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THE DUTCH DEEP SEISMICS PROGRAMME

by

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(3 figures & 2 tables)

ABSTRACT.- The Dutch Deep Seismics Programme consists of a broad network of 5 regional lines, totalling nearly 1000 kilometers. The objectives are :

a) Provide consistent seismic information, to conventional depth, in long regional profiles.

b) Provide deep seismic information down to the discontinuity of Mohorovicic.

In this presentation an overview will be given of project organisation, of the field techniques that are being applied and of the chosen processing approach.

Line 1, which has a length of 250 km and has a SW-NE direction, has been completed. A brief technical discussion of the results will be given as well as some preliminary interpretation.

RESUME.- Le programme néerlandais de sismique profonde consiste en un large réseau de 5 lignes régionales, totalisant à peu près 1000 kilomètres.
Les buts sont de :

a) fournir une information sismique homogène aux profondeurs conventionelles sur de longs profils régionaux.

b) fournir une information sismique à forte profondeur jusqu'à la discontinuité de Mohorovicic.

Dans ce texte, un survol est fait de l'organisation du projet, des techniques de terrain qui ont été appliquées et des processus d'approche choisis.

La ligne 1, qui a une longueur de 250 km et a une direction SW-NE est terminée. Une brève discussion technique des résultats est fournie ainsi que quelques interprétations préliminaires.

1.- INTRODUCTION

The Dutch Deep Seismics Programme is officially called the Regional Survey Onshore The Netherlands. It is different from the other deep seismic programmes in Europe because it combines two very different objectives :

a) Provide **consistent** seismic information, to **conventional** depth, in long regional profiles. Three profiles running SW-NE and two SE-NW profiles. This data will enable a **regional basin study** down to the Carboniferous. It will supplement the **data base** of both onshore and offshore **operators** and support their current detailed search for oil- and gas reservoirs.

b) Provide **deep seismic information** down to the discontinuity of **Mohorovicic**. This data will be of scientific and of commercial importance. It will enable a study of the **earliest crustal tectonic movements** on a broad regional scale. This will help to unravel the structural and subsidence history. In this way a better understanding of paleotemperature gradients will be obtained, which is of direct importance to the hydrocarbon potential.

The programme was initiated late 1985 by the Geological Survey of The Netherlands. It approached Delft Geophysical B.V. to organize the survey and to seek participation by the oil industry in order to create sufficient financial basis for the

