NGU Report 94.092

Geophysical surveying at five locations in Lithuania

NORGES GEOLOGISKE UNDERSØKELSE

Postboks 3006 - Lade
7002 TRONDHEIM
Tlf. 47 73 90 40 11
Telefax 47 73 92 16 20

REPORT

Report no. 94.092	ISSN 0800-3416	Grading: Open

Title:

Geophysical surveying at five locations in Lithuania

Author: Eirik Mauring, Jan S. Rønning, Jomar Gellein	Client: NGU/Geological Survey of Lithuania
County:	Commune:
Map-sheet name (M=1:250.000)	Map-sheet no. and name (M=1:50.000)
Deposit name and grid-reference:	Number of pages: 19 Price: NOK 190,- Map enclosures: 5

Fieldwork carried out:	Date of report:	Project no.:	Person responsible:
14.09.94-21.09.94	28.11.94	15.2582.01	Jan S. Rønning (signature)

Summary:

Ground-penetrating radar (GPR) profiling has been carried out at five locations in Lithuania. At one of these locations (Pajuoste airport), magnetic gradiometer measurements were conducted in four areas. The main purpose of the investigations was to demonstrate how GPR could be applied to geological, hydrogeological and geotechnical problems. The Geological Survey of Lithuania wanted to use the results as an aid to the decision on whether to purchase a GPR or not.

In the Neringa area, the GPR delineated the interface between layers of very fine sand and silt. Structures within an eolian deposit could readily be seen on a GPR record.

At Butinge, the interface between sand/gravel and clay could easily be identified. Mostly, the penetration depth was poor due to shallow, lossy material (clay).

Near the Letausas river, GPR delineated the base of a peat in areas where the base was shallower than c. 5 m.

At Puškoriai (Vilnius), GPR measurements were unsuccessful. There was practically no penetration of radar signals.

At the Pajuoste airport, GPR and magnetic gradient measurements indicated the position of a landfill, giving rise to strong gradient anomalies. In three other areas at the Pajuoste airport, only magnetic gradient measurements were conducted. Metal objects, such as buried oil tanks, could be detected.

Keywords: Geofysikk	Georadar	Magnetometri
Deponi	Forurenset grunn	Vindavsetning
		Fagrapport

CONTENTS

1 INTRODUCTION

Ground-penetrating radar (GPR) profiling has been carried out at five locations in Lithuania. At one of these locations (Pajuoste airport), magnetic gradiometer measurements were conducted in four areas. The main objective was to demonstrate the use of GPR for different purposes as part of a co-operation program between the Geological Survey of Lithuania and the Geological Survey of Norway (NGU). The Geological Survey of Lithuania wanted to see how the GPR could be applied to geological, hydrogeological and geotechnical problems to help in the decision on whether to purchase a GPR or not.

Geophysical measurements were carried out during the period 14th September to 21st September by Jan S. Rønning and Jomar Gellein from NGU. Participants from the Geological Survey of Lithuania were Dr. Rimantas Šeckus, Birute Stanzyte and Dainius Michelevicius. Interpretation of GPR and gradiometer records was carried out by Eirik Mauring, NGU.

2 INSTRUMENTATION AND ACQUISITION PARAMETERS

2.1 Ground-penetrating radar

Total length of the GPR profiles was about 4.5 km. In addition, four common mid-point (CMP) records were obtained for velocity analysis. Velocity analysis is performed for depth conversion of the GPR records. The location of the profiles and the GPR records are shown in map -01-05. Measurements were carried out using 'pulseEKKO IV' radar system (Sensors & Software Inc., Canada) with 50 MHz antennas. Signals were stacked 32 times at each station. Time sample interval was 1.6 ns and the antennae separation was 1 m. Other acquisition parameters are listed in table 1. Topographic correction was performed on all records, except at the Pajuoste airport, where the topography was relatively flat. Topography data was supplied by the Geological Survey of Lithuania or derived directly from the topographic maps. The distance between the timing lines on the GPR records is 100 ns.

Table 1. GPR acquisition parameters

Location	Profile	Record time (ns)	Position (m)	Transmitter voltage (V)	Step size (m)
Neringa	P1	1000	0-314	1000	1
Neringa	P2	600	0-300	1000	1
Neringa	P3	600	0-385	400	1
Butinge	P4	600	0-714	400	1
Butinge	P5	600	0-1100	400	1
Letausas	P6	600	1-308	400	1
Letausas	P7	400	0-293	400	1

Letausas	P8	400	0-305	400	1
Puškoriai	P9	1000	1-118	400	0.5
Puškoriai	P10	1000	0-100	400	0.5
Pajuoste	P11	400	0-165.5	400	0.5
Pajuoste	P12	400	0-30	400	0.5
Pajuoste	P13	400	0-330.5	400	0.5

2.2 Magnetic gradiometer

Measurements were carried out using the Scintrex ENVI-MAG magnetic gradiometer. Two sensors are used with a vertical spacing of 0.5 m. The lowermost sensor was placed 2 m above ground level. The measured value is the difference in total magnetic field strength between the two sensors and is expressed as nanoTeslas per metre (nT/m). As mentioned earlier, measurements were carried out in four areas at the Pajuoste airport. Area designation and acquisition parameters are listed in table 2.

Table 2. Magnetic gradiometer acquisition parameters

Area	Station spacing (m)	No. of profiles	Profile spacing (m)	Profile length (m)
Oil tank area (petrol waste deposit)	1	7	5	60-70
Ammunition storage facility area	2	6	10	44-100
Oil storage facility	1	6	5	80
Waste deposit	1	1		369

3 RESULTS

Results from velocity analysis of CMP records are shown in table 3. CMP records with velocity analysis are shown in appendix 1.

Table 3. Results from velocity analysis of CMP records.

CMP location	Time (ns)	Velocity (m/ns)	Time (ns)	Velocity (m/ns)
Neringa, P2-40	50	0.14	180	0.11
Butinge, P5-20	50	0.10	130	0.08
Letausas, P8-258	50	0.08	110	0.08
Puškoriai, P10-33	20	0.13		

The following velocities are used for depth conversion of GPR records; Neringa: 0.11 m/ns, Butinge: 0.08 m/ns, Letausas: 0.08 m/ns, Puškoriai: 0.13 m/ns. At the Pajuoste airport, no CMP measurements could be conducted, due to the lack of defined horizontal reflectors. A high groundwater table was assumed. A velocity of 0.07 m/ns, commonly encountered in areas with water-saturated alluvium, was chosen for depth conversion. GPR records are shown in maps -01-05.

Results from magnetic gradiometer measurements are presented as contour maps in appendix 3-5, except for the landfill (waste deposit area) where recordings were conducted along only one line. This line is shown in appendix 2. Sources of noise on the ground are denoted by an asterix (*).

3.1 Neringa

GPR recordings were conducted along three lines (P1, P2 & P3). Records and locations are shown in map -01. Profile P1 and P2 are located at Juodkrante, while profile P3 is located at Pervalka.

<u>P1, GPR</u>
Drillings have been carried out close to position 0 (well 40) and position 170 (well 41). A reflector at 5 m below sea level at position 0 corresponds to the interface between very fine sand (upper layer) and silt. The reflector can be followed throughout the profile, except between position 275 and 295 where a hummocky reflector can be seen. Velocity analysis of a CMP record at P2 (position 40) shows a high stacking velocity (0.14 m/ns) down to a reflector at c. 50 ns, indicating dry material. The reflector is interfering with the direct wave, and is representing the groundwater table at a depth of c. 3 m. Topographic data was supplied by the Geological Survey of Lithuania. Between position 215 and 253, it is indicated that the surface has a slope. This was not observed during profiling, so the topographic data can be somewhat erroneous in this area. From position 220 to 314, a distinct reflector can be seen at 11-13 m, representing the groundwater table. Between position 50 and 30, a very shallow reflector appears as a trough with a bottom at position 40 (depth of c. 4 m). This reflector represents the groundwater table whose structure is due to erroneous topographic correction. There is little or no penetration of radar signals in the silt sequence due to high electrical conductivity in silt leading to attenuation of signals. Dipping layers can be seen between position 215 and 260, indicating that the very fine sand can be eolian.

<u>P2, GPR</u>
A distinct reflector can be followed at a depth of 4.5 to 5.5 m. Since this profile crosses P1, it is very likely that this reflector corresponds to the prominent reflector described in P1 as the interface between very fine sand (upper layer) and silt. Again, there is no penetration in the silt layer. No distinct reflectors can be seen in the very fine sand layer.

P3, GPR

The profile is crossing an eolian deposit at Pervalka. A strong reflector at 3 to 9 m a.s.l. is probably representing the base of the deposit, i.e. the terrain surface prior to the deposition of the eolian sediments, and because the reflector is very strong, it is probably also representing the groundwater table. The reflector's wavy appearance, might be caused by erroneous topographic correction. Dipping reflectors can be seen throughout the eolian deposit. The reflectors are dipping in the same direction (towards the east) indicating a steady wind direction during deposition. Towards the ends of the profiles, several reflectors can be seen underneath the suggested base of the eolian deposit.

3.2 Butinge

GPR records P4 and P5 from Butinge north of Palanga are shown in map -02.

P4, GPR

The record generally shows very poor penetration. Some very shallow events can be seen from position 15 to position 310. These are weak, parallel reflectors to a depth of about 4 m. Drillholes in this area show that the predominant material is sand with or without organic material. Several vertical electrical soundings (VES) have been carried out in 1976 and 1978 in the vicinity of the profile (Birute Stanzyte, personal information). They show low resistivities (in the order of 20-50 ohmm) to depths far exceeding the depth of GPR penetration for these resistivity values.

P5, GPR

A geological section based on drillings (not shown) along the profile shows sand to a maximum depth of about 7 m overlying gravel with a thickness of about 0.5 m. Beneath the gravel, there is probably a clay unit (since units on the geological section is only identified by numbers, one cannot be sure). Vertical electrical soundings carried out in 1978 (Birute Stanzyte, personal information) very crudely show a two-layer model. The upper layer has resistivities in the order of 2000-7000 ohmm, whereas the lower layer has resistivities in the order of 20-50 ohmm. This is consistent with the results from drilling (sand/gravel over clay) (Birute Stanzyte, personal information). In the GPR record the interface between sand/gravel and clay is easily identified as a horizontal reflector at 4-7 m depth. In some places this reflector is not very prominent, and in these areas the penetration is deeper, indicating coarser material. This can most clearly be seen in the areas 50-150, 260-400 and 930-965. At position 108, increasing depth of coarser material has been confirmed by drilling (well 24). In this area there is an increased thickness of gravelly material, which is identified on the GPR record as an area of chaotic reflection pattern (position 50-150).

3.3 **Letausas**

GPR measurements were carried out along three profiles (P6, P7 and P8). The records and the location of the profiles are shown in map -03. The object of the investigations was to see how GPR could be applied to the mapping of a peat deposit.

<u>P6, GPR</u>
A reflector dipping down can be seen from position 85 to position 115 (at about 5 m depth). This reflector probably represents the base of the peat deposit. The reflector cannot be seen from position 115, probably because the peat has relatively high conductivity. From position 115 to the end of the profile (position 308) the base of the peat is beyond the depth of penetration. Thus, the thickness of the peat must be more than 5 metres in the area.

<u>P7, GPR</u>
This profile shows the base of the peat between position 0 and 50 (3-4 m depth). In the area 50-195 the base of the peat layer lies deeper than the depth of penetration (5 metres). From position 195 (at 4 m depth), the base of the peat layer reaches the surface around position 245.

<u>P8, GPR</u>
Along this profile, the base of the peat is clearly undulating. A depression in the base of the peat layer can be seen at position 275 (96 m.a.s.l.). Between position 265 and 195, a reflector, probably representing the base of the peat can be seen at 96-99 m.a.s.l. Between position 195 and 160, the peat base reflector is probably deeper than the depth of penetration. From position 160 to position 0, the base of the peat can be seen at 1.5 to 3 m depth with a depression at positions 142 and 10.

3.4 **Puškoriai (Vilnius)**

GPR measurements were carried out along two profiles shown in map 4. The profiles were measured on the top of an escarpment in till. The escarpment has resulted from erosion by the river Vilejka.

<u>P9 & P10, GPR</u>
GPR measurements were unsuccessful in this area, probably due to high conductivity in the near-surface deposits caused by high content of fine-grained materials in the till. Only very shallow events can be seen, especially between position 55 and 75 on P10.

3.5 **Pajuoste airport**

The GPR records for the three profiles (P11-P13) measured in this area are shown in map 5.

P11, GPR

This profile is measured in an area where the ground is polluted with oil spill. The penetration is very poor, maximum 3-4 m. Several dipping reflectors can be seen along the entire profile. The reflectors have a constant dip which differs slightly for each reflector. The most obvious interpretation of these reflectors is that they represent reflections from objects on the surface. However, no such objects could be observed, and the dips of the reflectors represent velocities that are lower than the EM airwave velocity. Although the dipping reflectors must be considered as noise, their origin is not known.

A borehole in the area shows that the overburden material consists primarily of sandy or silty clay down to the end of the hole at approximately 4 m. At the end of the hole, stones were encountered in the clay. This accounts for the poor penetration.

