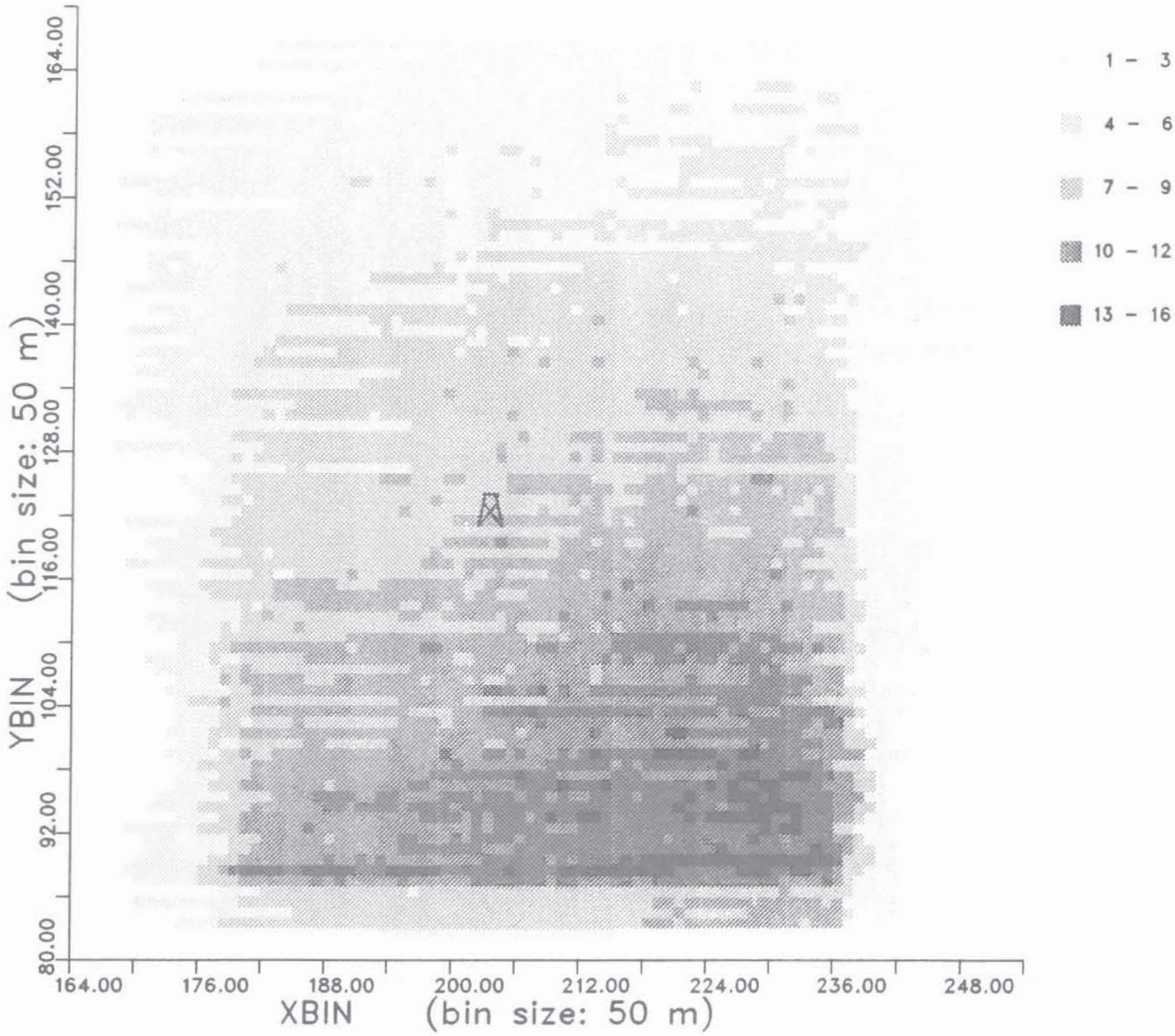

Fig. 9: Subsurface coverage for source-receiver azimuths restricted to 0^0 - 30^0.

00° -30° azimuth: 4-18.5 km: 80-fold; 8-18 km: 160-fold
30° -60° azimuth: 4-22.0 km: 80-fold; 8-21 km: 160-fold
60° -90° azimuth: 4-17.0 km: 80-fold; 8-16 km: 160-fold

The range 90°-180° is covered in an analogous manner. The small offsets are generally less covered. These distributions are valid for the entire area and Figs. 9 - 11 show the coverage in the area restricted to different azimuth ranges. The maximum coverage reached for these sections is 16-fold. The highly covered bins are restricted to smaller areas.