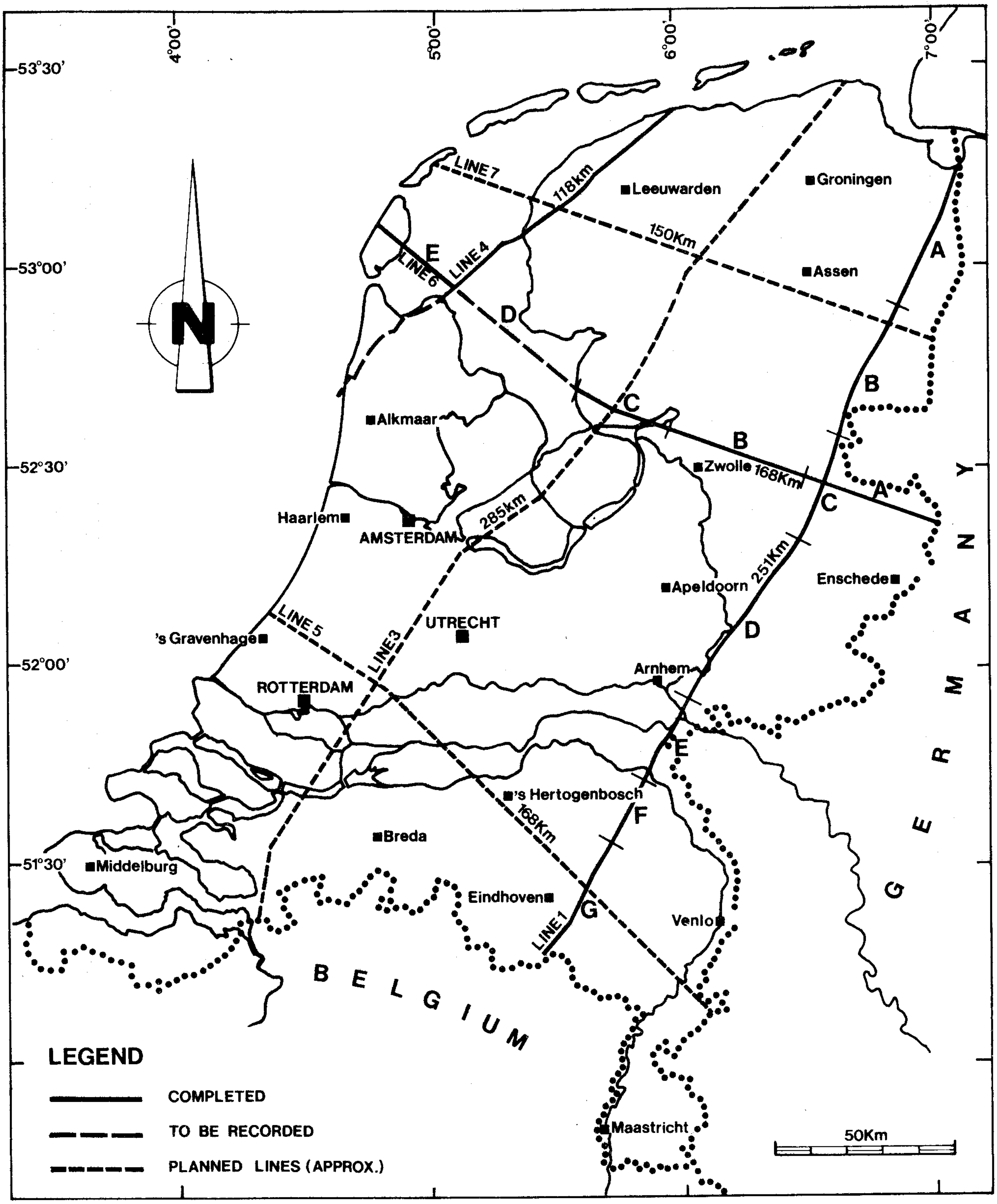

Figure 1.- Line location map.

implementation. With a number of potential participants discussions were held on the location of the lines and about the selection of field parameters.

Because of the variety of ideas on these points, the deliberations took quite some time. As a consequence the start of the survey was delayed until April 1986. Meanwhile, the price of crude oil dropped abruptly from $ 28 to $ 10 per barrel and some of the potential participants withdrew their options. Presently, the project is sponsored by the RGD and Petroland (Elf) and partially by NAM and Mobil. Additional sponsoring is needed to cover the actual project costs.

2.- DATA ACQUISITION

The field parameters are given in table 1. They are chosen such that the two survey objectives can be realized as well as possible. The main parameters are : 25 m station interval and 2 msec time sampling because of the resolution required to conventional depth. The source size is relatively small for this kind of survey. It was chosen for environmental reasons : large charges tend to cause subsidence of the soil, even when fired in a deep shothole. However, the shotpoint interval of 25 m leads to a nominal coverage of 120. This high stack-fold compensates partly for the modest size of the source. On several occasions the dynamite source had to be replaced by vibrators or by air guns. For example, line 4 which passes the «Afsluitdijk» was mainly acquired in vibroseis mode.

A survey map is shown in figure 1. The lines have been adapted to the main geological features in The Netherlands which consist of horsten and graben with a SE-NW orientation. Therefore the most important lines are 1 and 2. the cross lines are planned such that they avoid major fault zones. Line 1 which has a length of 250 km was recorded between May and August 1986. The average production was 80 kms per month. Total number of recorded shots was 7882, or 32 shots per km. The difference between planning and realization is caused by hindrances such as rivers, buildings, nature conservation areas etc.
Average daily production was approximately 120 shots and 3.5 to 4 line kilometers.

About 85 percent of the shotholes were flushed to a depth of 10 to 12 m. In polder areas groups of so-called pop shots were used. These shots are placed at a depth of about 2.5 m in holes that are made with lances. In some areas where for instance a hard clay layer was encountered the shotholes were made with drilling trucks.