P12, GPR

This very short profile in the oil spill area crosses P11 at position 150. A very weak, slightly dipping reflector can be seen at about 3-4 m depth from position 5 to position 17. This could represent a layer of stones in the clay, as encountered in the borehole.

P13, landfill (waste deposit), GPR and magnetic gradiometer

Both GPR and magnetic gradient profiling has been carried out along profile P13. The profile is crossing a landfill (waste deposit) in this area. The GPR penetration is poor, in parts probably due to fine-grained overburden material. A very shallow reflector (at about 2 m depth) can be seen between position 0 and 55. From position 55 to 60, the record is disturbed by noise from a fence. From position 62, the shallow reflector can no longer be seen on the record as we are probably entering the landfill. This is in agreement with the magnetic gradient values (appendix 2), which become anomalous from position c. 60. The two anomalies at position 32 and 55 are noise from surface objects. Very strong magnetic gradient anomalies can be seen to position 260. These are all probably due to magnetic sources in the landfill (i.e. objects containing iron). Between position 260 and 290 there are no distinct magnetic gradient anomalies. From position 290 to the end of the profile there are anomalies which are lower in magnitude (<200 nT/m) than the anomalies between position 60 and 260 (100-5000 nT/m). In this first landfill, the sources are either shallower or contain more metallic objects than in the second landfill (from position 290). In the GPR record, a shallow reflector can be seen from position 272, indicating the termination of the first landfill at this position. From position 287, the shallow reflector becomes more obscure, indicating the start of the second landfill. However, the start of the second landfill is more readily seen on the magnetic gradient profile.

On the basis of both GPR and magnetic gradient profiling, the most likely position of the first landfill is from position 60 to 272. The second landfill probably starts at position 290. The end of the second landfill is not clear, as magnetic gradient anomalies can be seen at the end of the profile.

Oil tank area, magnetic gradiometer

Magnetic gradient profiling was carried out along seven profiles in this area. The purpose of the measurements was to see if there were oil tanks buried in the ground, indicated by taps and pipes on the surface. A contour map based on minimum curvature gridding is shown in appendix 3. Several high anomaly areas can be seen on the map. The anomalies between profile 20X and 25 X (20Y-35Y) are due to a house and a streetlight. An anomaly is centred around 25Y on profile 15X. The anomaly is not crossing profile 20X and 10X, and it is probably due to one or perhaps two buried tanks indicated by two sets of taps on the surface. The eventuality of two tanks is not indicated on the contour map, but one cannot rule out the possibility that they are too closely spaced to give rise to two separate anomalies. The anomalous area between 10X and 15X at 43Y is caused by another oil tank which probably crosses both profiles. There are several other anomalous areas, although far smaller in magnitude than those described. These anomalies are all due to objects on the surface (e.g. steel rods, reinforced concrete).

Oil storage facility, magnetic gradiometer

Six profiles have been measured with the magnetic gradiometer in this area. The object of the investigations was to locate subsurface pipelines connected between the oil storage tanks and an old pumping site. As can be seen from the contour map in appendix 4, several anomalous areas can be seen. Almost all of these can be attributed to objects on the surface (noise). It is likely that these very strong anomalies overprint weaker anomalies from the subsurface pipelines. As a result, the pipelines could not be detected.

Ammunition storage facility, magnetic gradiometer

Magnetic gradient profiling was carried out along six profiles in this area. The purpose of the measurements was to look for buried metal. A contour map is showed in appendix 5. Three anomalous areas can be seen on the map. Anomalies at 30X, -143Y and 40X, -146Y are due to steel rods holding a volleyball net. The anomaly at 20X, -216Y cannot be explained by noise from objects on the surface. This could be a location for buried metal. The rest of the area contains no other detectable metallic objects

4 CONCLUSIONS

Ground-penetrating radar (GPR) profiling has been carried out at five locations in Lithuania. At one of these locations (Pajuoste airport), magnetic gradiometer measurements were conducted in four areas.

In the Neringa area, the GPR delineated the interface between layers of very fine sand and silt. Structures within an eolian deposit could readily be seen on a GPR record.

At Butinge, the interface between sand/gravel and clay could be easily identified. Mostly, the penetration depth was poor due to shallow, lossy material (clay).

Near the Letausas river, GPR delineated the base of a peat in areas where the base was shallower than c. 5 m.

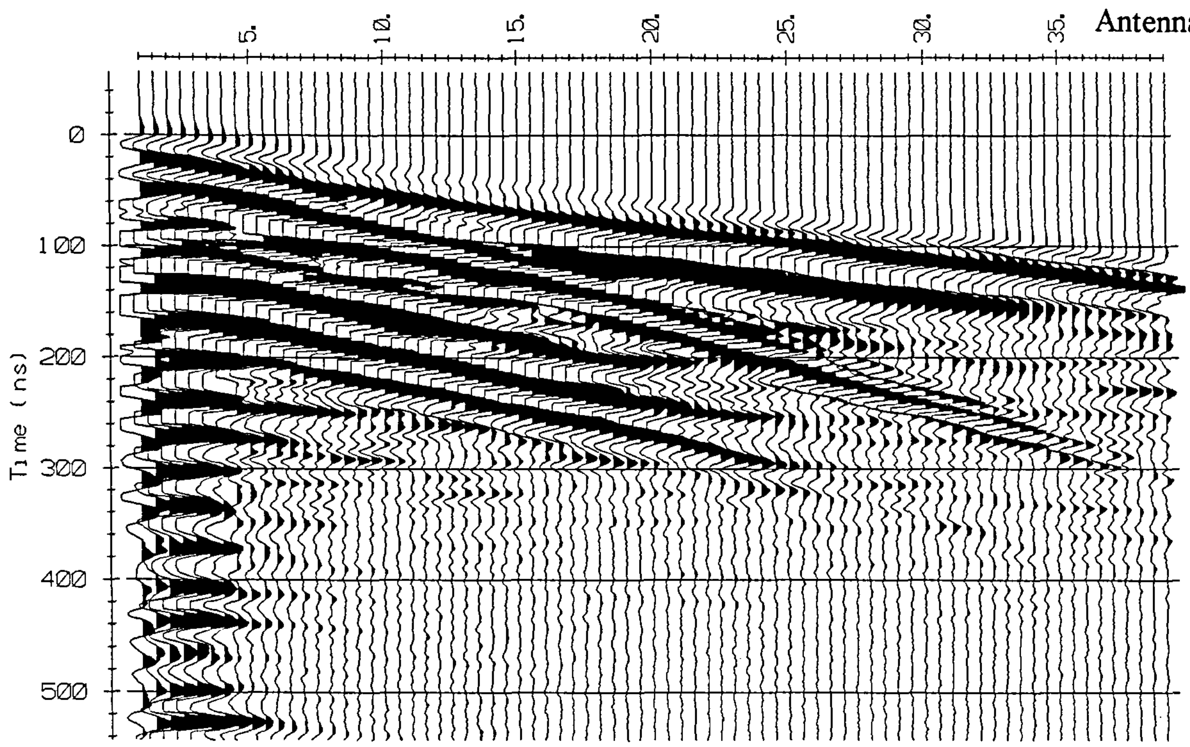
At Puškoriai (Vilnius), GPR measurements were unsuccessful. There was practically no penetration of radar signals.

At the Pajuoste airport, GPR and magnetic gradient measurements indicated the position of a landfill, giving rise to big gradient anomalies. In three other areas at the Pajuoste airport, only magnetic gradient measurements were conducted. Metal objects, such as buried oil tanks, could easily be detected. In one area, the search for underground pipelines was unsuccessful due to severe noise from surface objects, masking the weaker anomalies from the pipelines.

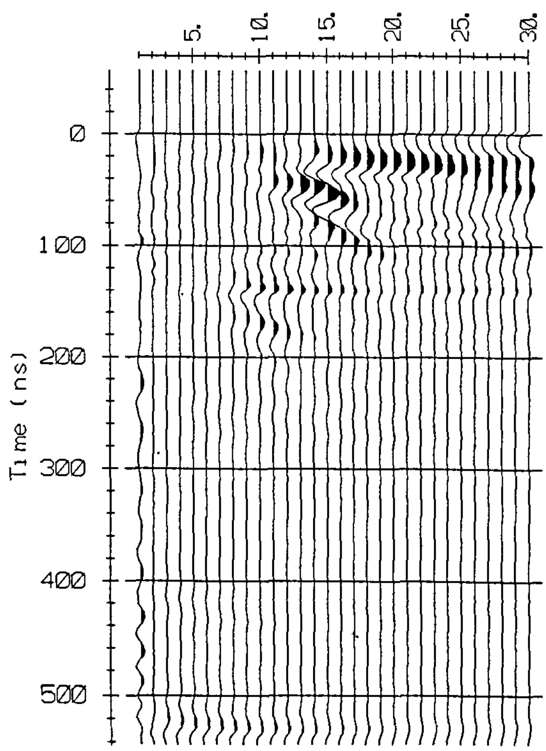
GPR profiling in Lithuania has showed (as in other parts of the world) that the method is very sensitive to the subsurface electrical properties. In areas of high electrical resistivity (> 1000 ohmm) the method can give valuable information. In areas with subsurface resistivities of less than 100 ohmm, the depth of penetration is very limited. These results should be taken into account when the purchase of a ground-penetrating radar will be discussed.

