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Ground Penetrating Radar Survey in the Asentolampi target, Portimojärvi, Ranua

MAP SHEET 3524 06

Pertti Sarala

GTK
GEOLOGIAN TUTKIMUSKESKUS • GEOLOGISKA FORSKNINGSCENTRALEN • GEOLOGICAL SURVEY OF FINLAND

PL / PB / P.O. Box 96
FI-02151 Espoo, Finland
Tel. +358 20 550 11
Fax +358 20 550 12

PL / PB / P.O. Box 1237
FI-70211 Kuopio, Finland
Tel. +358 20 550 11
Fax +358 20 550 13

PL / PB / P.O. Box 97
FI-67101 Kokkola, Finland
Tel. +358 20 550 11
Fax +358 20 550 5209

PL / PB / P.O. Box 77
FI-96101 Rovaniemi, Finland
Tel. +358 20 550 11
Fax +358 20 550 14

Y-tunnus / FO-nummer / Business ID: 0244680-7 • www.gtk.fi

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Pertti Sarala

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Abstract
Geological Survey of Finland (GTK) was carried out geophysical survey in the Asentolampi target area in Portimojärvi, Ranua at the end of February 2008. The work was ordered by Areva Resources Finland Oy. Equipment that was used in this study is Ground Penetrating Radar (GPR), the type SIR-3000 with 100 MHz antenna that was pulled by snow mobile. An aim of the study was to estimate the thickness of surficial, mostly glacigenic or lacustric/peat deposits, and to find the most potential areas to reach the bedrock surface with test pit excavations in the target area. Total length of the radar profiles was 12.5 km. As a result several places suitable for further surficial geological and detailed bedrock studies by the help of test pit excavations were found. In those places the thickness of glacigenic overburden is about 3-4 m at maximum. Instead, in many places bedrock observations are impossible even in the test pits, because the thickness of till cover seemed to be too high (5-10 m).

Keywords
Ground penetrating radar, geophysical survey, surficial geology, ribbed moraine, peat bog, Asentolampi, Ranua

Geographical area
Finland, Lapland province, Ranua, Portimojärvi, Asentolampi

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Other information
Ordered by Erkki Vanhanen, Areva Resources Finland Oy. Order number 0811 and it has been carried out under the skeleton agreement dnro K129/53/2004 for year 2008.

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Tiivistelmä

Geologian tutkimuskeskus (GTK) toteutti Areva Resources Finland Oy:n toimesta geofysikaalisen mittauksen ja siihen liittyvän maaperätulkinnan Asentolammin kohdealueella Portimojärvellä, Ranualla helmikuun 2008 lopussa. Laitteistona käytettiin maatutkaa (eng. Ground Penetrating Radar (GPR)), jonka tyyppi oli SIR-3000 varustettuna 100 MHz antennilla. Tutkaa vedettiin moottorikelkalla. Tutkimuksen tarkoituksena oli arvioida pääasiassa glasigeenisen tai lakustrisen maapeitteen ja turpeen paksuutta ja yrittää löytää sopivimmat alueet tavoittaa kallion pinta tutkimuskaivannoilla. Tutkaprofiilien kokonaispituus oli 12,5 km. Tutkimuksen tuloksena löydettiin useita sopivia kohteita tarkempien maaperä- ja kallioperätutkimusten tekemiselle kaivinkonetta apuna käyttäen. Noissa paikoissa maapeitteen paksuus tulkittiin enimmillään 3-4 metriä paksuksi. Useissa piakoissa kallioperää on vaikeaa saavuttaa edes tutkimusmonttujen avulla, sillä maapeitteen paksuus on liian suuri (5-10 m).

Asiasanat (kohde, menetelmät jne.)
Maatutka, geofysikaaliset mittaukset, maaperägeologia, ribbed-moreeni, suo, Asentolampi, Ranua

Maantieteellinen alue (maa, lääni, kunta, kylä, esiintymä)
Suomi, Lapin lääni, Ranua, Portimojärvi, Asentolampi

Karttalehdet
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Muut tiedot
Tilaaja Erkki Vanhanen, Areva Resources Finland Oy. Tilausnumero 0811. Tilauksessa on noudatettu puitesopimusta dnro K129/53/2004 vuodelle 2008.

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Pertti Sarala			

1 REFERENCE

This study is based on the preliminary working plan and offer (12.12.2007), and the discussions between the stuff of AREVA Resources Finland Oy (ARF) and the Geological Survey of Finland (GTK) during the winter 2007-2008, and followed order (order number 0811; 20.3.2008). The order is a part of skeleton agreement (dnro K129/53/2004) between ARF and GTK in 2008. The study was carried out under GTK's project FinU1 (1901006).

2 STUDY AREA

Study area situates on the northeastern side of the Portimojärvi village, Ranua, southern Lapland. The target is called Asentolampi after the largest lake in the most potential research area for uranium-bearing surficial boulders (Map sheet 3524 06).

3 METHODS AND THE AIM OF THE STUDY

Equipment that was used in this study is Ground Penetrating Radar (GPR), the type SIR-3000 with 100 MHz antenna. The radar measurements were done at the end of February 2008 during the winter time when the thickness of snow cover was about 50-60 cm. The radar was pulled with snow mobile (Fig. 1). The number of radar lines was 10 including 24 separate profiles and their length was 12.5 km in all (Fig. 2). Measurement time (marked to the profiles in Appendix 1) was usually 400 nano second (ns) but some duplicates were also measured using 350 ns. Position was determined using GPS during the radar survey.

Fig. 1. GPR measurement with snow mobile vehicle. The type of equipment was SIR-3000 with 100 MHz antenna. Photo P. Sarala.

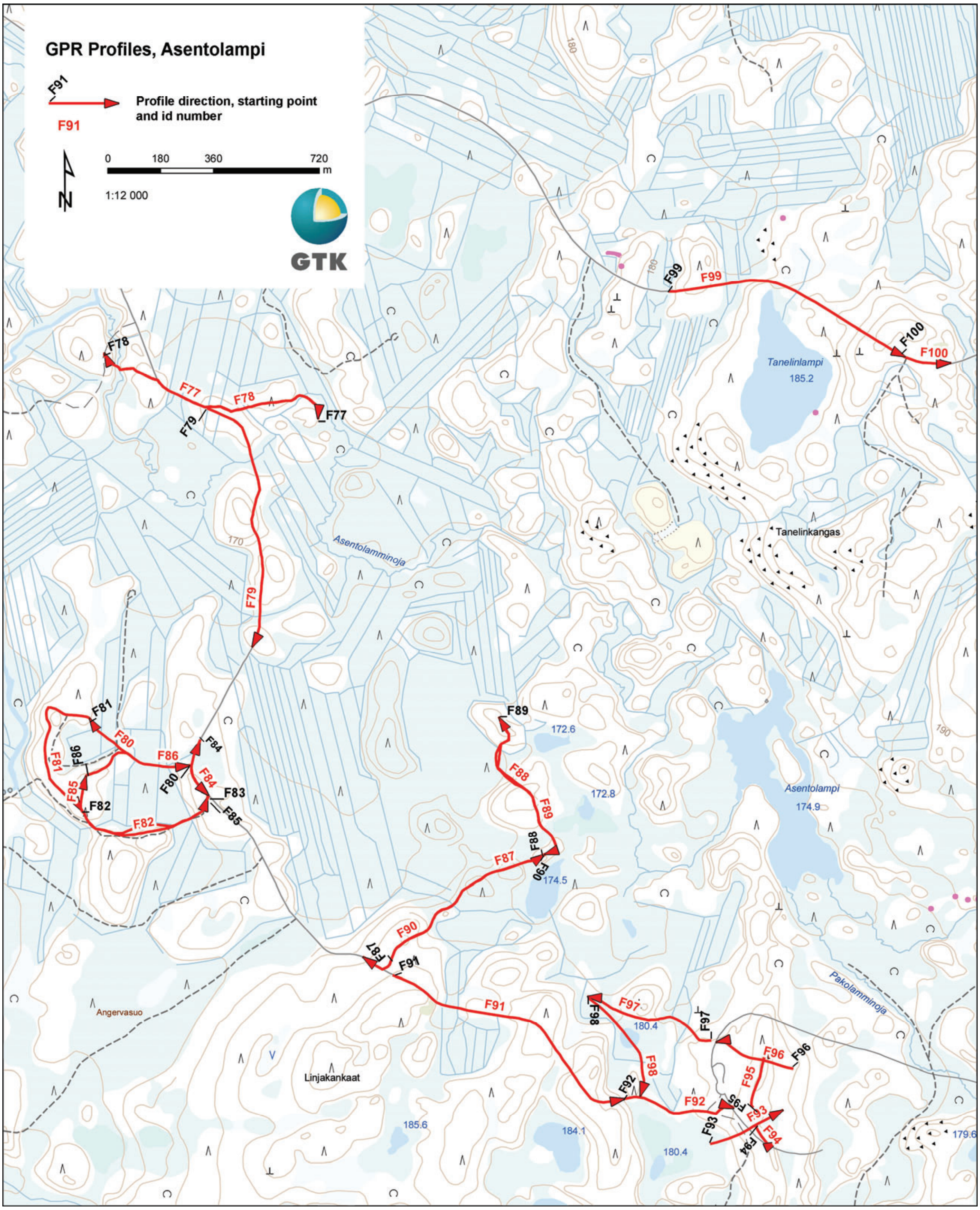


Fig. 2. Location of the GPR survey lines F77-F100 (see the text and the profiles in Appendix 1). The type of equipment was SIR-3000 with 100 MHz antenna. Topographic features © National Land Survey of Finland, permission number 13/MYY/08.