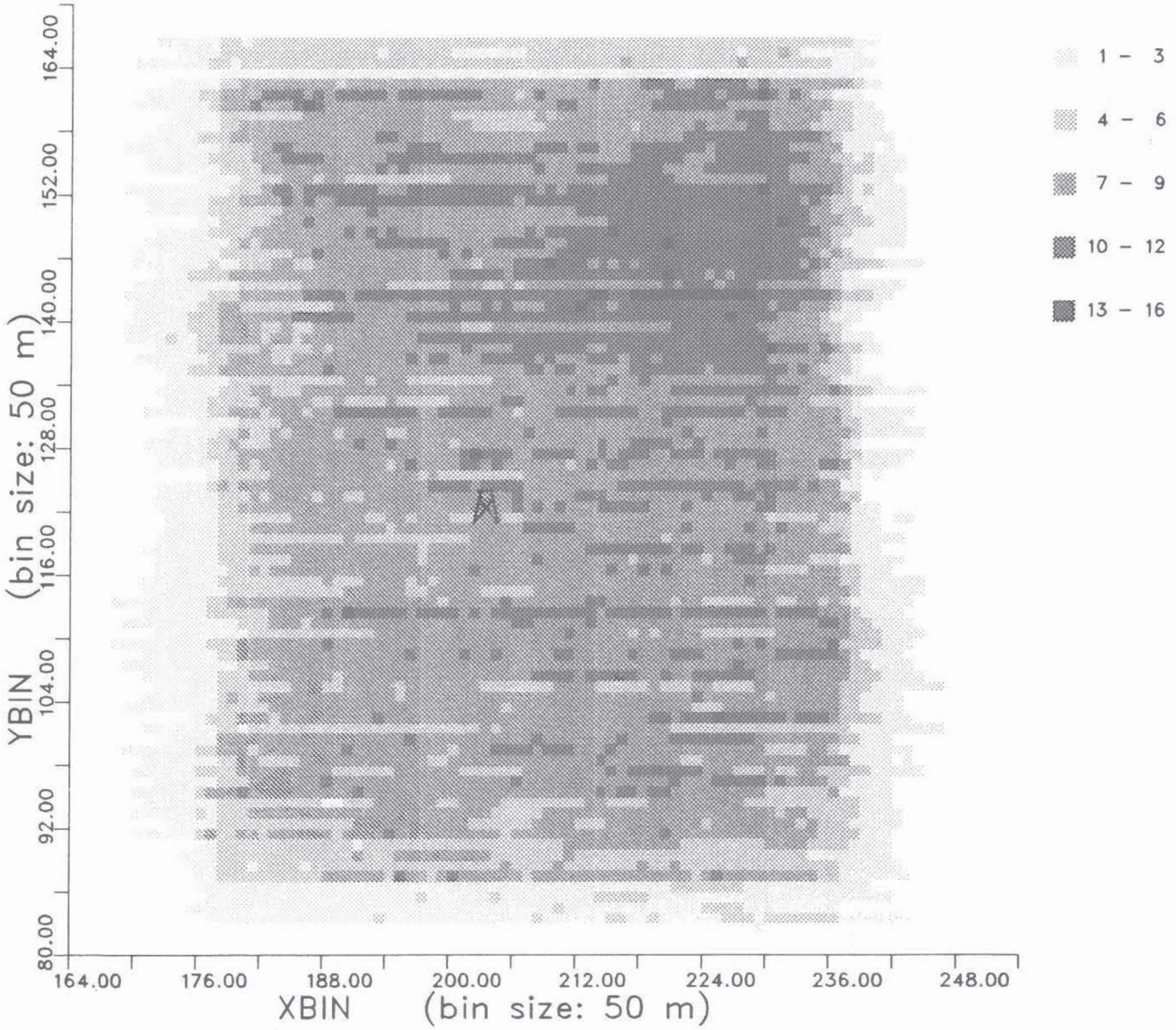

Fig. 10: Subsurfave coverage for source-receiver azimuths restricted to 30° - 60°.

An example of the data material is given in Fig. 12 where a common shot gather with the two parallel geophone spreads of 60 geophones each and an interval of 400 m is shown. The first break is in the range 1.8 s to 2.8 s. At about 4-5 s a strong reflection respectively reflection band is observed corresponding to approximate vertical reflection times of 3.5-4 s.