Velocity analysis, Neringa

CMP record, P2 position 40

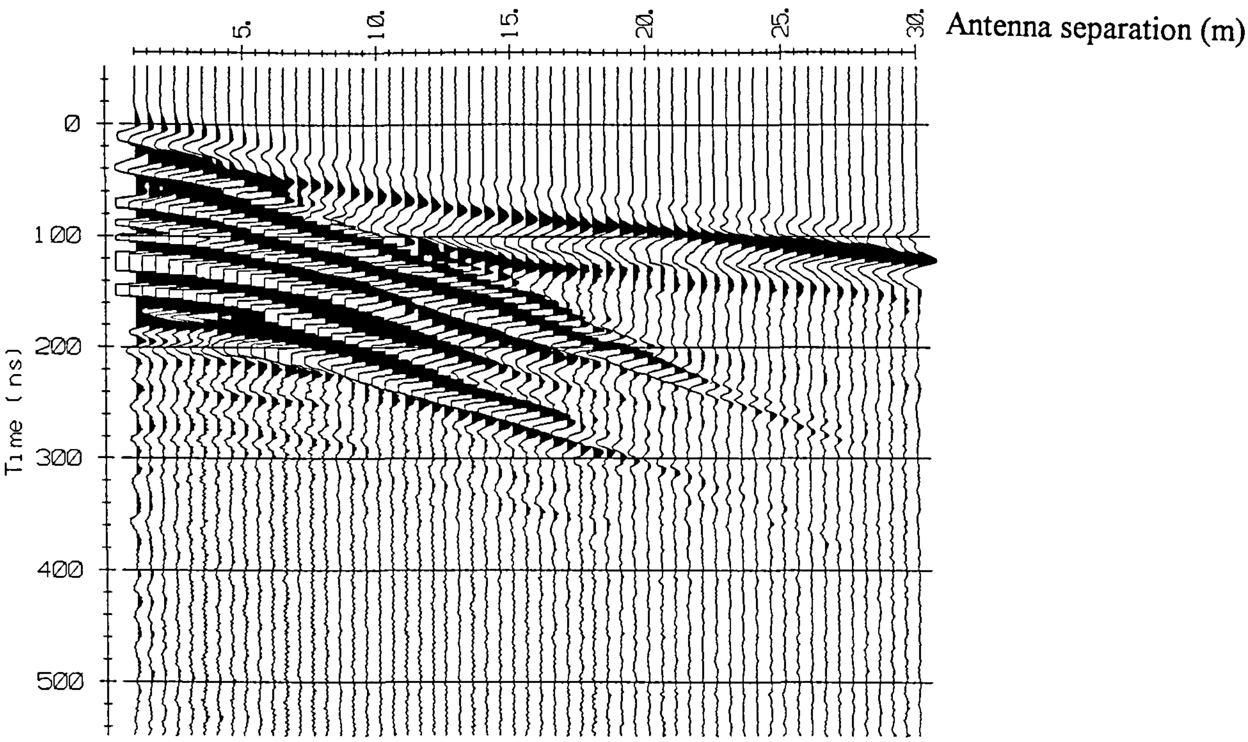


Velocity analysis

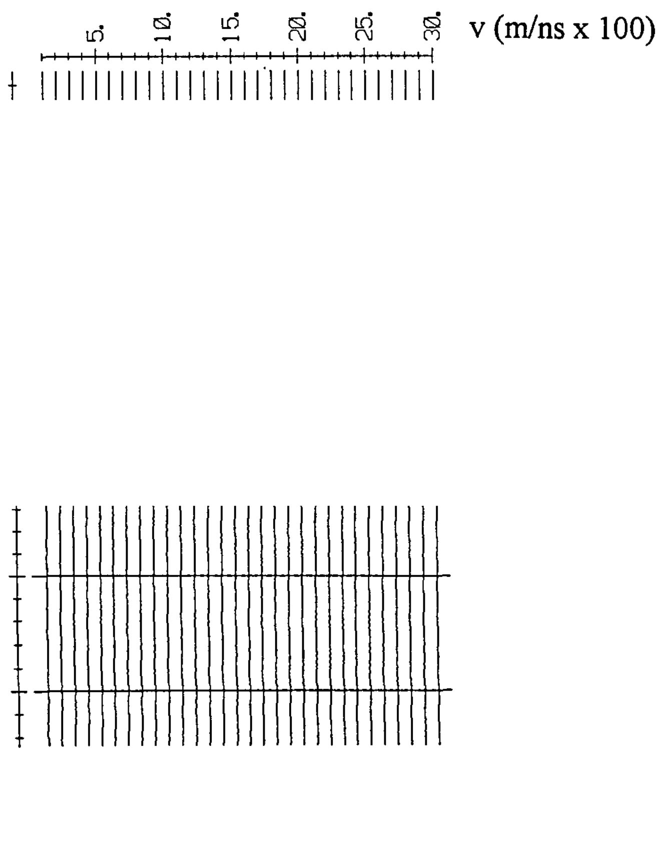


Velocity analysis, Butinge

CMP record, P5 position 20

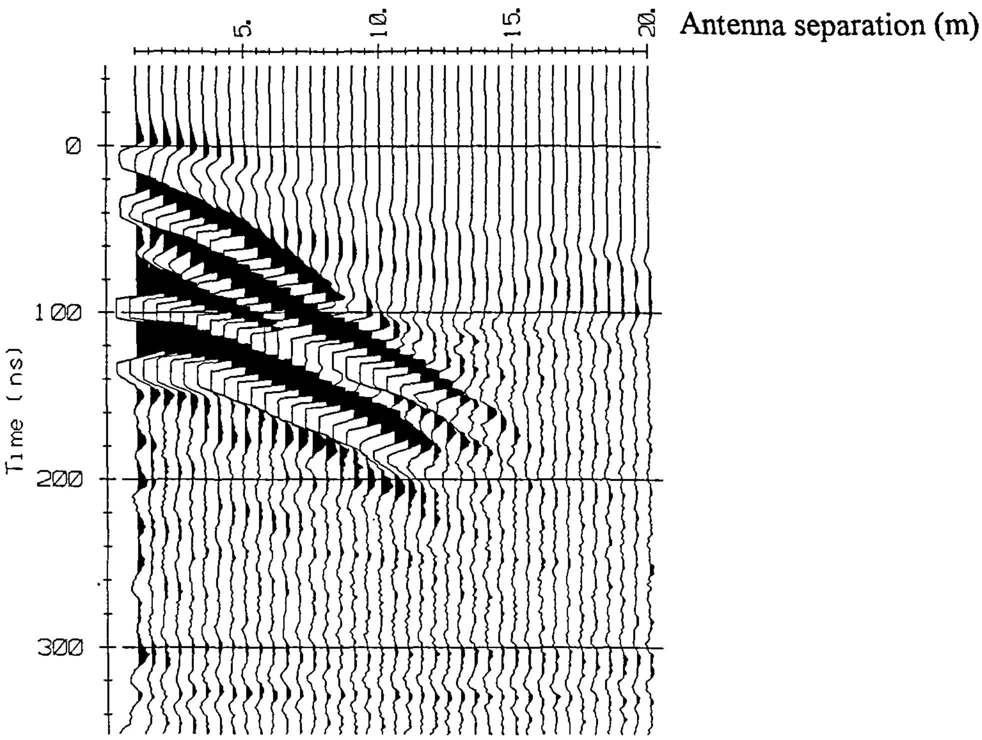


Velocity analysis

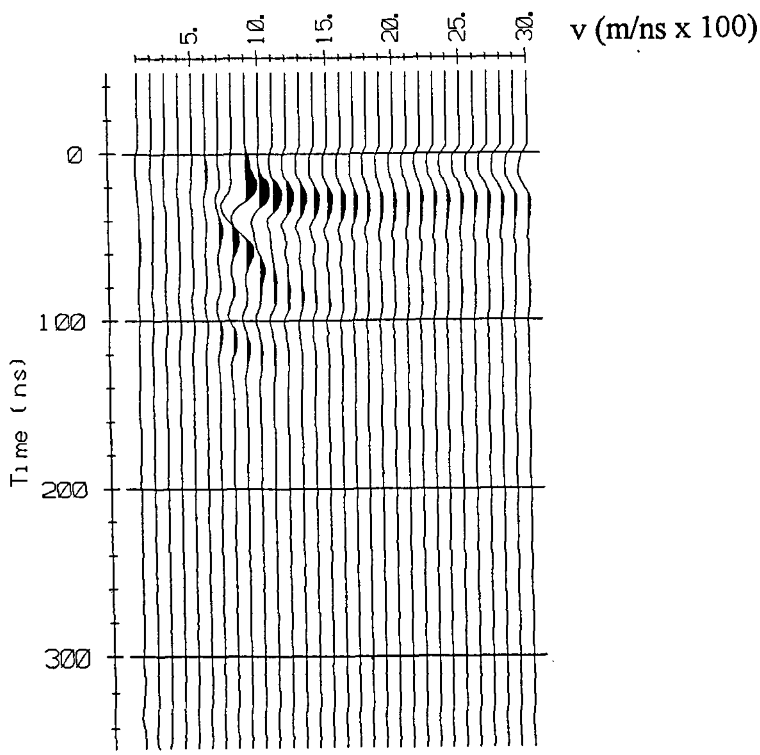


Velocity analysis, Letausas

CMP record, P8 position 258

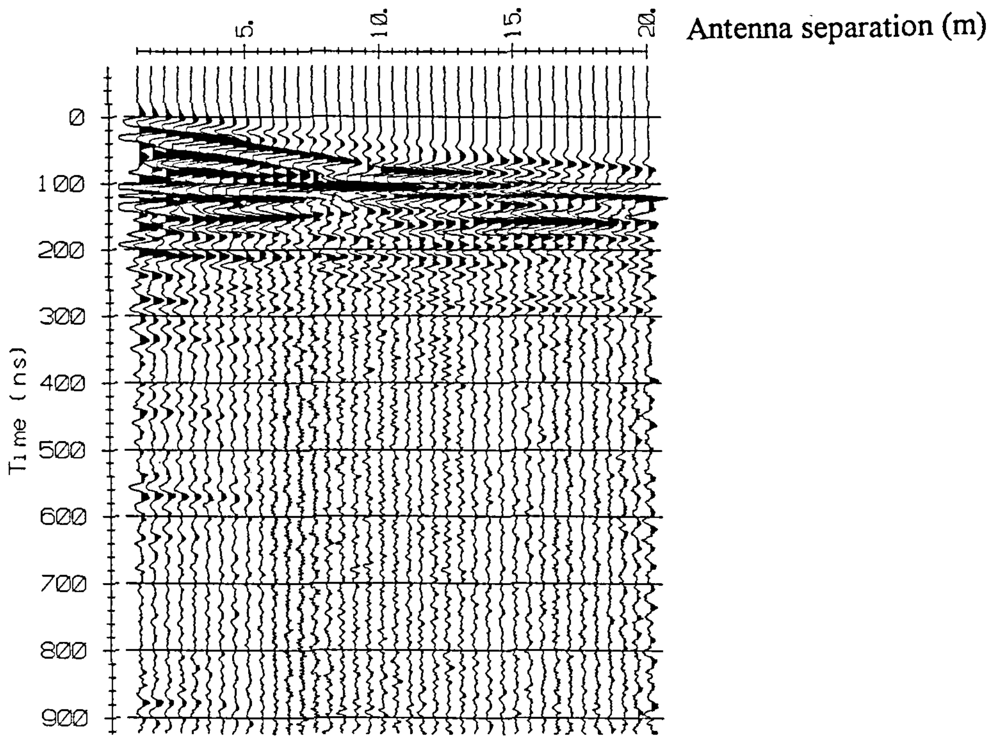


Velocity analysis

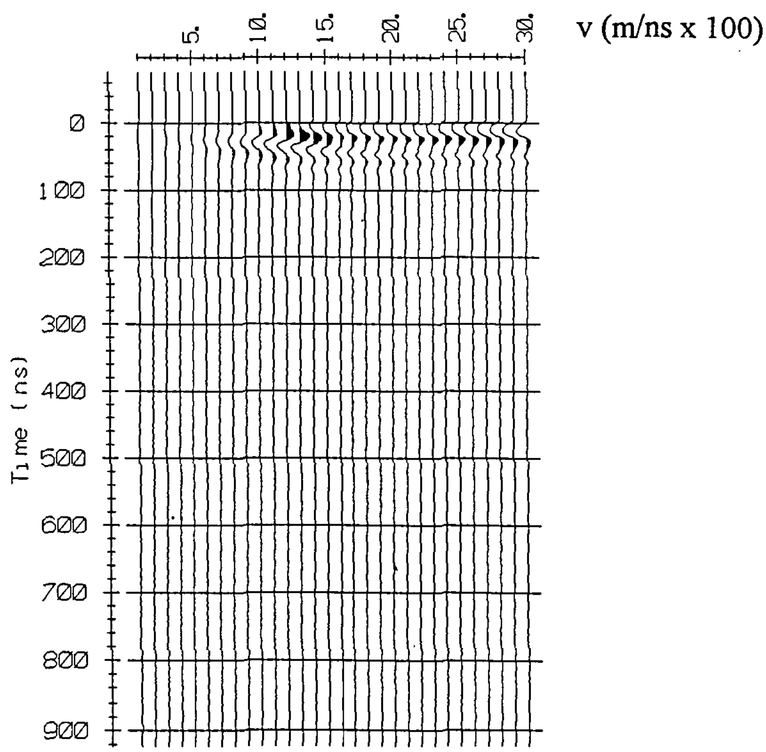


Velocity analysis, Puškoriai (Vilnius)

