LGA Bautechnik GmbH
Civil Engeneering Projects

Certified in accordance with DIN EN ISO 9001/14001

Report

BBMT0600183

date: February 7, 2007

December 12 – 15, 2006

client:

Fondacija Arheoloski Park
"Bosanska Piramida Sunca"
Fra Andela Zvizdovica br. 1/B11
71000 Sarajevo
Bosnia and Herzegovina

projekt: radar measurements to find inhomogenities in the ground

task from: Summer 2006

content of task: inhomogenities and structures under the ceiling

editor:

Dr.-Ing. A. Hasenstab
Ing. Dragan Juricevic
M.Eng. Sven Homburg
Dipl.-Ing. Annett Schönitz
Dipl.-Ing. Harry Deinhard

phone number: +49 (0) 911 655-5561

faxnumber: +49 (0) 911 655-5536

e-mail: andreas.hasenstab@lga.de

LGA Bautechnik GmbH • Tillystraße 2 • 90431 Nürnberg
Tel.: +49 (0) 911 655-5561 • Fax: +49 (0) 911 655-5536
E-Mail: andreas.hasenstab@lga.de • http://www.lga.de

Sitz und Registergericht Nürnberg HRB 20586
Geschäftsführer: Peter Tolls, Hans-Hermann Ueffing
Steuer-Nr. 241/115/90733 Ust-IdNr. DE813835574

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LGA Bautechnik GmbH • Tillystraße 2 • 90431 Nürnberg
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CONCLUSION

Radar measurements have been carried out at the area close to Visoco at important places to find inhomogenities in the ground. These measurements were done with two different radar antennas, one 270 MHz antenna which has a capacity to go into the ground up to 5 m and an 100 MHz antenna which makes measurements up to the depth of 20 m dependent on the surrounding conditions.

During the measurements in December (12.12. – 15.12.) the whether was good, but the ground has been very wet. That means the damping of the signals were very high. Nevertheless the results of the measurements have been good and a lot of inhomogenities were found like stone plates and other strong reflectors.

Measurements were done at:

North surface of a hill near Visoco called „pyramid of the sun“

- Grassland at top of Kapija
- at the Kapija
- Stone plates obove grassland of kapija
- stoneplates SONDE 4A
- at Sonde 12
- Plateau

Plateau

- Measurements at Plateau A and B

Bottom of Valley

- Measurements at bottom of vallery

Vratnica Kameni Hram and Dolovi Valjak

- Measurements at Vratnica Kameni Hram and Dolovi Valjak

Together 44 areas were marked with position and depth where inhomogenities are and there excavations can be made.

The depth of the marked inhomogentities differ between 0,8 m and 5 m.

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MOTIVE AND TASK

The LGA Bautechnik GmbH / TÜVRheinland was asked to make measurements with georadar at some areas in Visoko to find inhomogenities in the ground. With results of GPR measurement it is possible to explore exact excavations to be sure what kind of inhomogenities are in the ground. The areas of the measurements from 13.12. - 14.12.2006 are shown below.

1 MEASURINGSYSTEM

1.1 Radar

Ground penetrating radar is a nondestructive geophysical method that produces a continuous cross-sectional profile or record of subsurface features, without drilling, probing, or digging.

Ground penetrating radar (GPR) profiles are used for evaluating the location and depth of buried objects and to investigate the presence and continuity of natural subsurface conditions and features.

Ground penetrating radar operates by transmitting pulses of ultra high frequency radio waves (microwave electromagnetic energy) down into the ground through a transducer (also called an antenna). The transmitted energy is reflected from various buried objects or distinct contacts between different earth materials.
The antenna then receives the reflected waves and stores them in the digital control unit.

When the transmitted signal enters the ground, it contacts objects or subsurface strata with different electrical conductivities and dielectric constants. Part of the ground penetrating radar waves reflect off of the object or interface; while the rest of the waves pass through to the next interface.

The reflected signals return to the antenna, pass through the antenna, and are received by the digital control unit. The control unit registers the reflections against two-way travel time in nanoseconds and then amplifies the signals.
The output signal voltage peaks are plotted on the ground penetrating radar profile as different color bands by the digital control unit.
For each reflected wave, the radar signal changes polarity twice. These polarity changes produce three bands on the radar profile for each interface contacted by the radar wave.

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Ground penetrating radar waves can reach depths up to 100 feet (30 meters) in low conductivity materials such as dry sand or granite. Moist clays, shale, and other high conductivity materials, may attenuate or absorb GPR signals, greatly decreasing the depth of penetration to 3 feet (1 meter) or less.

The depth of penetration is also determined by the GPR antenna used. Antennas with low frequencies of from 25 to 200 MHz obtain subsurface reflections from deeper depths (about 30 to 100 feet or more), but have low resolution. These low frequency antennas are used for investigating the geology of a site, such as for locating sinkholes or fractures, and to locate large, deep buried objects.

Antennas with higher frequencies of from 300 to 1,500 MHz obtain reflections from shallow depths (0 to about 30 feet), and have high resolution. These high frequency antennas are used to investigate surface soils and to locate small or large, shallow, buried objects, such as utilities, and also rebar in concrete.

1.2 Limitation of the method

Radar is an indirect method, e.g. the accuracy and quality of the measured results depend on physical properties of the tested medium.
Error of measurement caused by a inhomogene structure are possible. The indirect measuring system is limitated by the named influences and to get exact information it is the best to isolate areas non-destructive and then look destructive like digging.

1.3 Way of measuring

The measurements were accomplished with a radar system SIR 20 (GSSI) and 270 MHz and 100 MHz a radar antenna. The radar antennas were pulled over the range which can be examined and the data were registered and archived by a measuring computer (SIR 20). The length regulation took place with a survey wheel. For the calibration of the radar facility some calibration measrements where done .

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figure 1: radar equipment left: computer, middle and right: radar antenna 270 kHz

figure 2: radar antenna 100 kHz

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1.4 Coordinating System of the measuring area

The measuring lines go parallel or in right angle to the hill.

1.5 measuring basis

Measured data:	time of flight and amplitude of waves
equipment:	digital geo radar equipment GSSI SIR20
sensor:	270 MHz; 100 kHz
way admission:	weel with increment giver
registration length:	70 – 200 nsek, corresponds to 4 - 20 m range
calibration:	stone plates with known dimension

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2 MEASURINGFIELD GRASSLAND AT TOP OF KAPIJA

2.1 Local conditions

figure 3: area of measurements

The measurements where carried out at different areas closed to “Kapija”.

figure 4: view of measurements on grassland

LGA Bautechnik GmbH • Tillystraße 2 • 90431 Nürnberg
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2.2 Coordinating System of the measuring area

The measuring lines go parallel or in right angle to the hill.

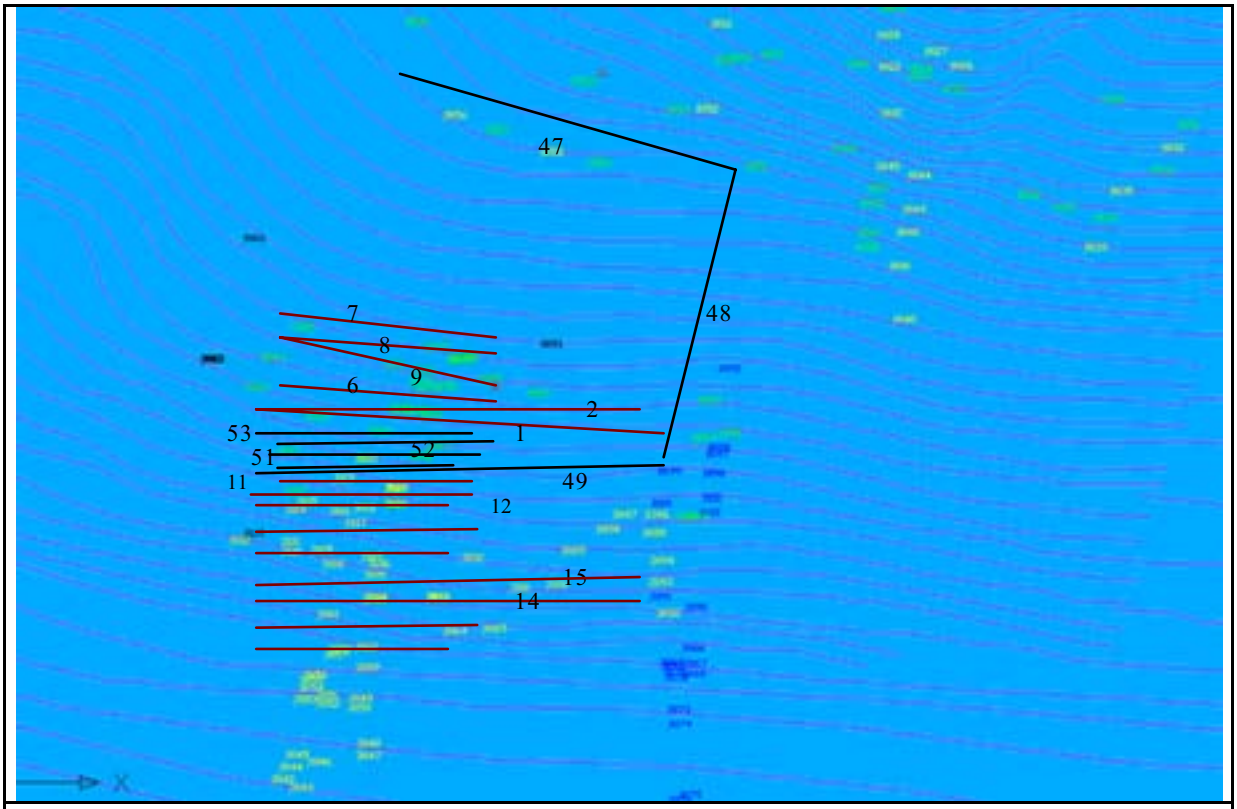

figure 5: overview of position of measuring lines

2.3 measuring basis

Measured data:	time of flight and amplitude of waves
equipment:	digital geo radar equipment GSSI SIR20
sensor:	270 MHz; 100 kHz
way admission:	weel with increment giver
registration length:	70 – 200 nsek, corresponds to 4 - 20 m range
calibration:	stone plates with known dimension

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2.4 RESULTS OF THE MEASUREMENTS

The measurements were done with an 270 MHz and an 100 MHz radar antenna. The ground was very wet which means the damping of the signals is high. Anywhere the results of the measurements were in the first 4 m very good. Following the results of measurements at the area called “Kapija” and the grassland closed to it are shown.

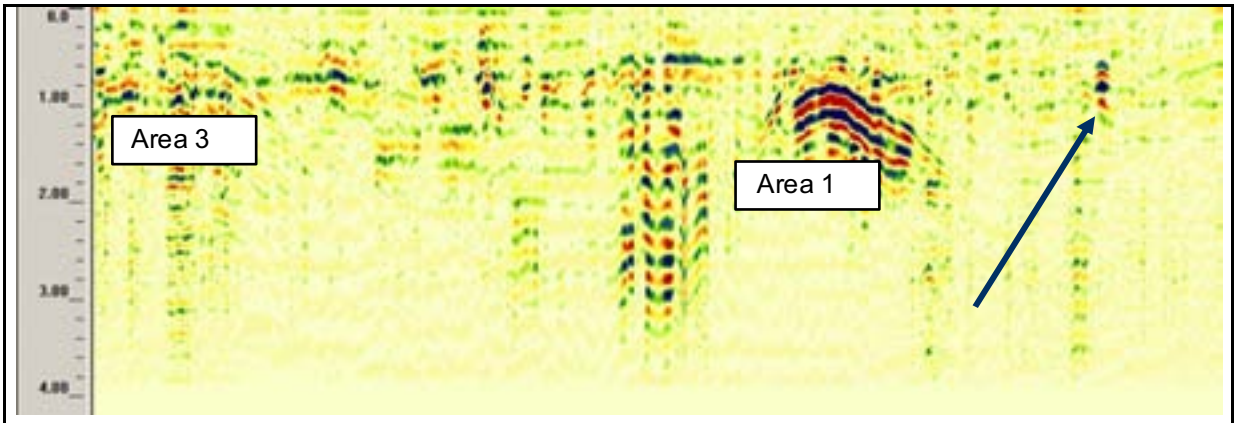

figure 6: radargram of a measuring along measuring line 49 (length: 50 m, GSSI, f = 270 MHz) with very interesting inhomogenity in grasland

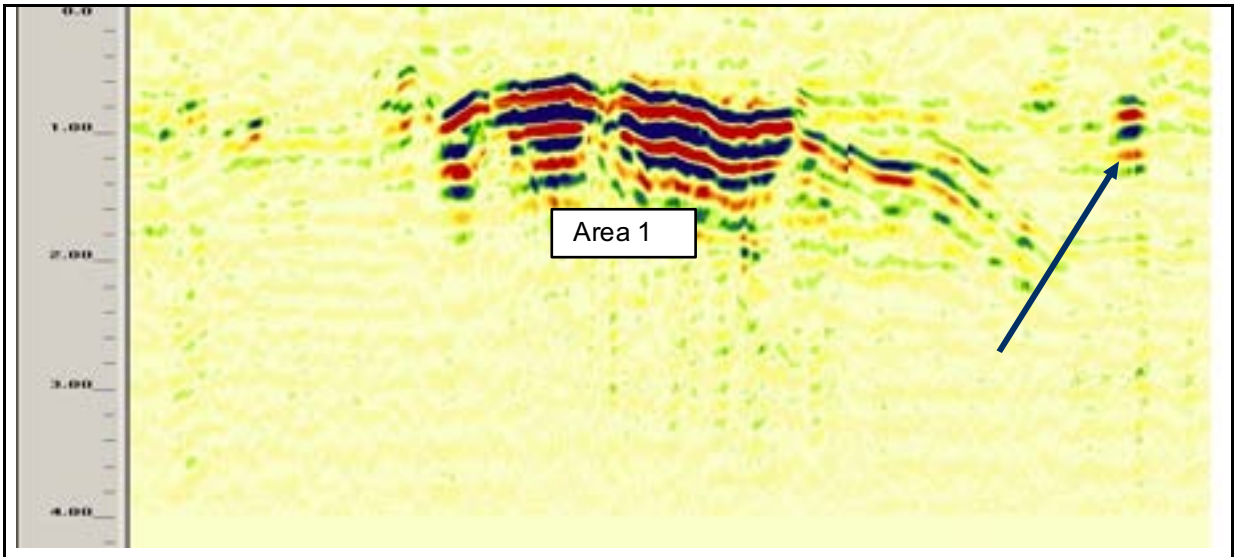

figure 7: radargram of a measuring along measuring line 51 (length: 22 m, GSSI, f = 270 MHz) with inhomogenities

LGA Bautechnik GmbH • Tillystraße 2 • 90431 Nürnberg
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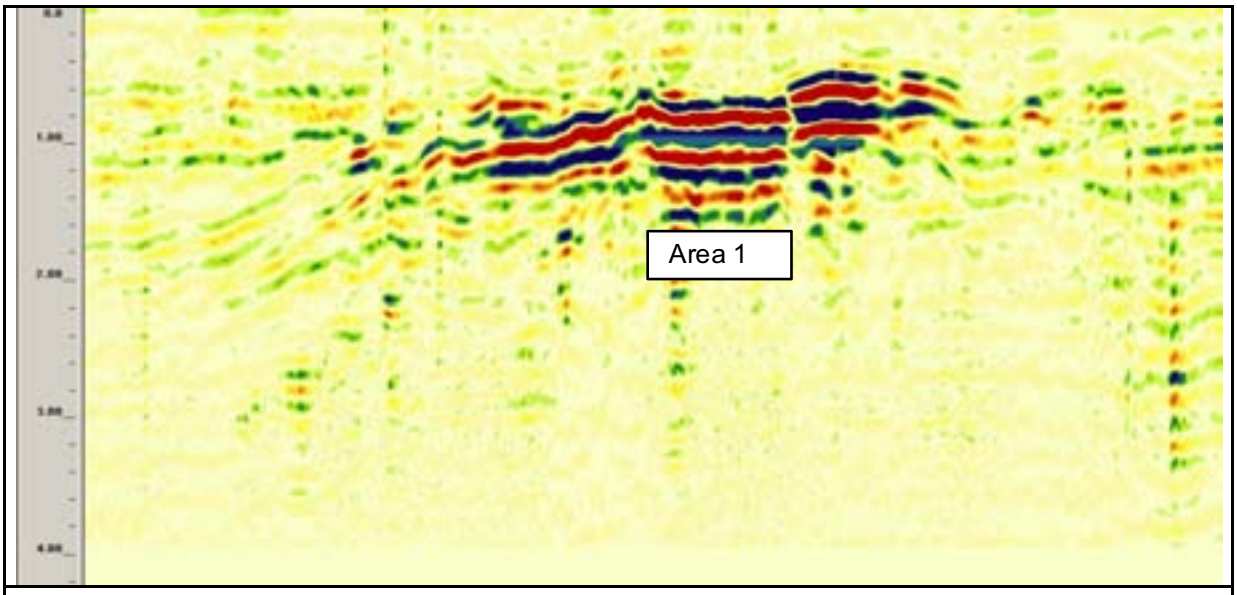

figure 8: radargram of a measuring along measuring line 52 (length: 19 m, GSSI, f = 270 MHz) with inhomogenities

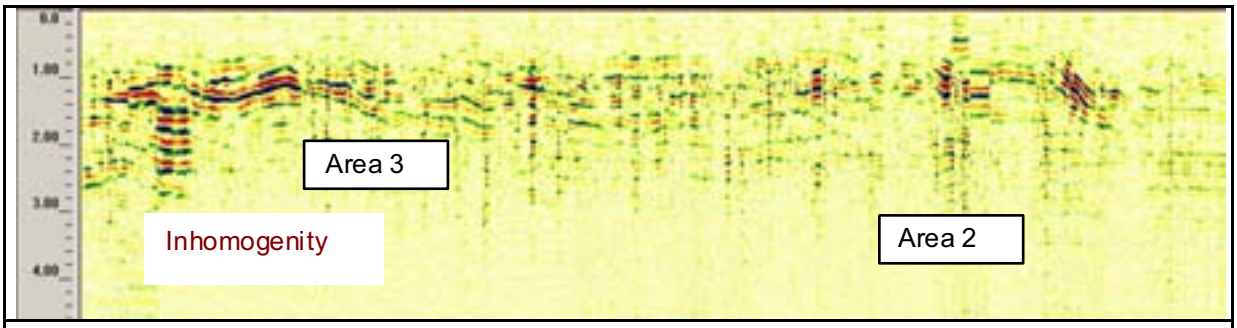

figure 9: radargram of a measuring along measuring line 15 (length: 57 m, GSSI, f = 270 MHz) with inhomogenities

LGA Bautechnik GmbH • Tillystraße 2 • 90431 Nürnberg
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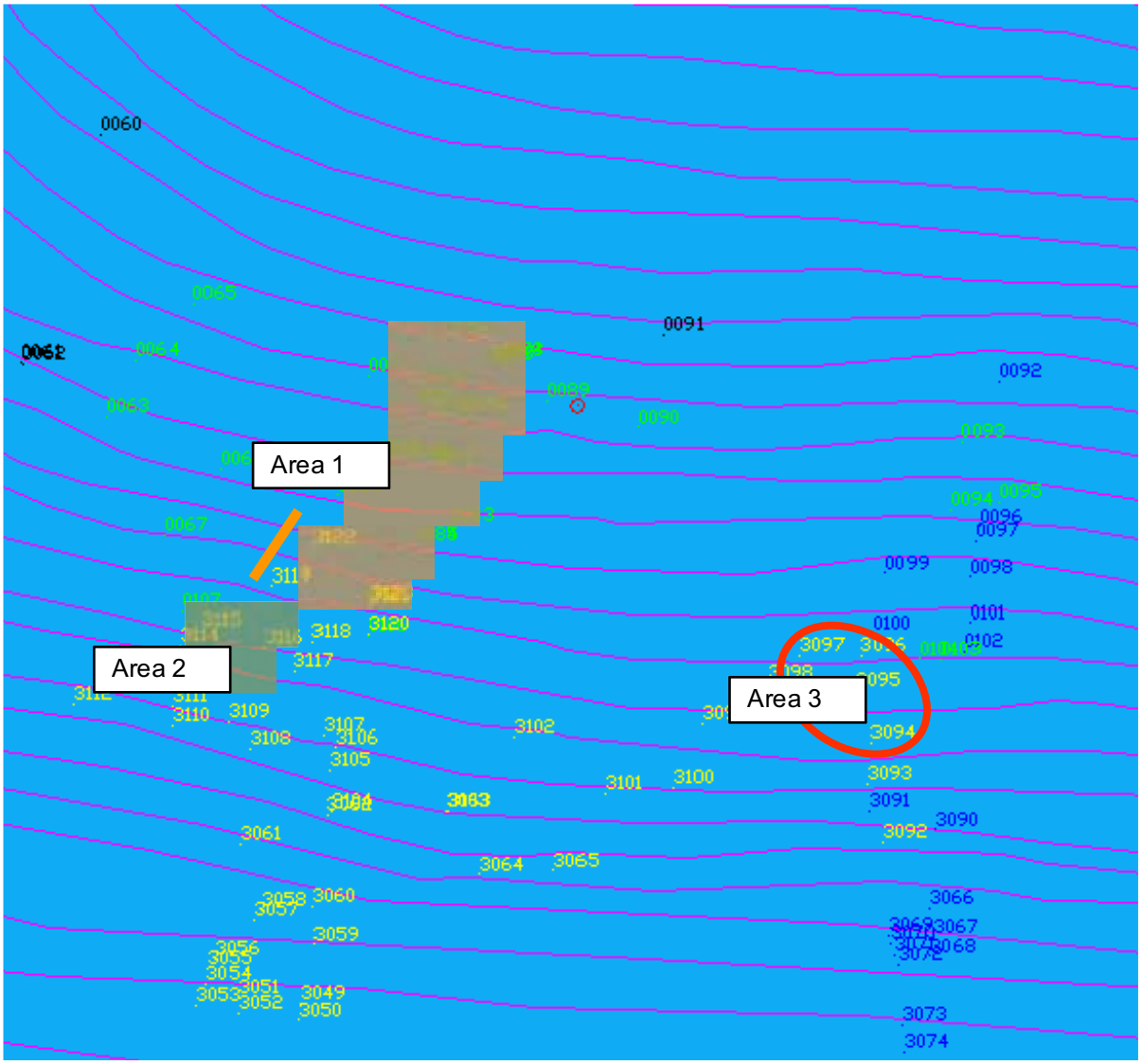
2.5 EVALUATION OF RESULTS



In the picture above the measuring lines and the areas with inhomogenities are shown.