Radar data was processed by Geo Doctor 2 software. Processing includes noise suppression and feature emphasizing. Profiles were also topographic corrected using DEM (Digital Elevation Model with 5 m grid) for helping interpretation. Measurements and data processing were done by Miikka Paalijärvi from GTK.

An aim of the study was to estimate the thickness of surficial, mostly glacigenic or peat bog deposits for getting an idea of depth of the bedrock surface in the ribbed moraine ridge area (Sarala 2007), and for finding potential areas to reach the bedrock surface with test pit excavations. The inner structure of the ridges and the depth of ground water table are also possible to estimate in places based on the radar profiles. Interpretation of the radar profiles was done by Pertti Sarala and Miikka Paalijärvi.

4 RESULTS

4.1 Radar line 1 (F77 and F78; F77_001-002.JPG and F78_001-002.JPG)

Radar line 1 locates on northern side of the Asentolamminoja River and goes almost on the west-east direction (280°-290°) over five moraine ridges. The first profile (F77), where the measurement time was 400 ns, is oriented from the east to the west. In the highest ridges, the bedrock surface (black line in interpreted figures) is usually quite clearly seen in the depth 3-5 m, although the moisture till near the bedrock surface disturbs the reflection. Ground water table that is its lowest level during the late winter is usually not detectable. The bedrock may be reachable by the tractor excavations in the distance 220-490 m and 670-730 m from the eastern end. In places (720-740 m and 800-830 m, and possible 580-600 m), there are also deeper structures that may be faults or shear structures in the bedrock. The same features are also seen in the second profile (F78) that has been measured in the opposite direction (W to E) using 350 ns time. Inner structures of the ridges are clearer seen with shorter measurement time. For example, in the distance 100-180 m and 340-420 m from the western end, the surface between upper till units is seen in the depth about 1.5-2 m rising with about 5° angle to the east. Big erratic boulders on the surface or in the uppermost till are also seen as giving stronger reflection in the 0.5-1.5 m depth.

4.2 Radar line 2 (F79; F79_001-002.JPG)

Radar line 2 locates mainly on southern side of the Asentolamminoja River and goes on the north-south direction over 3 ridges perpendicular to the last ice flow direction (about 270°-280°). First 250 m of the profile is on the northern side of the river. The profile was measured along the road. Only 400 ns measurement was done in this profile. The thickness of glacigenic overburden varies from 3-4 m (in the northern part) up to 8-10 m in the middle and southern parts of the profile. Stronger reflections in the depth about 5 m in the distance 500-740 m from the northern end may be indicating the ground water table. Otherwise, the inner structures of the ridges are hard to distinguish. Test pit surveys for reaching the bedrock surface are only possible in the northern part of the profile.

4.3 Radar line 3 (F80-F83, F84-F86; F80_001.JPG, F81_001.JPG, F82_001.JPG, F83_001.JPG, F84_001.JPG, F85_001.JPG and F86_001.JPG)

Radar line 3 is located in the south-western part of the target area. It is a circle-like line that starts and ends at the same point crossing four separate ridges. This line was measured to the both direction starting at first with 400 ns via northern route to the west (F80-F83) and then, opposite with 350 ns by taking a little bit shorter route (F84-F86).

In this line the bedrock is detectable only in places. First 60 m at the eastern end of the profile F80, and 80-300 m, 360-440 m and 500-540 m of the profile F81 are the most potential places to reach the bedrock surface by test excavations. Also, 0-50 m and 280-310 m on the profile F82 may be suitable places. In the profile F83, the bedrock surface seems to be reachable at the northern part (120-210 m), which is logic because the profile crosses the start point of the profile F80. In other areas instead, the overburden is too deep or the bedrock surface is hard to distinguish exactly. The same features are also visible when looking the profiles driven opposite with 350 ns measuring time (F84-F86).

4.4 Radar line 4 (F87-F88, F89-F90; F87_001-002.JPG, F88_001-002.JPG, F89_001-002.JPG, F90_001-002.JPG)

Radar line 4 is located in the middle of target area. It begins from the Linjakankaat Hill going at first to the north-east direction and near the small lake in the middle of the line it turns to the north. The line crosses five ridges and four peat bogs. This line was measured to the both direction starting at first with measurement time 350 ns (F87-F88) and then, opposite direction with 400 ns (F89-F90).

The profile F87 begins from the hill top having only 2 to 3 m thick overburden over 100 m on the way to the hill slope on the northern edge of the ridge. After that the thickness of till cover reaches the depth over 5 m until the 480-540 m point in the line is reached, and the bedrock surface is once again at the level 3-4 m from the surface. This is also the point where there is a deeper bedrock structure seen as a reflection dipping with almost 45° to the east. Next place where the bedrock surface can be reached is at the beginning of the profile F88 (20-80 m). After that the profile crosses the peat land and in the next ridge the overburden is thick once again. Very nice peat bog profile with thin fine-grained sediment layer at the bottom is seen in the point 360-480 m. The bedrock surface is once again strong in the ridge at the end of profile with about 5 m overburden.

Measurement to the opposite direction with longer measurement time (400 ns) draws quite same phenomenon. Bouldery surface typical for ribbed moraine ridges is very clearly seen in places, especially on the profile F89 in the ridge between 280-380 m. The bedrock structures on the profile F90 (160-200 m) are even stronger seen and seems to indicate deeper thrust or fault zone. Thin (1-2 m) peat cover on the depressions is clearly seen in the profiles.

4.5 Radar line 5 (F91-F92; F91_001-002.JPG, F92_001-002.JPG)

Radar line 5 is located in the middle of target area but goes to the east from almost the same starting point as the profile F87. The profile F91 goes all the way through dry land having very clear indication of the bedrock surface. In many places the bedrock surface is reachable. Interesting bedrock structures are seen at the point 700-720 m.

In the profile F92, the bedrock surface seems to be easily reachable under thin peat cover. Suitable places for excavations seem to be from the starting point to the western edge of the next ridge (20-280 m). After that the thickness of overburden grows too high (> 6 m) for test pit surveys.

4.6 Radar line 6 (F93; F93_001.JPG)

Radar line 6 crosses one of the most interesting uranium-bearing-boulder-covered ridges in south-eastern part of the Asentolampi target area. It begins from the peat land and goes to the north-east over the ridge top. There seem to be very strong reflections coming from the bedrock surface on the western slope of the ridge. Till cover is only 3 m thick in this part and for that reason it may be suitable place for detail bedrock studies. Once again, the reflections caused by the big surficial boulders on the top of the ridge are clearly seen. Laminar layers on the upper part of the profile between 200-220 m indicate stratified sediments of the bottommost part of the transversal marginal deposit on the top of the ribbed moraine ridge (cf. Sarala 2007).

4.7 Radar line 7 (F94, F95; F94_001.JPG, F95_001.JPG)

Radar line 7 goes along the north-south oriented narrow ridge that occurs on the top of the ribbed moraine ridge. The line was measured on the top of the ridge as two separate profiles of which the profile F94 was measured from the profile F93 towards the south and the profile F95 towards the north. Radar measurements show that the deposits in narrow ridge are thin and it is composed of stratified sediments seen as laminar layers in places. Also, some inner structures and big boulders are seen in the profile. The bedrock surface seems to be in the depth of 5 m or more and is not easily reached by test pits.

4.8 Radar line 8 (F96, F97; F96_001.JPG, F97_001.JPG)

Radar line 8 is composed of two profiles with east-west orientation, and it is located on the south-east part of the target area. Line crosses two ribbed moraine ridges and the narrow marginal moraine ridge on the eastern part of the profile F96. The profile was cut by the reindeer fence.

Glacigenic overburden seems to be thick all the way through the profile F96. Only the point between 120-140 m is possible place to reach the bedrock surface. In the profile F97 the bedrock surface is very strongly seen in the middle of the profile between 220-350 m. The thickness of till cover seems to be only two metres and this area could be the best place to reach bedrock by test excavations. It is also very clearly seen that the bedrock surface is much deeper in the areas between the ridges i.e. under the peat bogs. This correlates well with the idea of quarrying activity during the deposition process of the ribbed moraine formations in between the ridges. Freezing-thawing process that occurs between the ridges, and reaches the bedrock surface, crashes the bedrock into the blocks that are able to move under moving glacier to the top of the next ridges (Sarala 2005).

4.9 Radar line 9 (F98; F98_001.JPG)

Radar line 9 is more or less only a test line that crosses peat bog and a small lake in the south-eastern part of the target area. It is interesting to see how variable the thickness of the bog bottom is, although the thickness is maybe only a half of the presented in the moisture places. However, it seems to be so that the bedrock surface might be reachable in the points 110-130 m and 300-400 m. These places can be dug only during the winter time when the ground is frozen.

4.10 Radar line 10 (F99, F100; F99_001-002.JPG, F100_001.JPG)

Radar line 10 is located in the north-eastern corner of the target area. It crosses four ribbed moraine ridges with peat bogs between them. The line goes in the west-east direction and is composed of two profiles F99 and F100. Thickness of the overburden seems to get thinner when moving to the eastwards. The bedrock surface is reachable almost everywhere in the eastern part of the line (F99_200 and F100) where the overburden seems to be only two metres thick.

5 CONCLUSIONS

GPR program worked well in the Asentolampi target area giving information of the ribbed moraine ridge and peat land structures, and the depth of glacigenic overburden in the target area. GPR data strengthen the preliminary knowledge of thick till deposits in the ridges at the Portimojärvi area. Bedrock outcrops are not present in the target and the surface is reachable by tractor excavations only in places in the ridges and only couple of places in the peat land area, in the south-eastern part of the target. The best areas are in the southern and north-eastern parts of the area. Bedrock seems to be mostly unbroken although some faults and sheared or fractured parts can be found. Possible places for detail bedrock study with test pits based on the GPR data are presented in the Fig. 3.