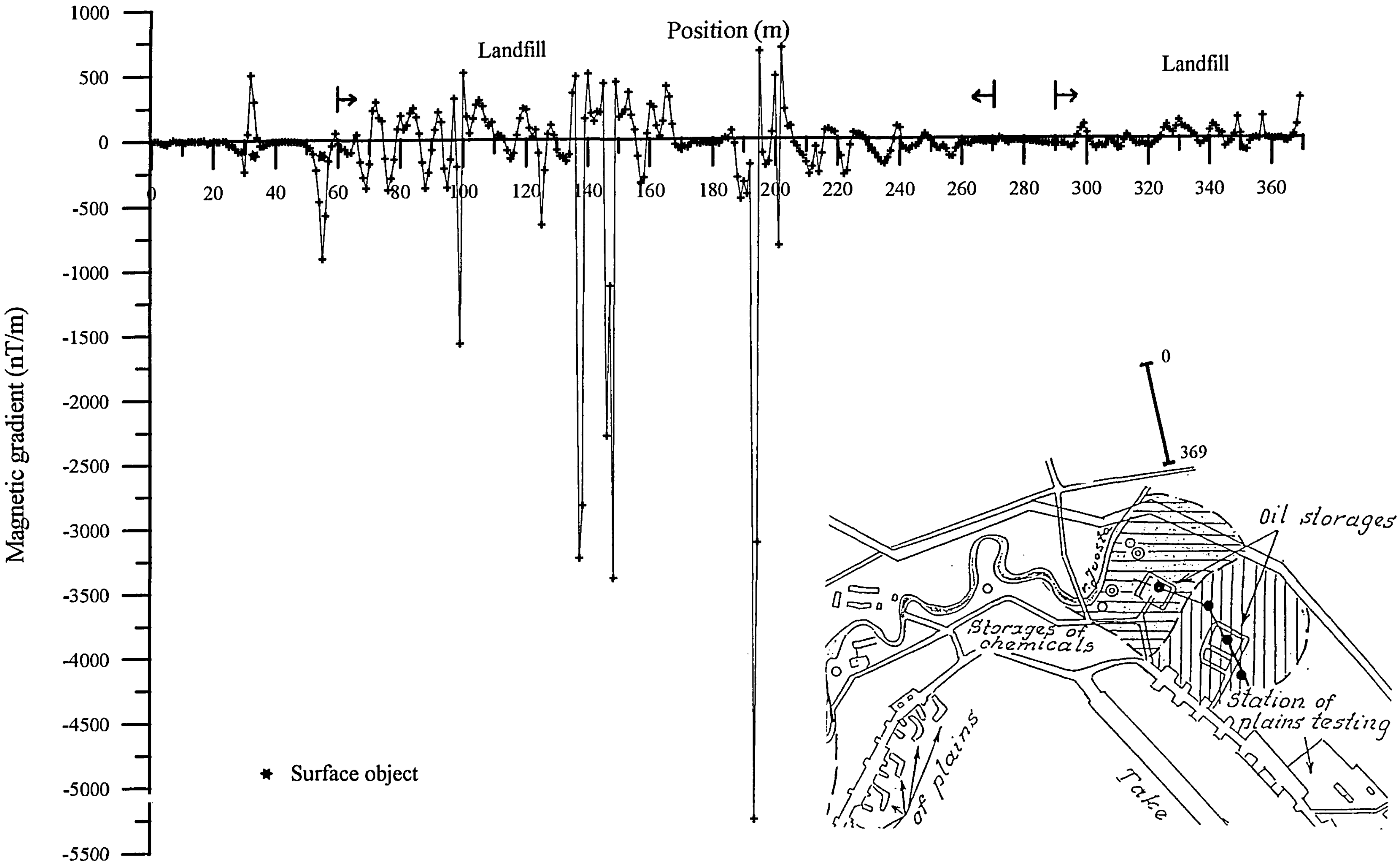
CMP record, P10 position 33



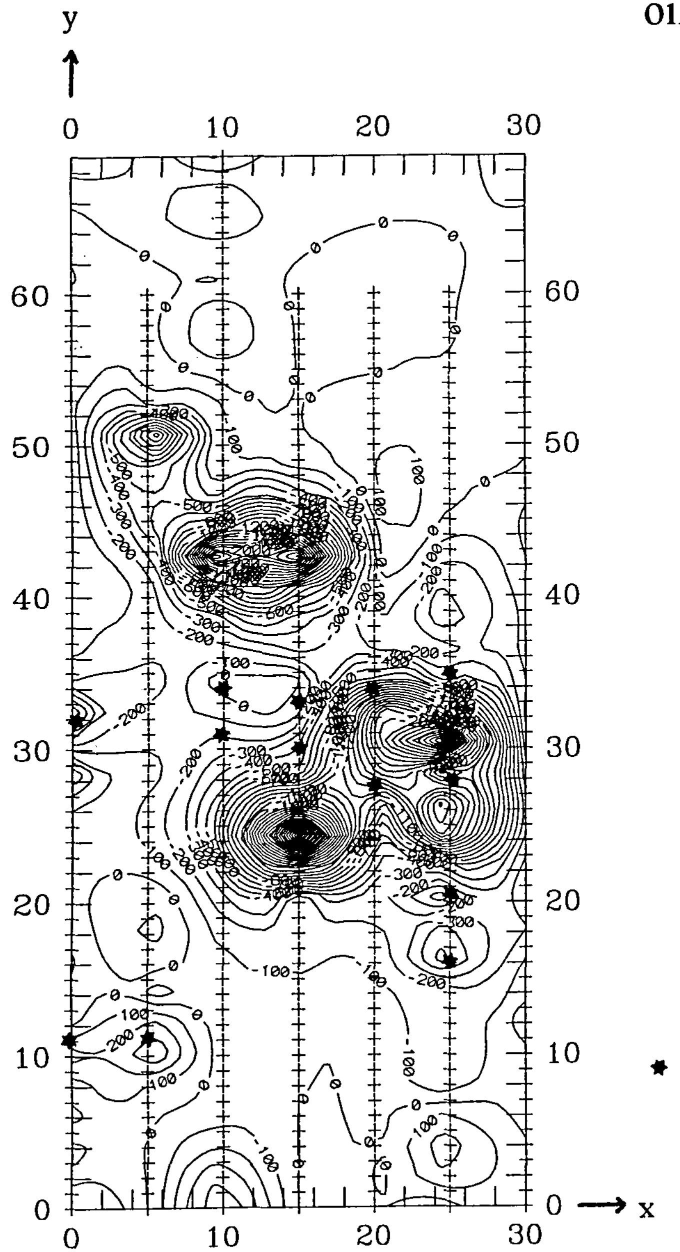
Velocity analysis

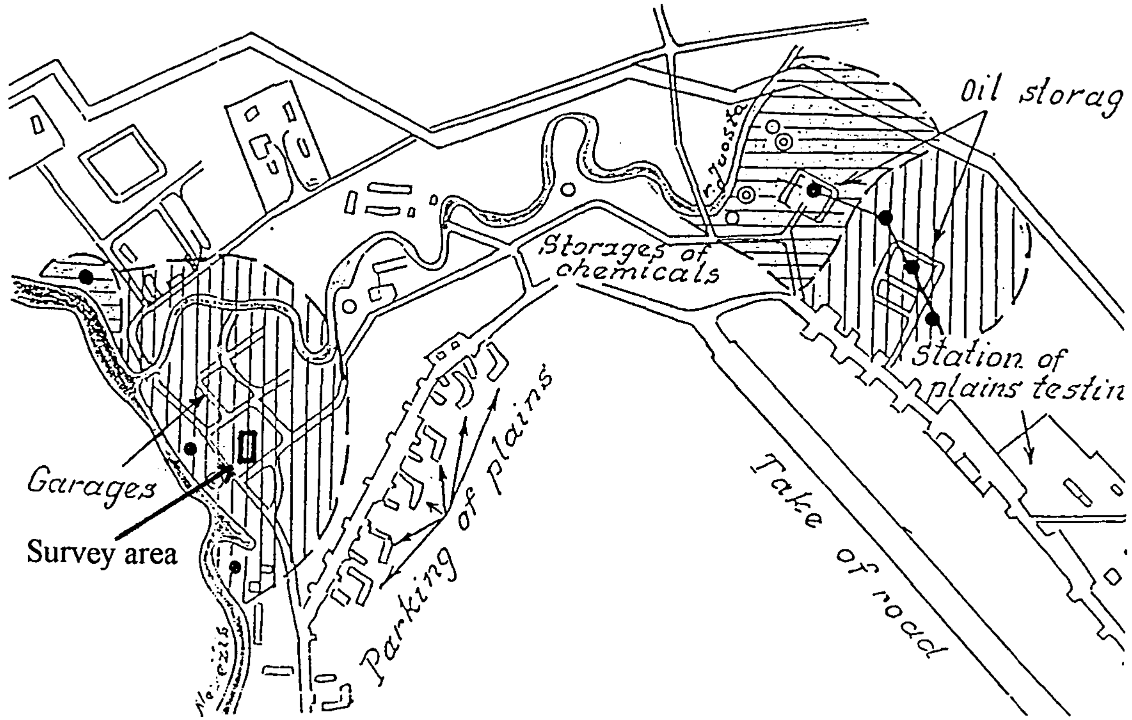


Pajuoste airport, landfill (waste deposit), profile 13

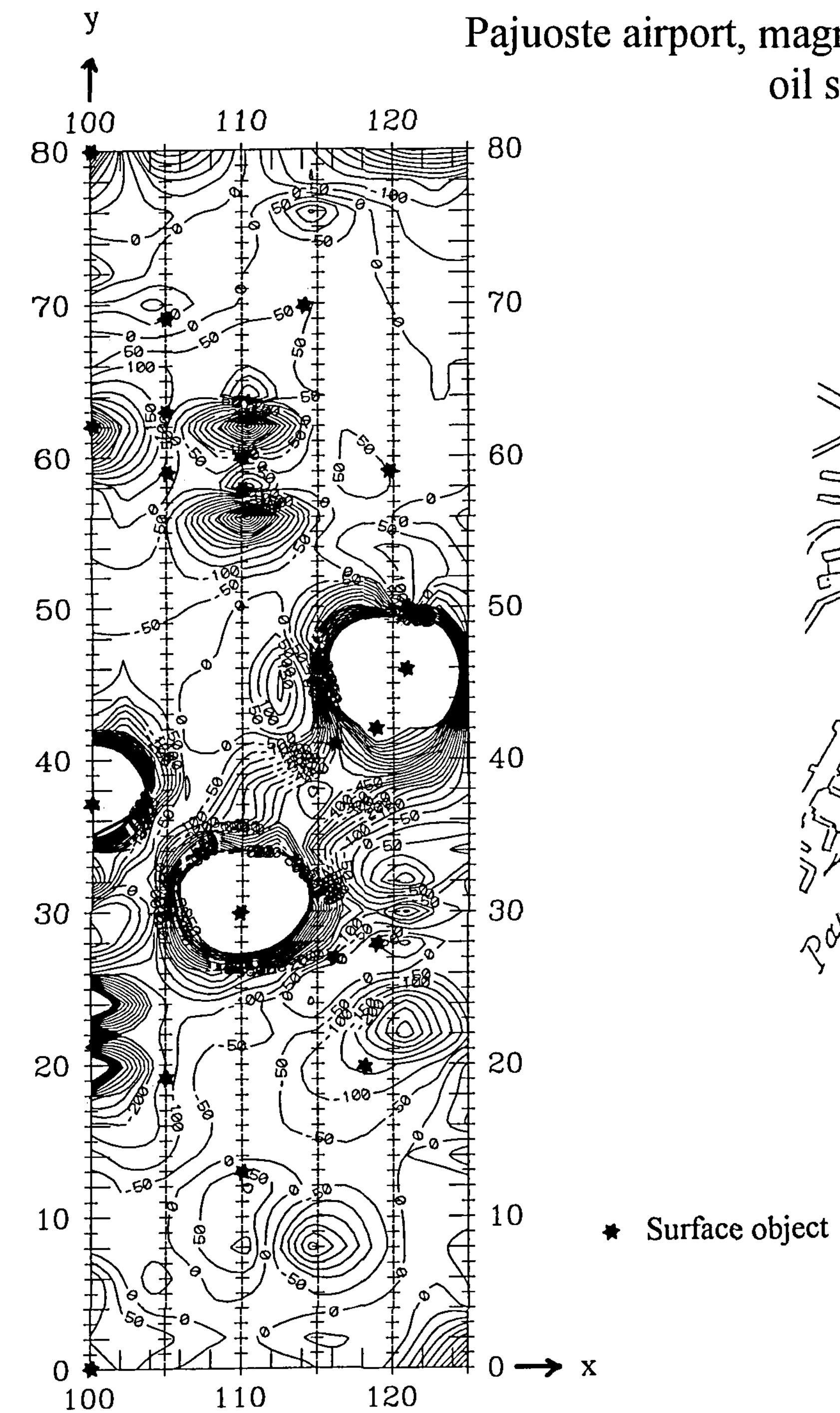


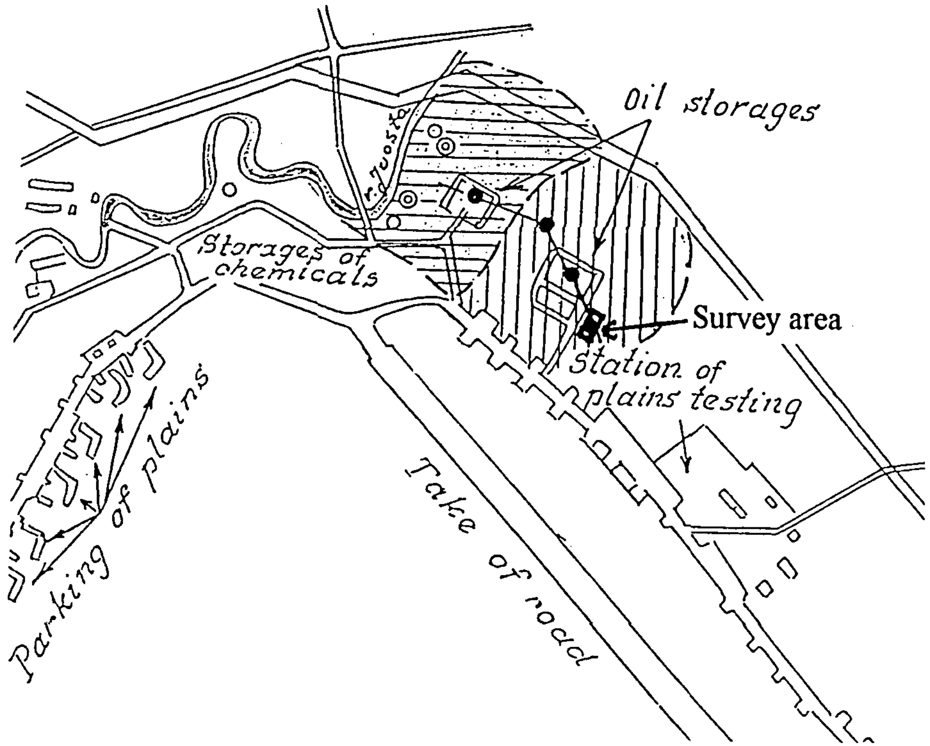
Pajuoste airport, magnetic gradiometer, contour map, oil tank area (petrol waste deposit)