Table 1.- Basic field technique

Nr. of channels	: 240
Spread	: Asymetric 80-160
Station interval	: 25 m
Station configuration	: 12 geophone linear criss-cross
Geophone type	: SM 4 10 Hz
Instrument	: Sercel 368
Sampling interval	: 2 msec.
Record length	: 15 sec.
Filter setting	: Low cut out High cut 125 Hz
Energy source	: Dynamite
Charge size	: 1500 G or 2000 G
Depth	: 12 m
Shot interval	: 25 m (middle between stations)
Nominal fold	: 120
Variations	: Vibroseis Marine acquisition

Line 6 and the NE part of line 4 where recorded during the winter season of 1986/1987.

On the Northwestern half of line 6 a combination of techniques was applied. On the tidal flats of the Waddenzee dynamite was used as source, either in flushed or drilled holes. Drilling was done with a truck that was mounted on a shallow draft barge. On the receiver side bay cables or a telemetric spread were used, depending on the water depth. In deep channel crossings dynamite was replaced by a tuned air gun array that Delft Geophysical operates from the shallow draft source vessel m.v. Van 't Hoff. On Texel island conventional seismics was applied, with pop shot groups at the source side. Finally, the North Sea extremity of line 6 was acquired with bay cables and with the m.v. Van 't Hoff. The resulting section is of excellent quality.

3.- DATA PROCESSING

One of the first problems for data processing was to cope with the enormous volume of data. The dimensions of one record are : 240 channels,