Area 1:	Large inhomogenity in a varying depth of: 0,8-1,5 m
Pipe parallel to Area 1:	inhomogenity depth of: 0,8-1,0 m
Area 2	Top of Area 1 Depth of inhomogenity: 0,9 - 1,1 m
Area 3:	Depth of inhomogenity: 1,0-1,3 m

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2.6 RADARGRAMS OF MEASUREMENTS

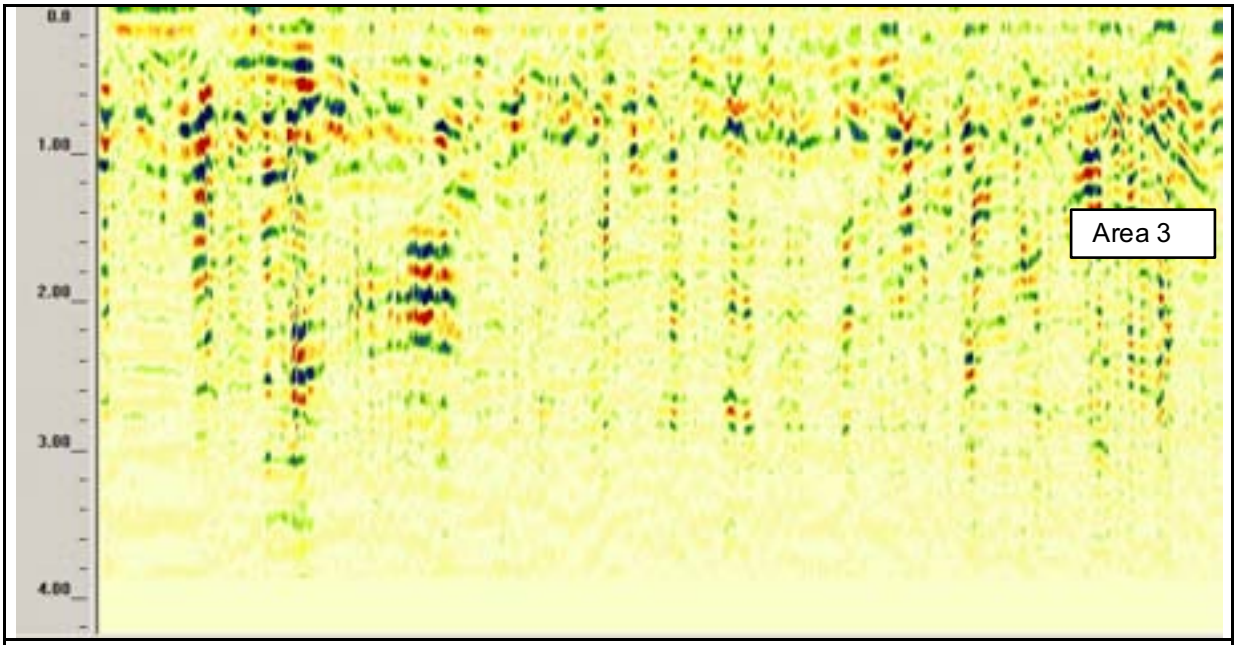

figure 10: radargram of a measuring along measuring line 48 (length: 44 m, GSSI, f = 270 MHz) with inhomogenities

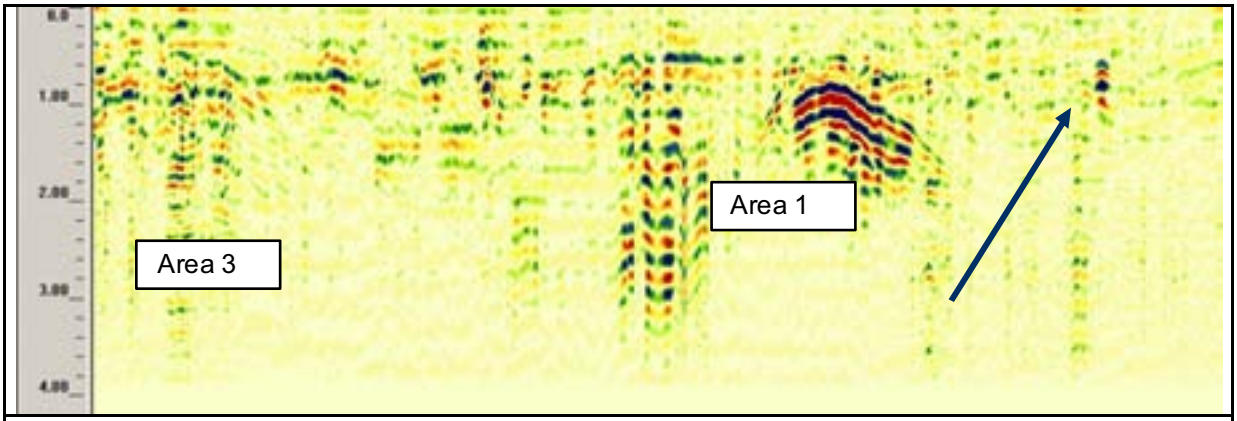

figure 11: radargram of a measuring along measuring line 49 (length: 50 m, GSSI, f = 270 MHz) with very interesting inhomogenity

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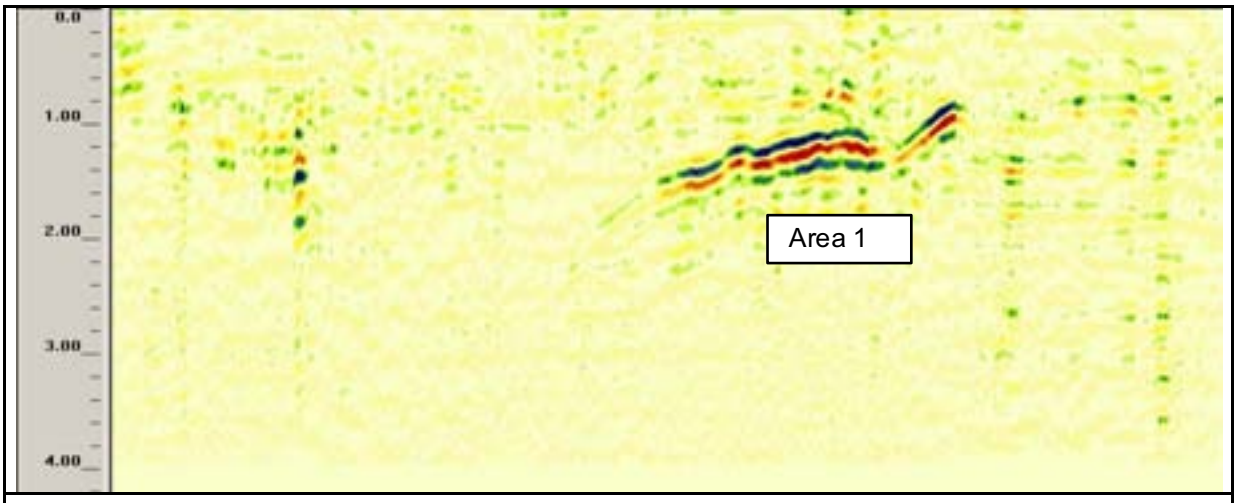

figure 12: radargram of a measuring along measuring line 50 (length: 26 m, GSSI, f = 270 MHz) with inhomogenities

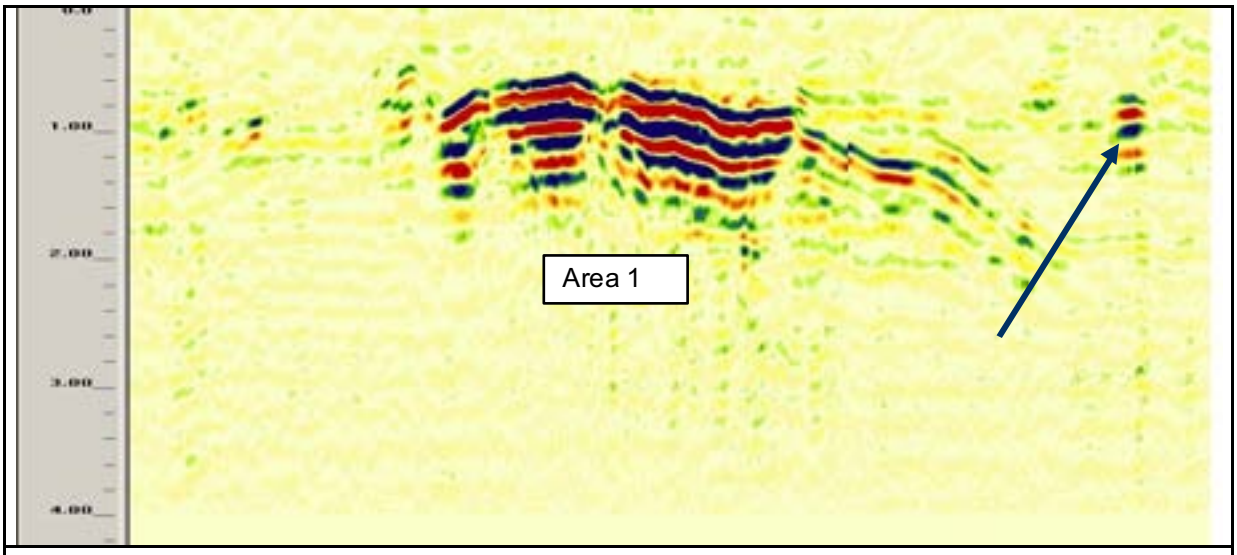

figure 13: radargram of a measuring along measuring line 51 (length: 22 m, GSSI, f = 270 MHz) with inhomogenities

LGA Bautechnik GmbH • Tillystraße 2 • 90431 Nürnberg
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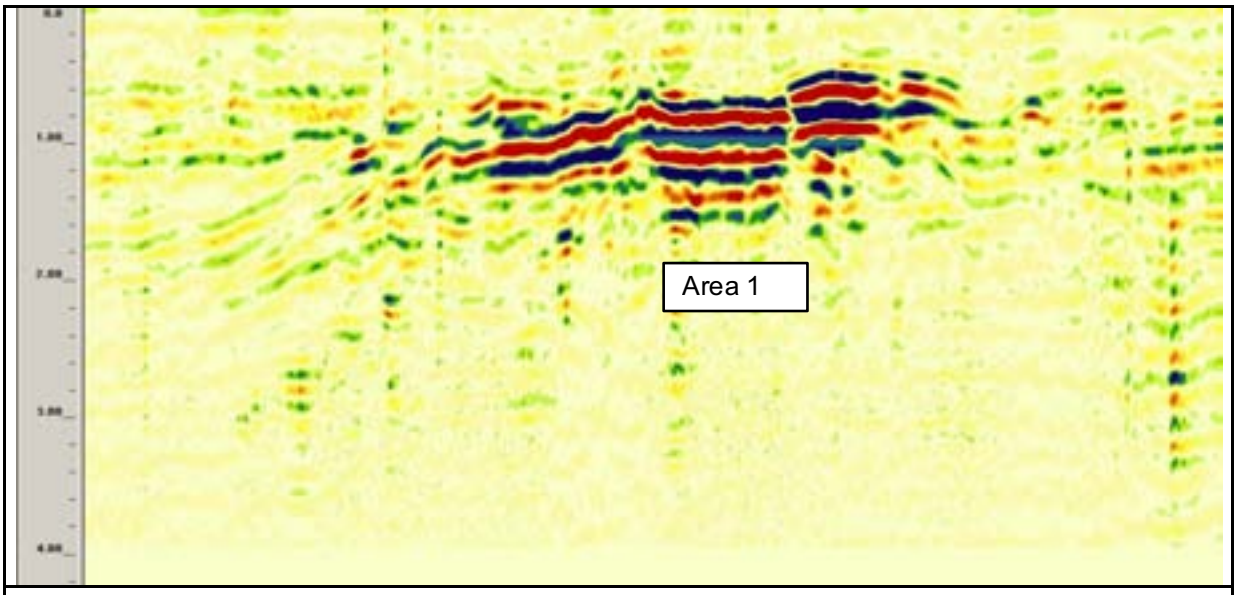

figure 14: radargram of a measuring along measuring line 52 (length: 19 m, GSSI, f = 270 MHz) with inhomogenities

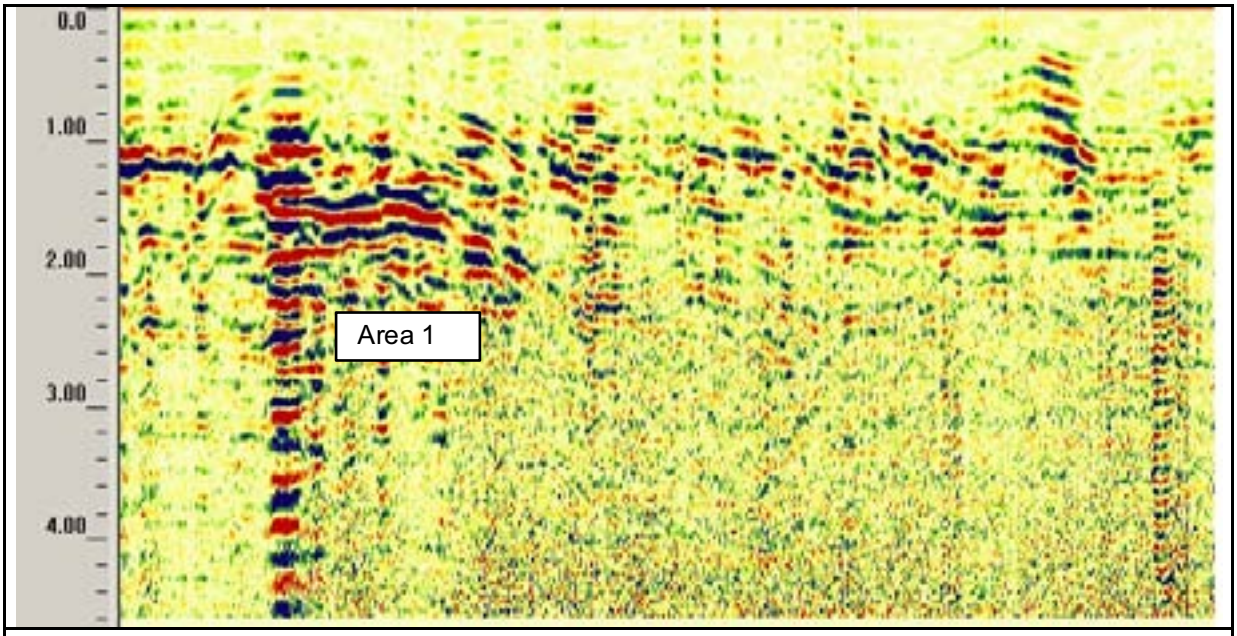

figure 15: radargram of a measuring along measuring line 6 (length: 23,45 m, GSSI, f = 270 MHz) with inhomogenities

LGA Bautechnik GmbH • Tillystraße 2 • 90431 Nürnberg
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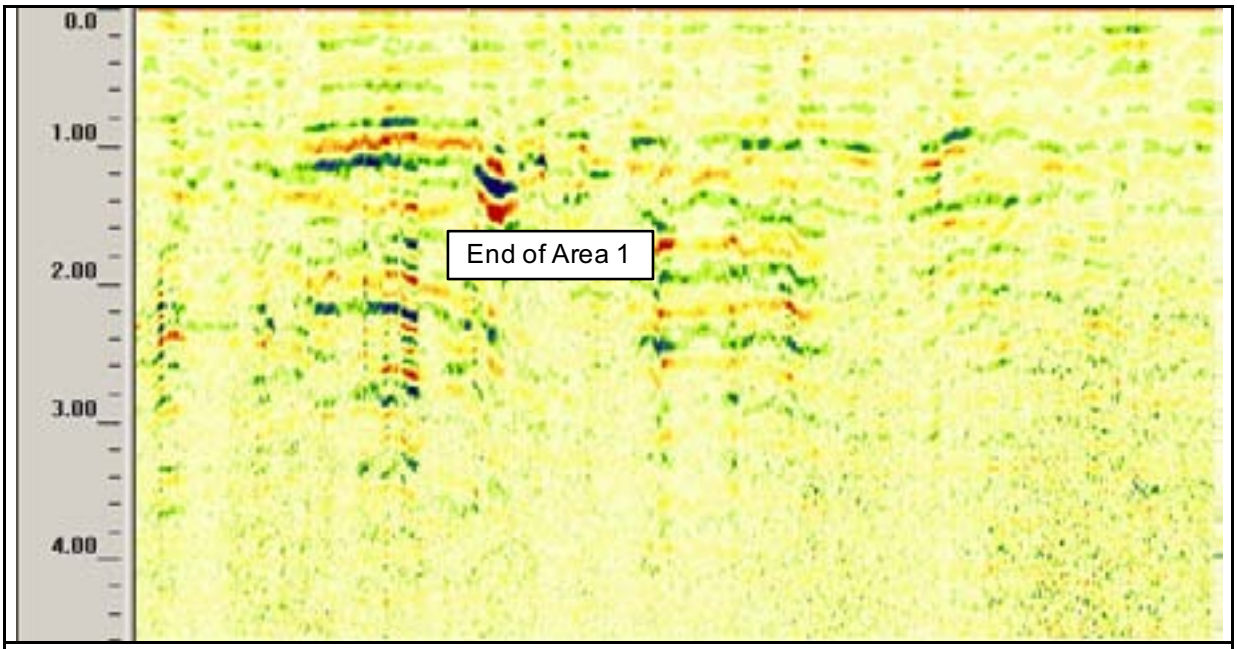

figure 16: radargram of a measuring along measuring line 7 (length: 20,5 m, GSSI, f = 270 MHz) with no inhomogenities

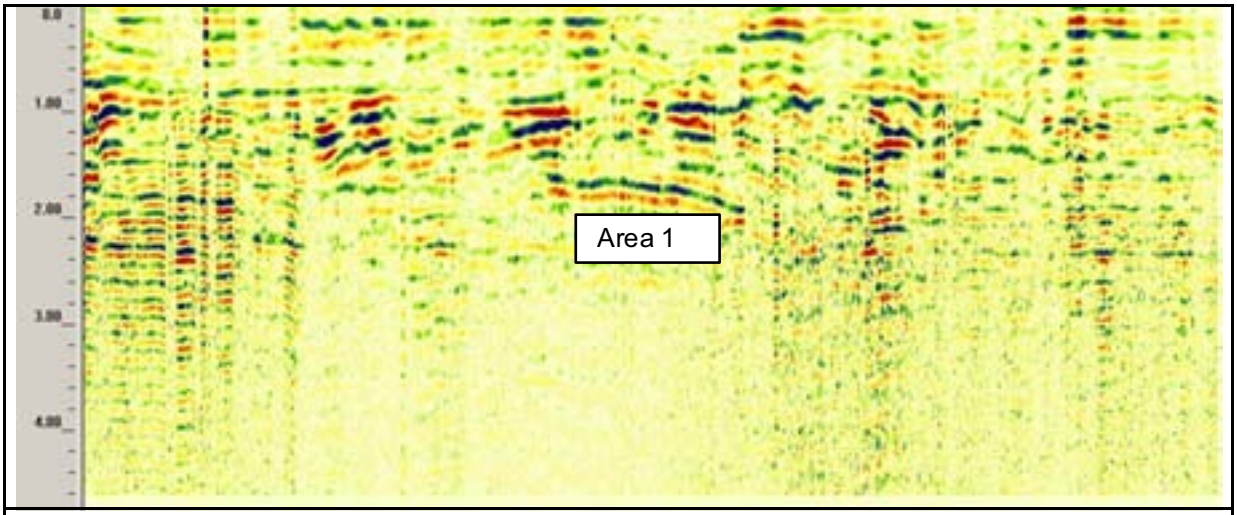

figure 17: radargram of a measuring along measuring line 8 (length: 19 m, GSSI, f = 270 MHz) with inhomogenities

LGA Bautechnik GmbH • Tillystraße 2 • 90431 Nürnberg
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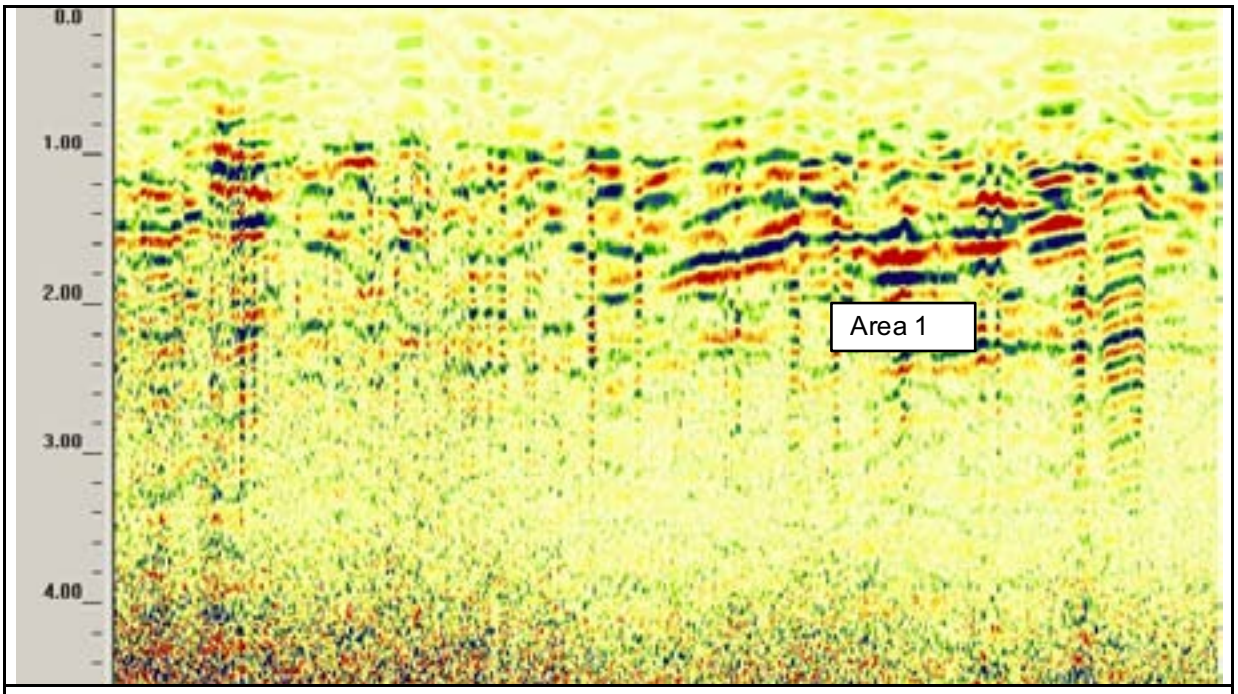

figure 18: radargram of a measuring along measuring line 9 (length: 12,6 m, GSSI, f = 270 MHz) with inhomogenities

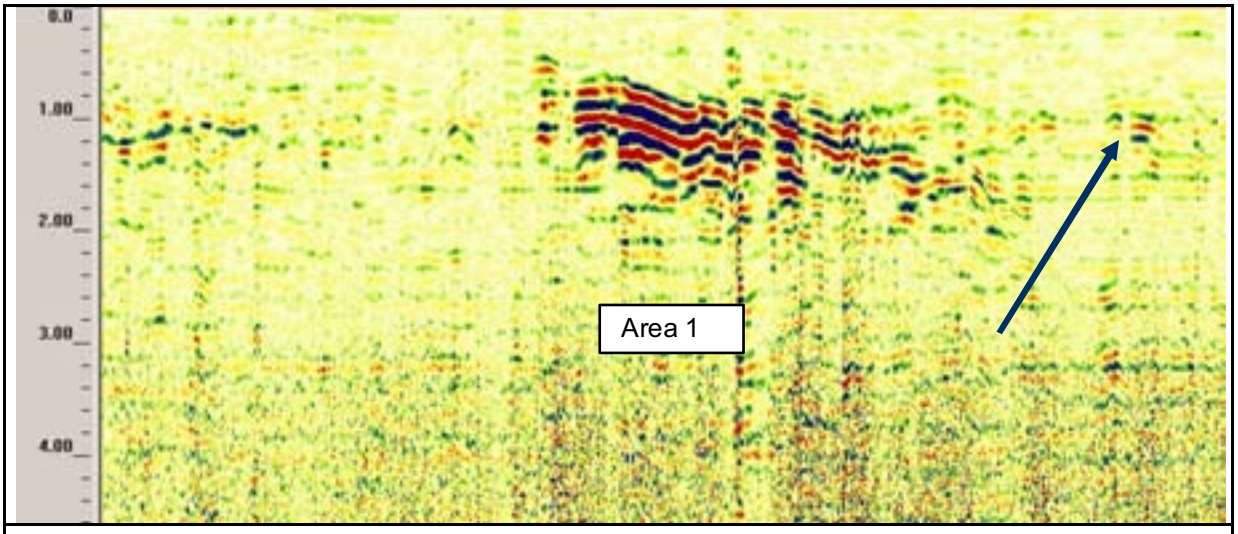

figure 19: radargram of a measuring along measuring line 10 (length: 29 m, GSSI, f = 270 MHz) with inhomogenities

LGA Bautechnik GmbH • Tillystraße 2 • 90431 Nürnberg
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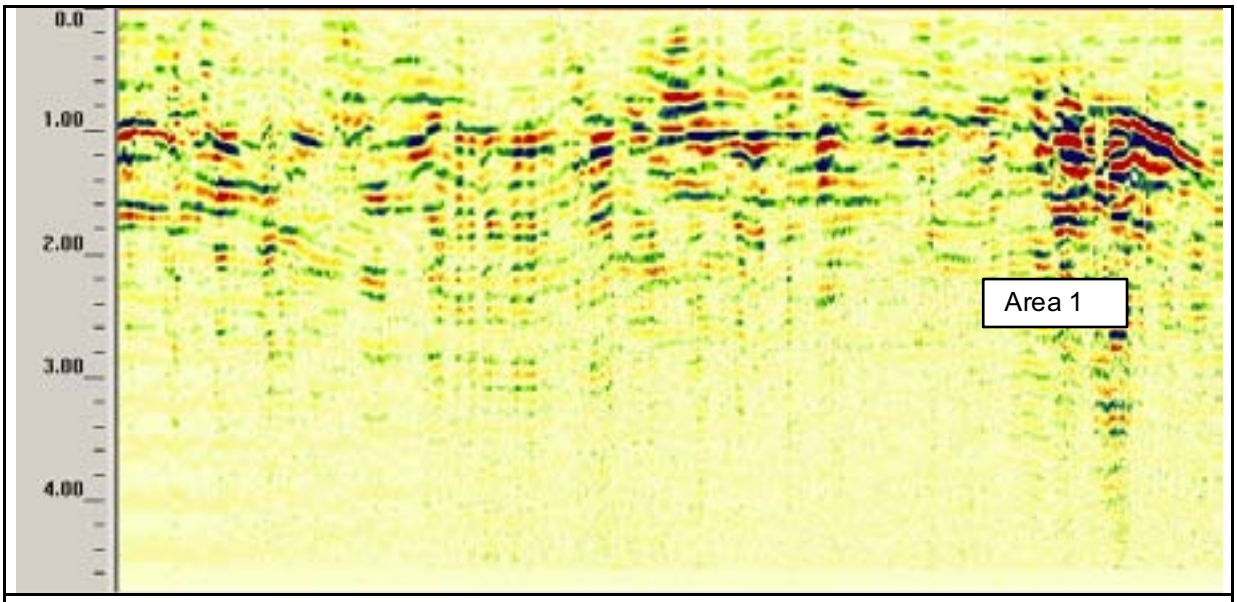

figure 20: radargram of a measuring along measuring line 11 (length: 23,7 m, GSSI, f = 270 MHz) with inhomogenities

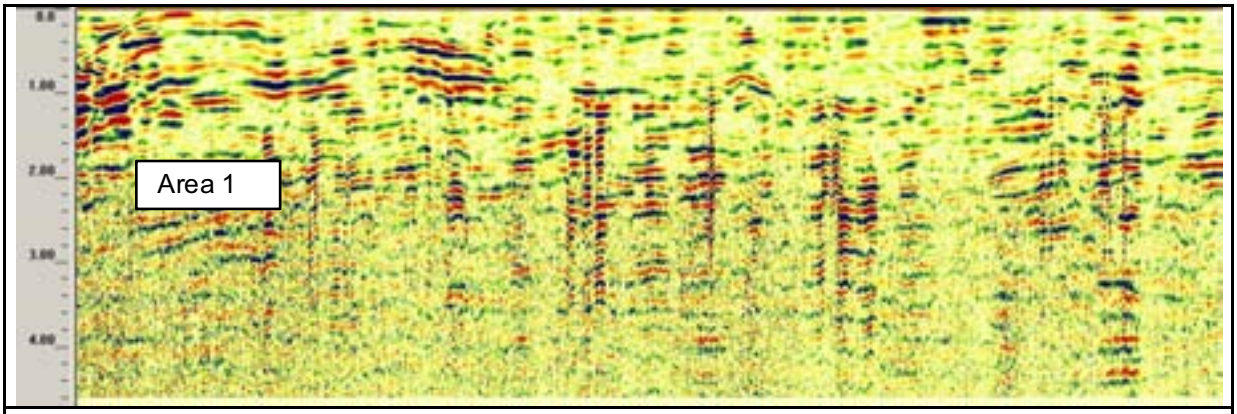

figure 21: radargram of a measuring along measuring line 12 (length: 19 m, GSSI, f = 270 MHz) with inhomogenities