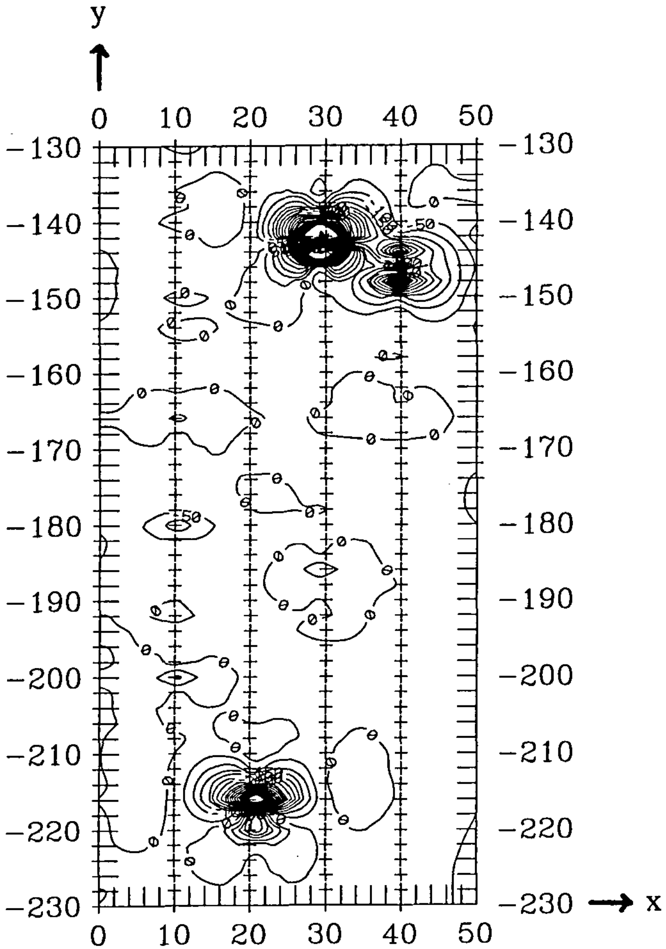


Pajuoste airport, magnetic gradiometer, contour map, oil storage facility

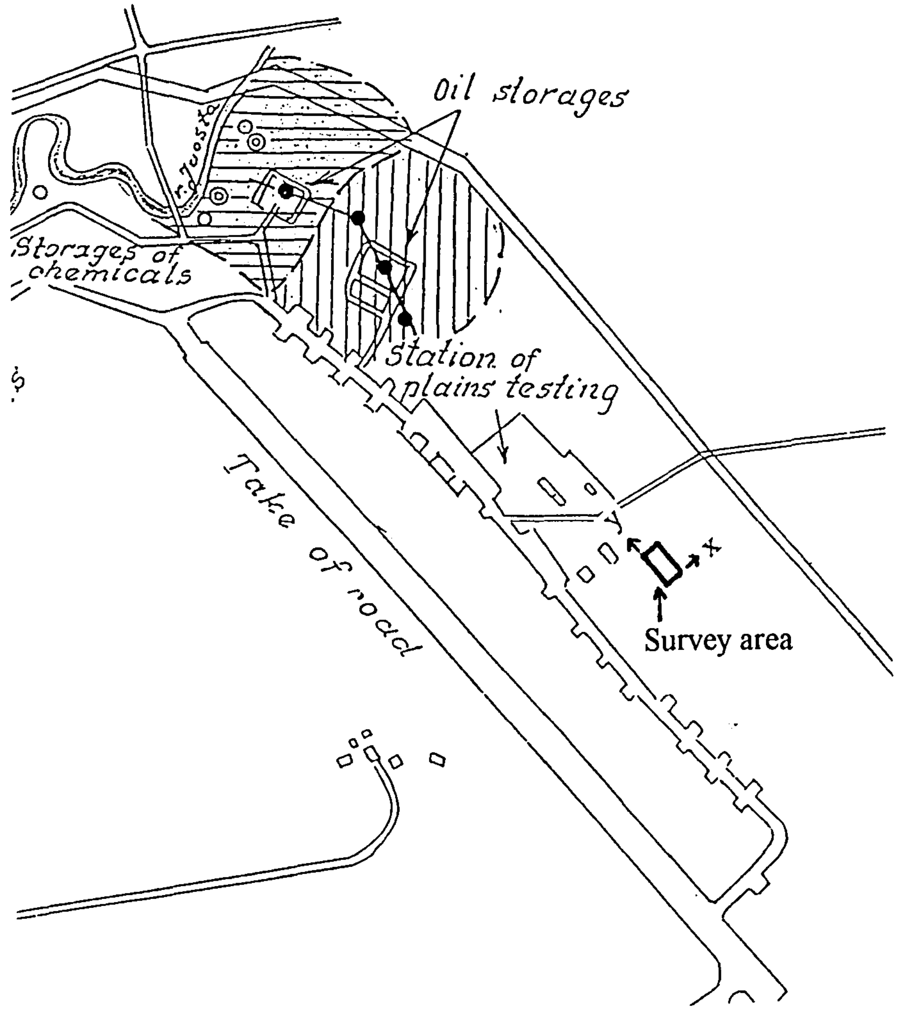




Pajuoste airport, magnetic gradiometer, contour map, ammunition storage facility

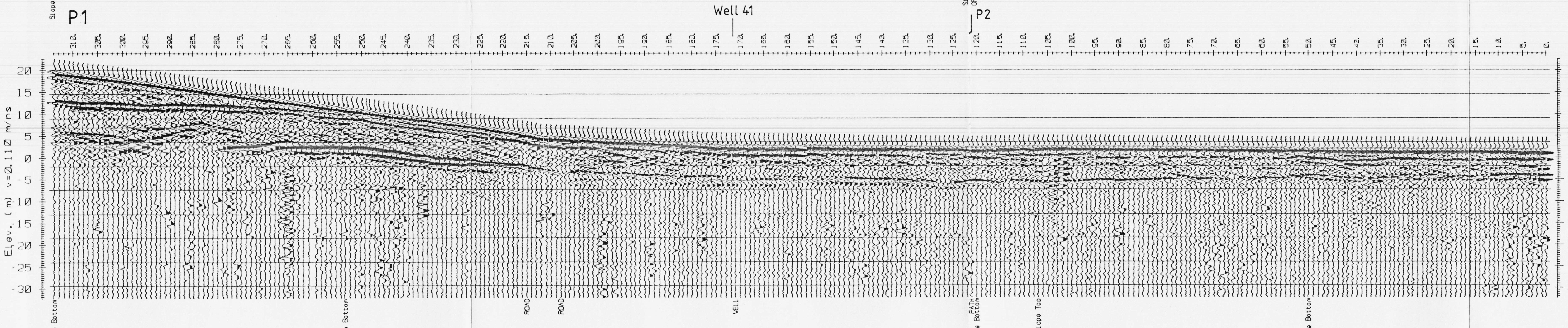


★ Surface object

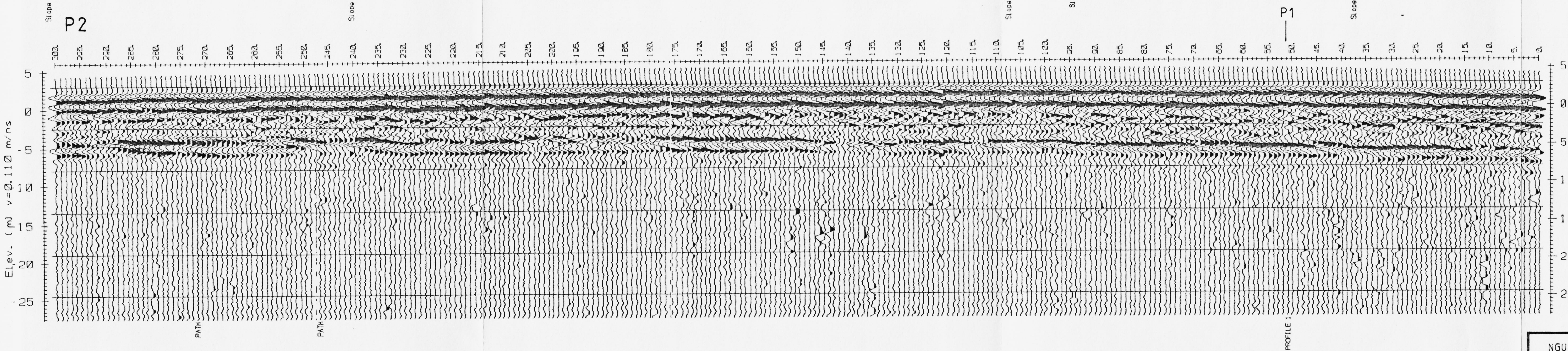


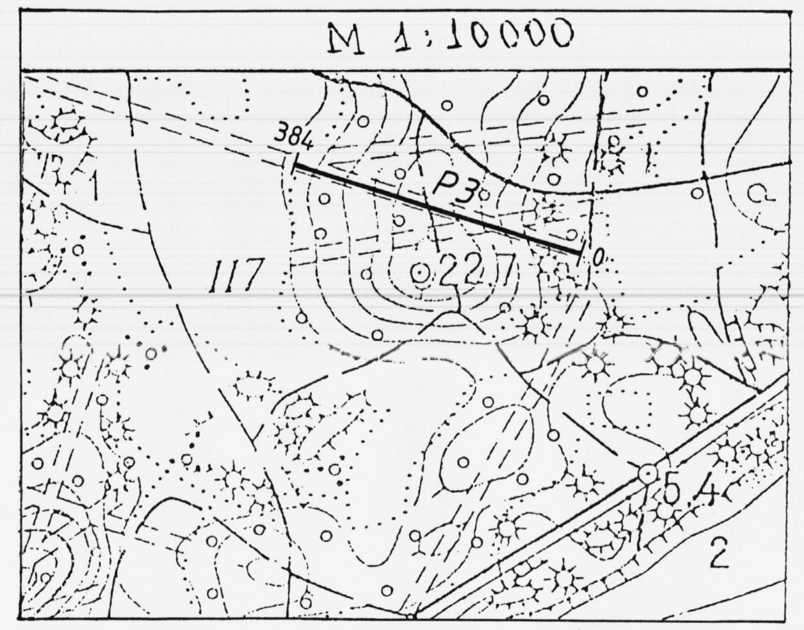
P3

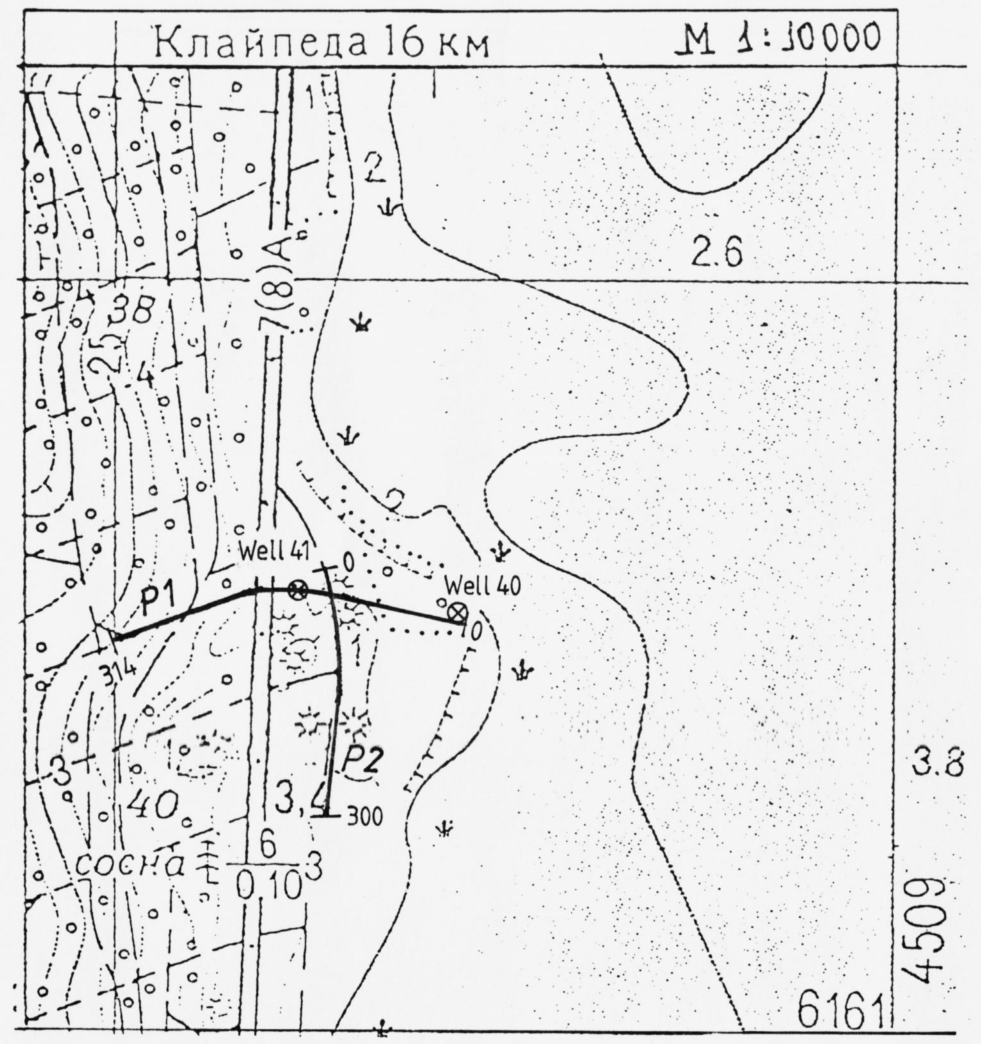
P1



P2

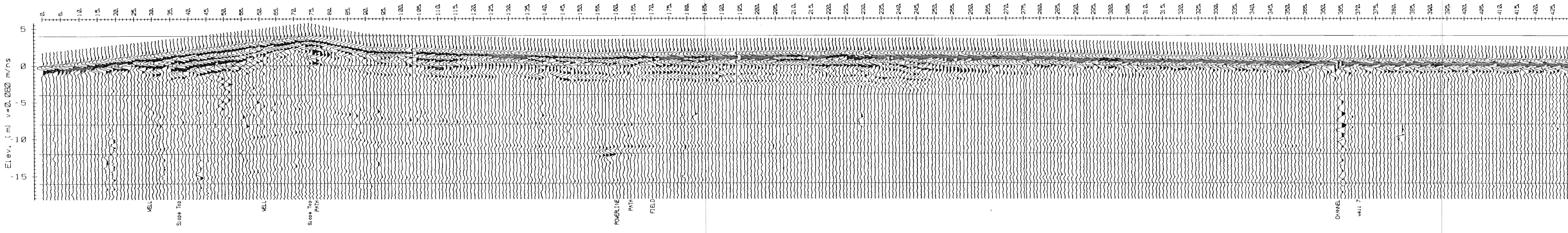




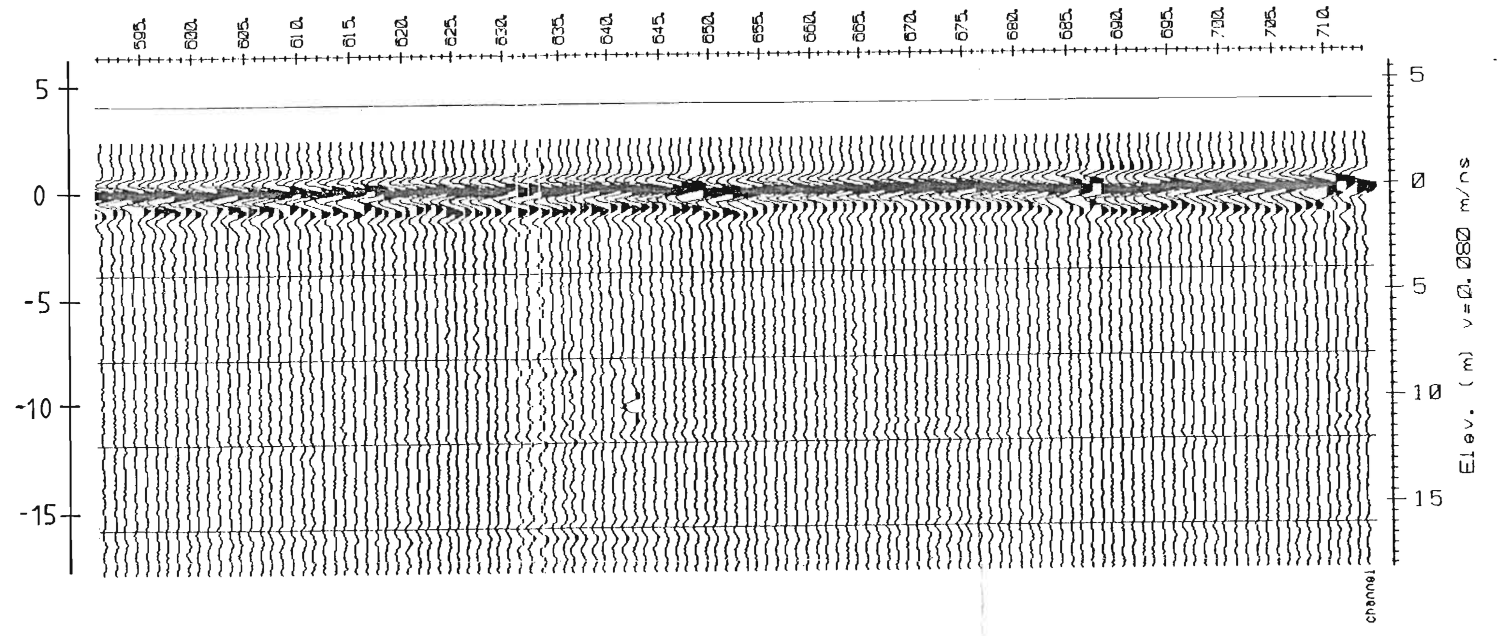


NGU/ GEOLOGICAL SURVEY OF LITHUANIA GROUND-PENETRATING RADAR PROFILES NERINGA LITHUANIA	MÅLESTOKK MAP 1:10000	MÅLT JSR TEGN EM TRAC KFR	SEPT.-94 NOV.-94