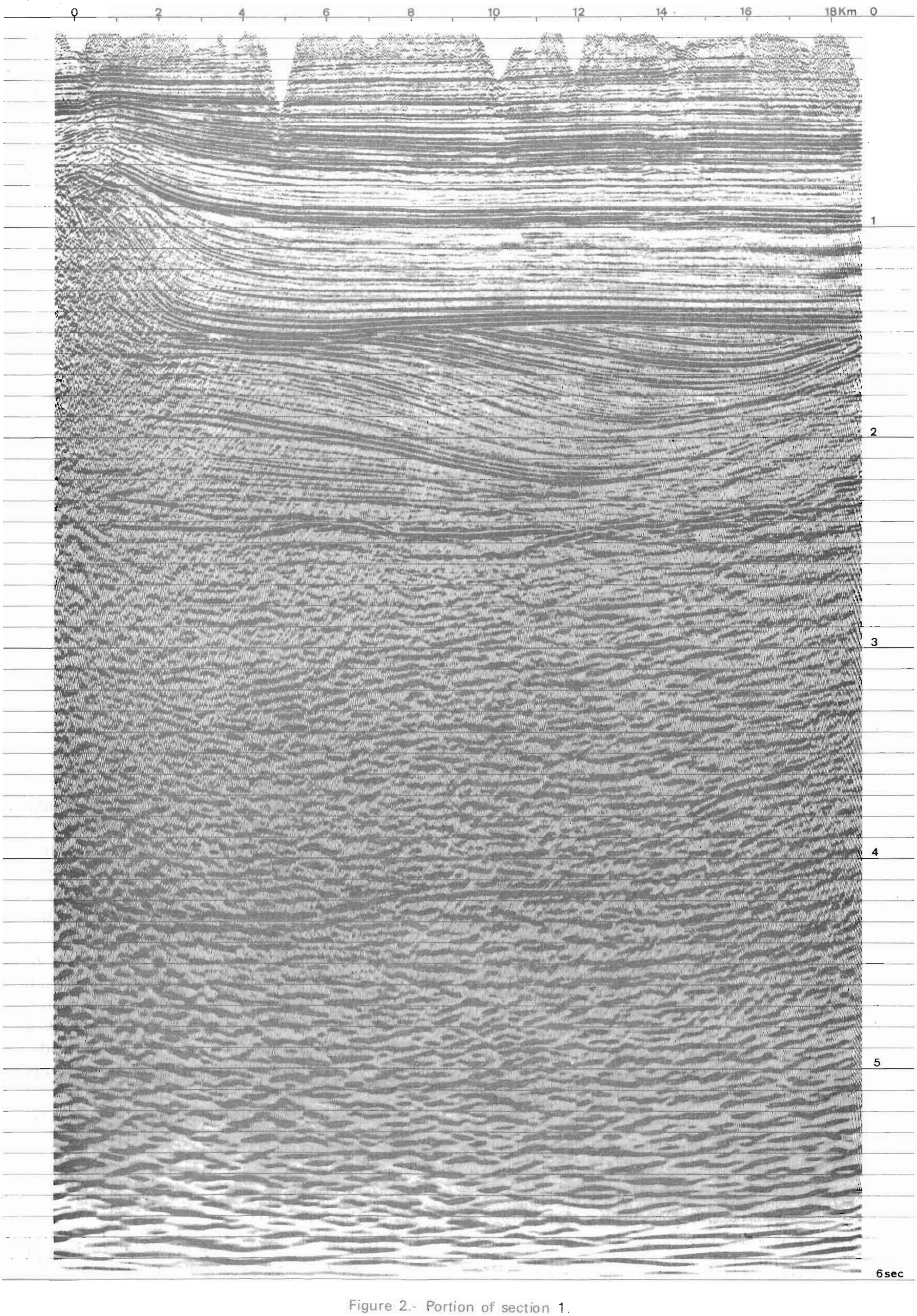

Figure 2.- Portion of section 1.