LGA Bautechnik GmbH • Tillystraße 2 • 90431 Nürnberg
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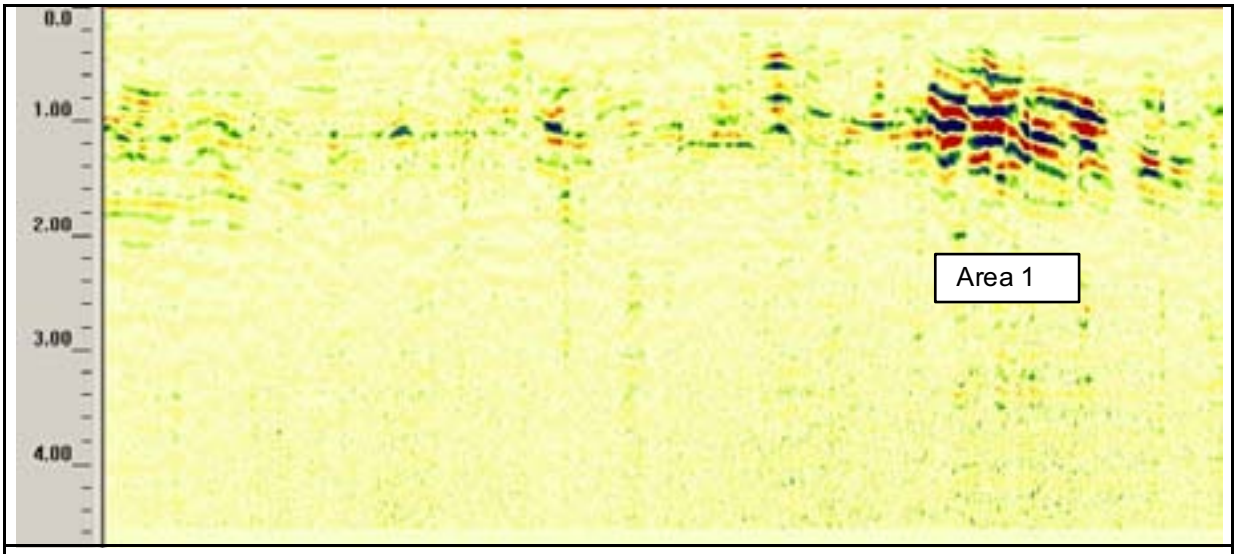

figure 22: radargram of a measuring along measuring line 13 (length: 25,3 m, GSSI, f = 270 MHz) with inhomogenities

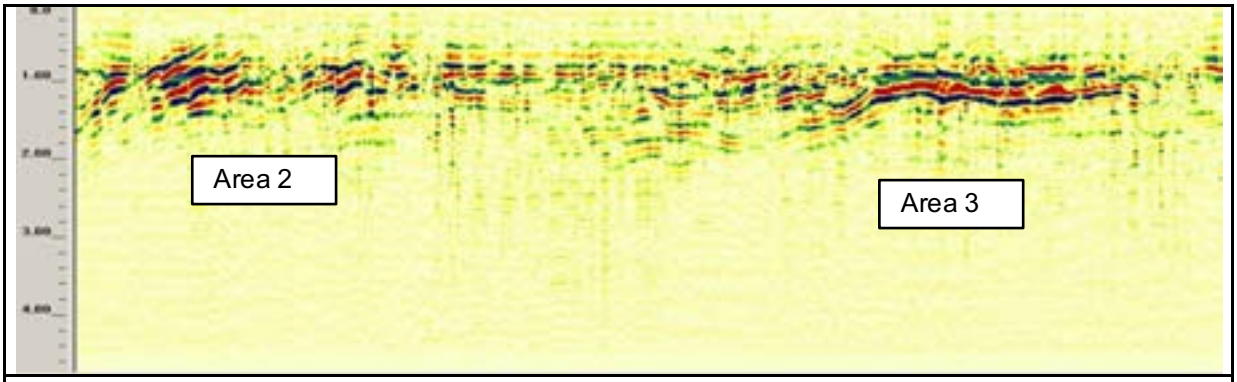

figure 23: radargram of a measuring along measuring line 14 (length: 51 m, GSSI, f = 270 MHz) with inhomogenities

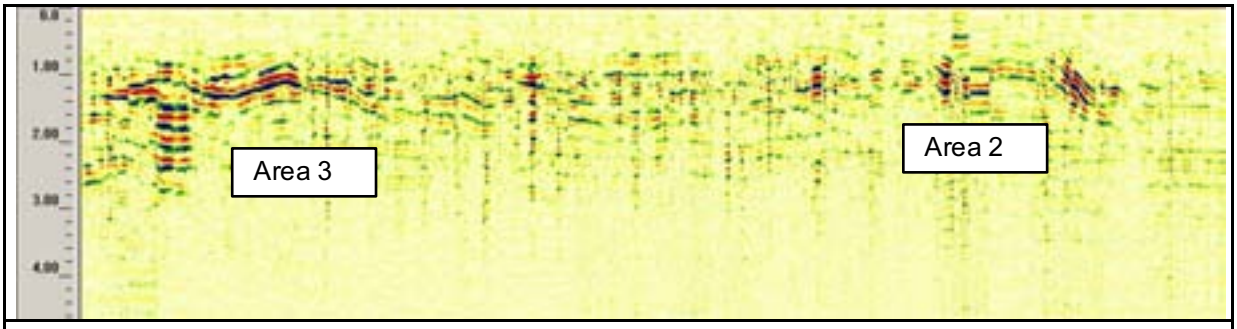

figure 24: radargram of a measuring along measuring line 15 (length: 57 m, GSSI, f = 270 MHz) with inhomogenities

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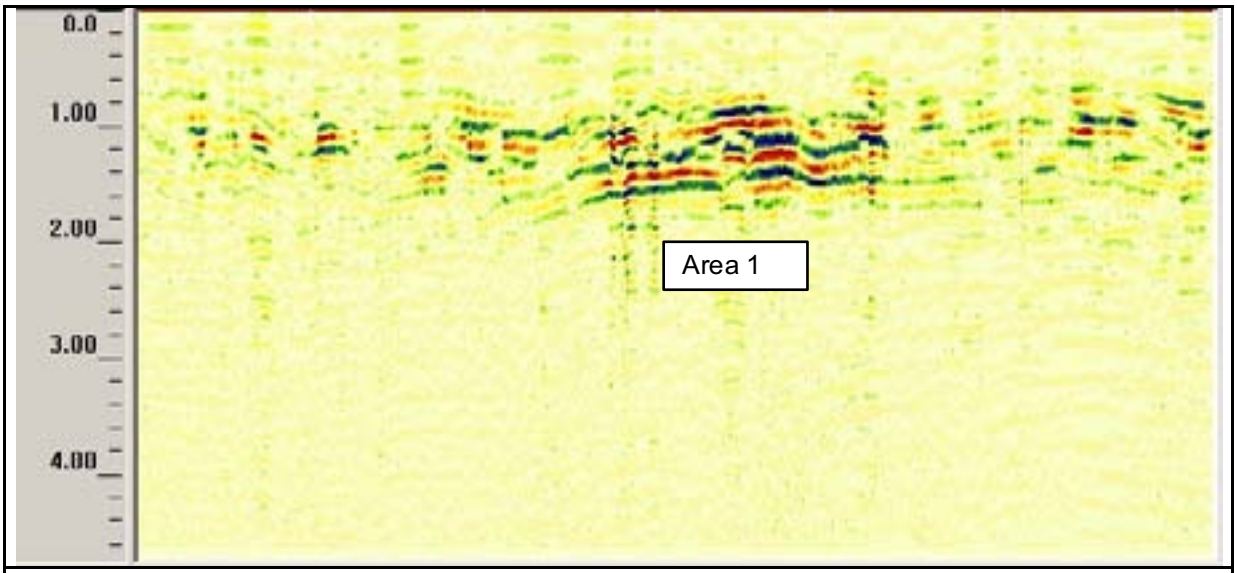

figure 25: radargram of a measuring along measuring line 16 (length: 19,6 m, GSSI, f = 270 MHz) with inhomogenities

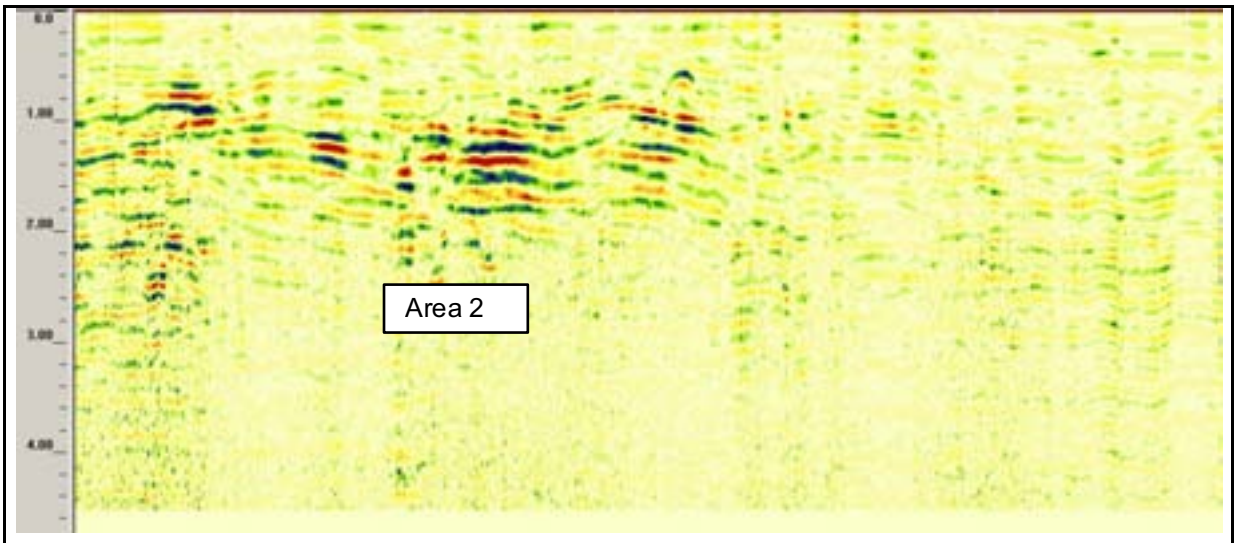

figure 26: radargram of a measuring along measuring line 17 (length: 19,4 m, GSSI, f = 270 MHz) with inhomogenities

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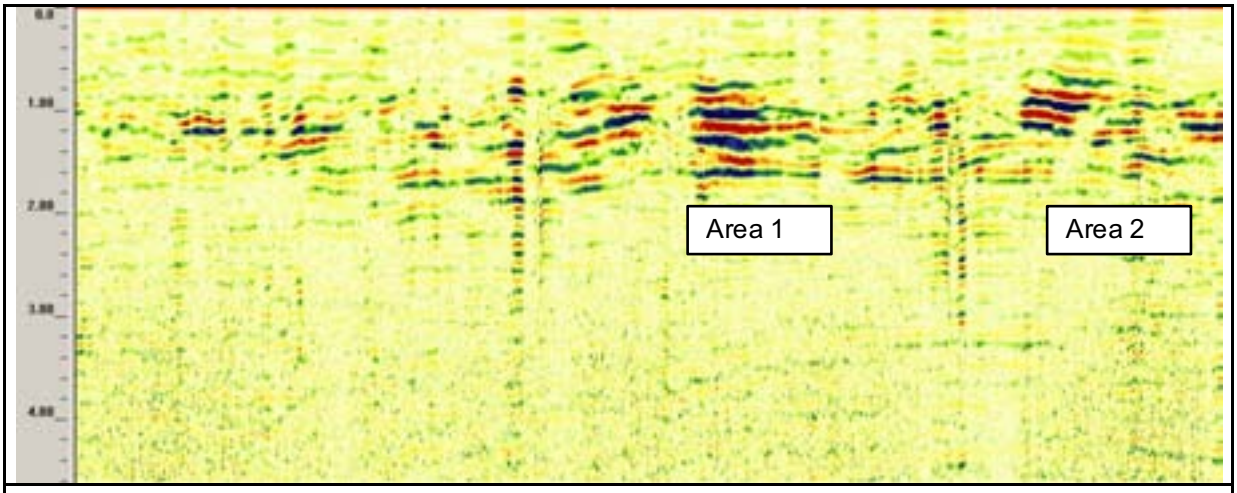

figure 27: radargram of a measuring along measuring line 18 (length: 19,4 m, GSSI, f = 270 MHz) with inhomogenities

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3 MEASUREMENTS AT THE KAPIJA

3.1 Local conditions

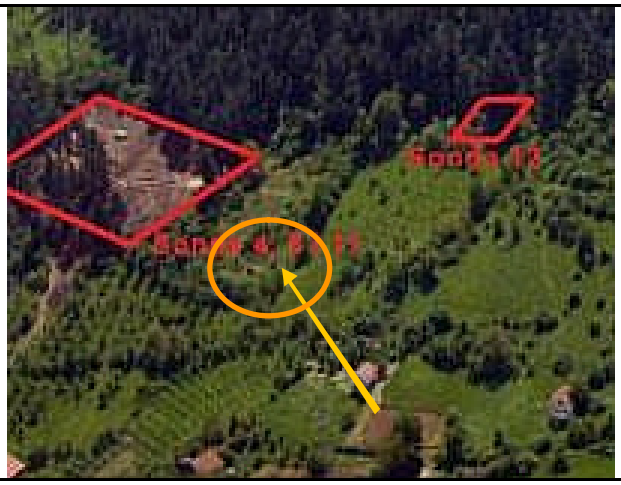

figure 28: area of measurements

The measurements where carried out at different areas closed to “Kapija”.

figure 29: view of measurements in kapija

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figure 30: view of measurements at area closed to kapija

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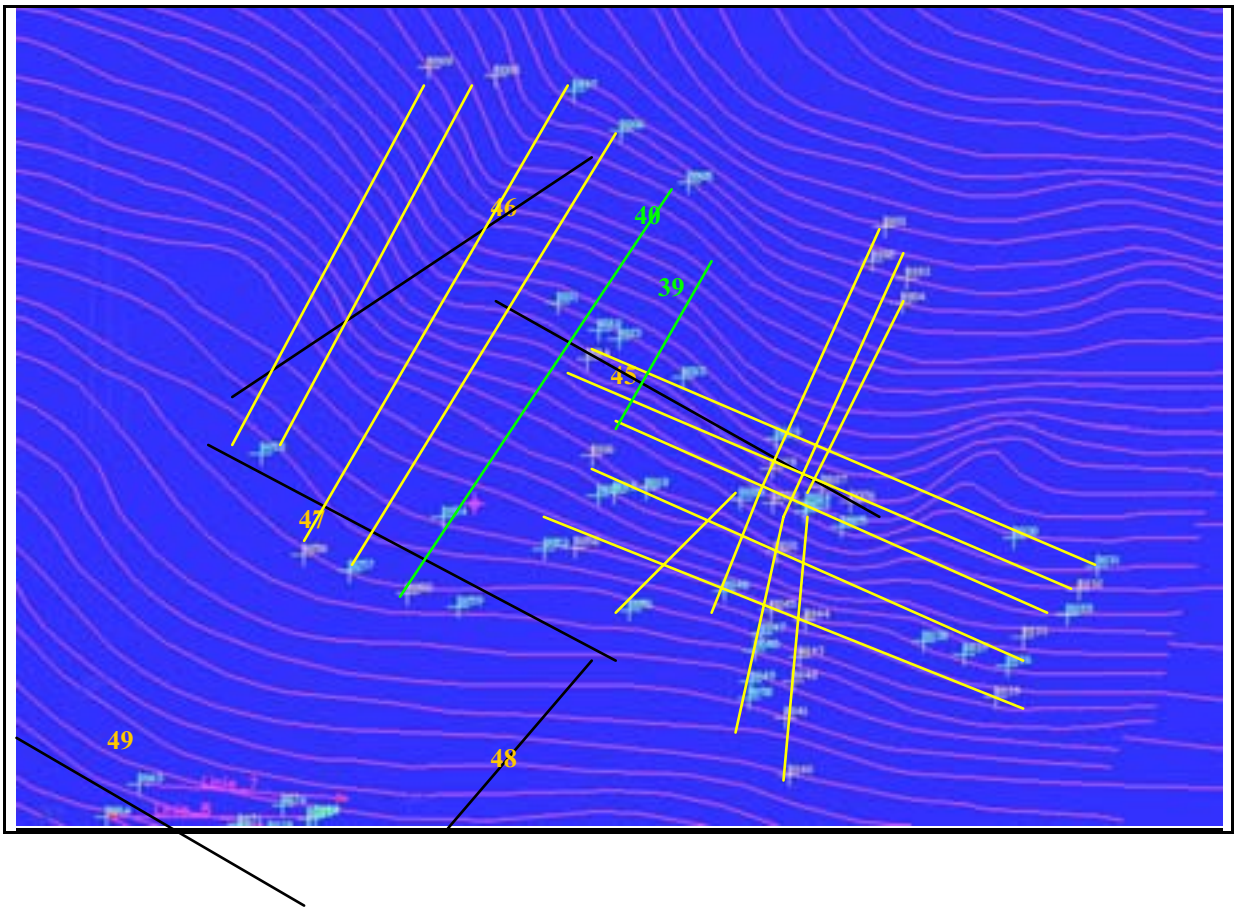
3.2 Coordinating System of the measuring area

The measuring lines go parallel or in right angle to the hill.



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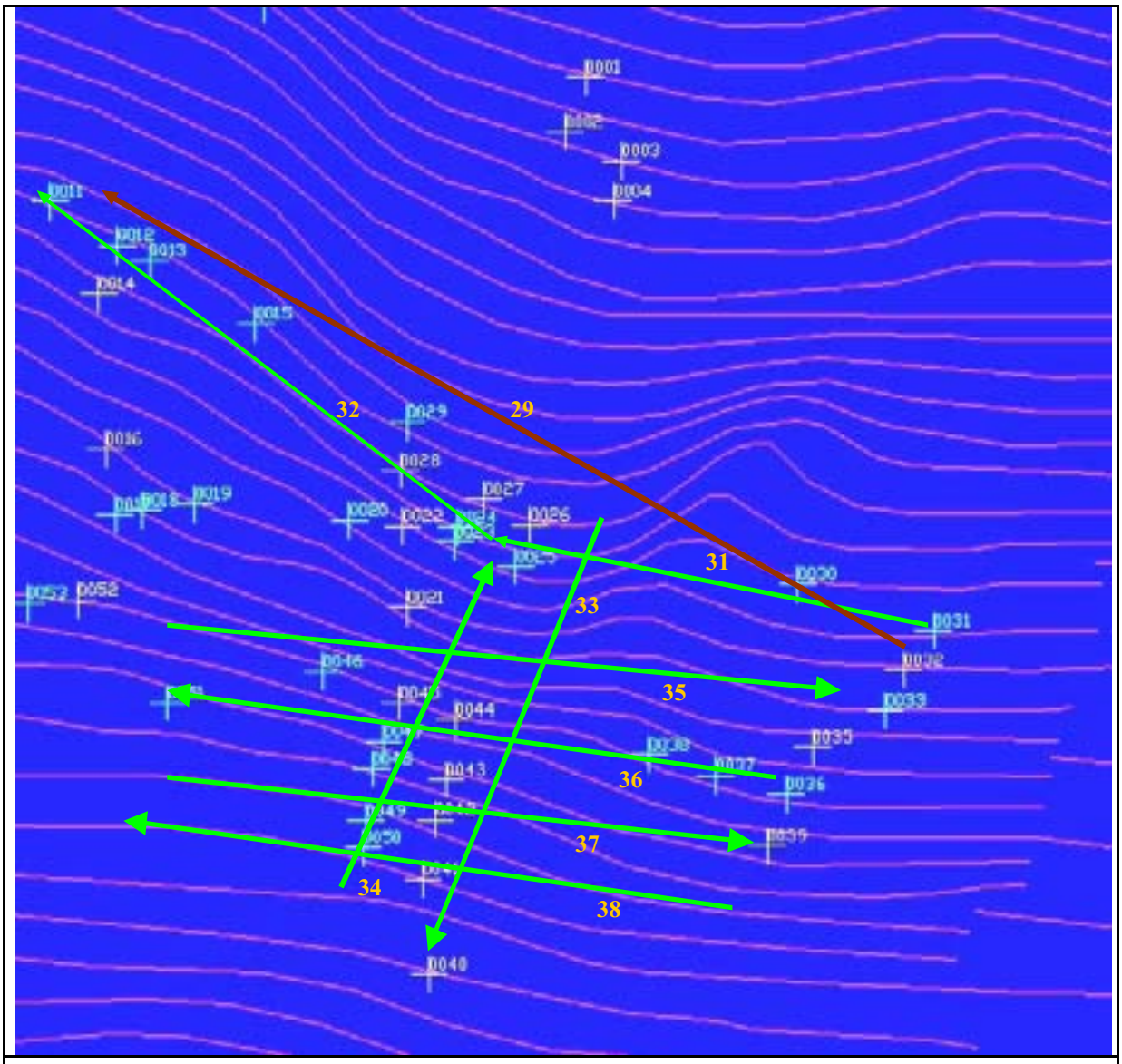

figure 31: overview of position of measuring lines

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3.3 RESULTS OF THE MEASUREMENTS

The measurements were done with an 270 MHz and an 100 MHz radar antenna. The ground was very wet which means the damping of the signals is high. Anywhere the results of the measurements were in the first 4 m very good. Following the results of measurements at the areacalld “Kapija” and the grassland closed to it are shown.

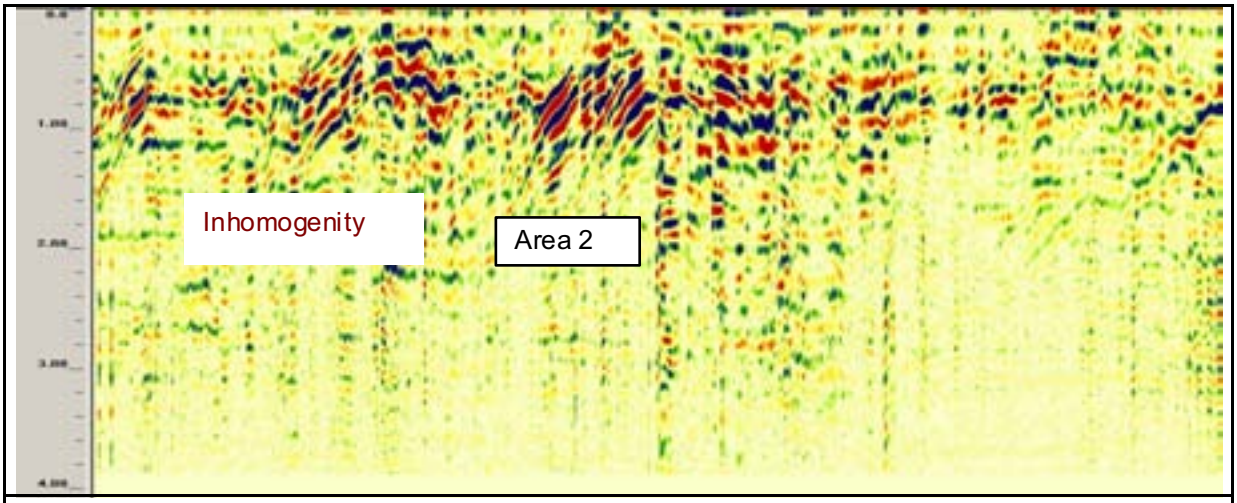

figure 32: radargram of a measuring along measuring line 32 (length: 48,3 m, GSSI, f = 270 MHz) with inhomogenities and edge of Kapija

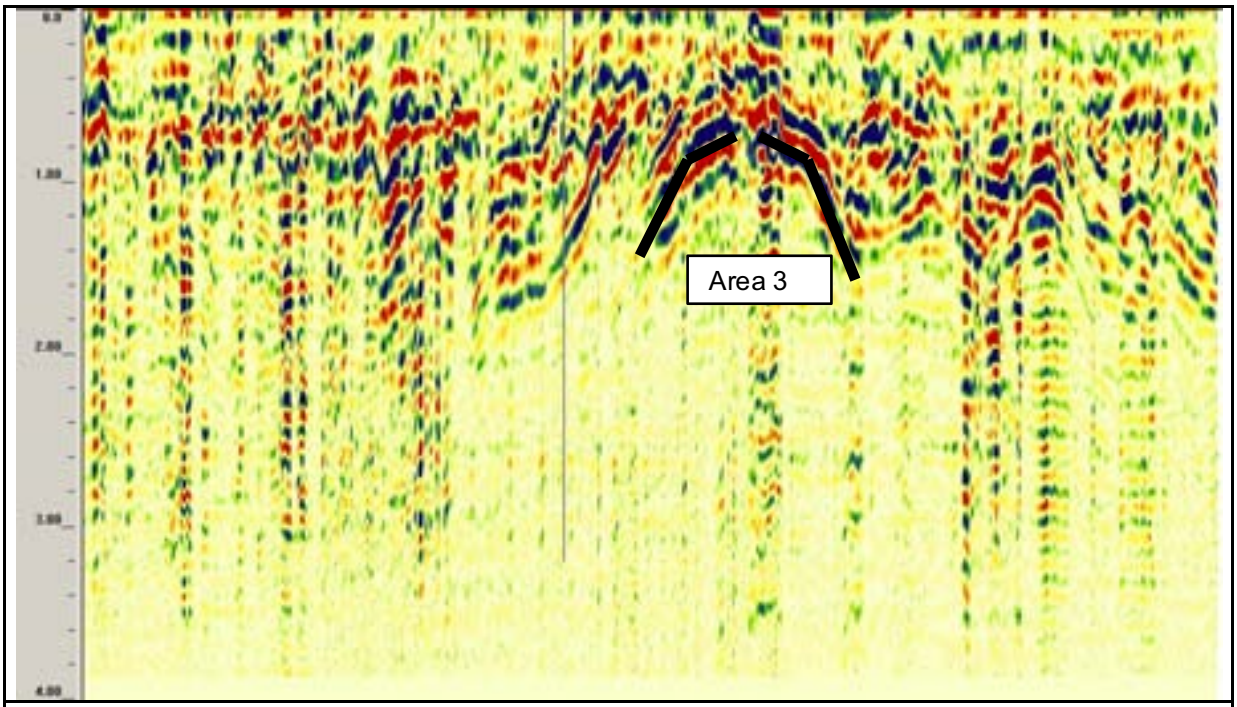

figure 33: radargram of a measuring along measuring line 37 (length: 57 m, GSSI, f = 270 MHz) with important inhomogenity at top of “Kapija”