6 FUTURE STUDIES

Detailed studies for estimating surface boulders transport distances should be done in the areas where the bedrock can be reached near the most potential ore boulder anomalies. Test pit excavations with stratigraphical, geochemical and heavy mineral studies are the most suitable methods in this case when the glacigenic overburden is thick and outcrops are rare. Test trenches are also needed for the profile sampling and the till structure observations. Bedrock observations and sampling should be done at the same time with the test pit surveys. Test pit excavations are able to do in the ridge areas during the summer and autumn but the excavations in the peat lands need frozen ground. Also, the frozen ground is usually needed if the test pits locate farer from the roads and the peat bogs should be crossed by the way. Late winter may be the best time for the excavations in the moisture areas due to low groundwater table and minor damages to the ground and vegetation.

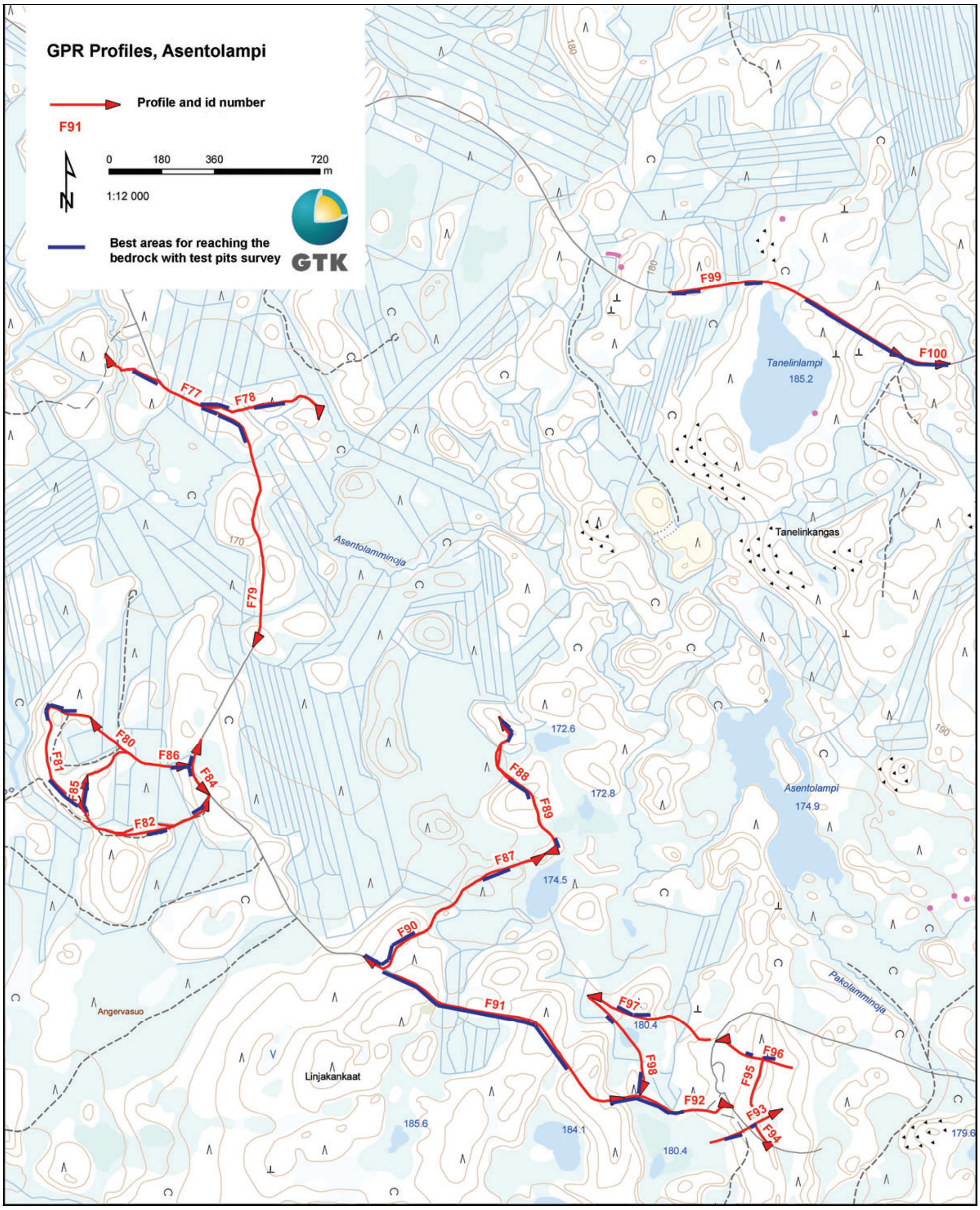


Fig. 3. Location of the most potential places for reaching the bedrock surface in the Asentolampi target area using test pits. Estimations are based on the GPR surveys. Topographic features © National Land Survey of Finland, permission number 13/MYY/08.

7 REFERENCES

Sarala, P., 2006. Ribbed moraine stratigraphy and formation in southern Finnish Lapland. Journal of Quaternary Science 21:4, 387-398.
Sarala, P. 2007. Preliminary report - Surficial geology at Portimojärvi, Ranua, Geological Survey of Finland, Archive report P23.4/2007/105, 9 p.

In Rovaniemi

Pertti Sarala
Senior System Analyst, PhD

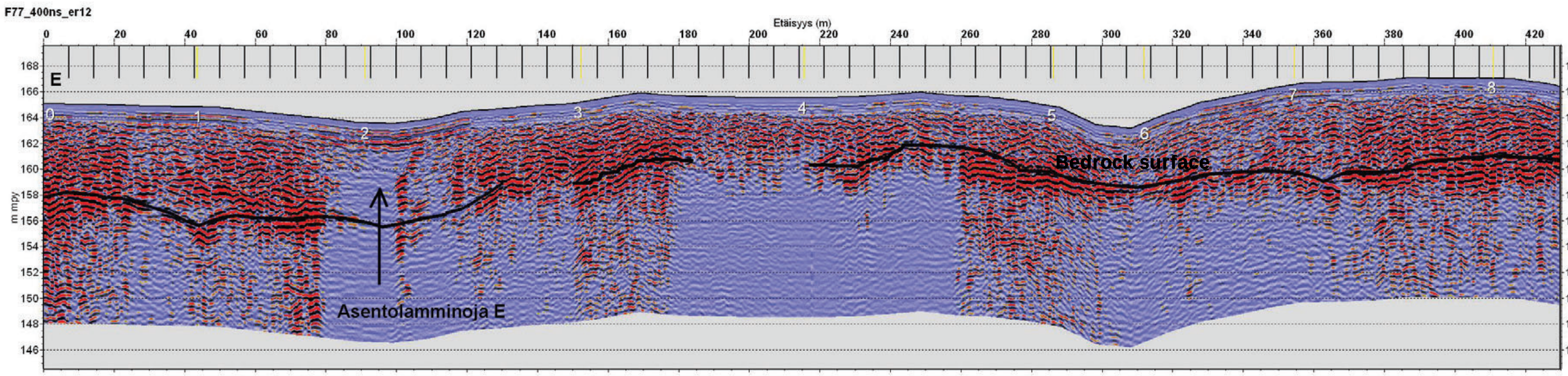
APPENDICES

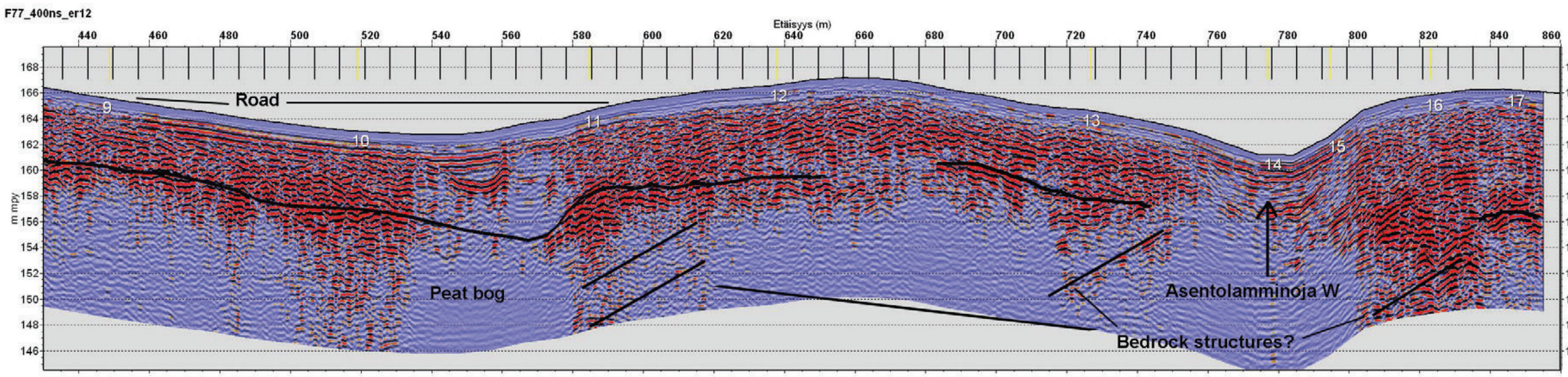
1. Interpreted GPR profiles, where the bedrock surface and the structures are estimated and marked as black lines.
2. DataCD disk including original profiles as colored or black and white versions, and location of the profiles as ESRI shape format.