NORGES GEOLOGISKE UNDERSØKELSE TRONDHEIM	TEGNING NR. 94.092-01	KARTBLAD NR.	

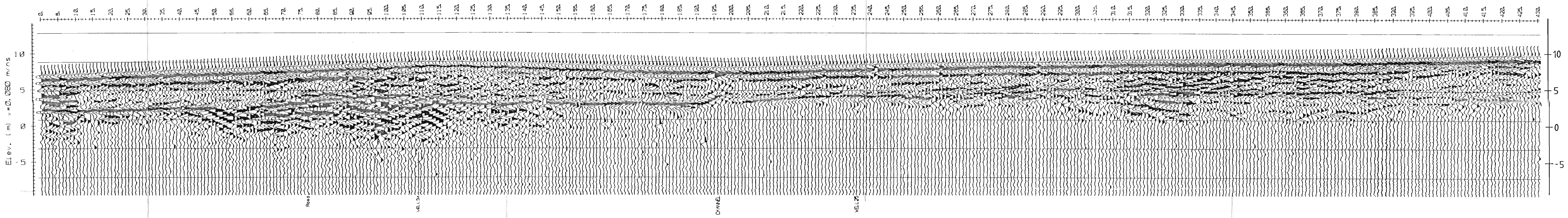
P4



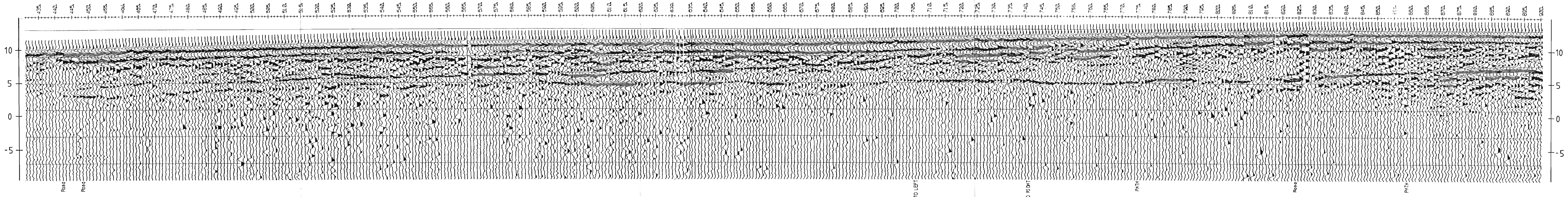
P4 (continued)



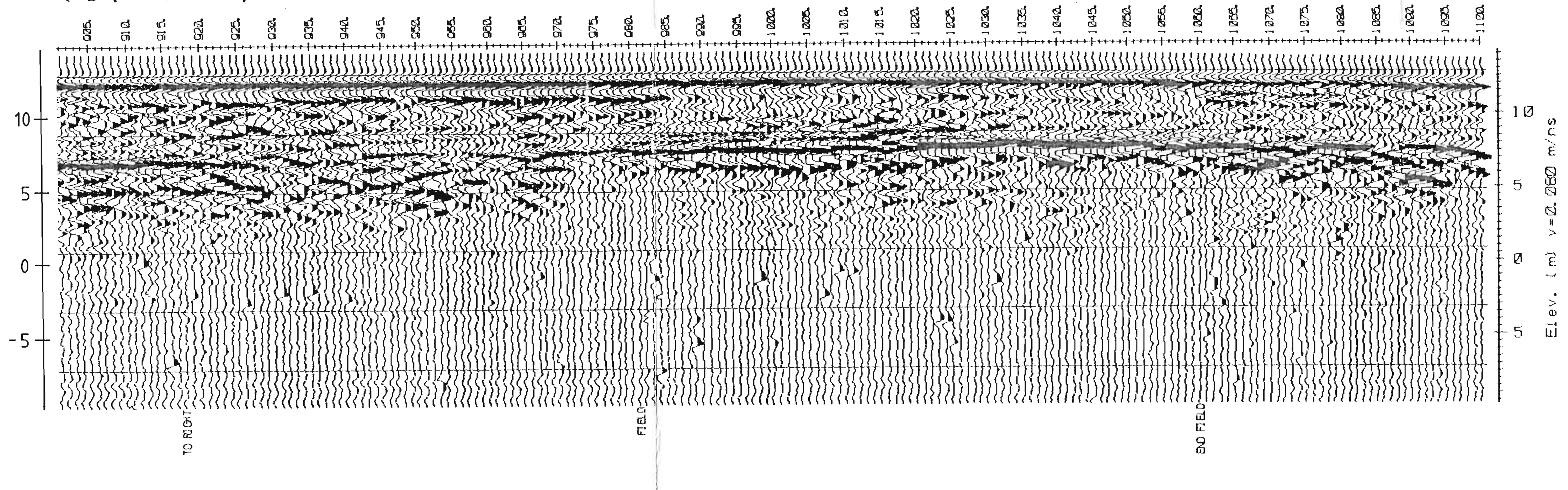
P5

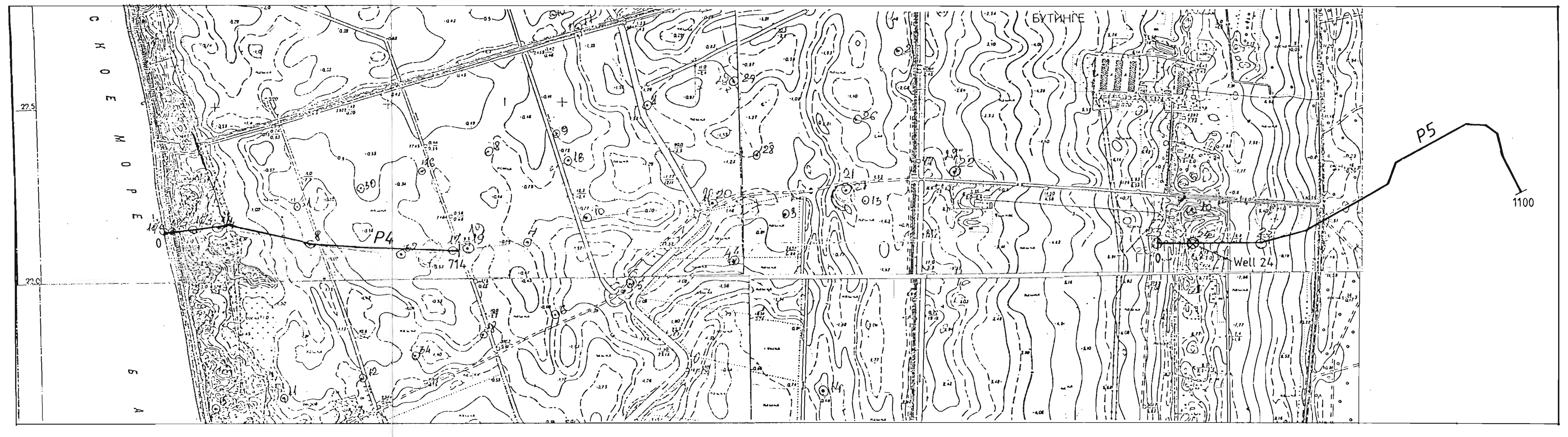


P5 (continued)



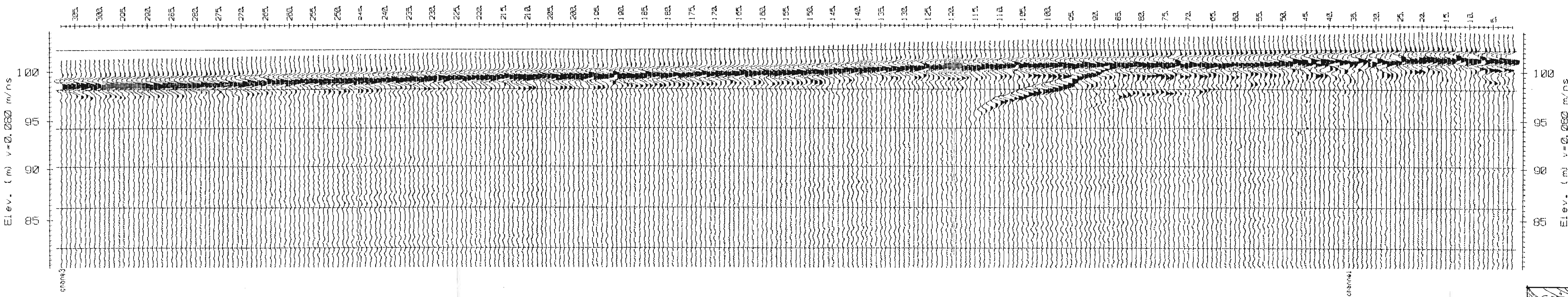
P5 (continued)



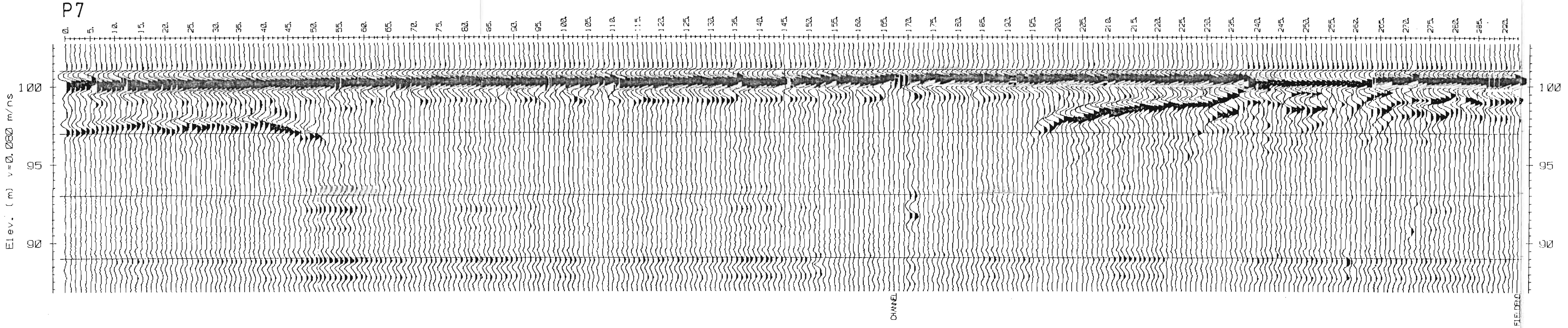


NGU/GEOLOGICAL SURVEY OF LITHUANIA GROUND-PENETRATING RADAR PROFILES BUTINGE LITHUANIA	MÅLESTOKK MAP 1:10000	OBS. JSR	SEPT.-94
		TEGN. EM	NOV. 94
		TRAC.	
		KFR.	
NORGES GEOLOGISKE UNDERSØKELSE TRONDHEIM	TEGNING NR. 94.092-02	KARTBLAD NR.	