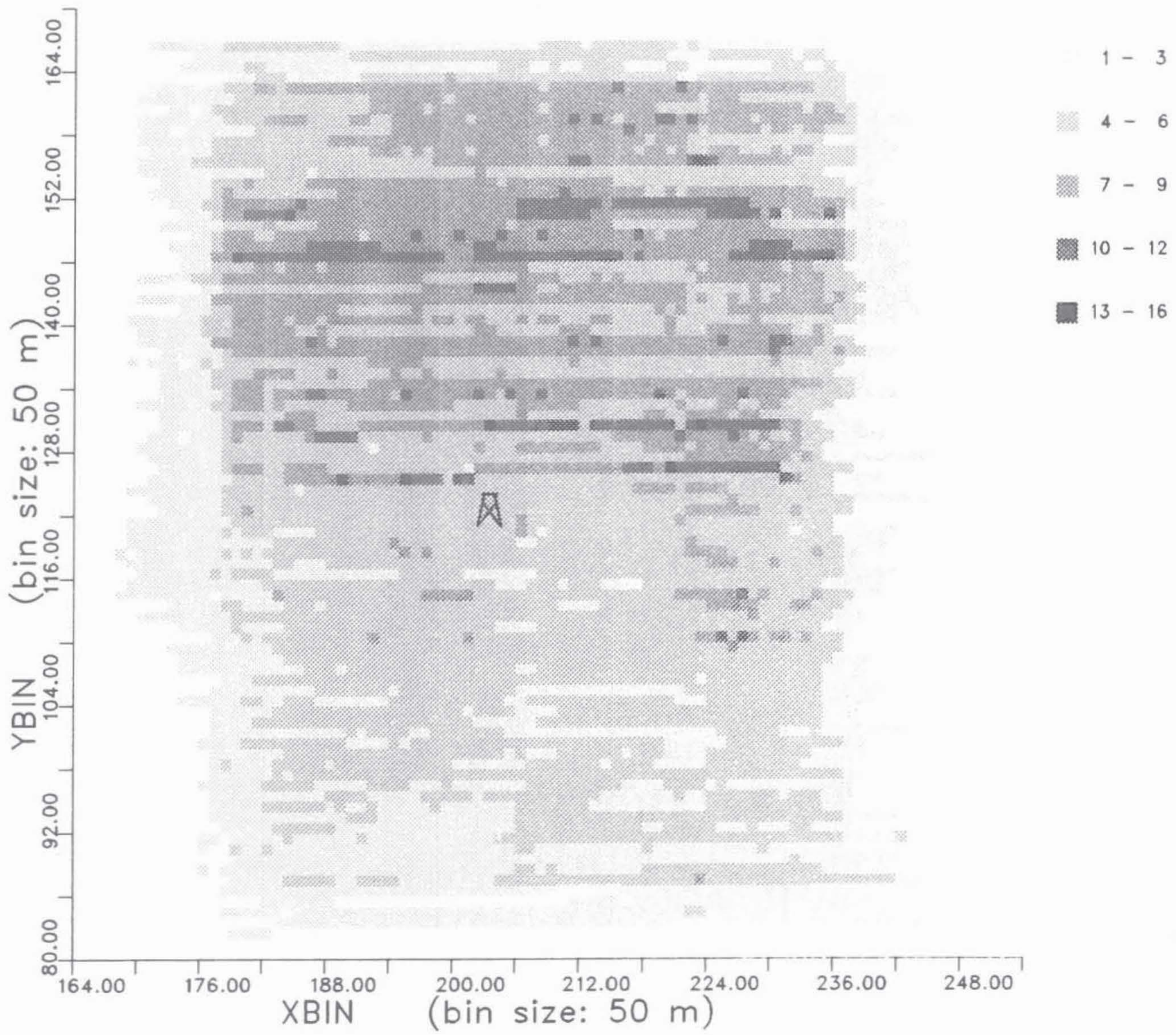

Fig. 11: Subsurface coverage for source-receiver azimuths restricted to 60° - 90°.