APPENDIX 1

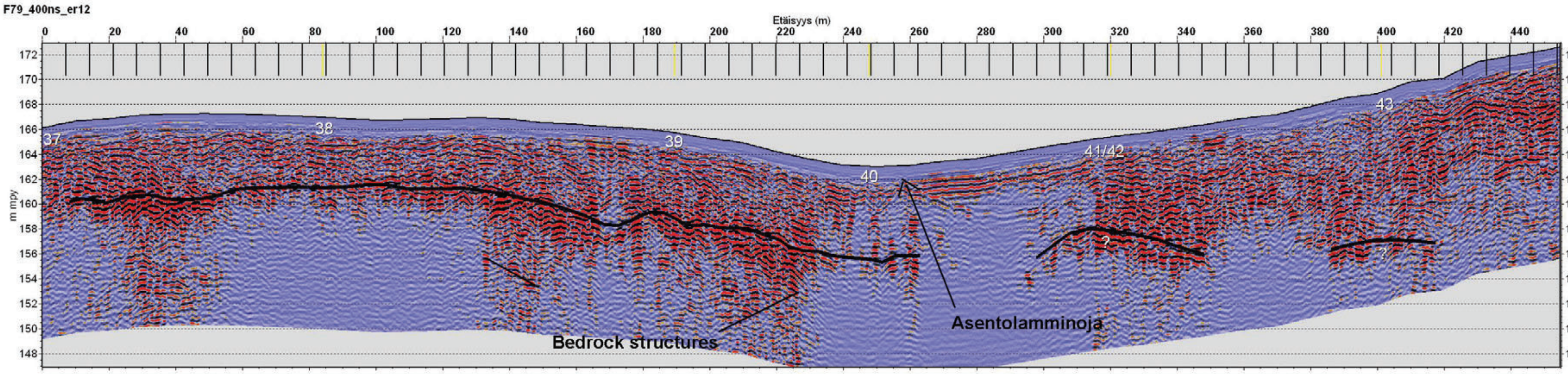
GPR profiles

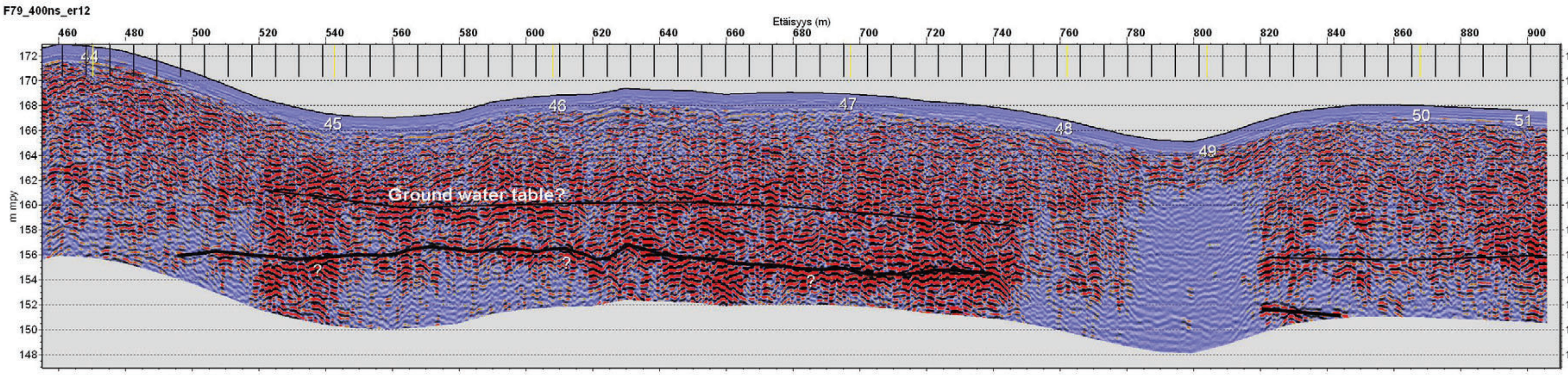
1.1 Radar line 1 (F77 and F78; F77_001-002.JPG and F78_001-002.JPG)



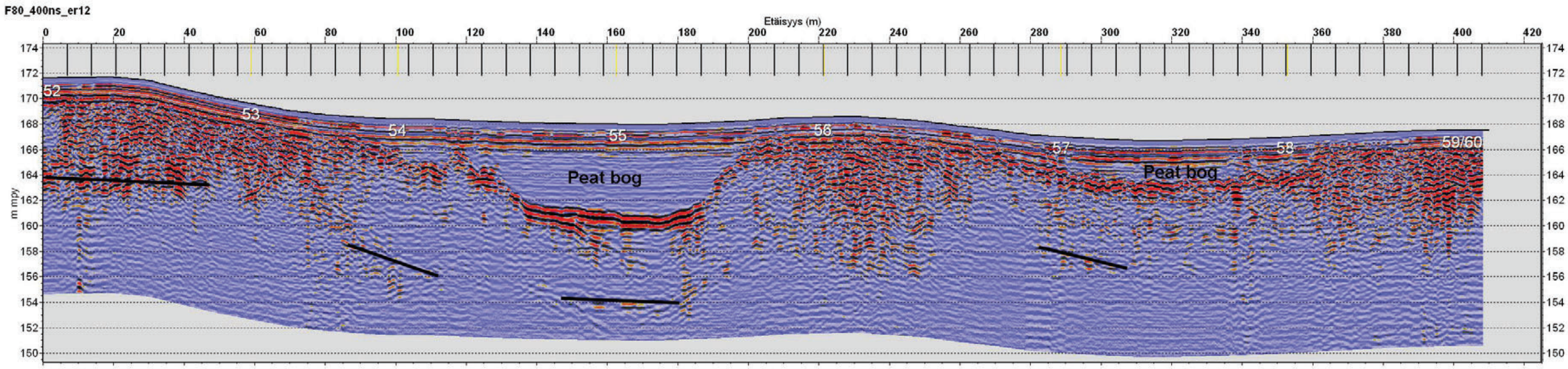


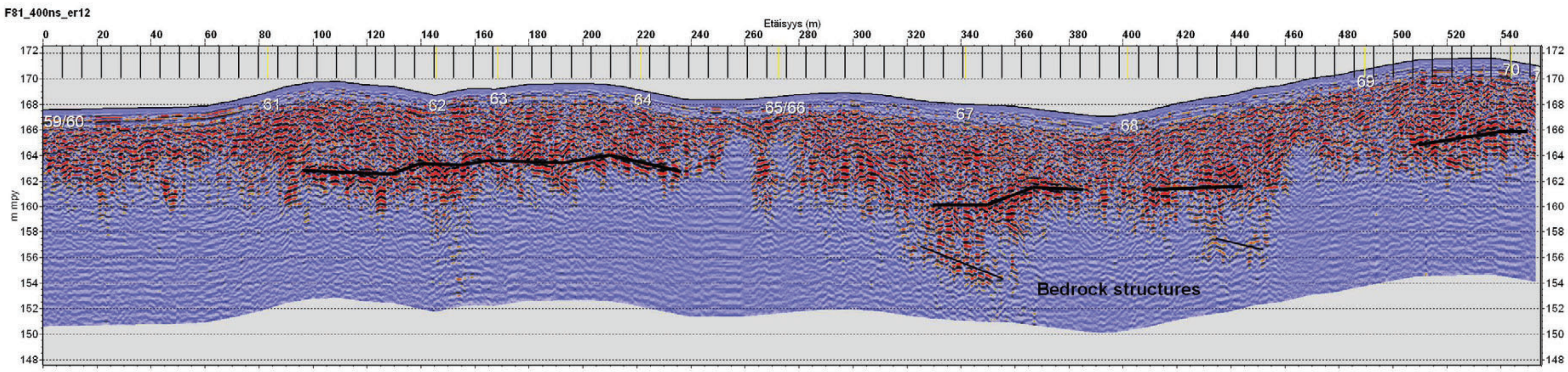
1.2 Radar line 2 (F79; F79_001-002.JPG)