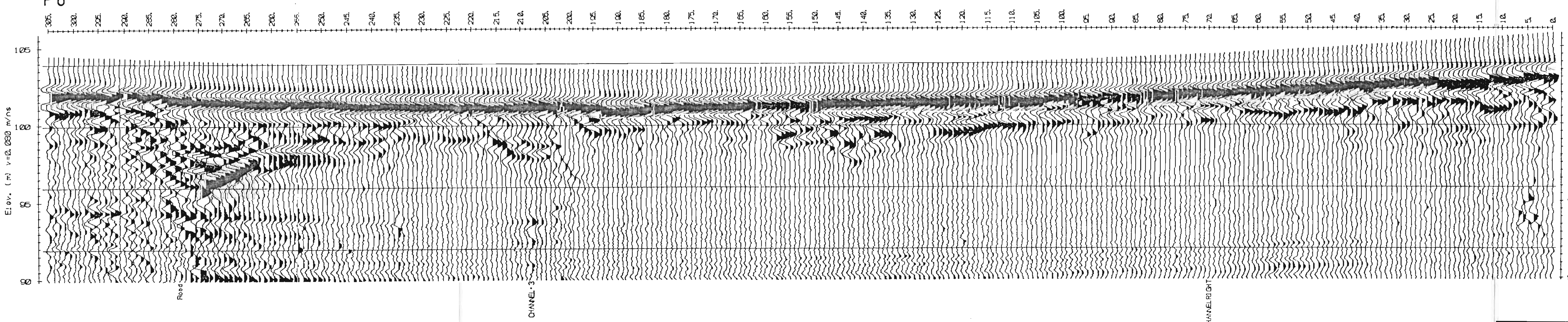
P6

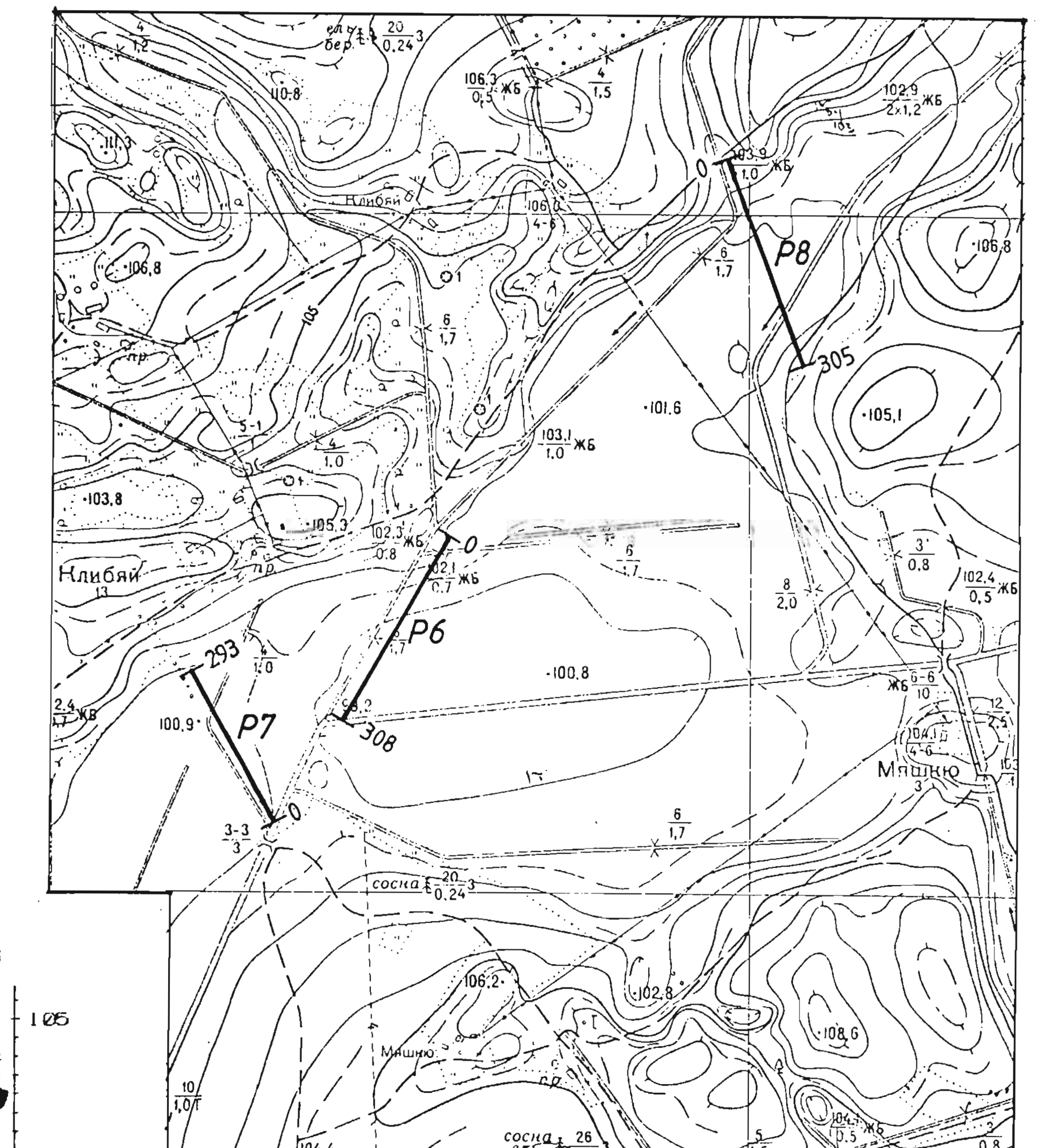


P7

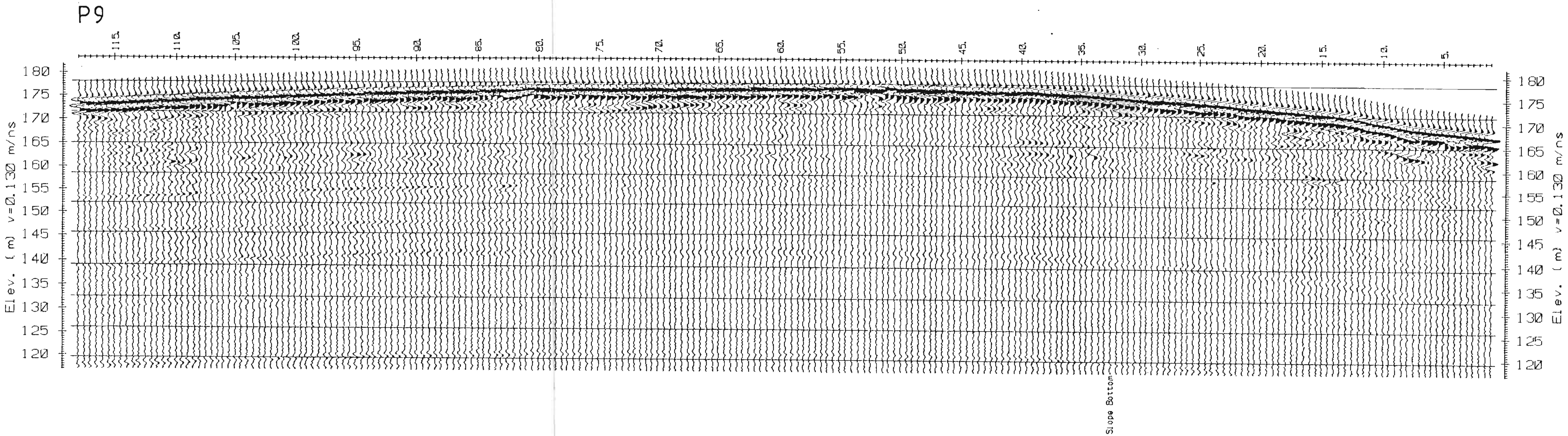


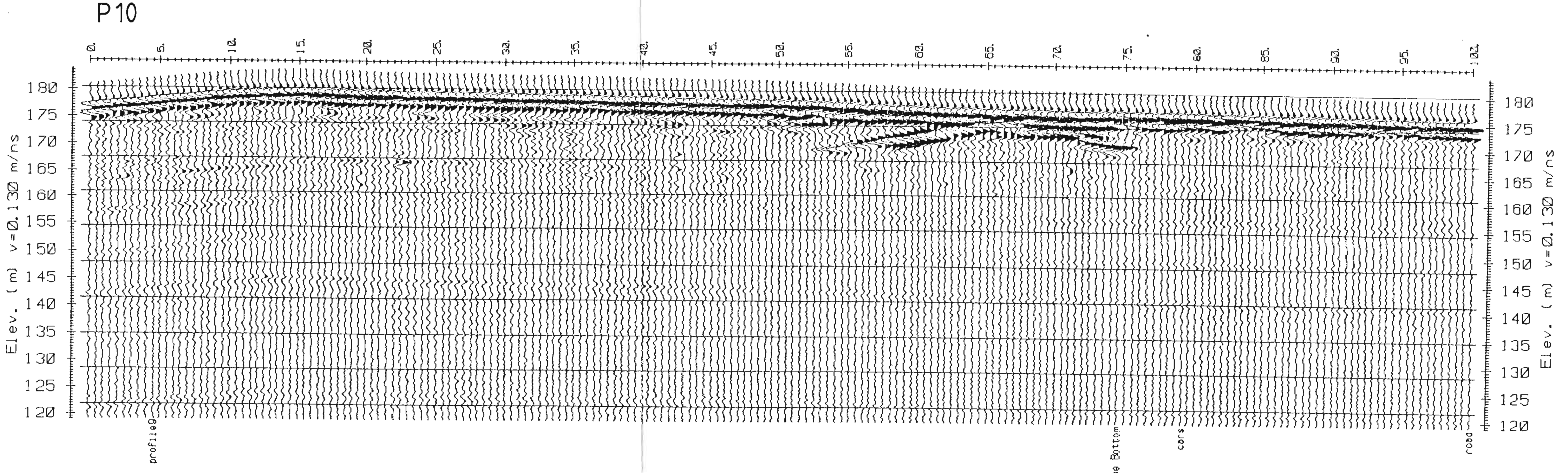
P8

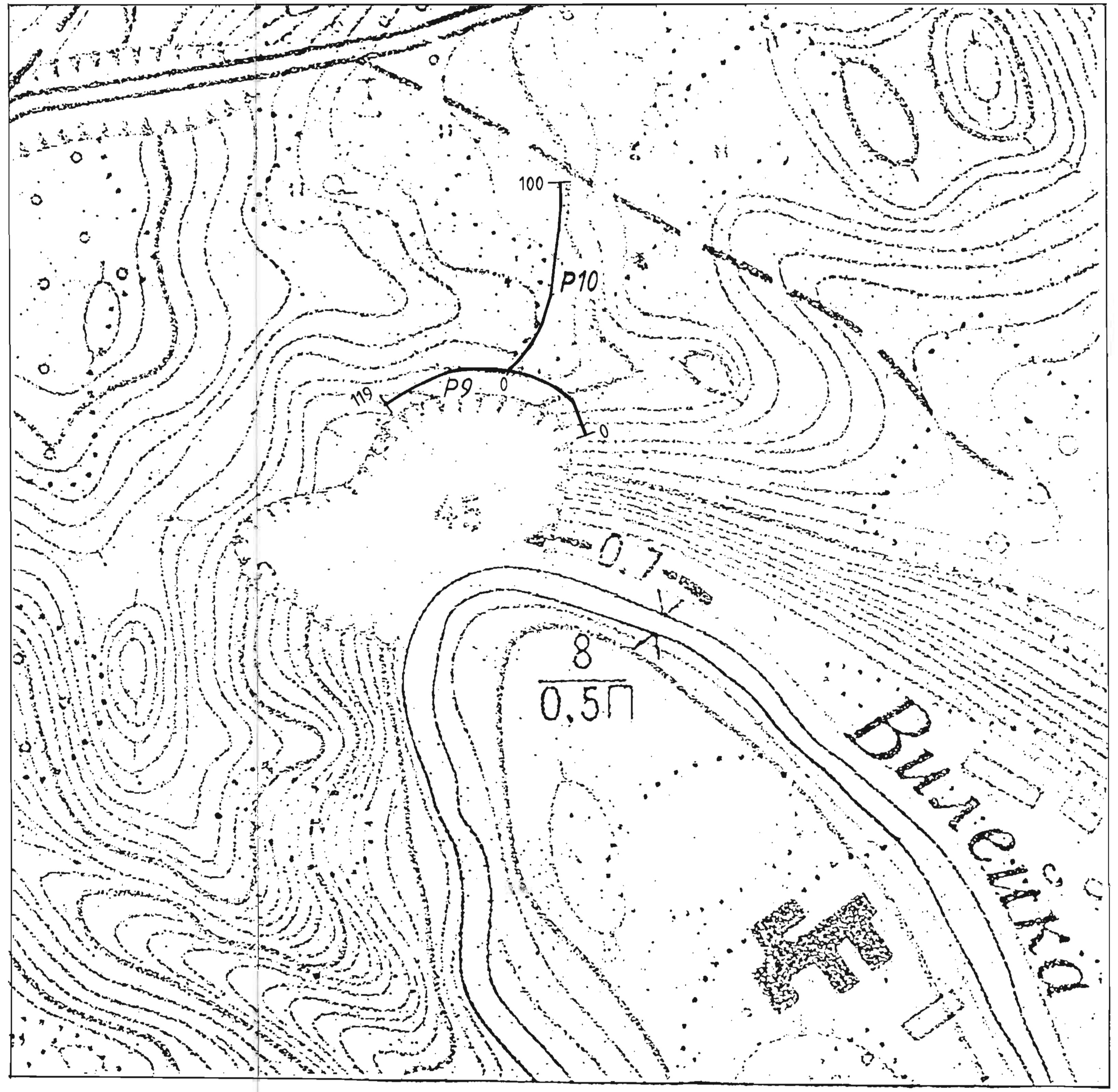




NGU/GEOLOGICAL SURVEY OF LITHUANIA GROUND-PENETRATING RADAR PROFILES LETAUSAS LITHUANIA	MÅLESTOKK MAP 1:10000	MÅLT JSR	SEPT-94
		TEGN EM	NOV-94
		TRAC	
		KFR	
NORGES GEOLOGISKE UNDERSØKELSE TRONDHEIM	TEGNING NR. 94.092-03	KARTBLAD NR.	

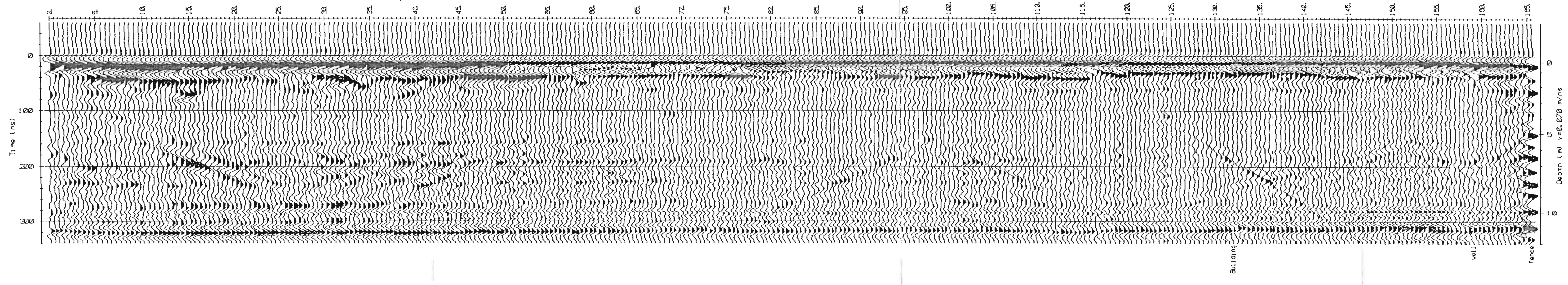




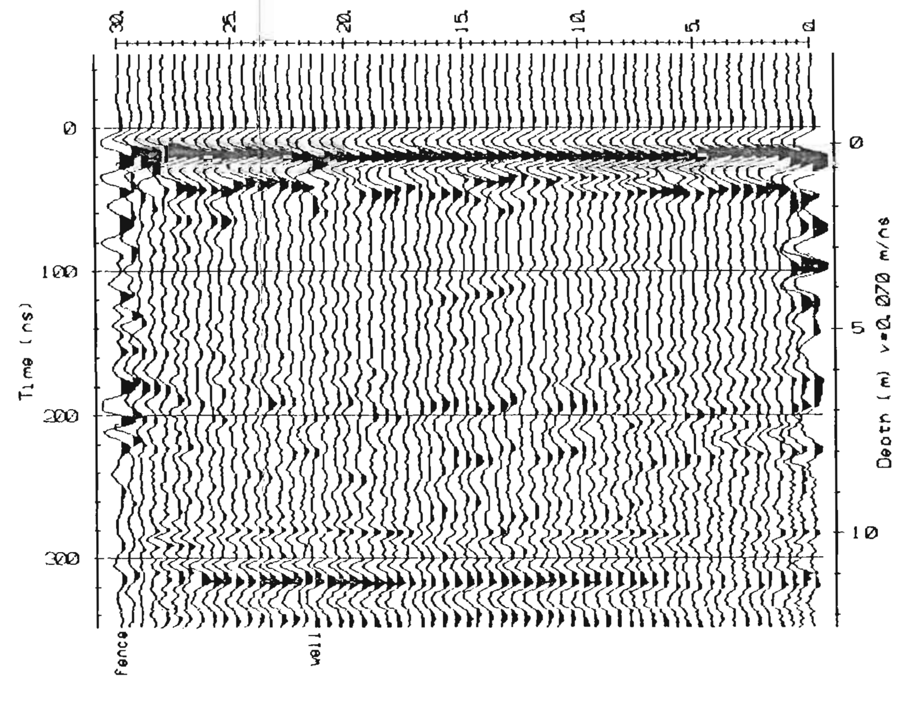


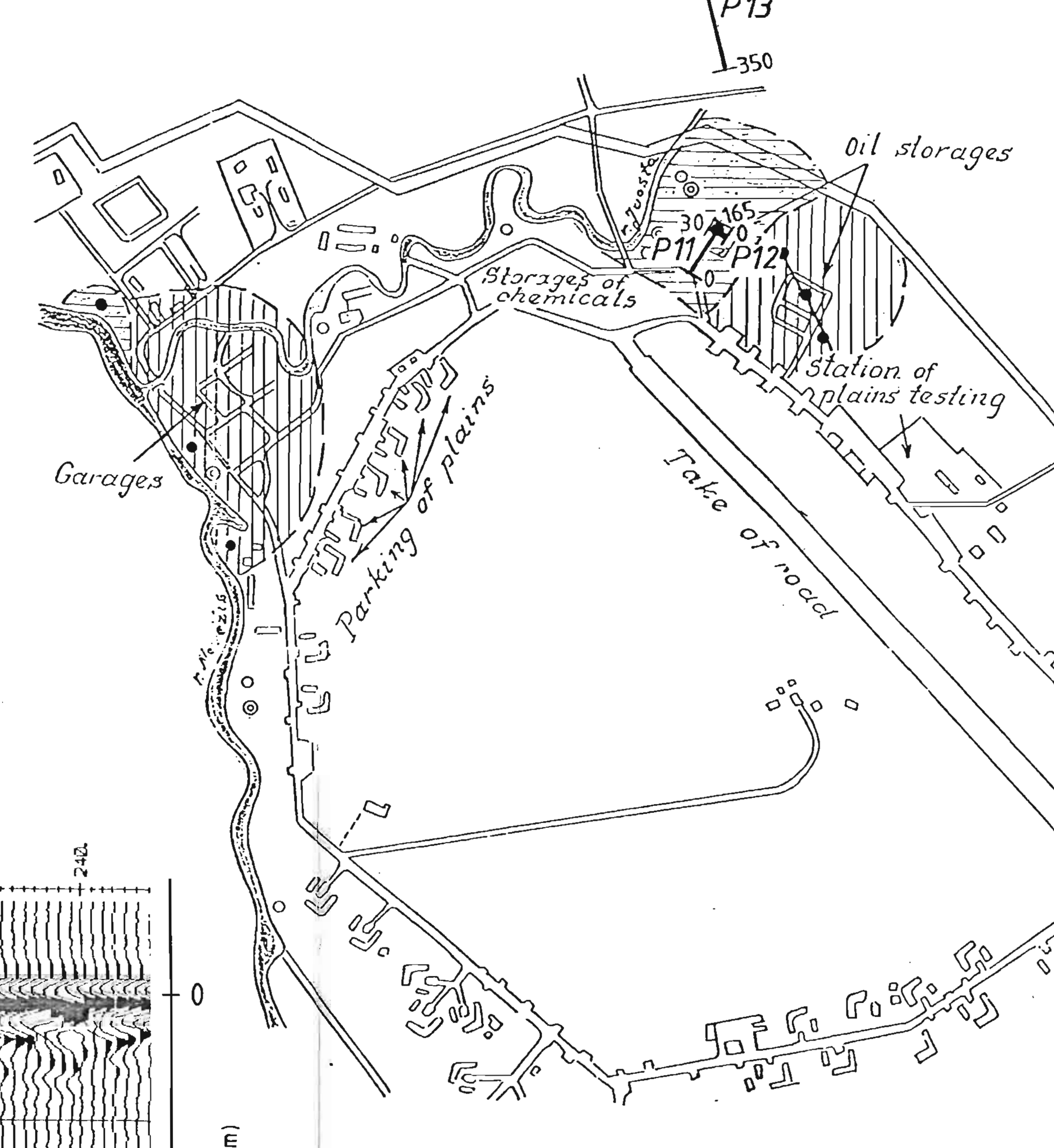