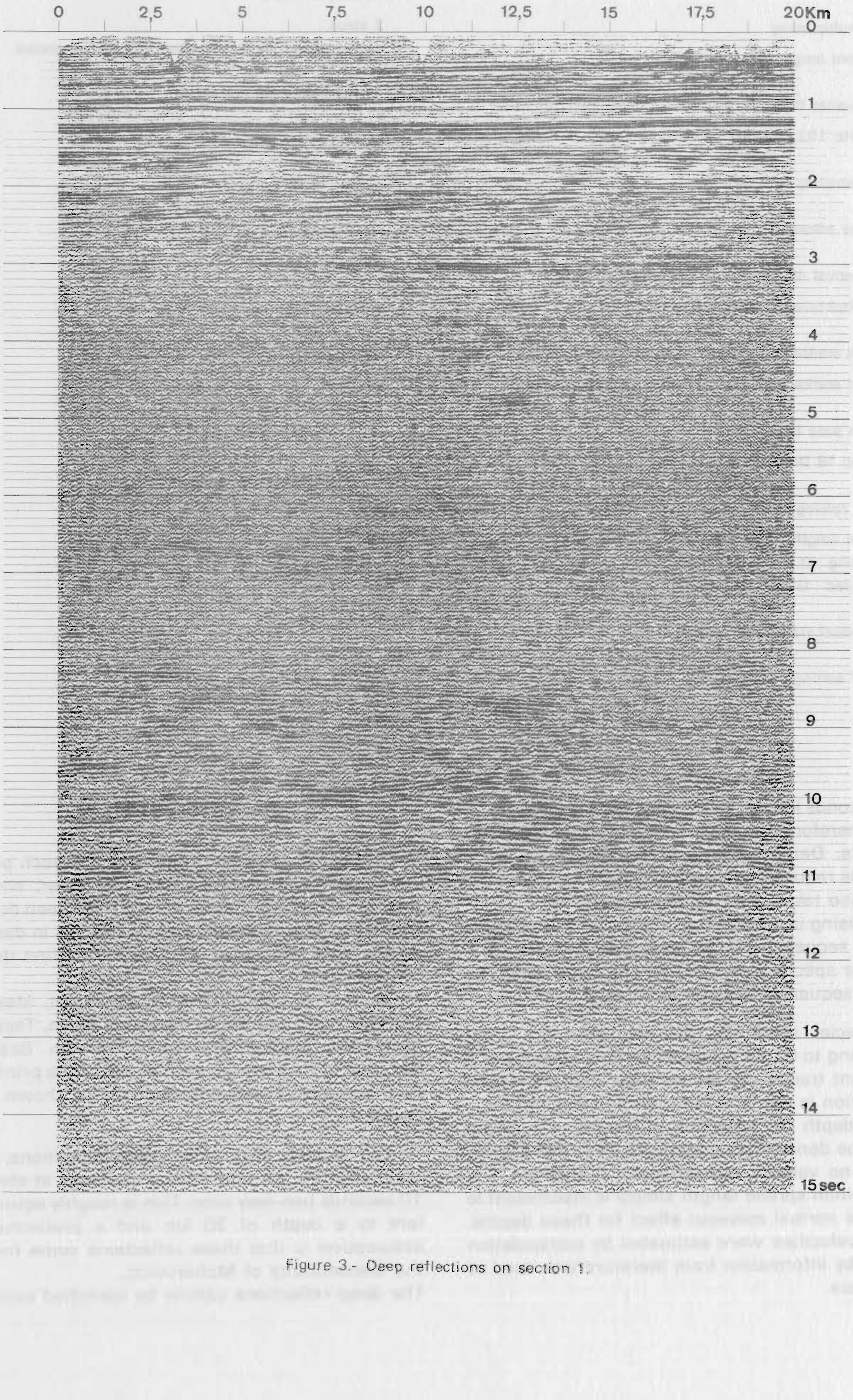

Figure 3.- Deep reflections on section 1.

Table 2.- Processing sequence deep data

1. Demultiplexing
   Record length (S) : 15
2. Anti-alias filter
   90 Hz; 192 DB/OCT
3. Resampling to 8 MS
4. Trace editing
5. Spherical divergence correction
   Multiplication by V-Average*T/2
6. Field statics correction
   Field statics derived from short refraction surveys
7. High pass filter
   6 Hz; 18 DB/OCT
8. T.V. spiking and gapped deconvolution
   Filter length : 240 MS
   Spiking : 0.1 % white noise
   Gapped : GAP = 24 MS
9. Residual statics correction
10. CDP sorting
11. Velocity analysis
    2 steps :
    each followed by a calculation of residual statics
12. Normal move out correction
13. Muting of stretched trace parts
14. Scaling
15. Normalized stacking
    Nominal fold : 120
16. T.V. bandpass filter
17. Scaling
18. Coherency filtering
    Pass : -7 to 7 Msec/Trace
19. Finite-difference time migration
20. Vertical stacking of 2 adjacent CDP'S
21. T.V. bandpass filter
22. High pass filter
23. Scaling

15 seconds length, 0.002 seconds sampling interval. Therefore one record contains 4.5 Megabytes of data. Demultiplexing and sorting such large records requires extraordinary hardware capacity and also takes a lot of computer time.
Processing is done in two phases. First a conventional sequence for the first 6 seconds of data. Then a special sequence for the deep data. The latter sequence is given in table 2.

Special items in this sequence are : resampling to 0.008 seconds, vertical stacking of 2 adjacent traces, coherency filter and migration. Migration is not straightforward : because of the great depth the selection of migration aperture must be done with utmost care. Also there is virtually no velocity control below 6 seconds. The acquisition spread length simply is insufficient to provide normal moveout effect for these depths. Deep velocities were estimated by extrapolation whereby information from literature was used as guidance.

4.- INTERPRETATION

The participants to the project will each perform their own interpretation. However, some preliminary interpretation of line 1 has been done in the processing center and this shows in detail all the main geological features for the first time on one profile.
From S to N : Roer Graben, Peelhorst, Maasbommel high, Central Netherlands Basin, Texel/ ijsselmeer high and Lower Saxonian Basin. Because of its size, the section cannot be printed in this paper, however, a portion is shown in figure 2.

The section also shows deep reflections, in general in the form of a band of events at about 10 seconds two-way time. This is roughly equivalent to a depth of 30 km and a preliminary assumption is that these reflections come from the discontinuity of Mohorovicic.
The deep reflections cannot be identified every-

where. At some places they are patchy and in other places they are absent. The impression is that favourable subbottom conditions for acquisition can be correlated with good penetration and vice versa.

A portion of the deep section is shown in figure 3.

5.- CONCLUSIONS

The parameters that were applied in this survey have successfully served the dual purpose of providing high resolution seismic data to conventional depth and deep reflections at about 10 seconds. The source size had to be limited because of environmental considerations.
This is partly compensated by the high stack-fold of the data. In favourable acquisition areas the deep reflections are of good quality.

To determine seismic velocities at greater depth wide angle observations or refraction surveys are required.