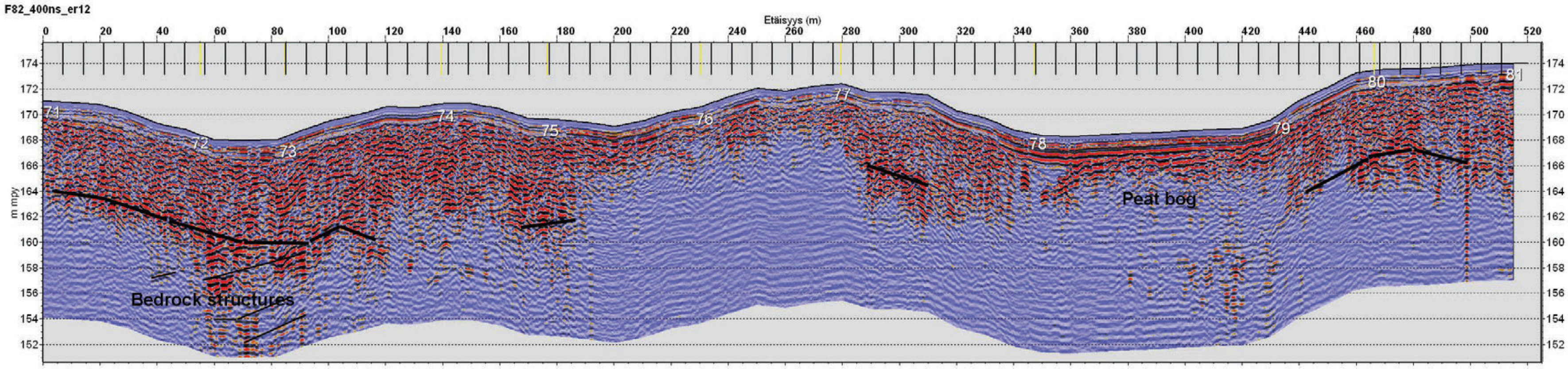


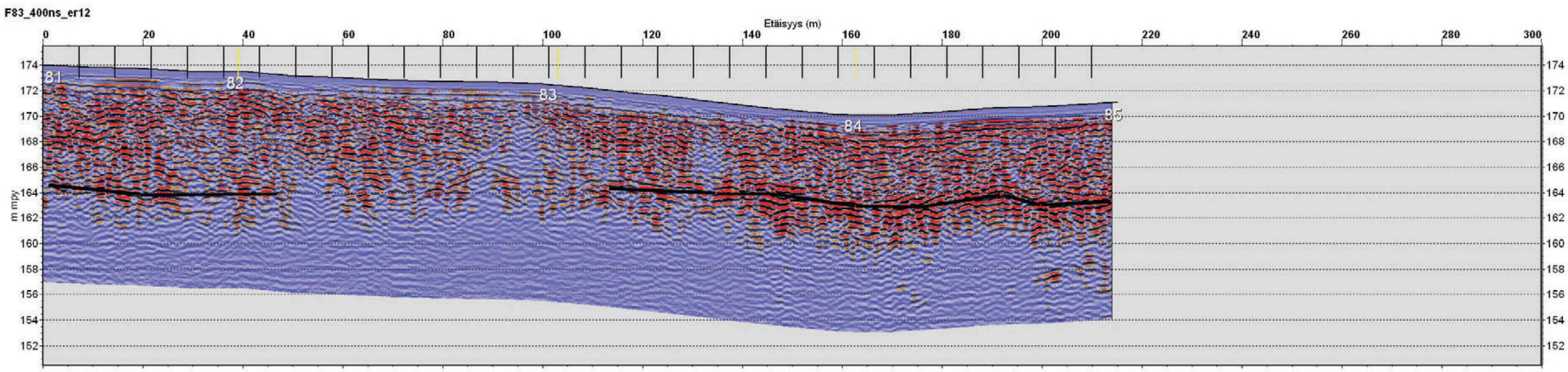


1.3 Radar line 3 (F80-F83, F84-F86; F80_001.JPG, F81_001.JPG, F82_001.JPG, F83_001.JPG, F84_001.JPG, F85_001.JPG and F86_001.JPG)






F82_400ns_er12
Etäisyys (m)
m mpy
Bedrock structures
Peat bog
71
72
73
74
75
76
77
78
79
80
81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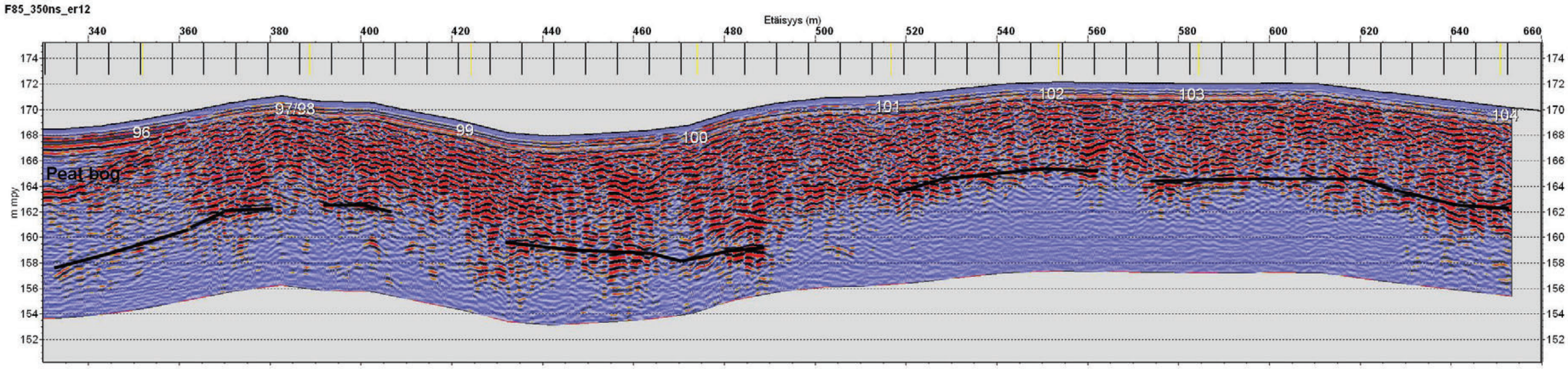
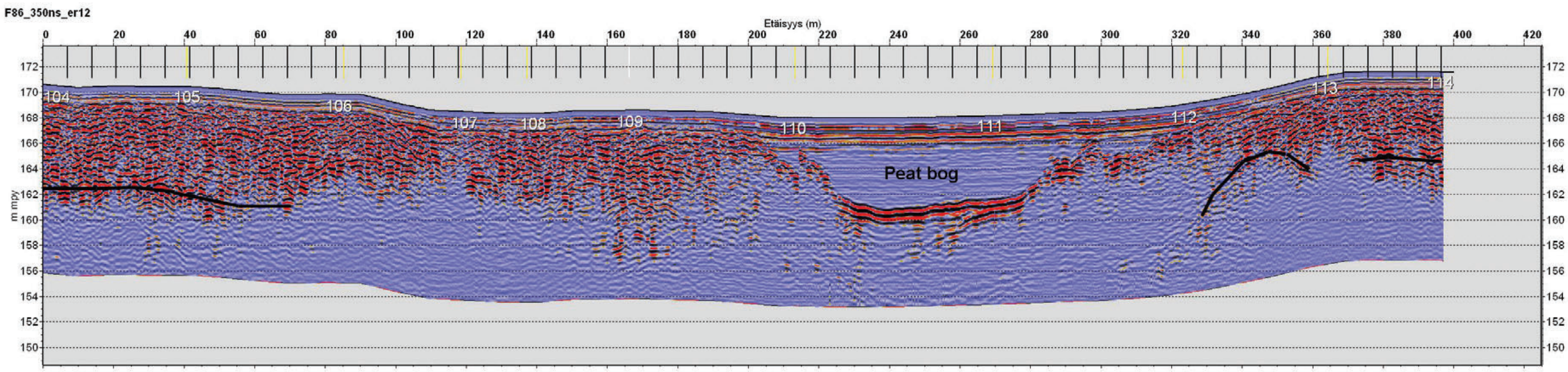
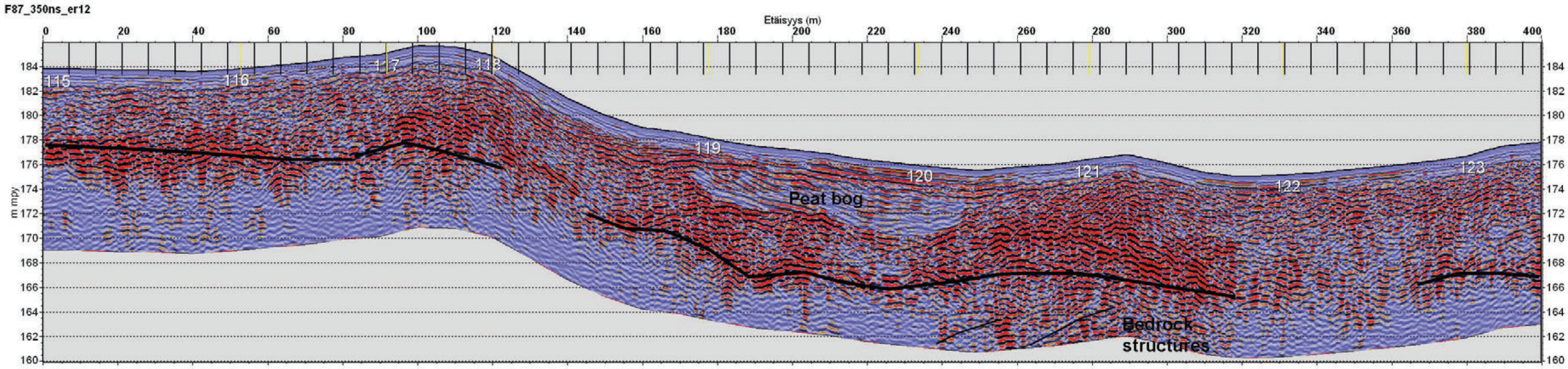
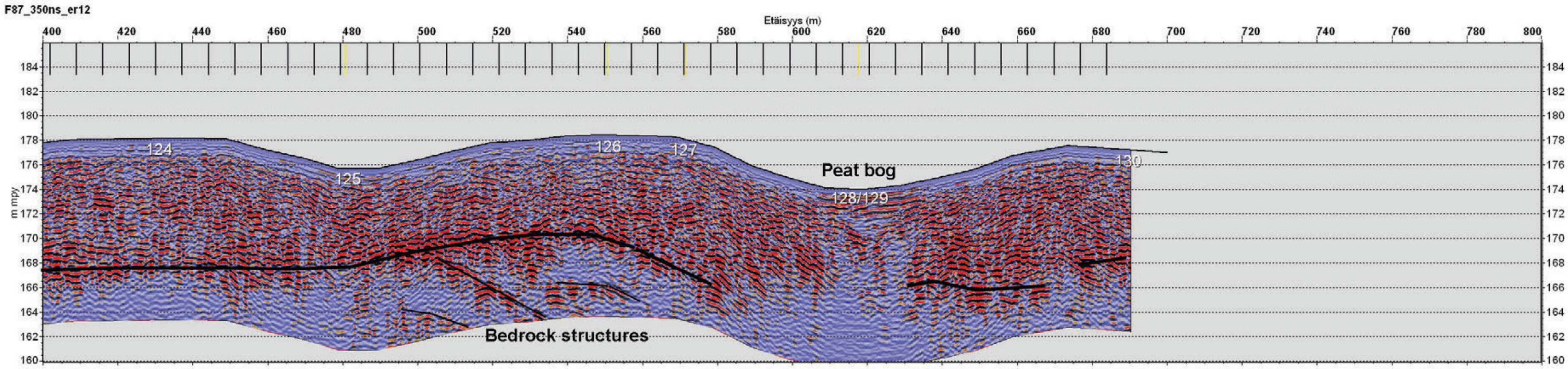
Etäisyys (m)
m mpy
81
82
83
84
85