NGU/GEOLOGICAL SURVEY OF LITHUANIA GROUND-PENETRATING RADAR PROFILES PUŠKORIAI (VILNIUS) LITHUANIA	MÅLESTOKK MAP 1:2500	MÅLT JSR TEGN. EM TRAC. KFR.	SEPT.-94 NOV.-94
NORGES GEOLOGISKE UNDERSØKELSE TRONDHEIM	TEGNING NR. 94.092-04	KARTBLAD NR.	

P11



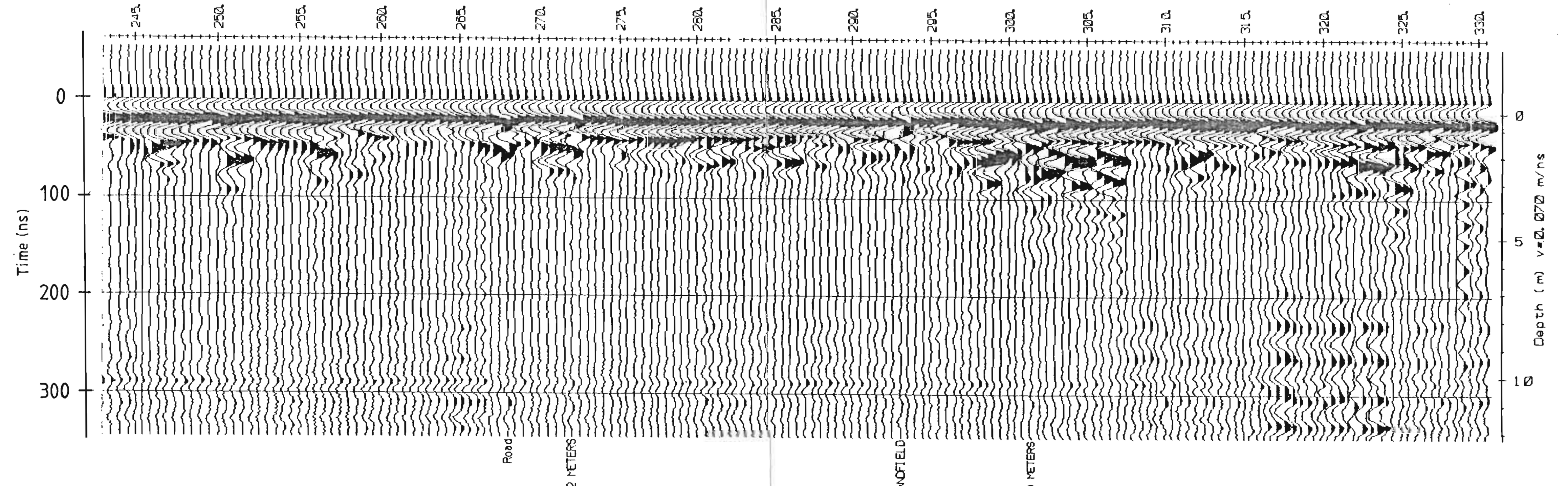
P12





P13

P13 (continued)



NGU/GEOLOGICAL SURVEY OF LITHUANIA GROUND-PENETRATING RADAR PROFILES PAJUOSTE AIRPORT LITHUANIA	MÅLESTOKK MAP ~1:19000	MÅLT JSR	SEPT.-94
		TEGN EM	NOV.-94
		TRAC	
		KFR.	
NORGES GEOLOGISKE UNDERSØKELSE TRONDHEIM	TEGNING NR. 94.092-05	KARTBLAD NR.	