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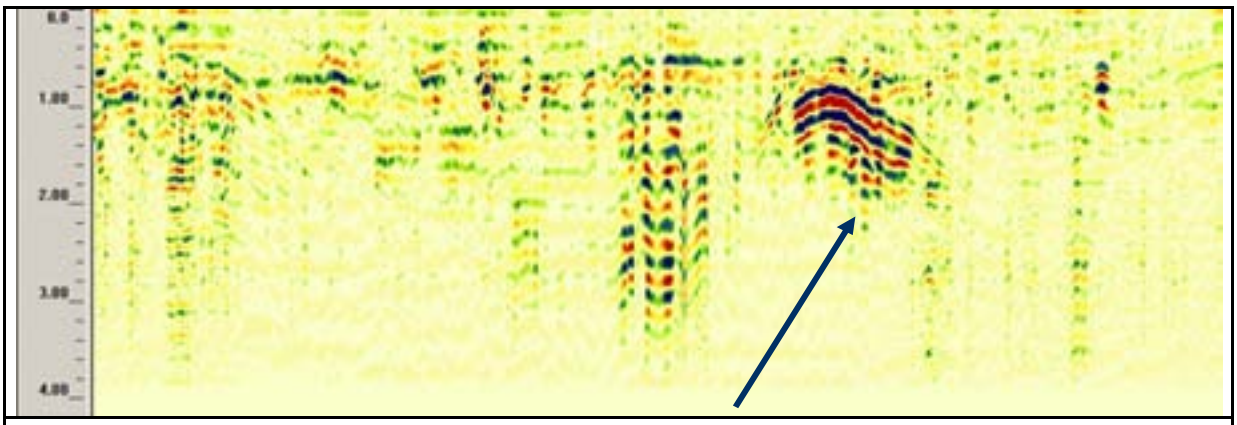
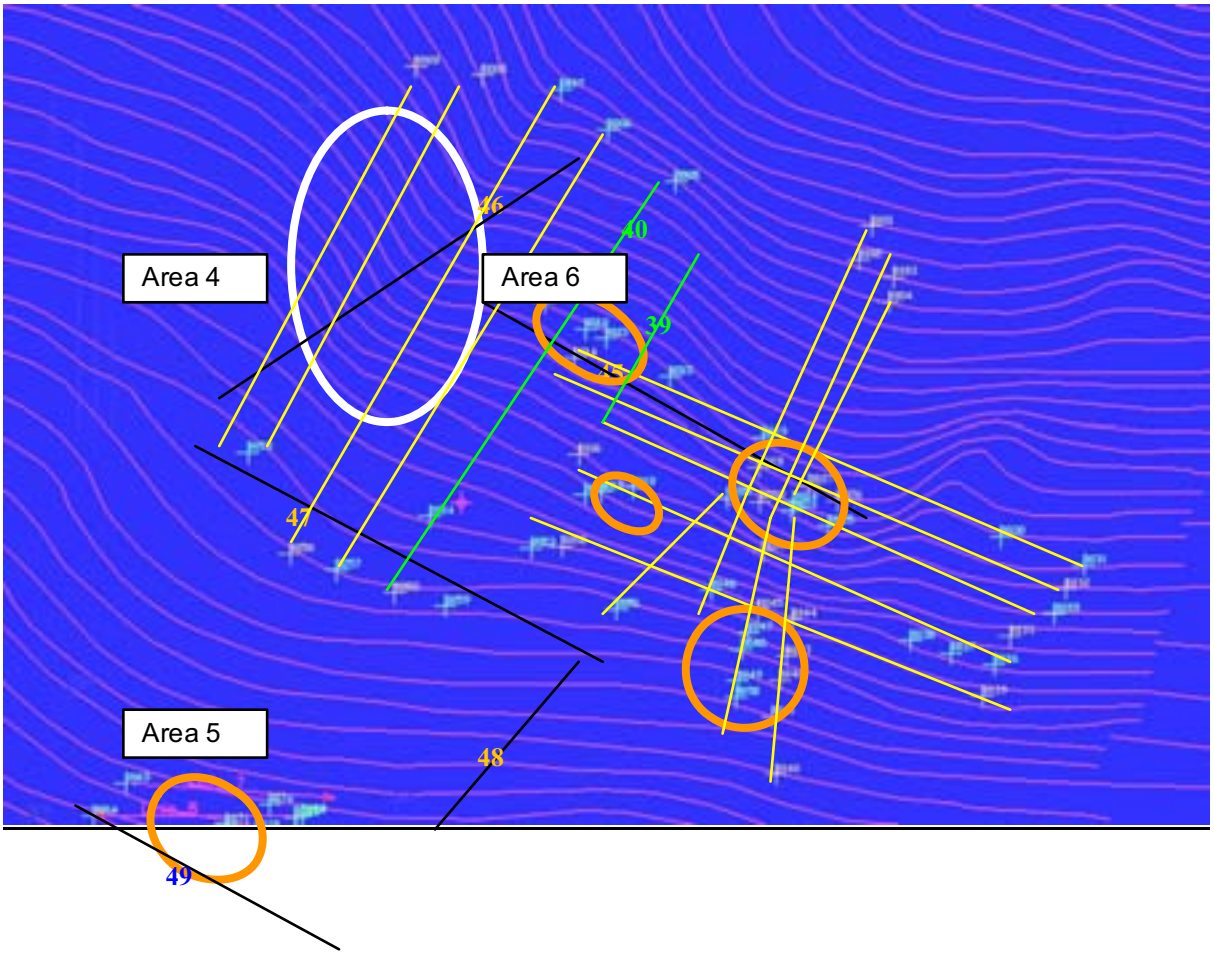


figure 34: radargram of a measuring along measuring line 49 (length: 50 m, GSSI, f = 270 MHz) with very interesting inhomogenity in grasland

3.4 EVALUATION OF RESULTS

In the picture above the measuring lines and the areas with inhomogenities are shown.



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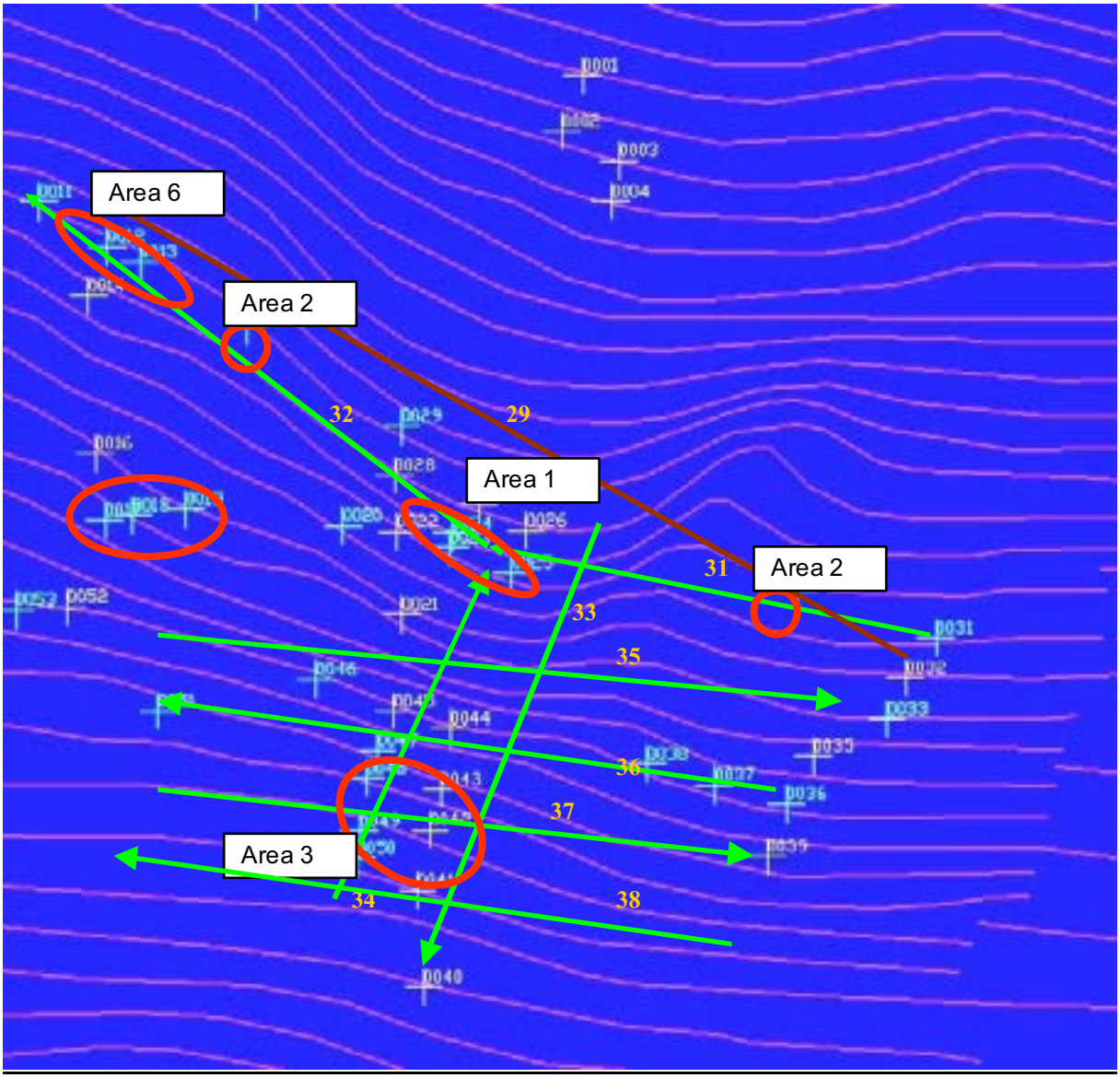

Area 1:	Depth of inhomogenity: 0,8-1,0 m
Area 2	Edge of Kapija (left and right) Depth of inhomogenity: 0,9 - 1,2 m
Area 3:	Edge of Kapija (top) Depth of inhomogenity: 0,9-1,0 m
Area 4:	In the whole area are no inhomogenies
Area 5:	North of all the measuring area Depth of inhomogenity: 0,9-1,0 m
Area 6:	Closed to area 2, outside of “Kapija” Depth of inhomogenity: 1,5 – 2,1 m

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3.5 RADARGRAMS OF MEASUREMENTS

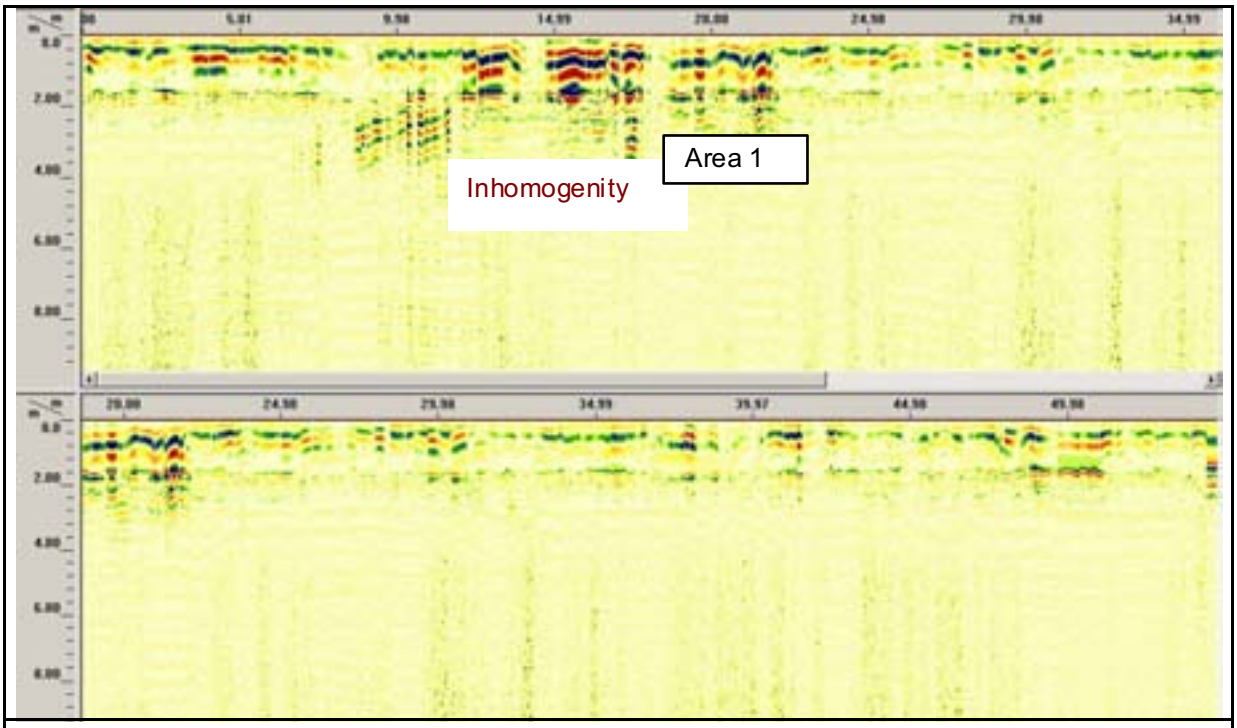

figure 35: radargram of a measuring along measuring line 29 (length: 55,0 m, GSSI, f = 100 MHz) with inhomogenity

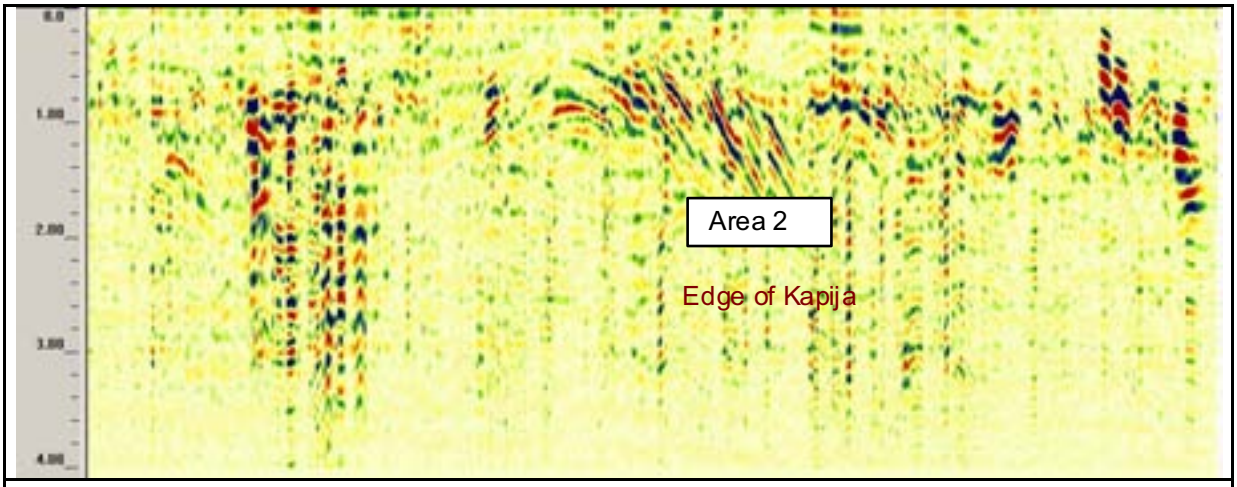

figure 36: radargram of a measuring along measuring line 31 (length: 52,1 m, GSSI, f = 270 MHz) with inhomogenities and edge of Kapija

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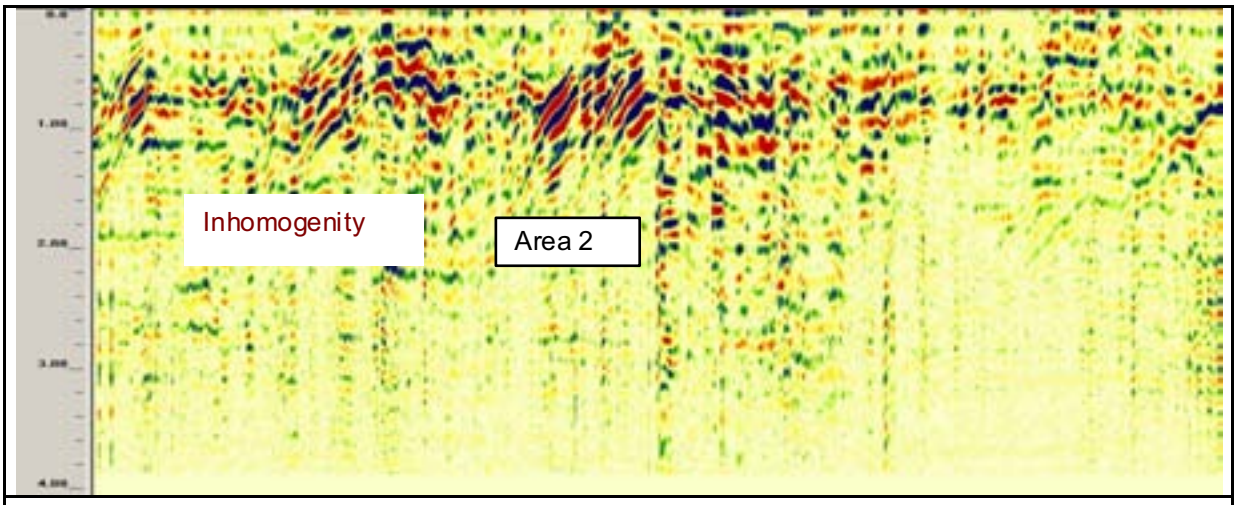

figure 37: radargram of a measuring along measuring line 32 (length: 48,3 m, GSSI, f = 270 MHz) with inhomogenities and edge of Kapija

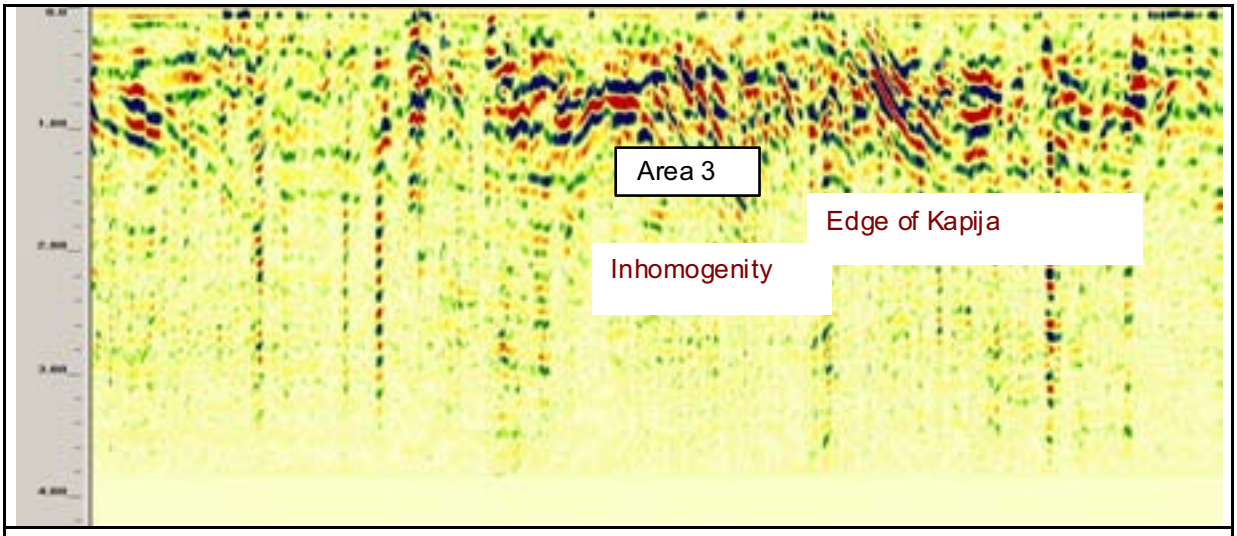

figure 38: radargram of a measuring along measuring 33 line (length: 50,4 m, GSSI, f = 270 MHz) with inhomogenities and edge of Kapija

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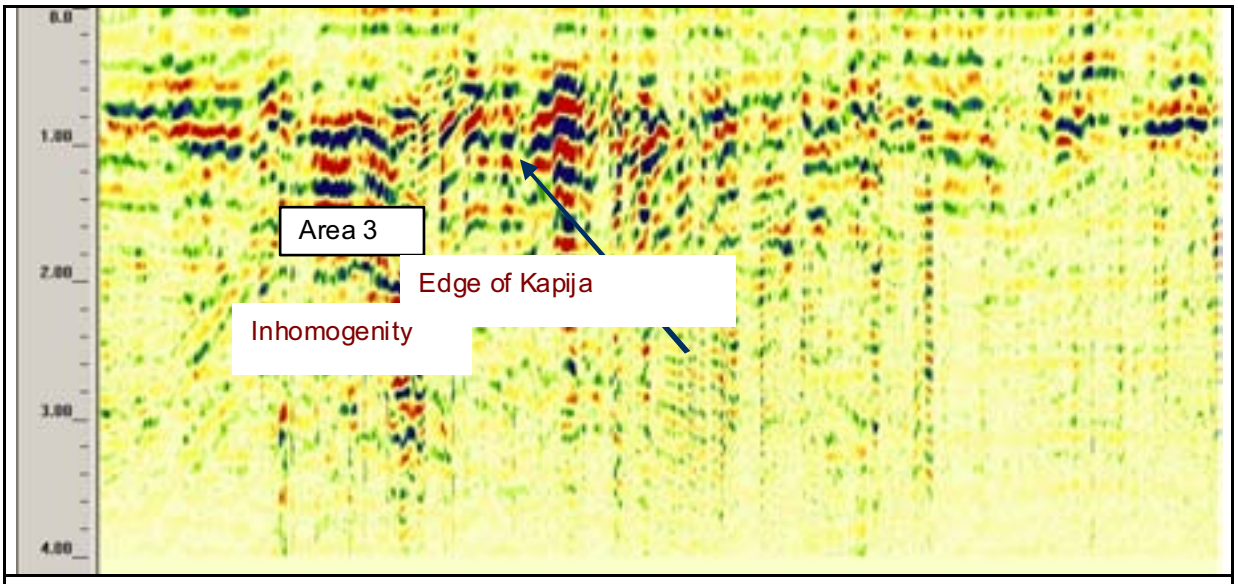

figure 39: radargram of a measuring along measuring line 34 (length: 46,1 m, GSSI, f = 270 MHz) with inhomogenities and edge of Kapija

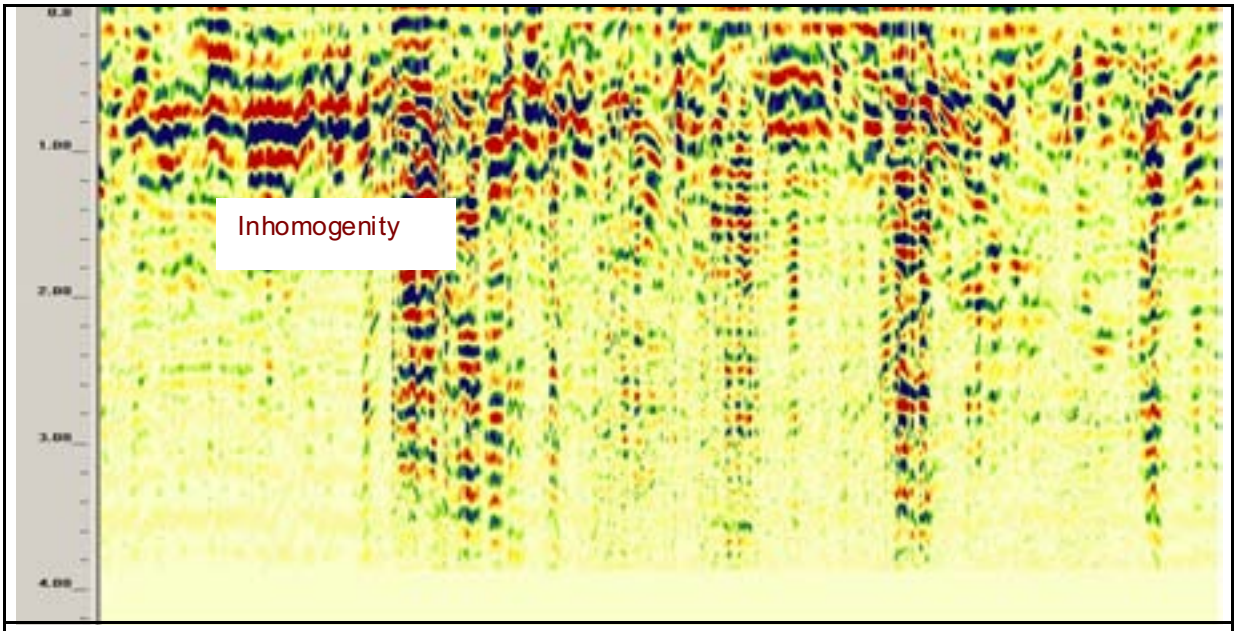

figure 40: radargram of a measuring along measuring line 35 (length: 43,9 m, GSSI, f = 270 MHz) with inhomogenities