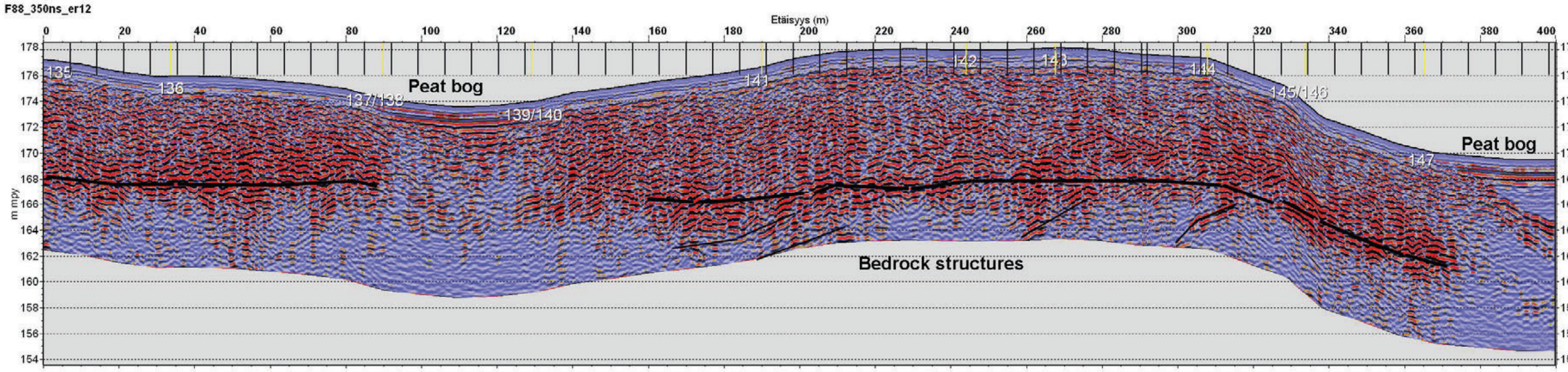

F85_350ns_er12
Etäisyys (m)
m mpy
96
97/98
99
100
101
102
103
104
Peat bog

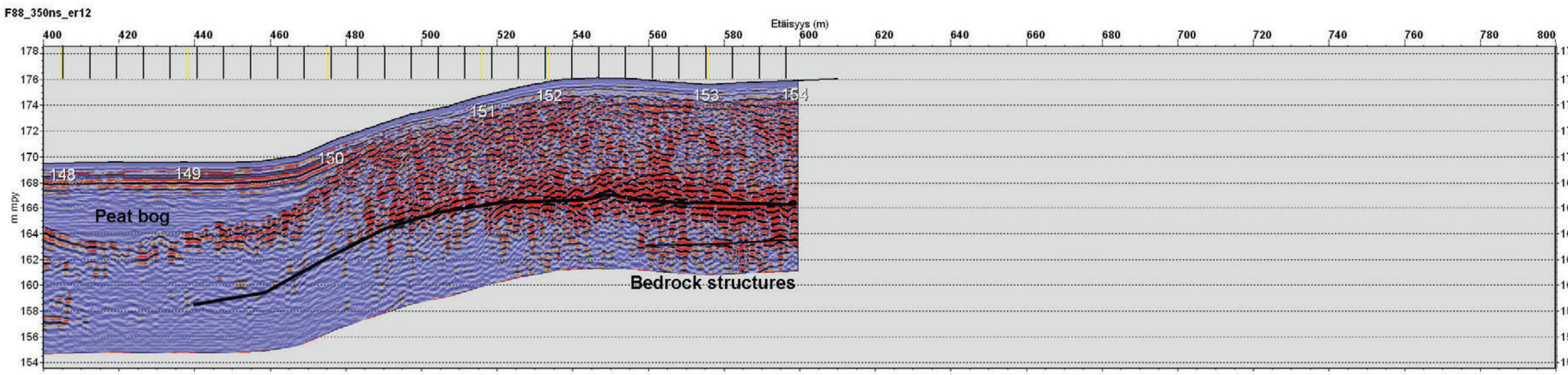

F86_350ns_er12
Etäisyys (m)
m mpy
104
105
106
107
108
109
110
111
112
113
114
Peat bog

1.4 Radar line 4 (F87-F88, F89-F90; F87_001-002.JPG, F88_001-002.JPG, F89_001-002.JPG, F90_001-002.JPG)

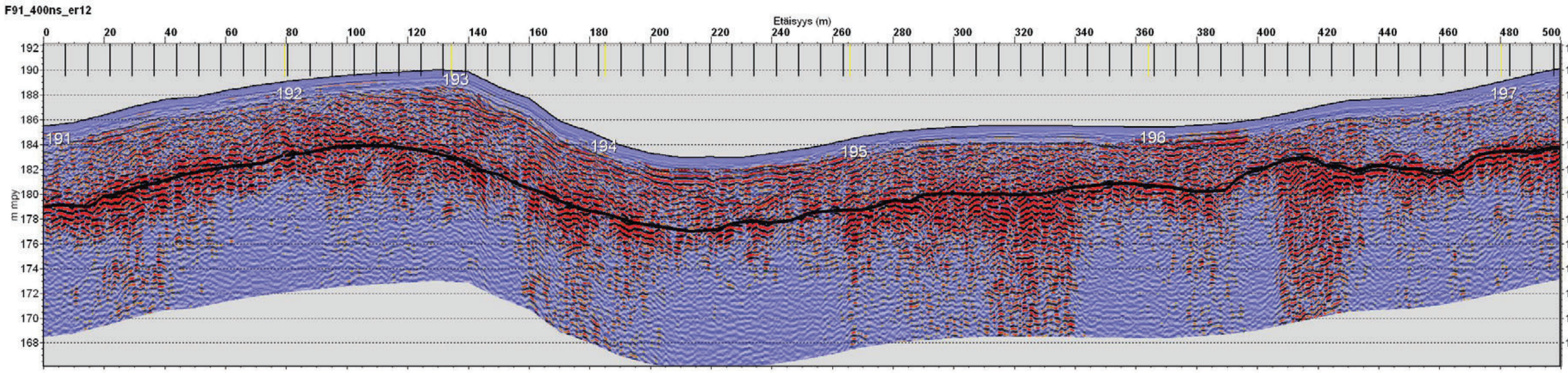


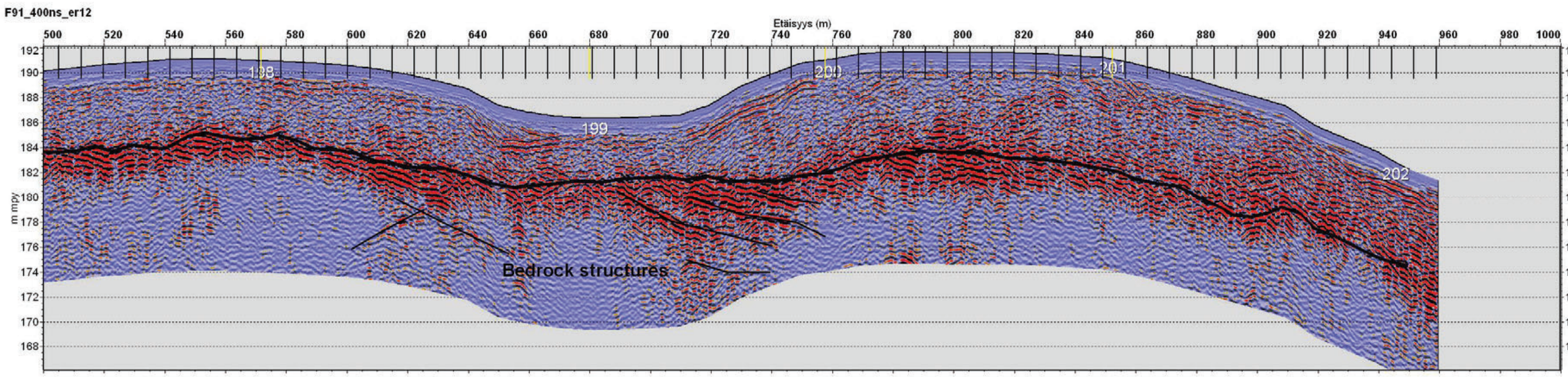


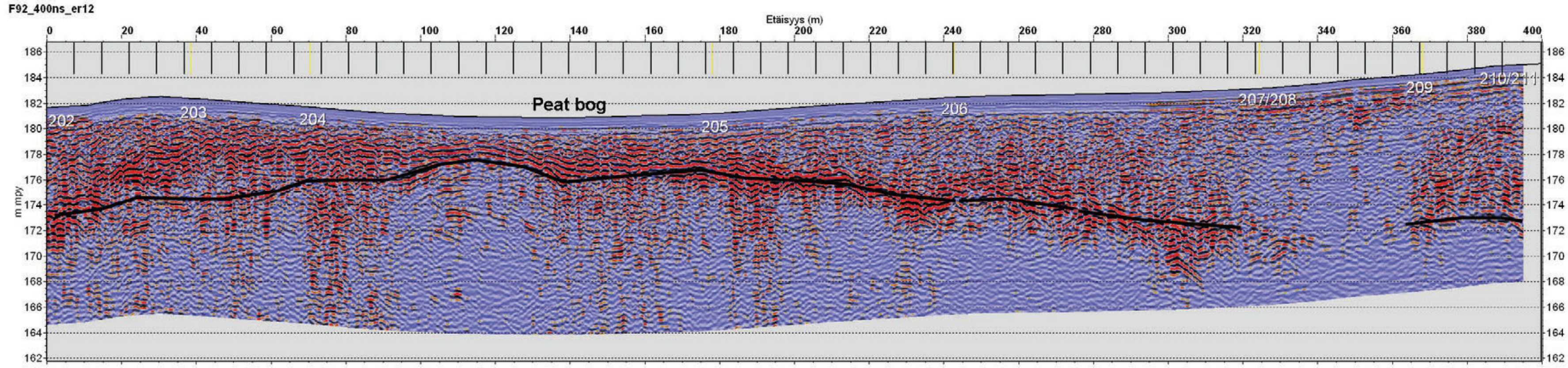

F88_350ns_er12
Etäisyys (m)
m mpy
Peat bog
Peat bog
Bedrock structures
135
136
137/138
139/140
141
142
143
144
145/146
147