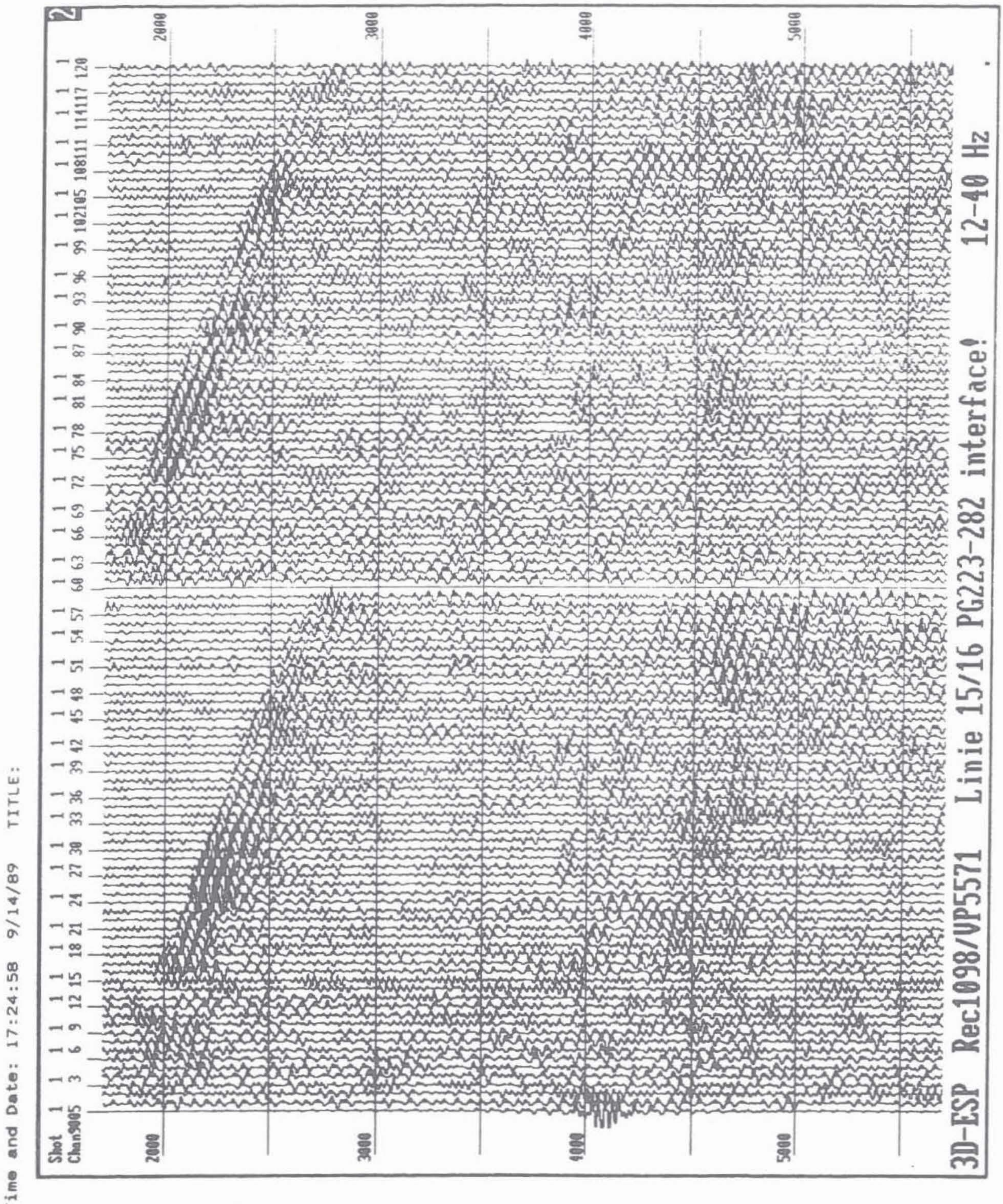

Fig. 12: Common shot gather. Vibration point 5571, channel 1-60 correspond to geophone line 15 and channel 61-120 to geophone line 16.

OUTLOOK

The data material described above is expected to give a strong basis for a detailed velocity model throughout the crust for the area of the KTB. First static corrections have to be implemented. As it is known that the rocks are seismically anisotropic, the velocity analysis has to be restricted to distinct azimuth ranges. Preliminary values of the velocities can be obtained by normal moveout corrections, constant velocity stacks or x^2/t^2 diagrams. Problems may arise applying hyperbolic normal moveout functions at large offsets. Further problems are due to dipping reflectors and the complex geology. So for example the influence of the Franconian Line is unknown. However, by means of the results of the 3D survey and all the other experiments of the ISO 89 experiment a detailed picture of the velocity field will be obtained. Various types of raytracing modelling will be used, and from all these we hope that ISO 89 will make a substantial contribution to the understanding of the complex geologic situation.

REFERENCES

REHLING, J.G., STILLER, M., 1990: 3D Reflection Survey of the Area around the Continental Deep Drilling Project Site. - NLfB, Hannover, KTB-Report 90-6B.