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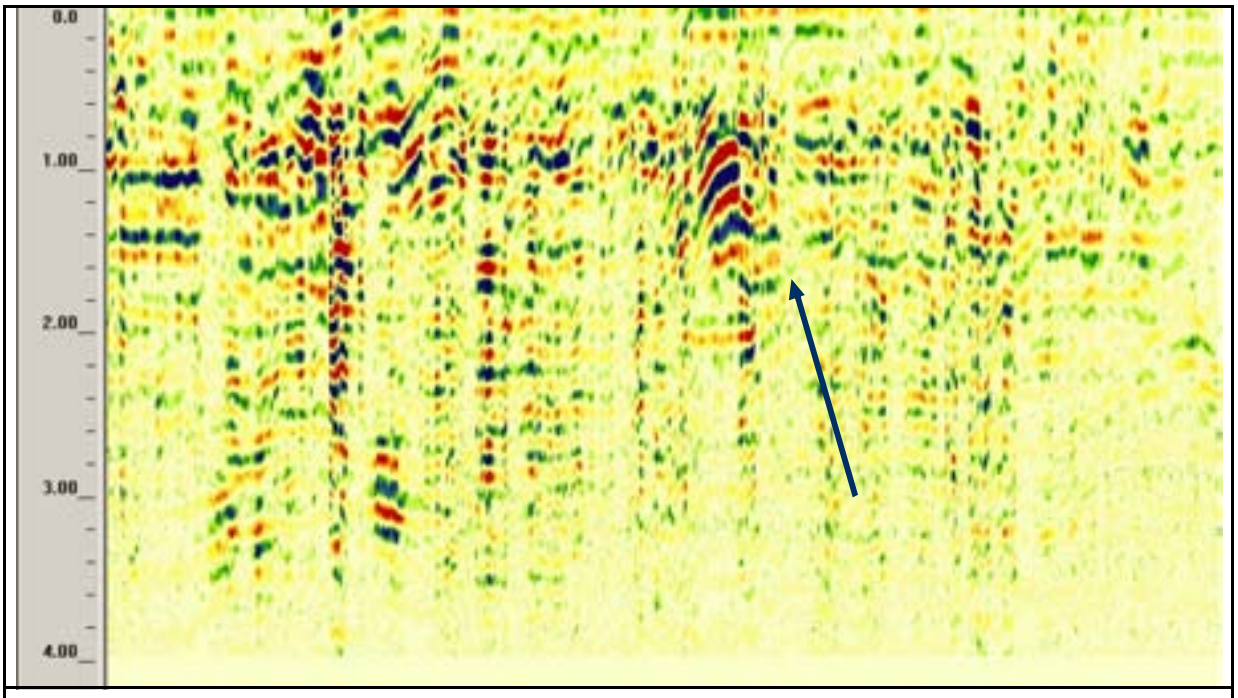

figure 41: radargram of a measuring along measuring line 36 (length: 42 m, GSSI, f = 270 MHz) with inhomogenities

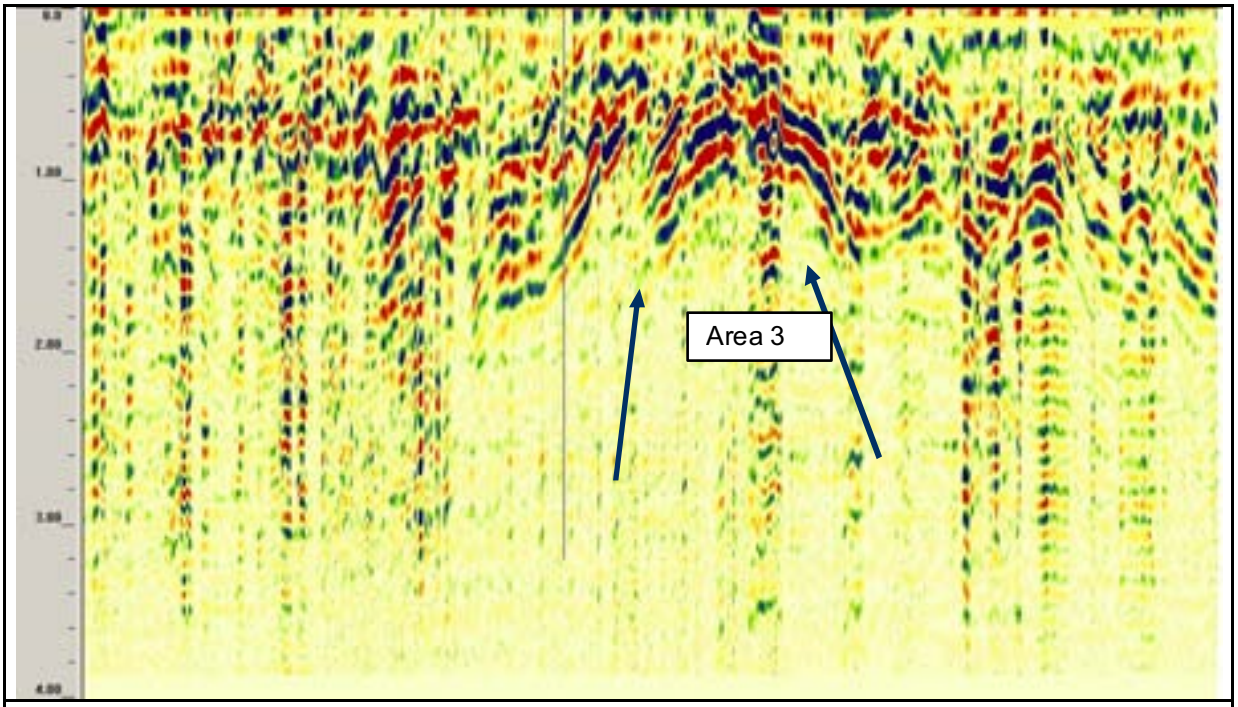

figure 42: radargram of a measuring along measuring line 37 (length: 57 m, GSSI, f = 270 MHz) with important inhomogenity

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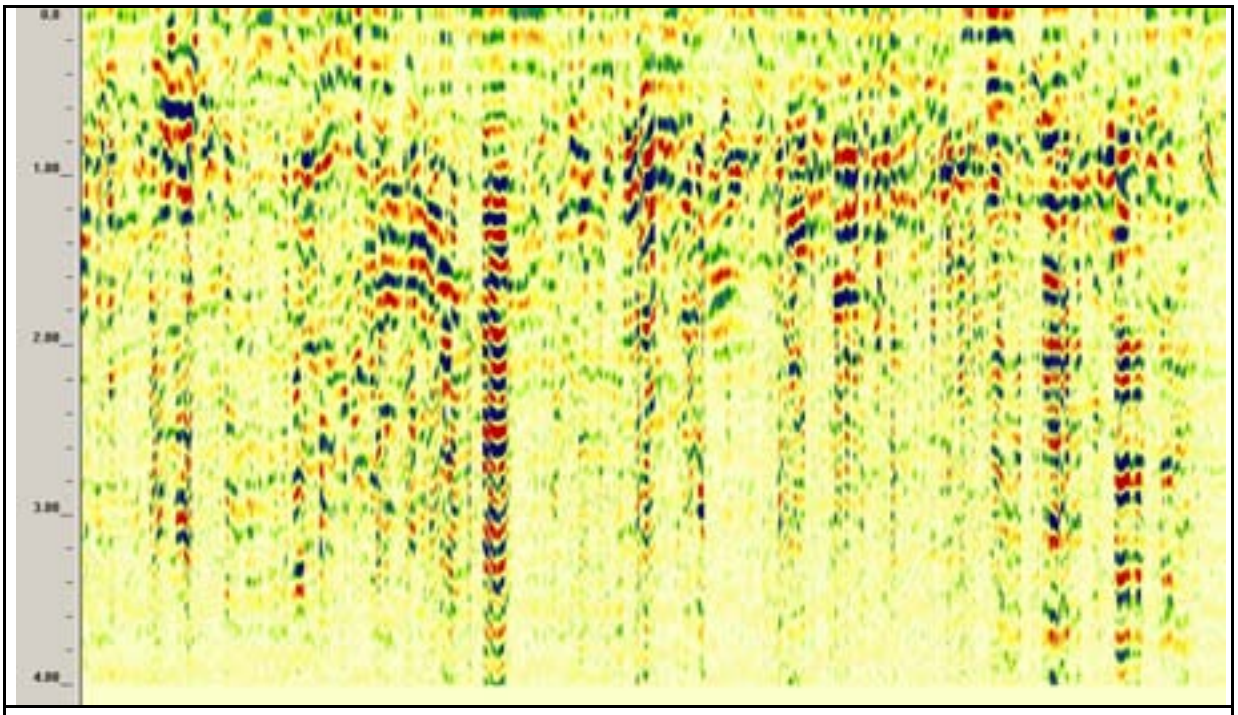

figure 43: radargram of a measuring along measuring line 38 (length: 57 m, GSSI, f = 270 MHz) with small reflectors

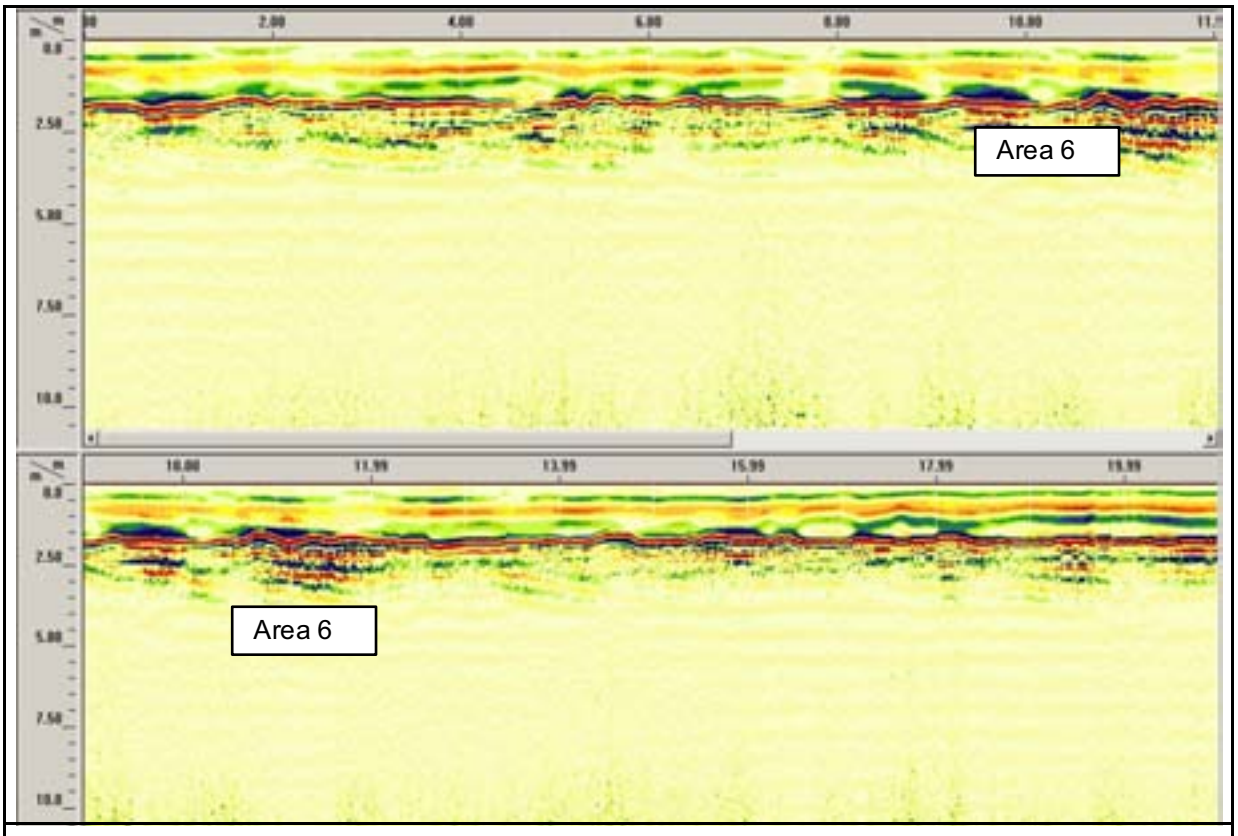

figure 44: radargram of a measuring along measuring line 39 (length: 21 m, GSSI, f = 100 MHz) with inhomogenities

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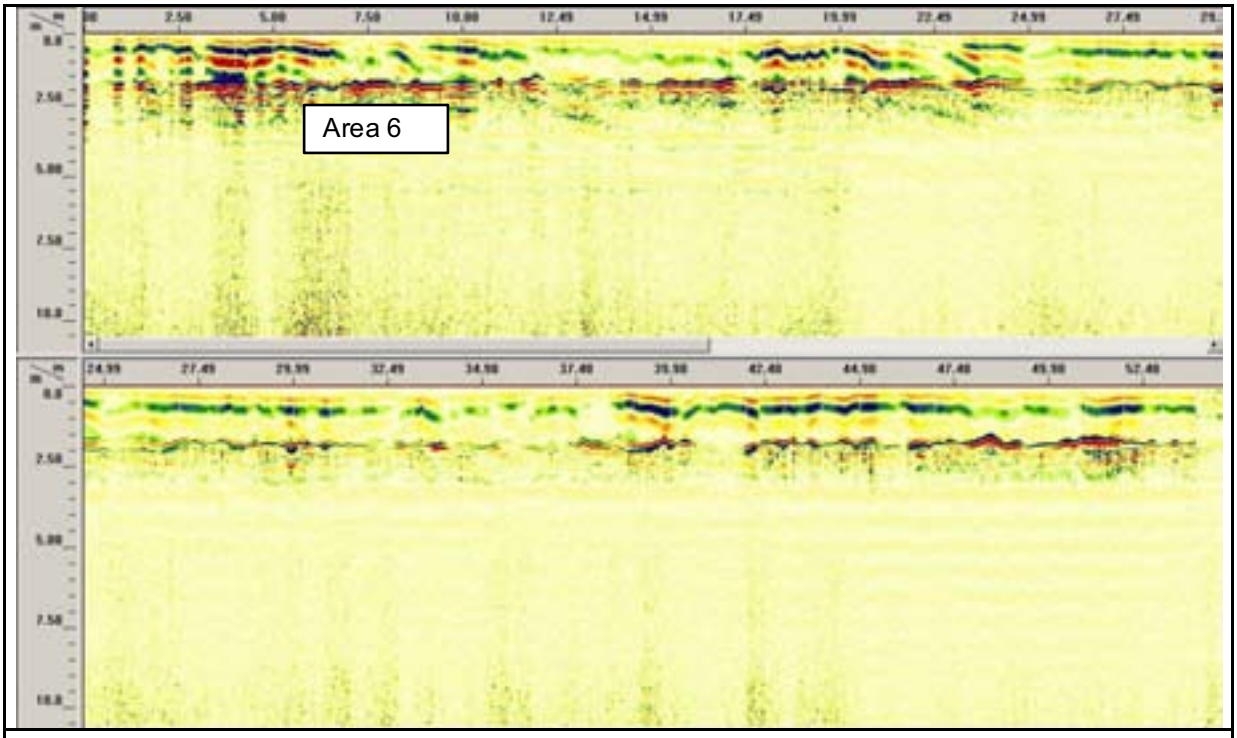

figure 45: radargram of a measuring along measuring line 40 (length: 54,5 m, GSSI, f = 100 MHz) with small inhomogenities

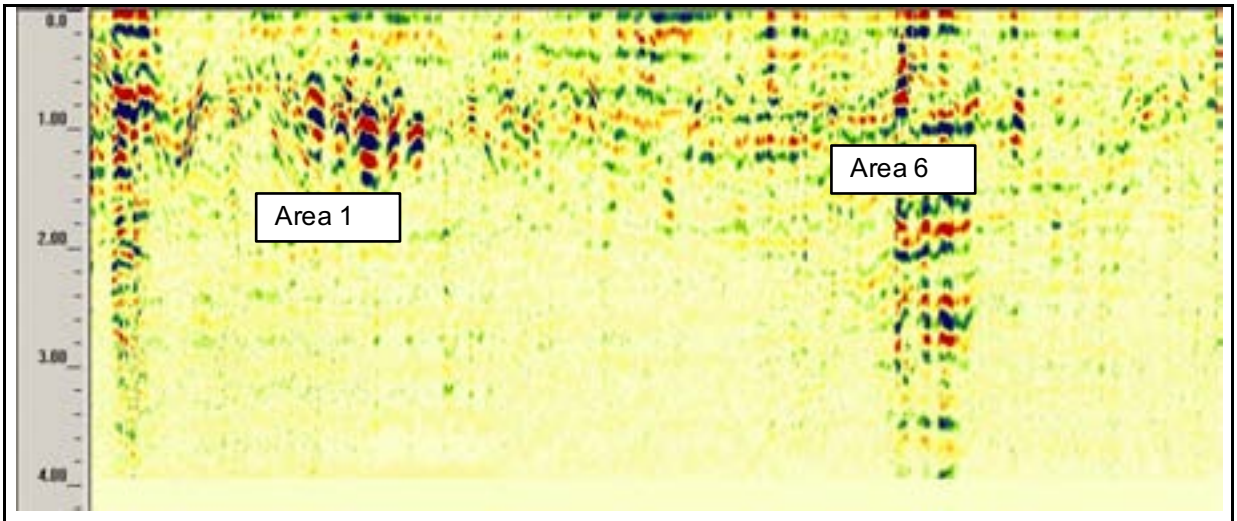

figure 46: radargram of a measuring along measuring line 45 (length: 51 m, GSSI, f = 270 MHz) with inhomogenities

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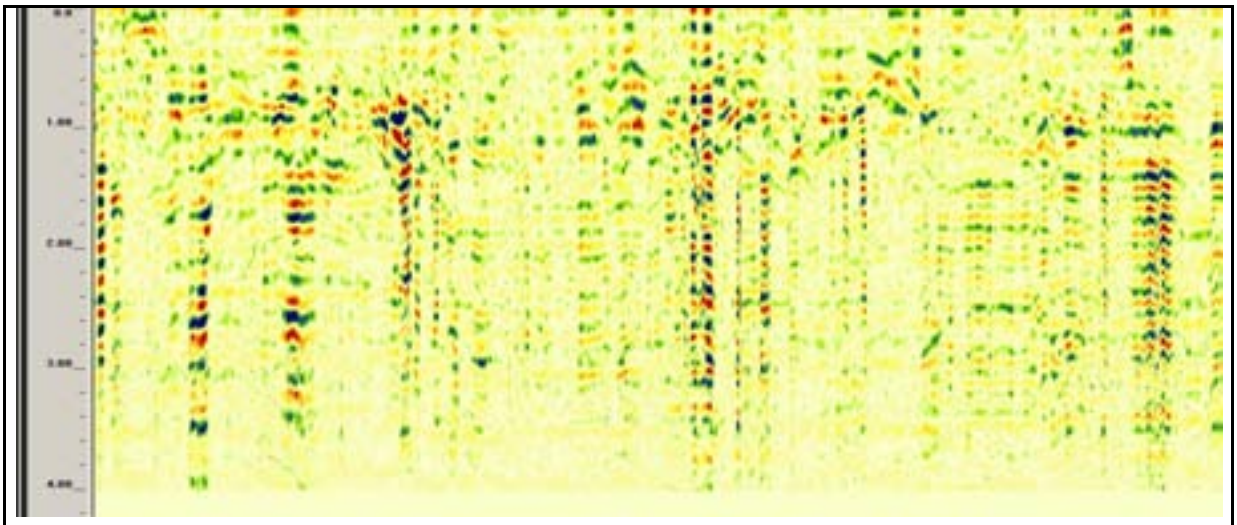

figure 47: radargram of a measuring along measuring line 46 (length: 43 m, GSSI, f = 270 MHz) with no inhomogenities

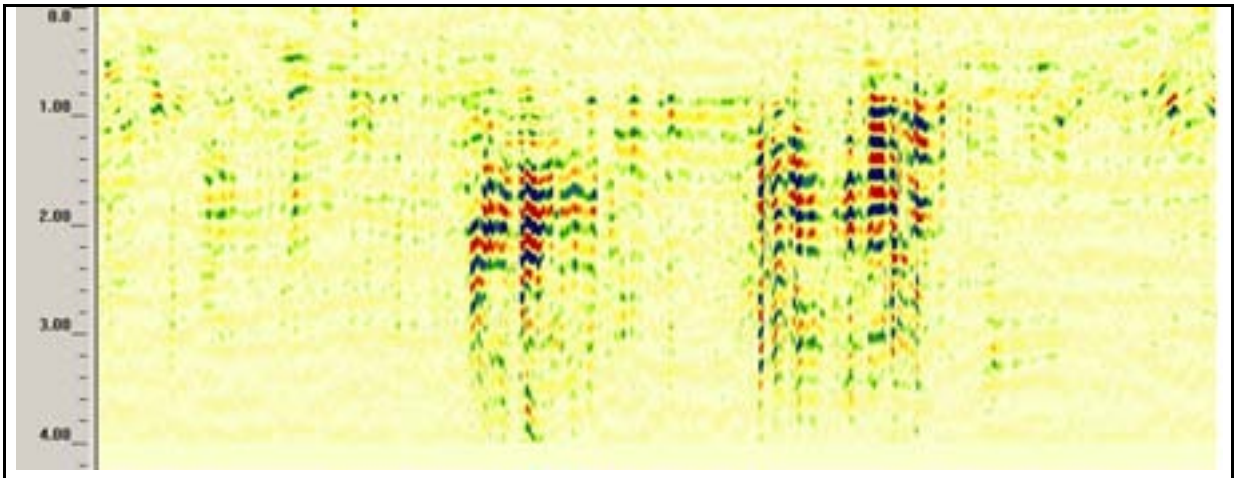

figure 48: radargram of a measuring along measuring line 47 (length: 46 m, GSSI, f = 270 MHz) with inhomogenities

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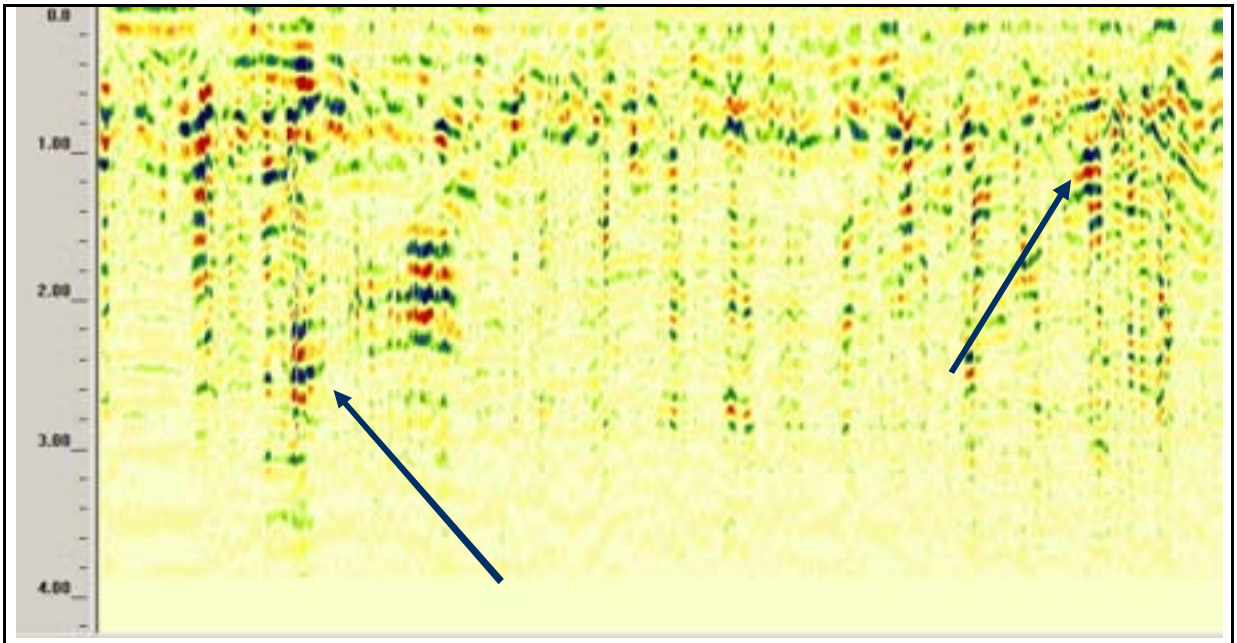

figure 49: radargram of a measuring along measuring line 48 (length: 44 m, GSSI, f = 270 MHz) with inhomogenities

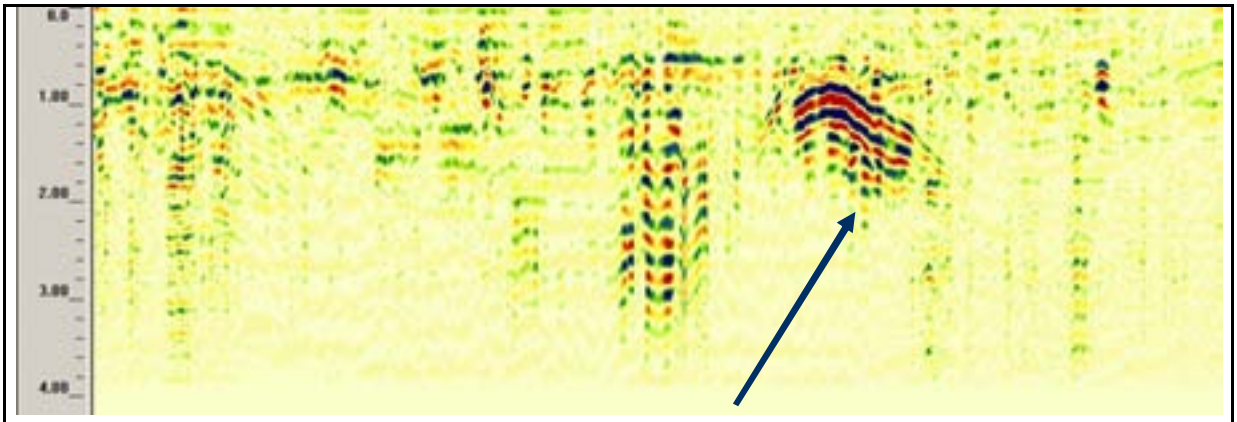

figure 50: radargram of a measuring along measuring line 49 (length: 50 m, GSSI, f = 270 MHz) with very interesting inhomogenity

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4 STONE PLATES OBOVE GRASSLAND OF KAPIJA

4.1 Local conditions

figure 51: area of measurements

The measurements where done at different areas near to the stone plates at the edge of the forest.