F88_350ns_er12
Etäisyys (m)
m mpy
Peat bog
Bedrock structures
148
149
150
151
152
153
154

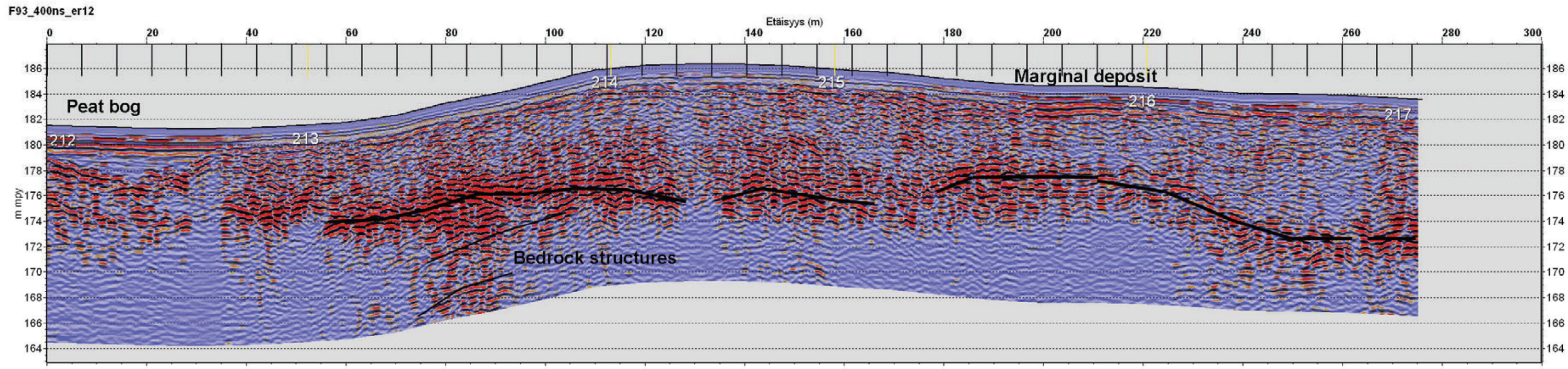
1.5 Radar line 5 (F91-F92; F91_001-002.JPG, F92_001-002.JPG)



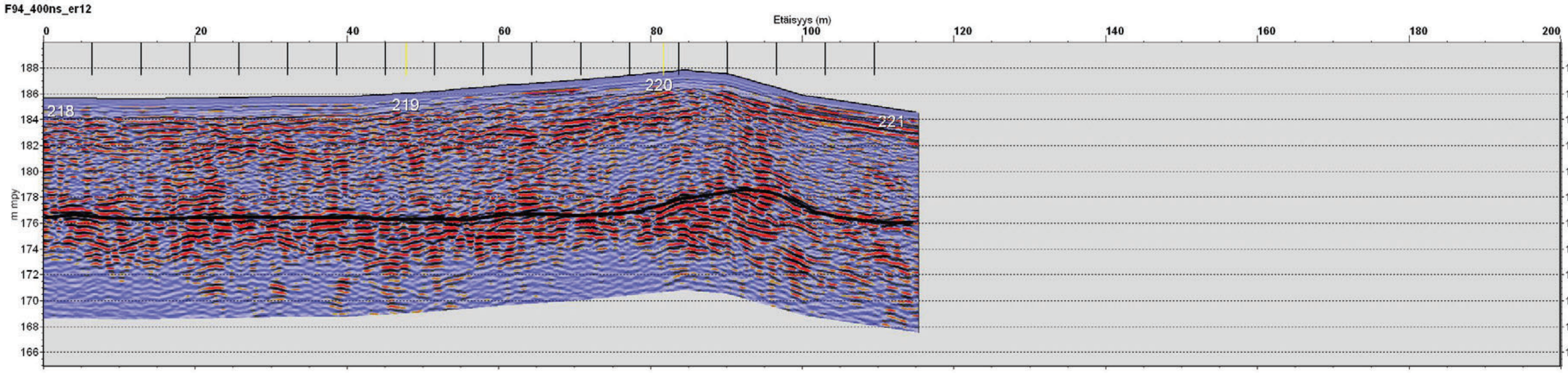


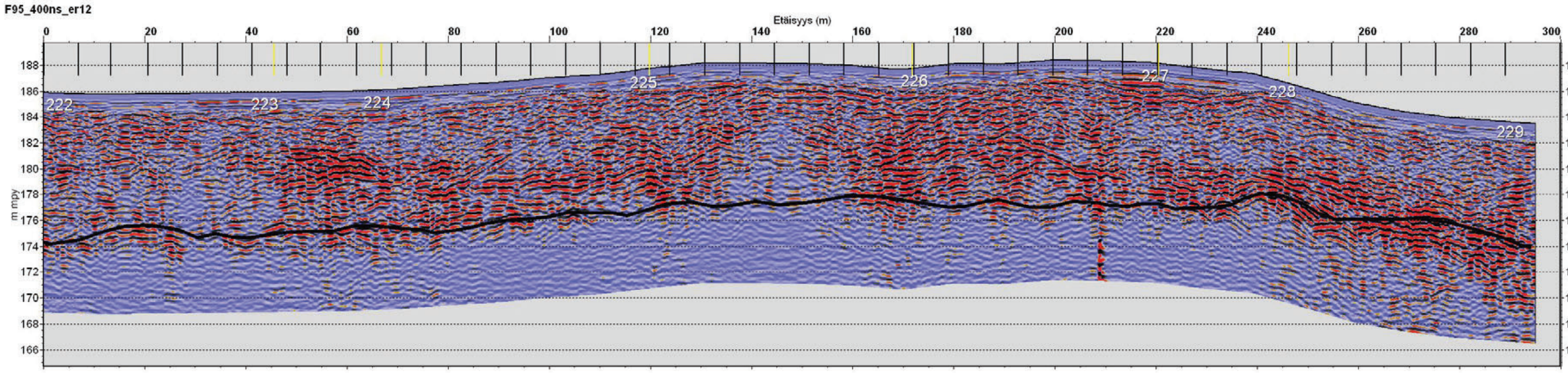


1.6 Radar line 6 (F93; F93_001.JPG)

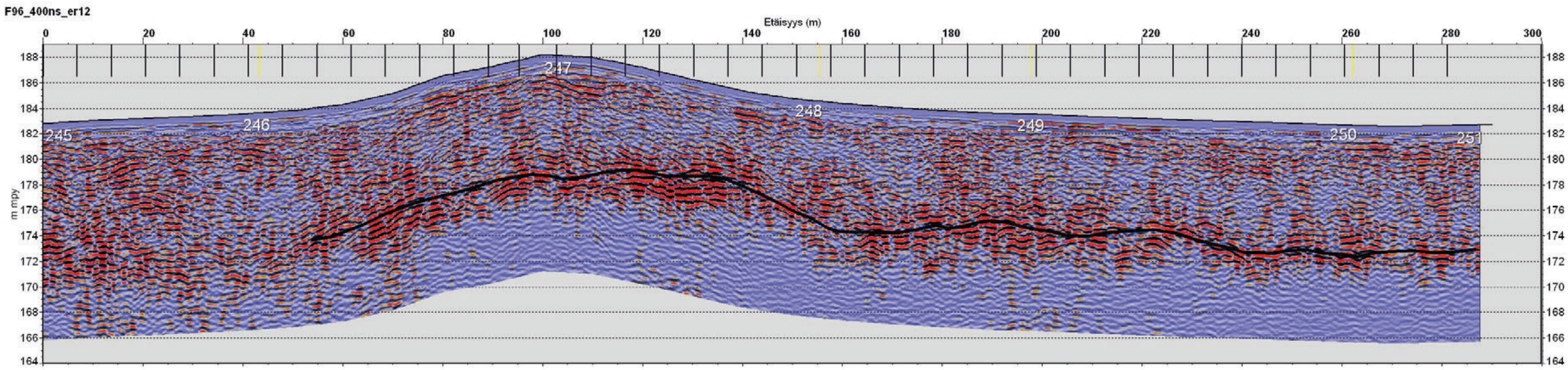


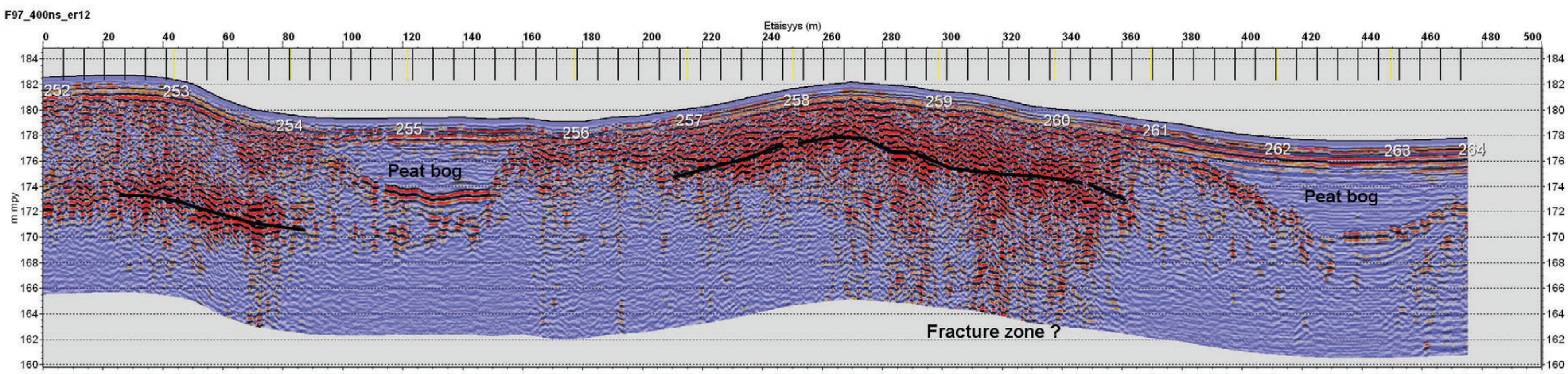
1.7 Radar line 7 (F94, F95; F94_001.JPG, F95_001.JPG)



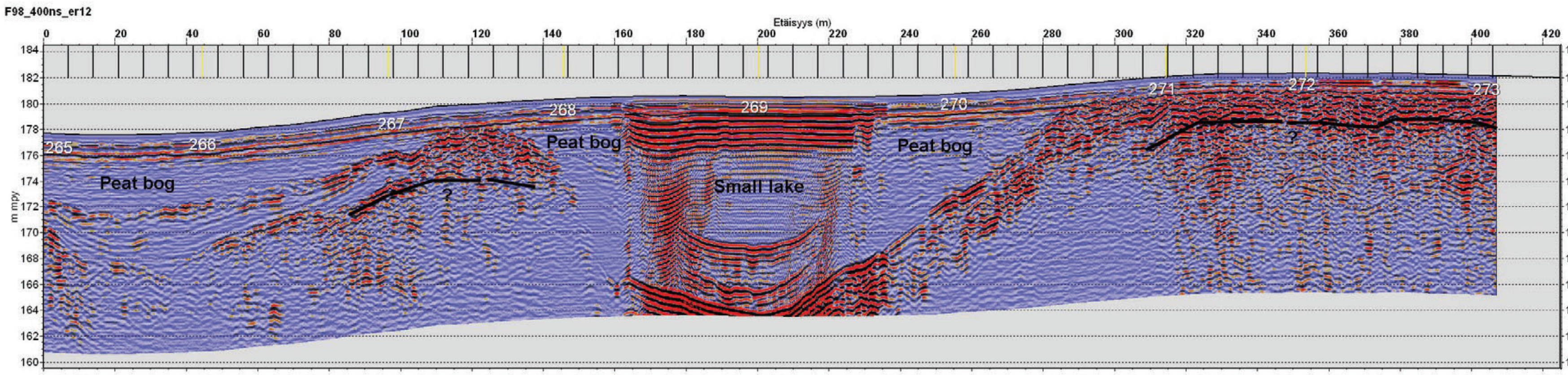


1.8 Radar line 8 (F96, F97; F96_001.JPG, F97_001.JPG)

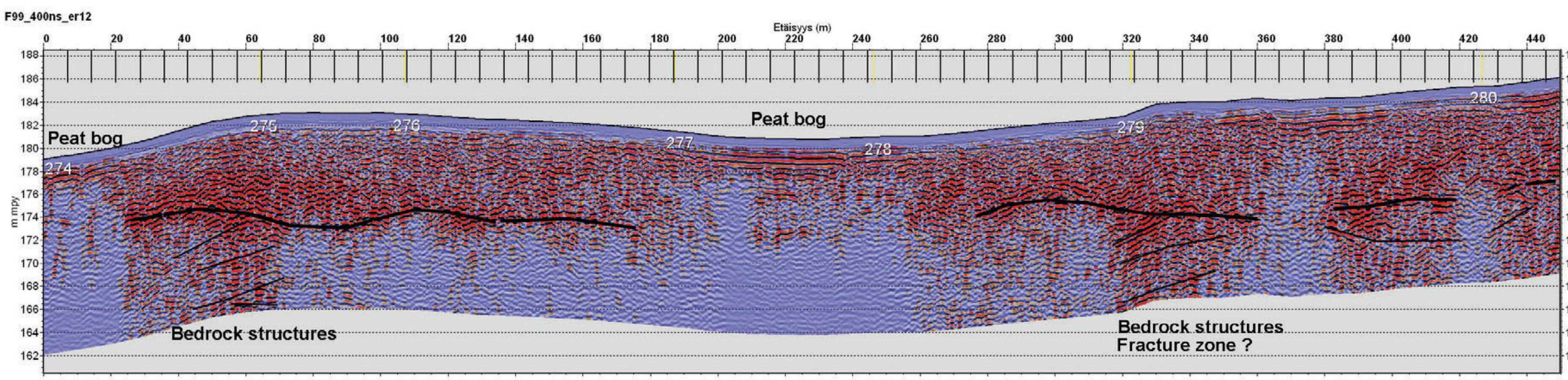


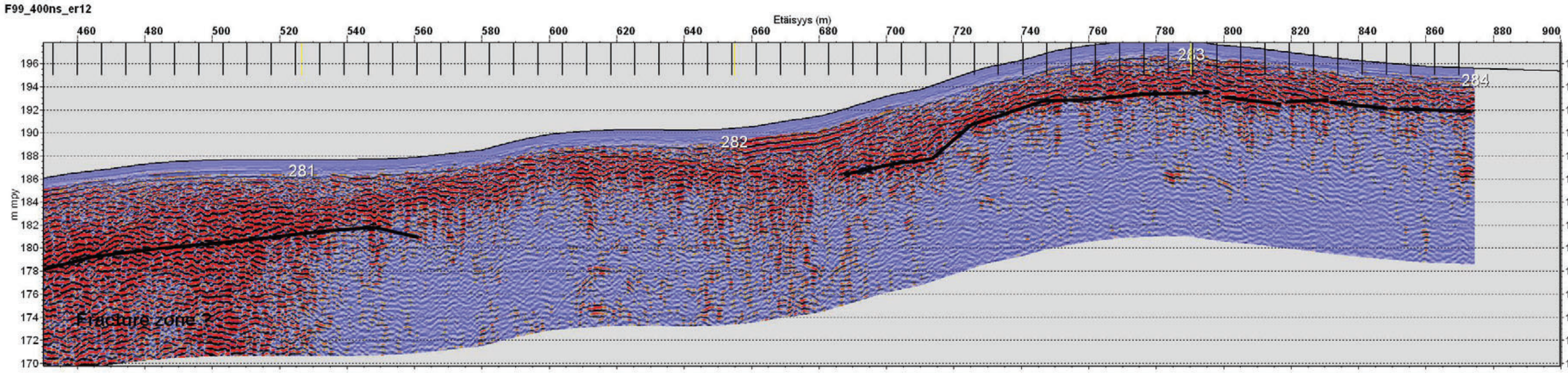


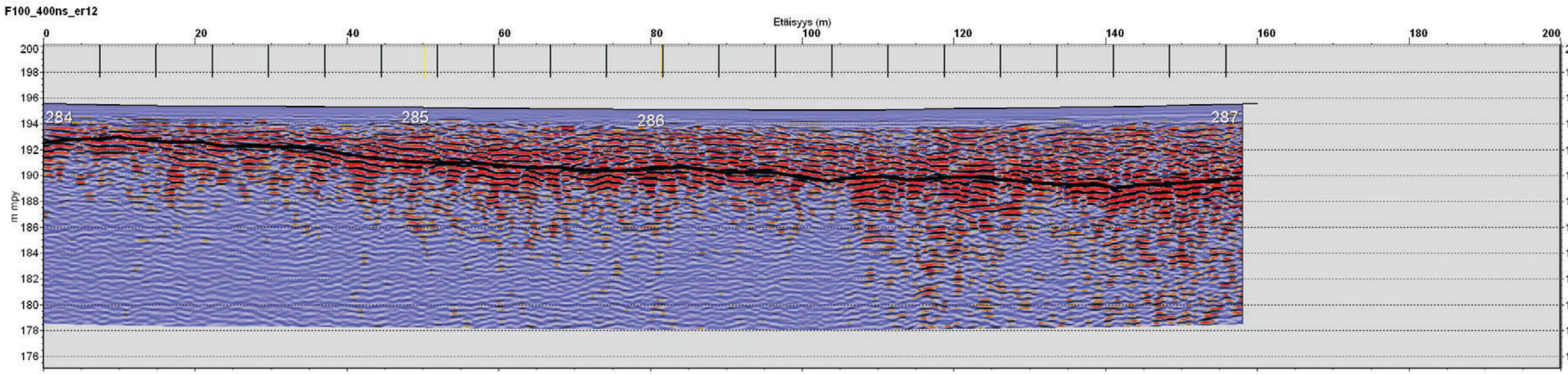
1.9 Radar line 9 (F98; F98_001.JPG)



1.10 Radar line 10 (F99, F100; F99_001-002.JPG, F100_001.JPG)




F99_400ns_er12
Etäisyys (m)
m mpy
281
282
283
284
Fracture zone ?


F100_400ns_er12
Etäisyys (m)
m mpy
284
285
286
287