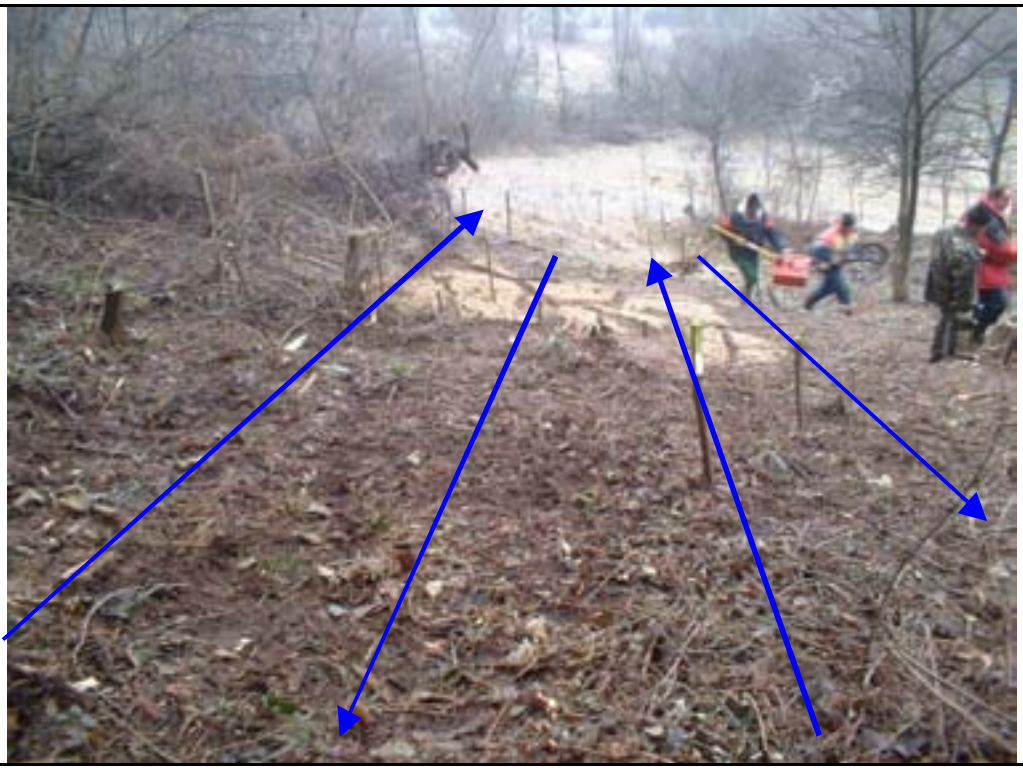

figure 52: view of measurements with sticks to sign the inhomogenities

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4.2 Coordinating System of the measuring area

The measuring lines go parallel or in right angle to the hill.

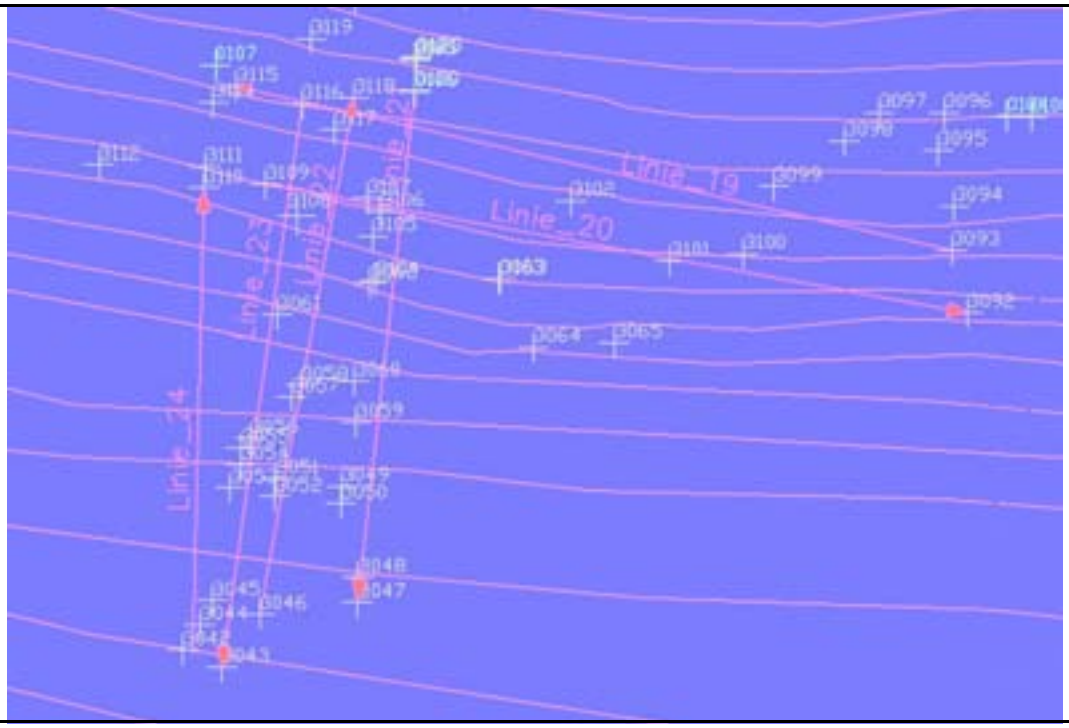

figure 53: overview of position of measuring lines 19-24

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4.3 RESULTS OF THE MEASUREMENTS

The measurement shows, that it is possible to find inhomogenities with radar. Beside the expected echo of the stone plates are even some other results.

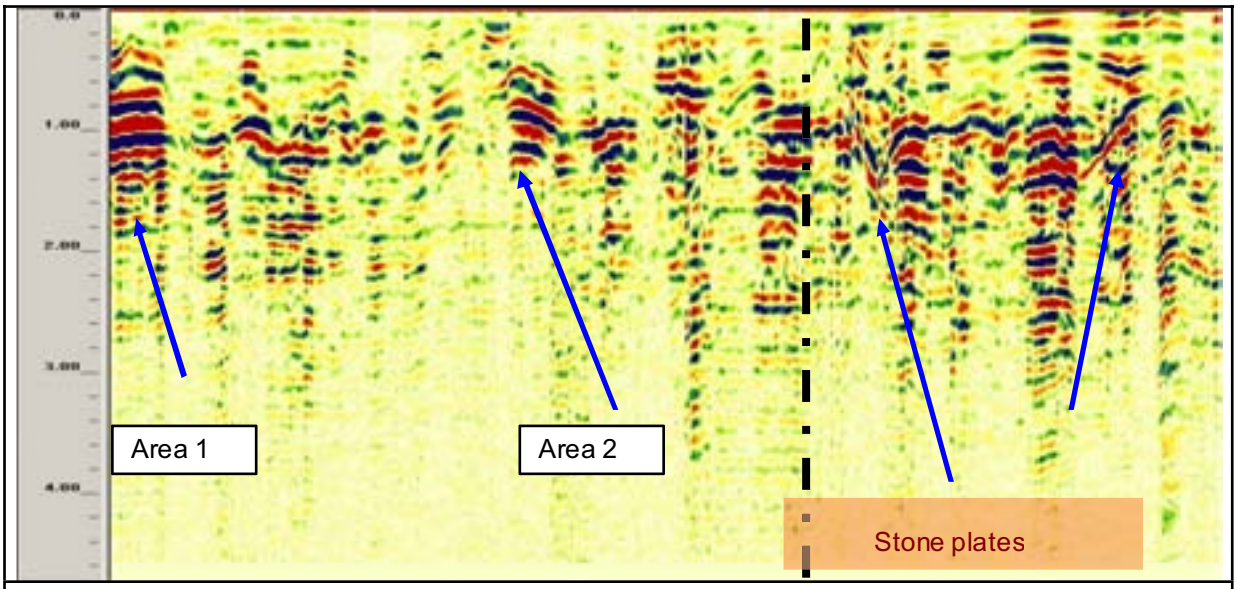

figure 54: radargram of a measuring measuring line 24 (length: 27 m) (GSSI, f = 270 MHz), the left two arrows show inhomogenities in the ground, the right arrows show the beginning and end of the stone plates

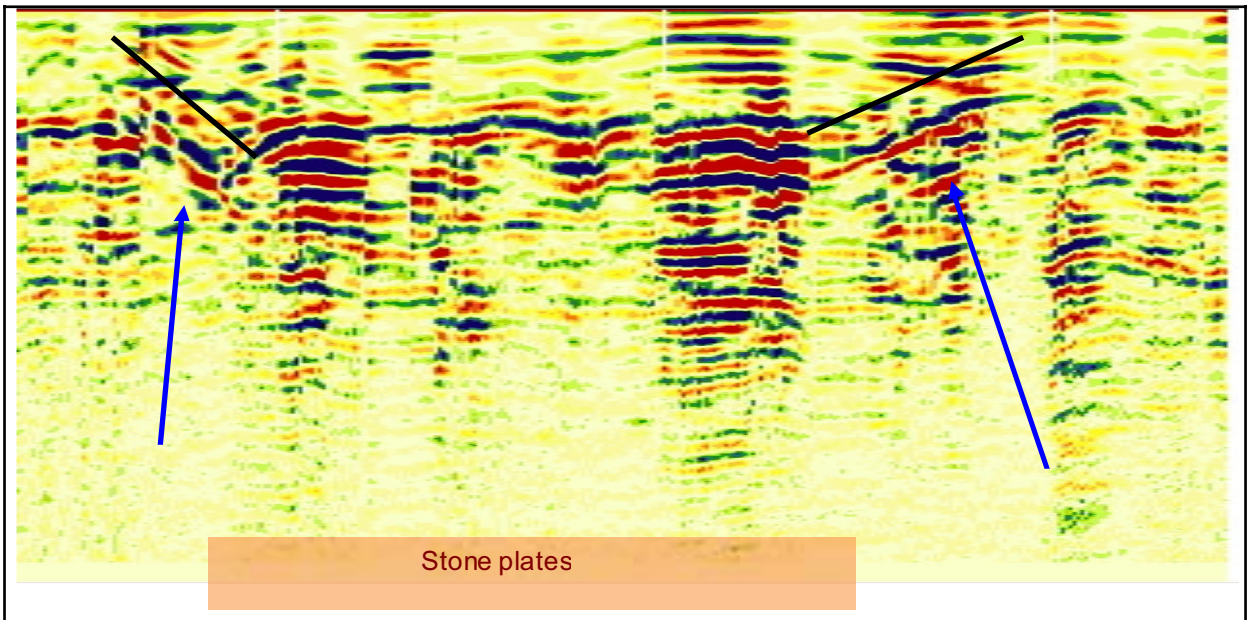

figure 55: part of radargram above to see more details: left the beginning and right the end of the stone plates, because of the moving of the antenna like a diagonal line

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4.4 EVALUATION OF RESULTS

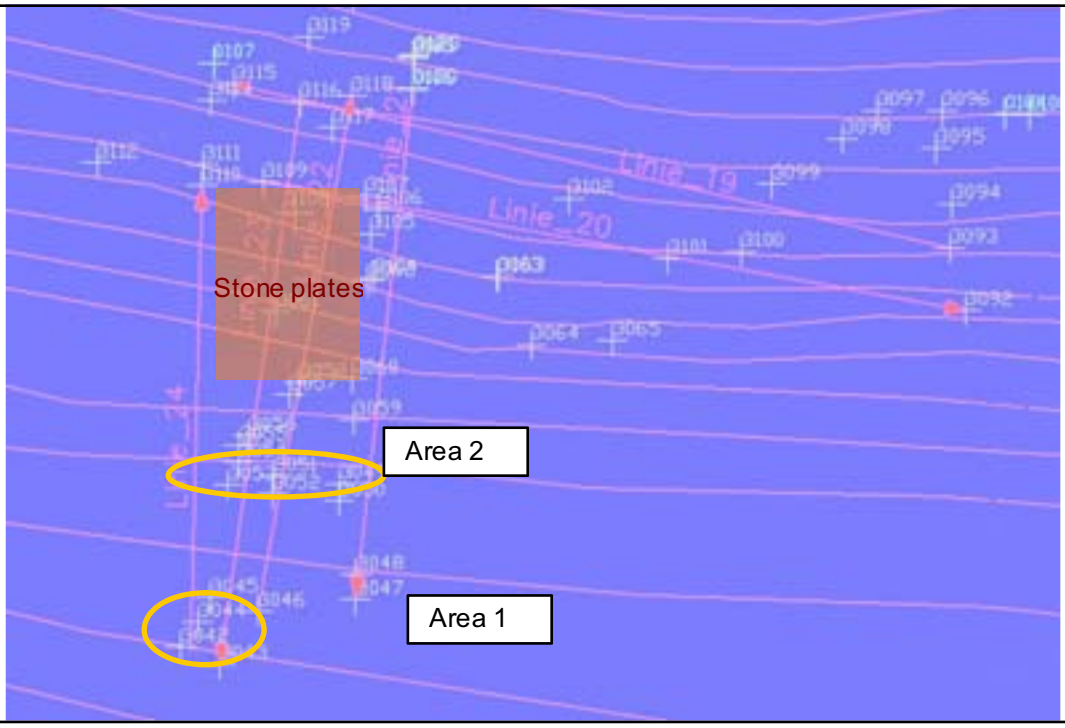

figure 56: overview of position of measuring lines with the areas of inhomogenities and the stone plates

Area 1:	At the end of line 23 and beginning of line 24 (in the forest) Depth of inhomogenity: 0,9 m
Area 2	Area hit by line 21, line 22, line 23, line 24 Depth of inhomogenity: 1,2 m

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Tel.: +49 (0) 911 655-5561 Fax: +49 (0) 911 655-5536
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figure 57: marked inhomogenities in the measuring field (Area 2)

4.5 RADARGRAMS OF MEASUREMENTS

In the appendix all radargrams of the measurements are shown.

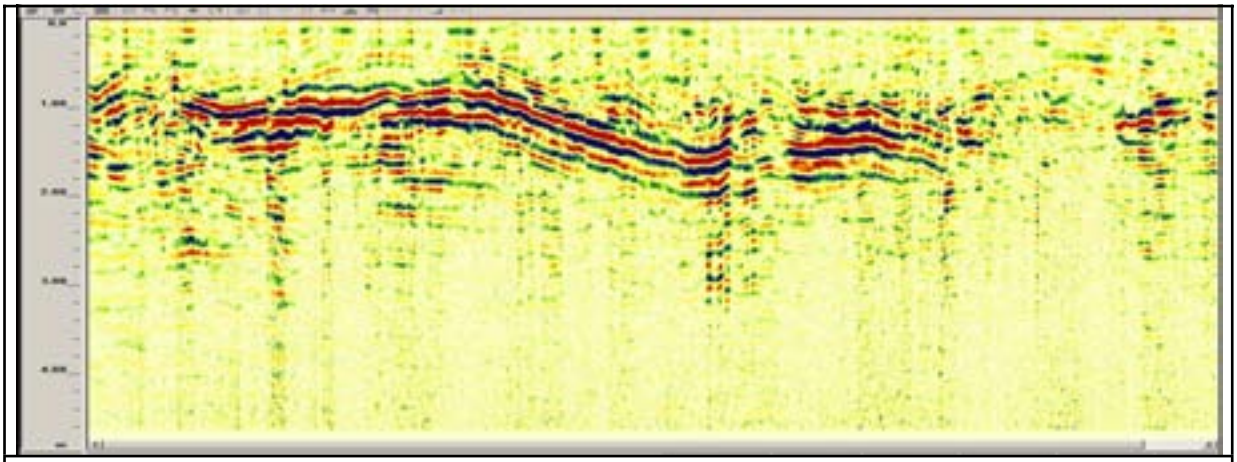

figure 58: radargram of a measuring along measuring line 19 (length: 38,5 m GSSI, f = 270 MHz) with echo from a depth of 1,0 1,5 m along the line

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E-Mail: andreas.hasenstab@lga.de http://www.lga.de

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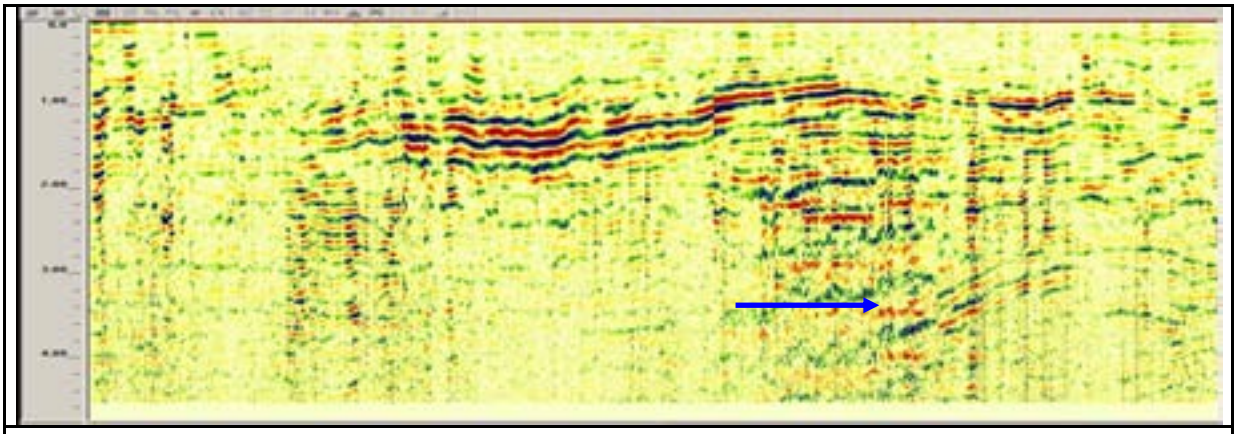

figure 59: radargram of a measuring along measuring line 20 (length: 38 m, GSSI, f = 270 MHz) with echo from a depth of 1,2 – 0,9 m along the line (and also echo from 3,5 m in the right part)

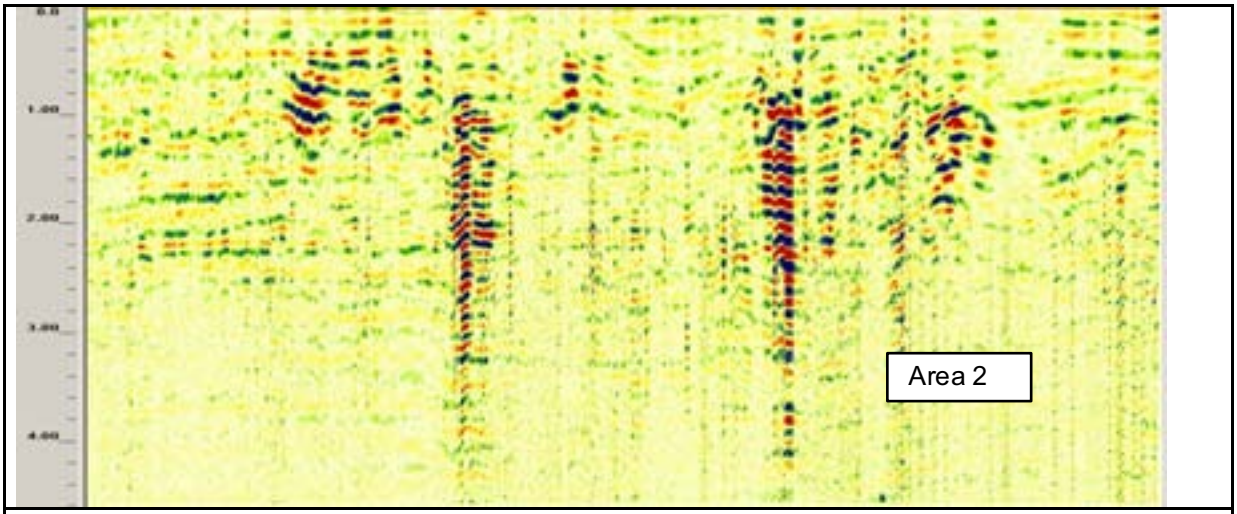

figure 60: radargram of a measuring along measuring line 21 (length: 29 m, GSSI, f = 270 MHz)

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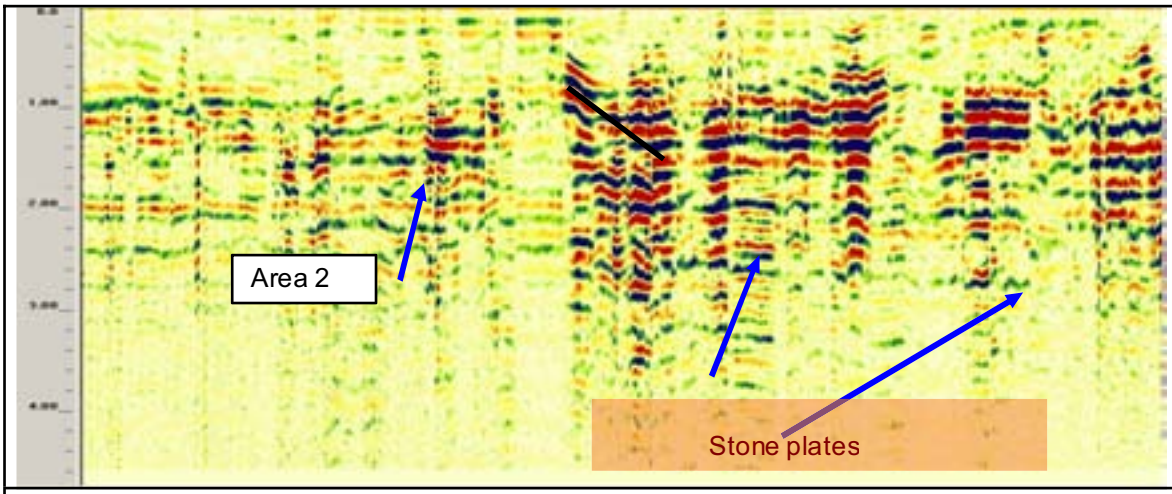

figure 61: radargram of a measuring along measuring line 22 (length: 31,5 m, GSSI, f = 270 MHz), on the right side echo of the stone plates

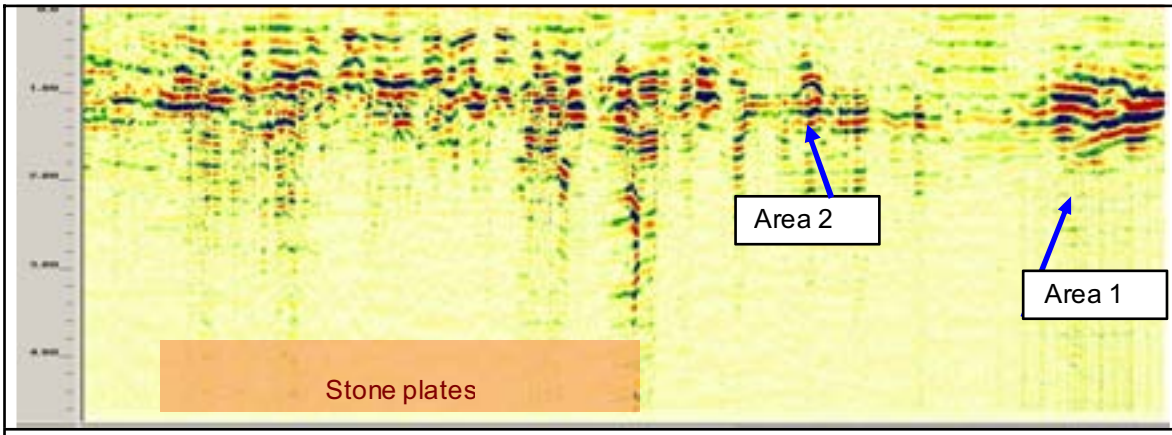

figure 62: radargram of a measuring along measuring line 23 (length: 32 m, GSSI, f = 270 MHz) stone plates on the left side, inhomogenity on the right side

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5 STONEPLATES SONDE 4A

5.1 Local conditions

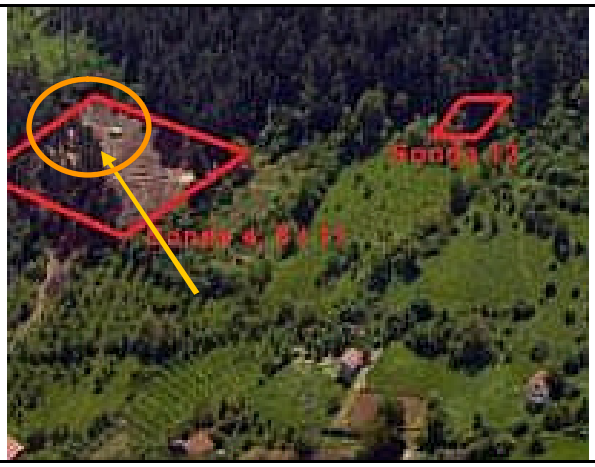

figure 63: area of measurements

The measurements where carried out at different areas closed to Sonde 4A.

figure 64: view of measurements on stone plates

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figure 65: view of measuring area

figure 66: The electricity cable closed to the measuring area. The high voltage influenced the 100 MHz radar measurement.

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5.2 Coordinating System of the measuring area

The measuring lines go parallel or in right angle to the hill.

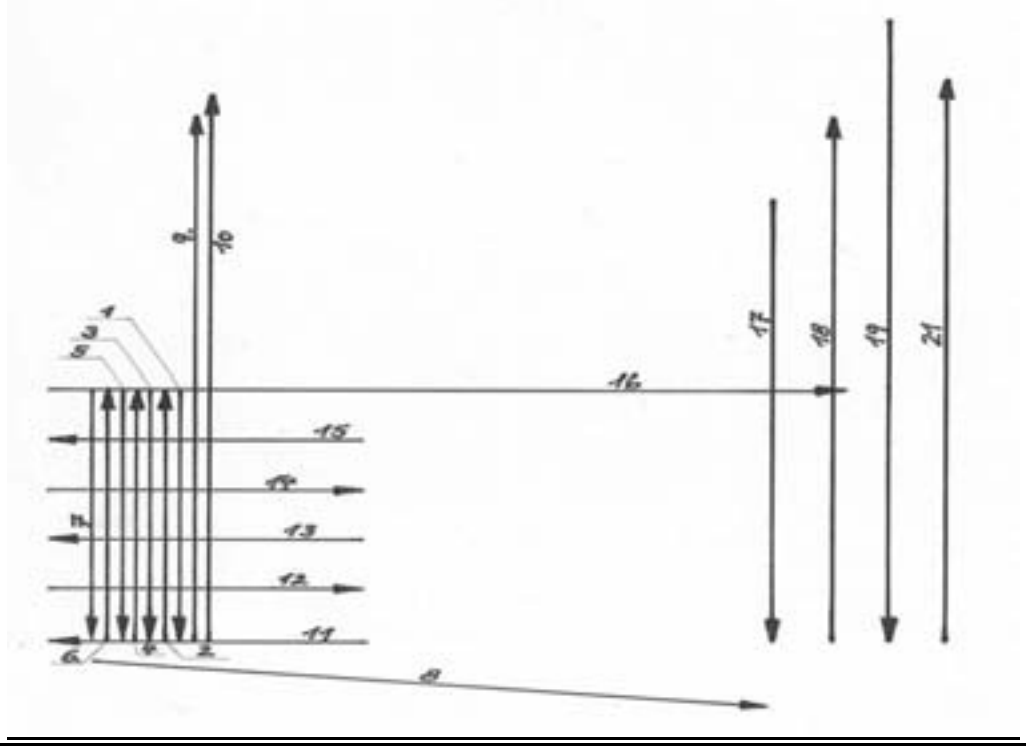

figure 67: overview of position of measuring lines 1-21

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5.3 RESULTS OF THE MEASUREMENTS

The measurements were carried out with an 270 MHz and an 100 MHz radar antenna.
The ground was very wet, what result to bad conditions for radar measurements. Anywhere the results with the 270 MHz antenna were very good. The results of the 100MHz antenna were not so good, the damping and the influences of area around and the signals from the electricity were to high.
Following the results of measurements at the stone plates are shown. The radargram below, show that in some areas just the upper layer of stone plates is found.

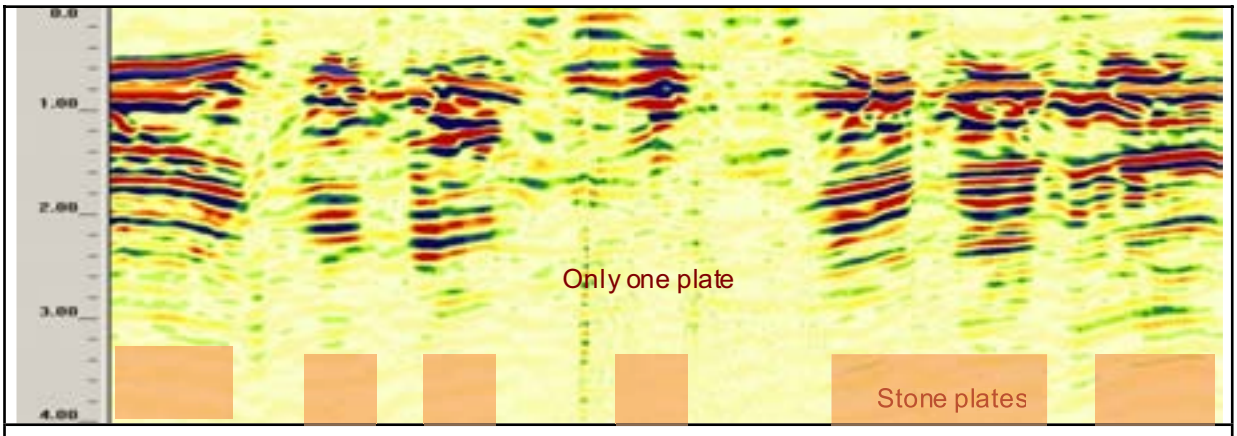

figure 68: radargram of a measuring along line 3 (length: 12,4 m, GSSI, f = 270 MHz) with two layers of stone plates, in the middle of the measurement the second plate is missing

To get a better understanding of the structure some radargrams were registered in parallel lines (here every 0,5 m) and time slides have been calculated.

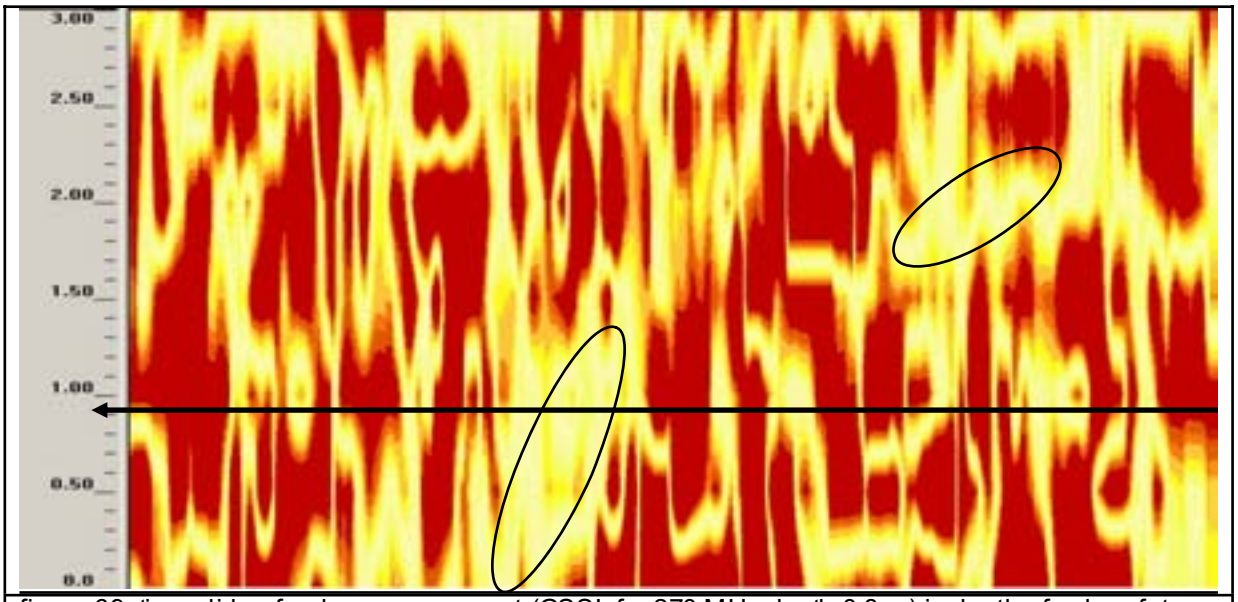

figure 69: time slide of radar measurement (GSSI, f = 270 MHz depth 0,8 m) in depth of echo of stone plates, at the marked areas no stone plates were found (look at picture at the beginning of the report), the top of the hill is on the right side, the arrow shows the position and direction of the radargram above

LGA Bautechnik GmbH Tillystraße 2 90431 Nürnberg
Tel.: +49 (0) 911 655-5561 Fax: +49 (0) 911 655-5536
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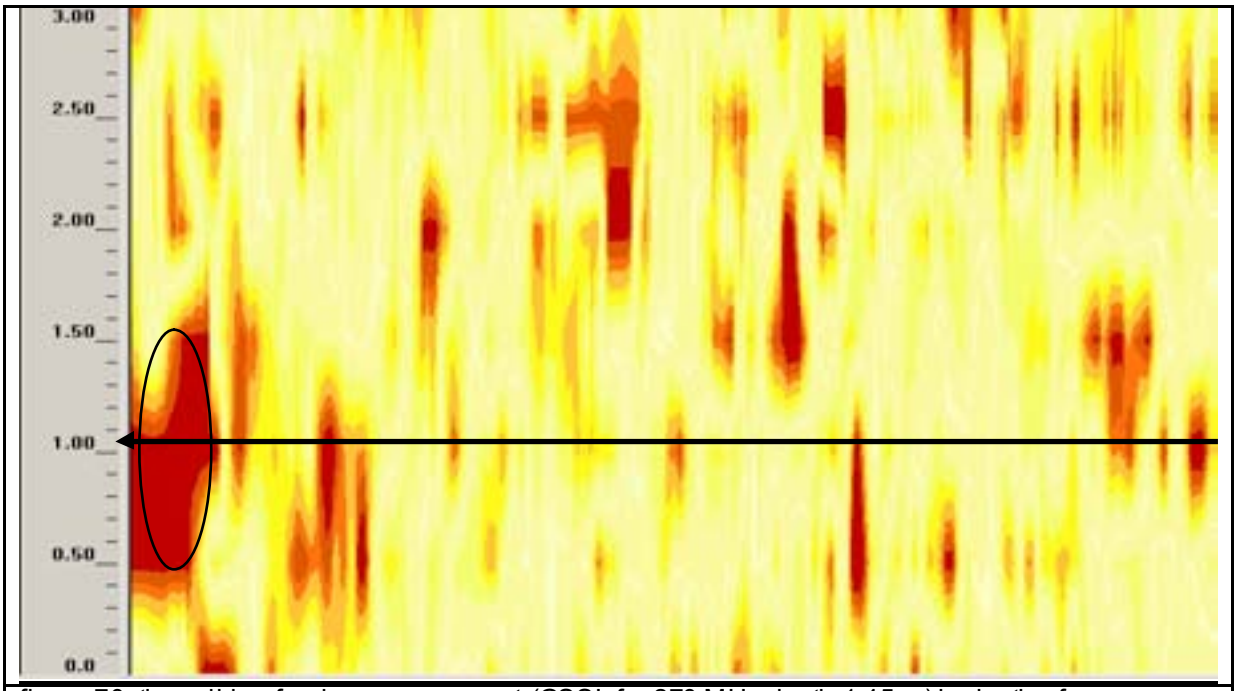

figure 70: time slide of radar measurement (GSSI, f = 270 MHz depth 1,45 m) in depth of area between the two layers of stone plates, on the left side in this area echo from stone are received, the arrow shows the position and direction of the radargram above

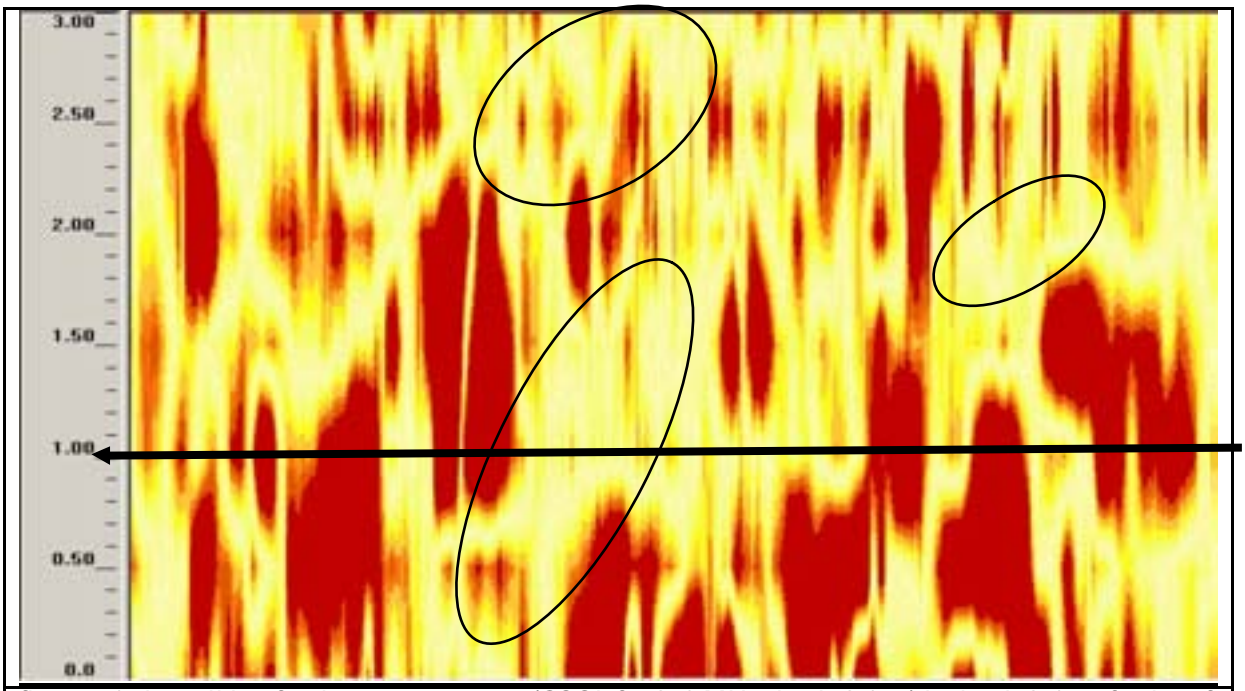

figure 71: time slide of radar measurement (GSSI, f = 270 MHz depth 2,1 m) in depth 2,1 mof echo of second layer of stone plates with areas where no stone plates, the top of the hill is on the right side, the arrow shows the position and direction of the radargram above

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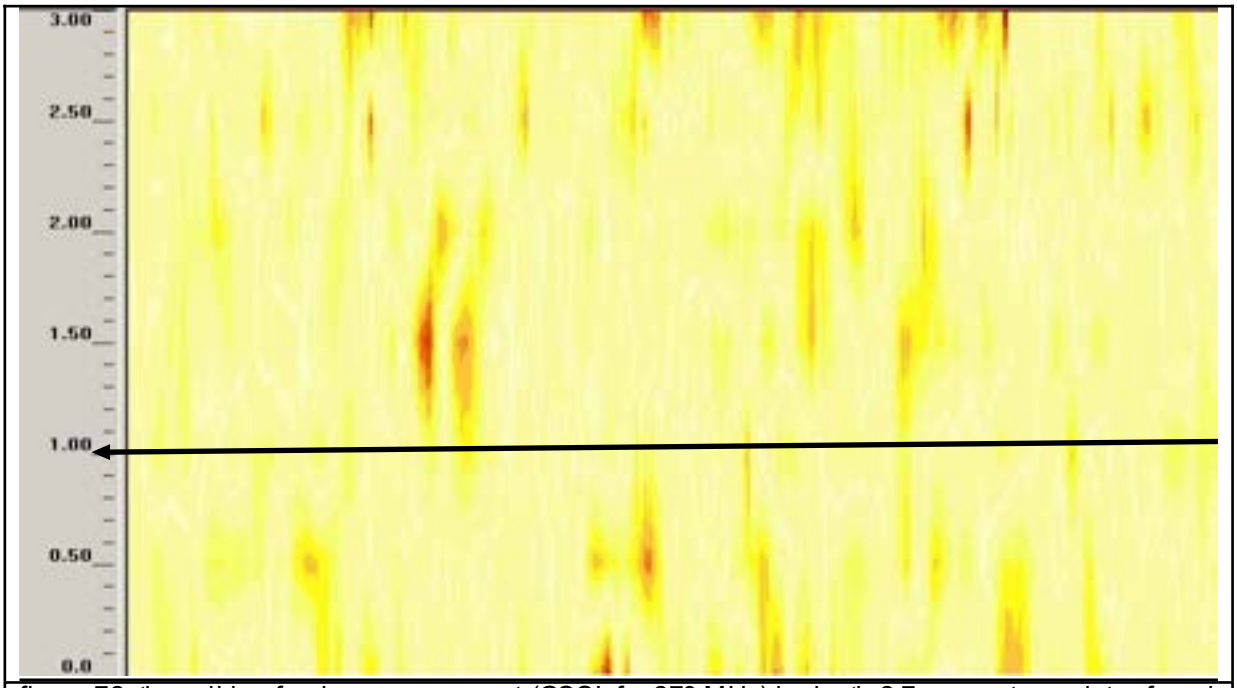

figure 72: time slide of radar measurement (GSSI, f = 270 MHz) in depth 2,7 m, no stone plates found

The wavelength of the 270 MHz antenna is three times smaller than of the 100 MHz Antenna, that means the results are much sharper with the 270 MHz antenna. The results with the 100 MHz antenna are not as detailed. Deeper measurements were not possible because of the signal damping of wet clay.

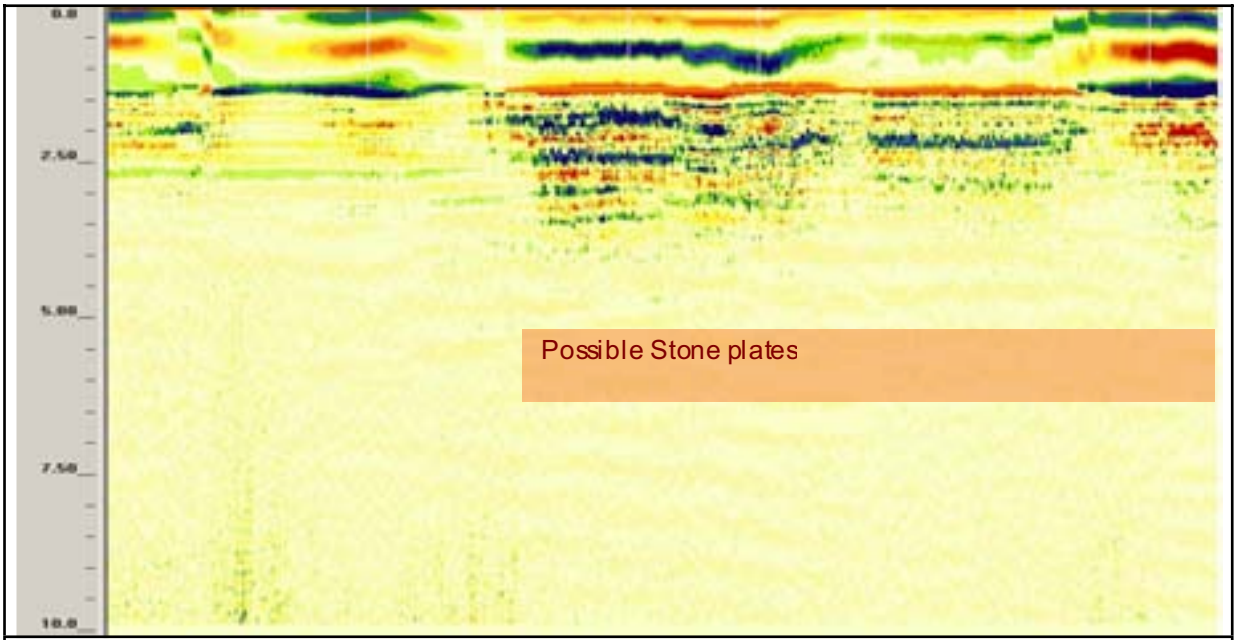

figure 73: radargram of a measuring along measuring line 23 (length: 8,5 m, GSSI, f = 100 MHz) stone plates on the left side, inhomogenity on the right side

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5.4 EVALUATION OF RESULTS

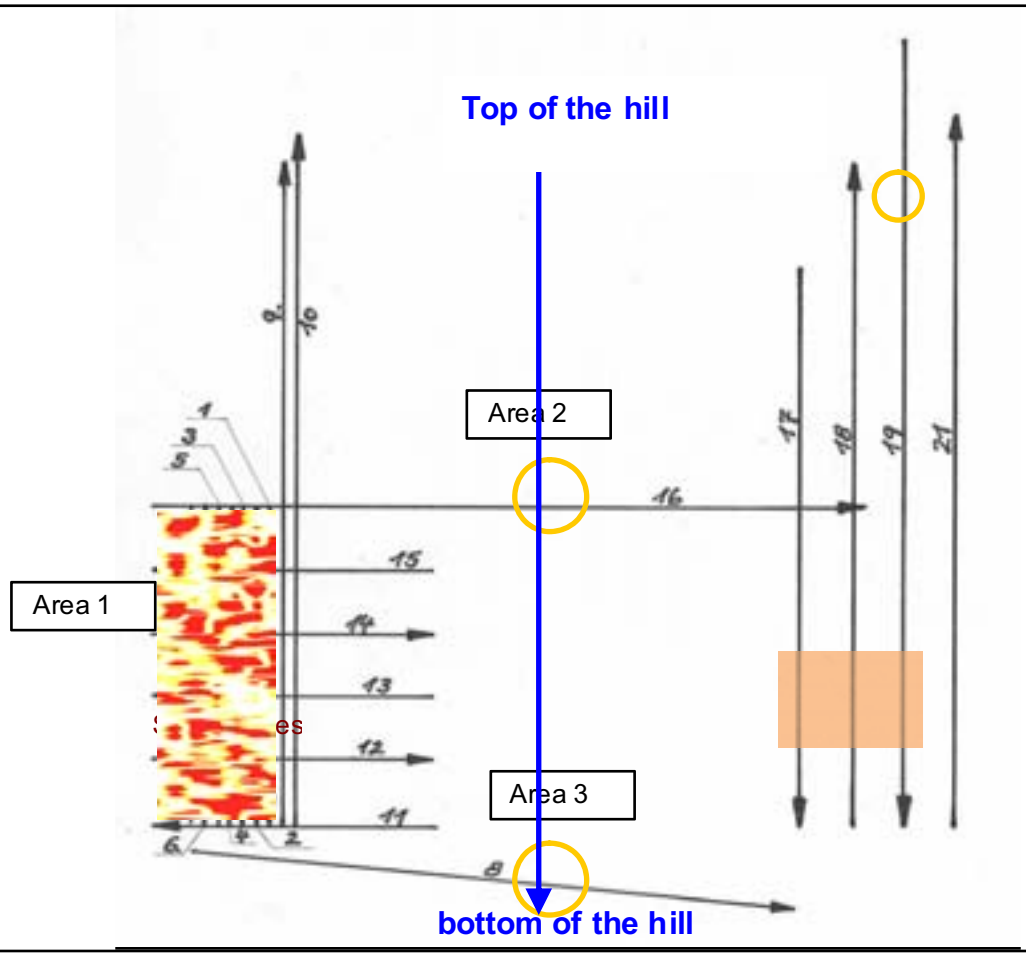

figure 74: overview of position of measuring lines with the areas where the there is no second layer of stoneplates (no red echo) and areas inhomogenities (Area2 and Area 3 lay on one line from the top to the bottom of the mountain

Area 1:	In some areas the stoneplates are just one layer
Area 2	Area hit by line 19 Depth of inhomogenity: 1,2 m
Area 3	Area hit by line 19 Depth of inhomogenity: 0,8 1,3 m

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Tel.: +49 (0) 911 655-5561 Fax: +49 (0) 911 655-5536
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5.5 RADARGRAMS OF MEASUREMENTS

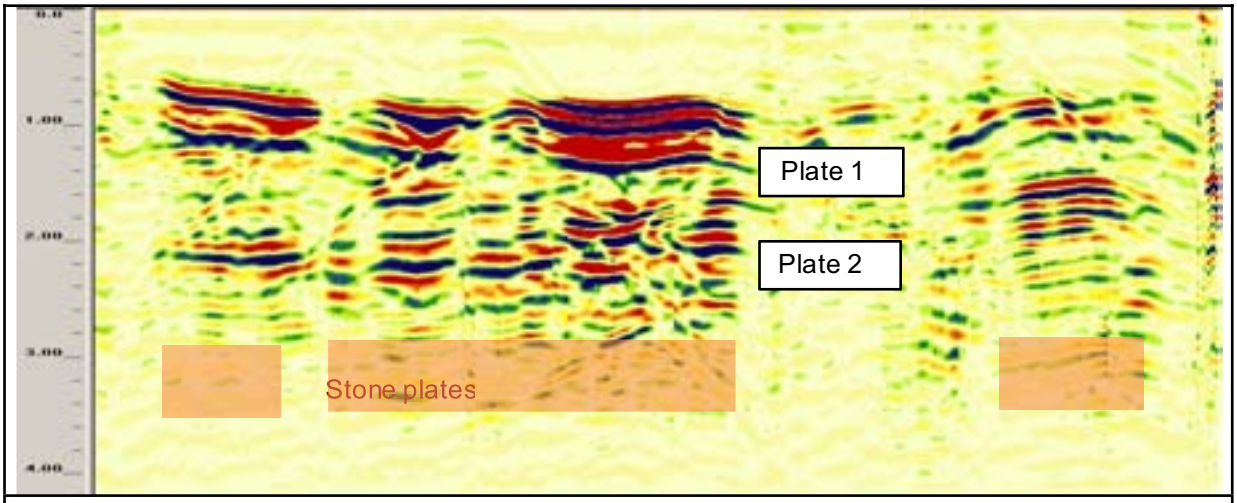

figure 75: radargram of a measuring along measuring line 1 (length: 13 m, GSSI, f = 270 MHz) with two layers of stone plates

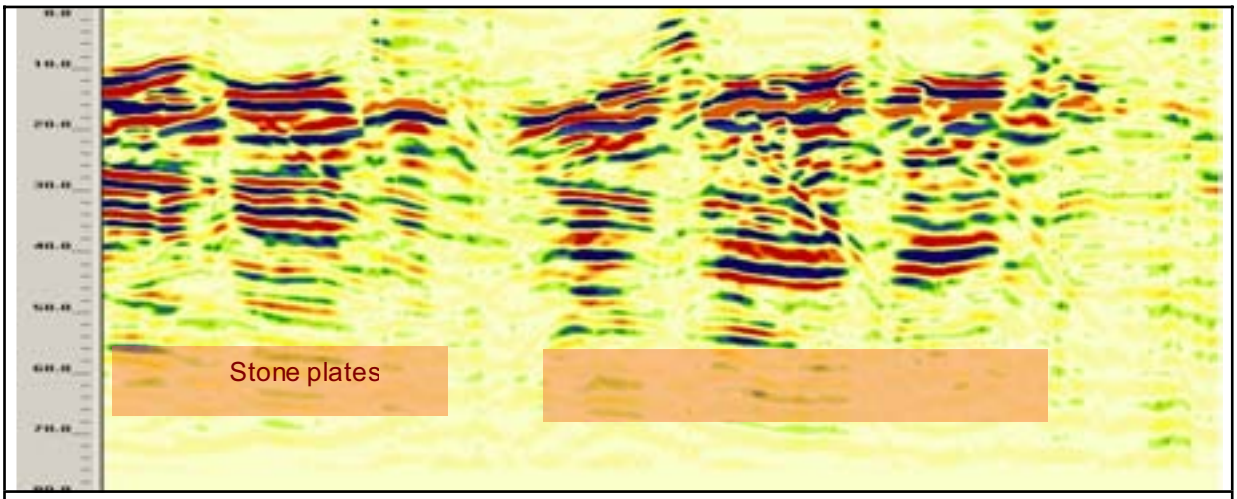

figure 76: radargram of a measuring along measuring line 2 (length: 13 m, GSSI, f = 270 MHz, depth in ns) with two layers of stone plates

LGA Bautechnik GmbH Tillystraße 2 90431 Nürnberg
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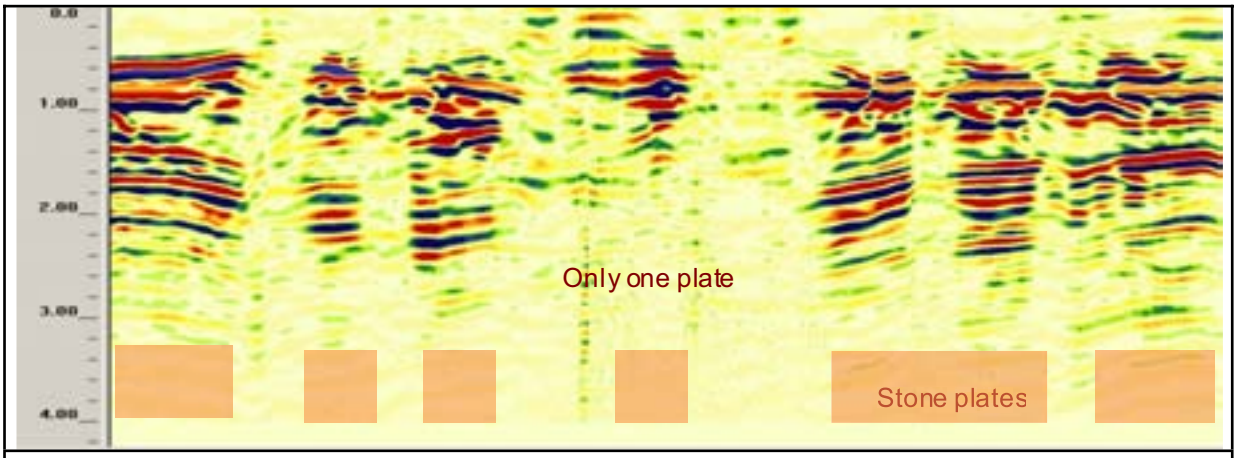

figure 77: radargram of a measuring along measuring line 3 (length: 12,4 m, GSSI, f = 270 MHz) with two layers of stone plates, in the middle of the measurement the second plate is missing

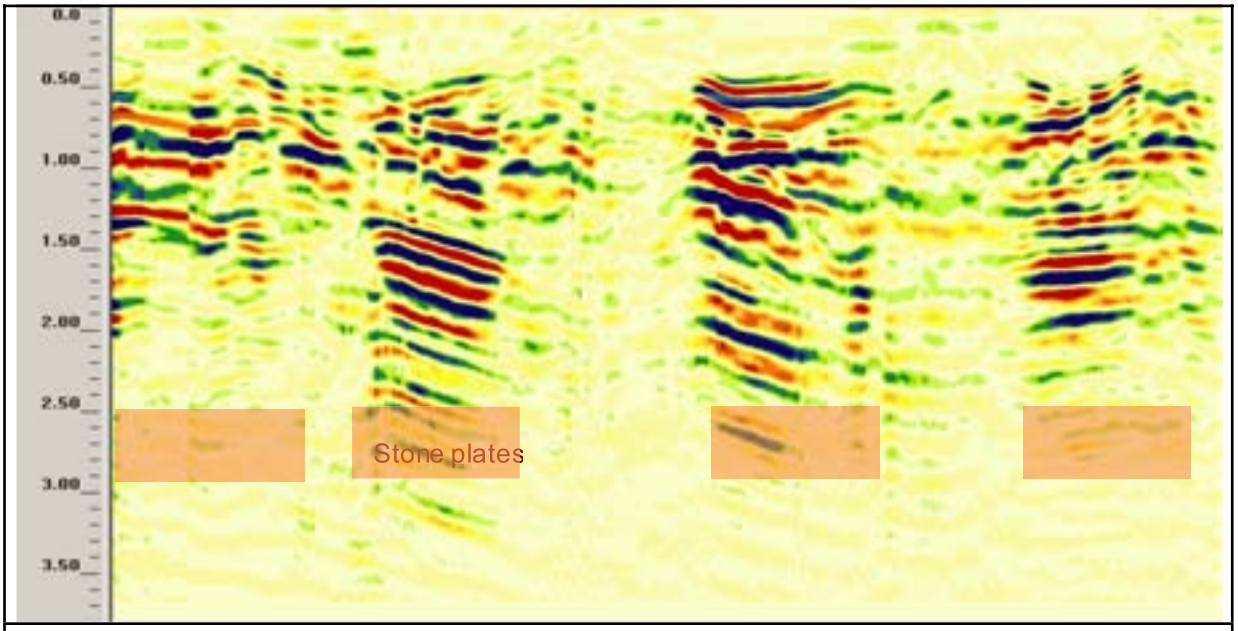

figure 78: radargram of a measuring along measuring line 4 (length: 12,5 m, GSSI, f = 270 MHz) echo of stone plates

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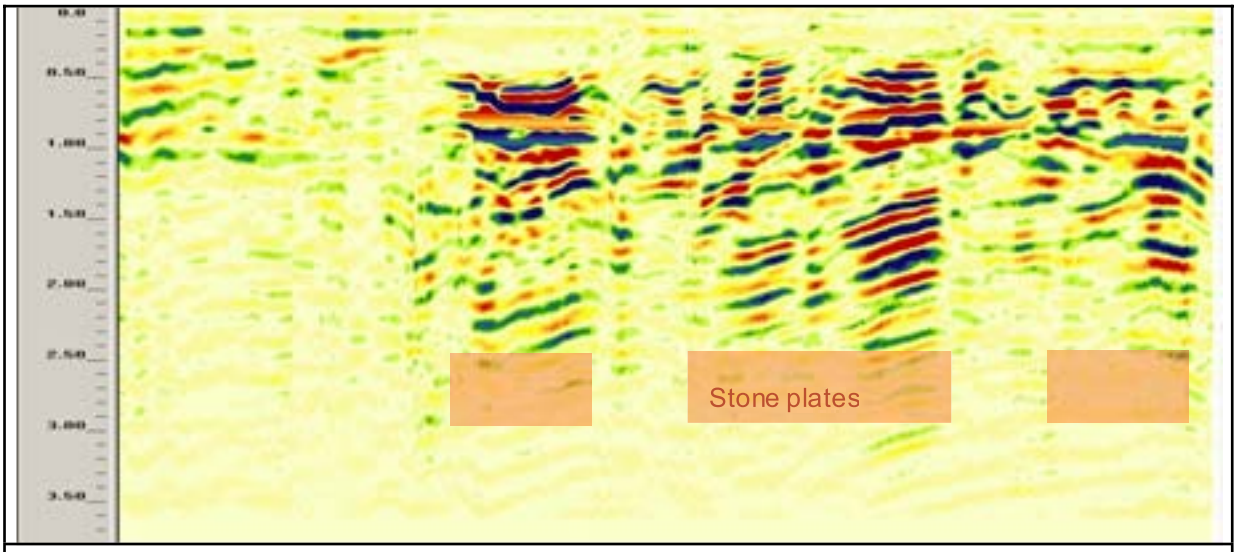

figure 79: radargram of a measuring along measuring line 5 (length: 12 m, GSSI, f = 270 MHz) with stone plates, the second layer of the plates is not parallel to the first layer

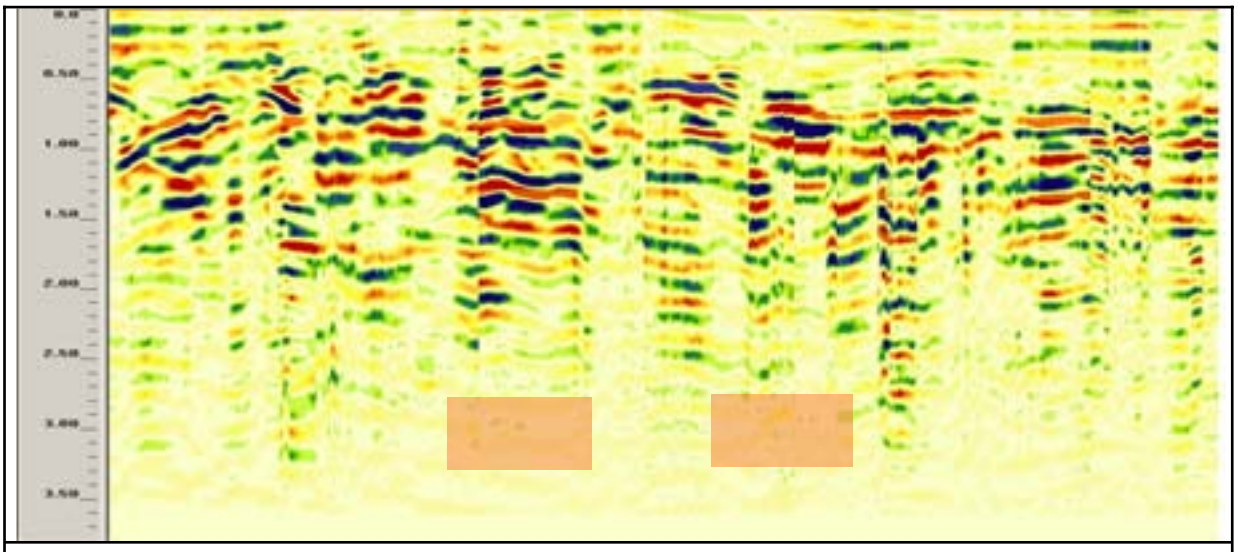

figure 80: radargram of a measuring along measuring line 6 (length: 13,5 m, GSSI, f = 270 MHz) with stone, at the edge of the stone plates just in the middle of the measuring line some stone plates are visible

LGA Bautechnik GmbH Tillystraße 2 90431 Nürnberg
Tel.: +49 (0) 911 655-5561 Fax: +49 (0) 911 655-5536
E-Mail: andreas.hasenstab@lga.de http://www.lga.de

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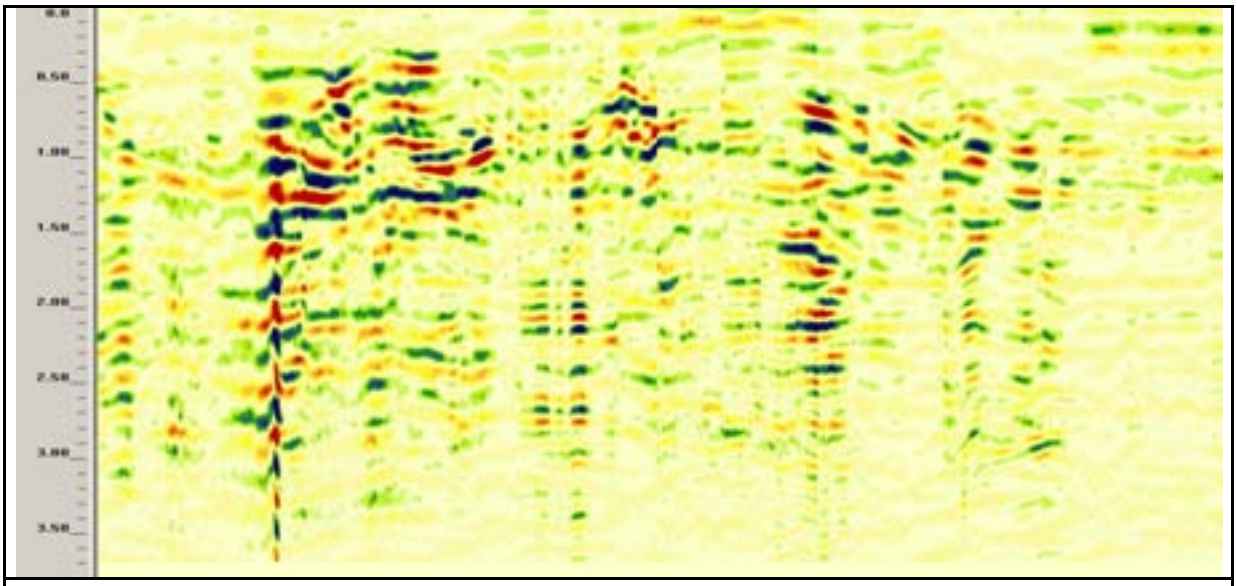

figure 81: radargram of a measuring along measuring line 7 (length: 15 m, GSSI, f = 270 MHz) closed to the edge of the stone plates

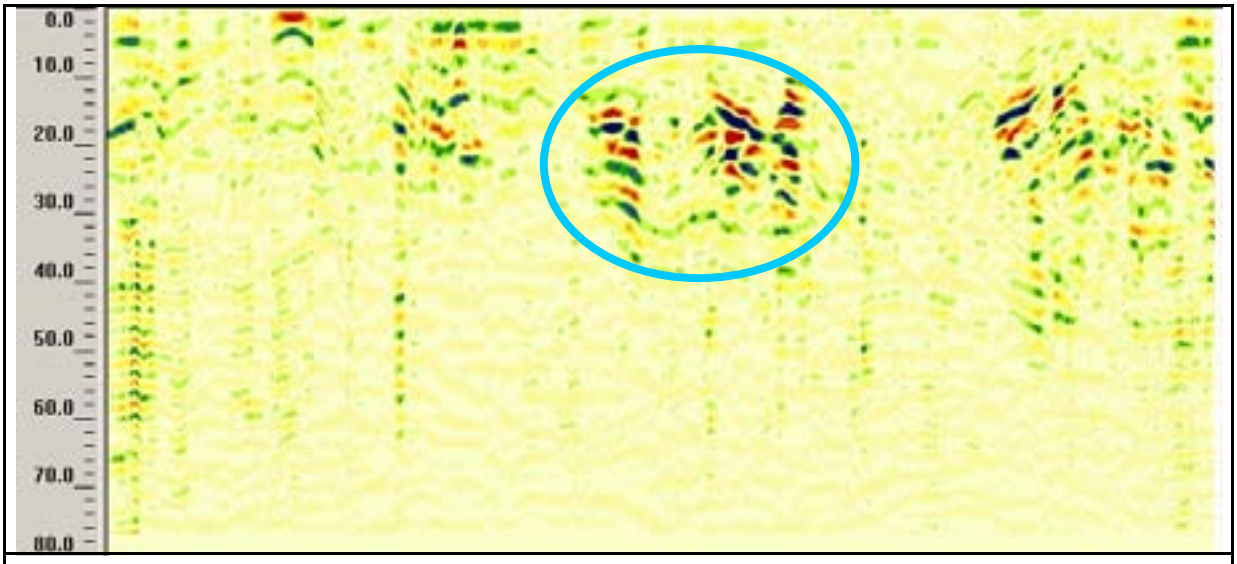

figure 82: radargram of a measuring along measuring line 8 (length: 24 m, GSSI, f = 270 MHz, depth in ns), one inhomogenity

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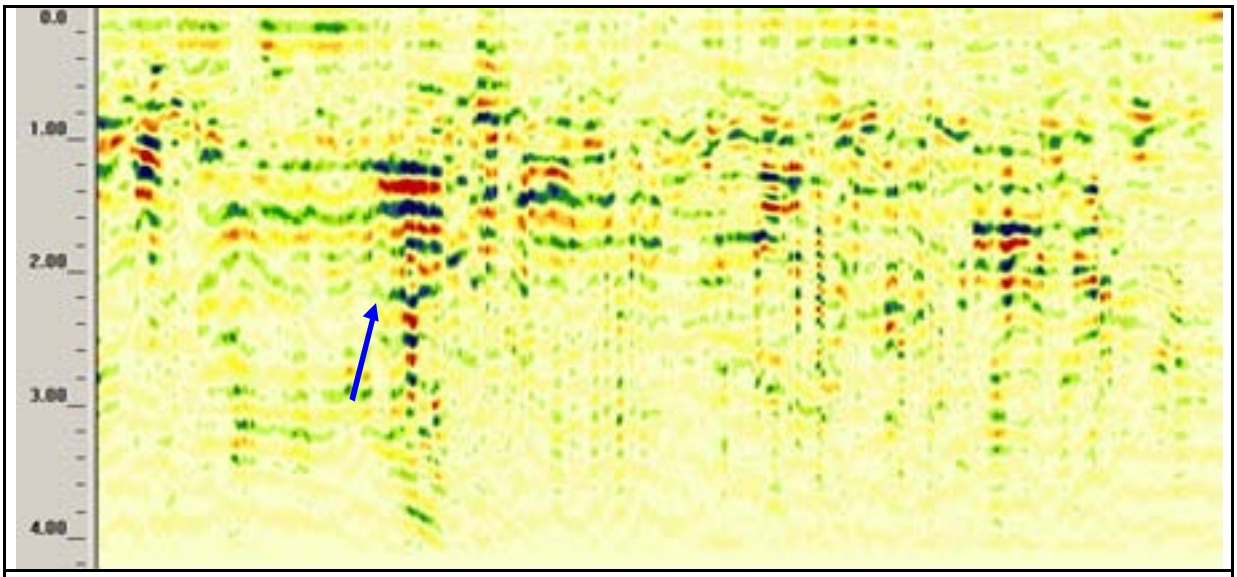

figure 83: radargram of a measuring along measuring line 9 (length: 26 m, GSSI, f = 270 MHz) a small part with a stone plates on the left side

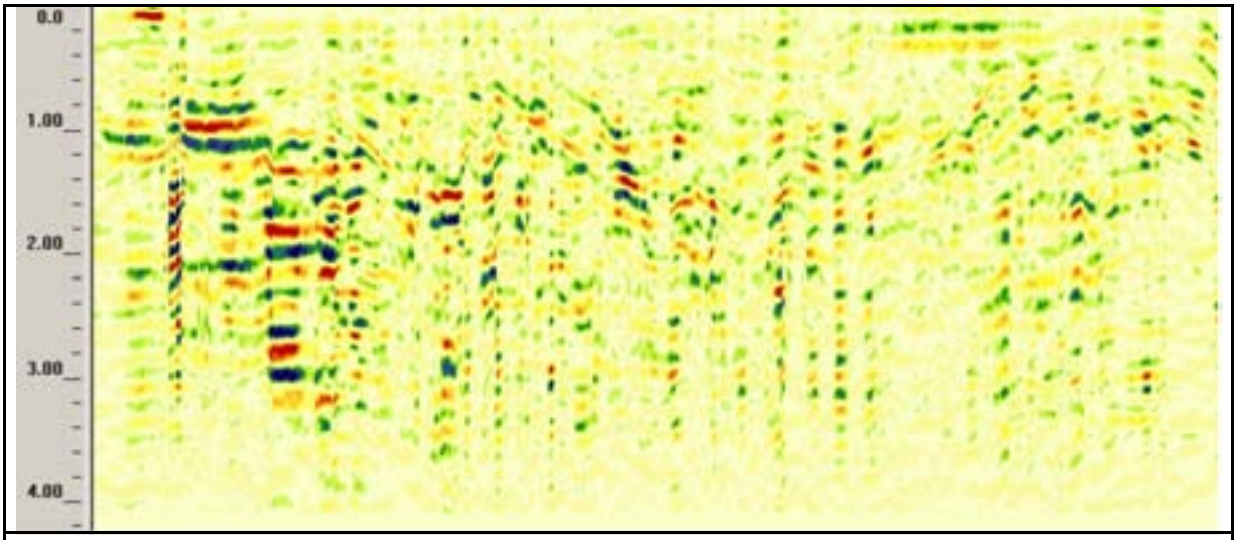

figure 84: radargram of a measuring along measuring line 10 (length: 27 m, GSSI, f = 270 MHz), no stone plates are visible

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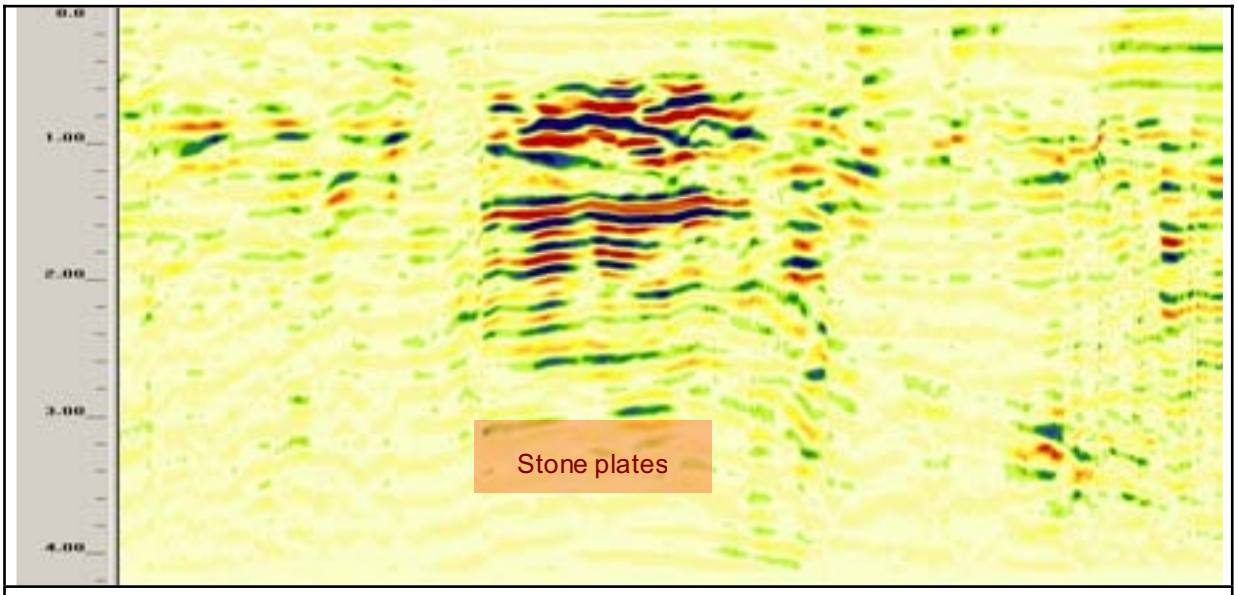

figure 85: radargram of a measuring along measuring line 11 (length: 9 m, GSSI, f = 270 MHz) stone plates in the middle of the line

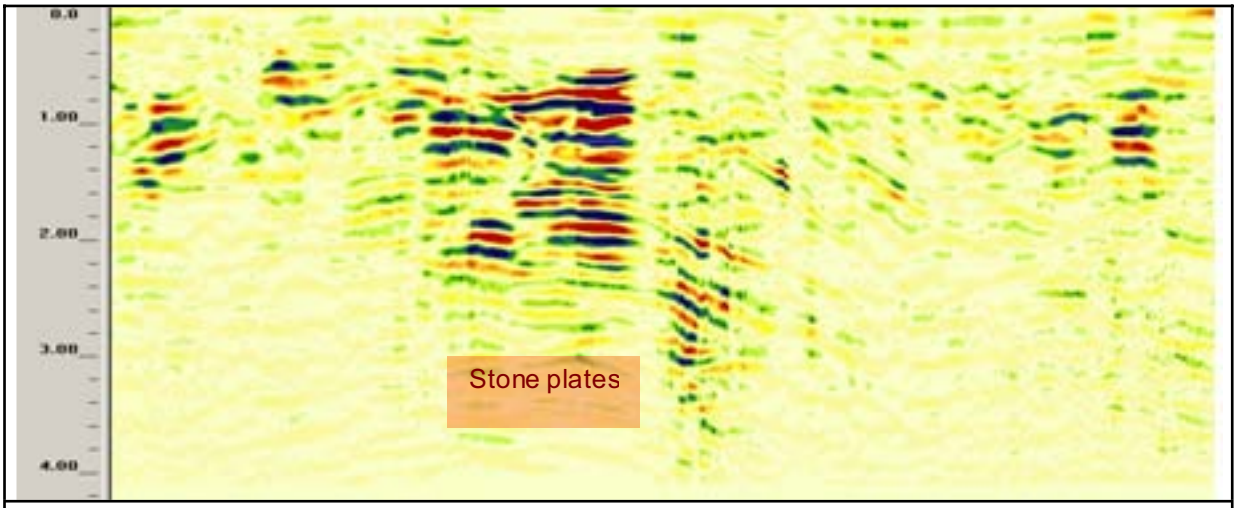

figure 86: radargram of a measuring along measuring line 12 (length: 12 m, GSSI, f = 270 MHz) stone plates in the middle of the line

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E-Mail: andreas.hasenstab@lga.de http://www.lga.de

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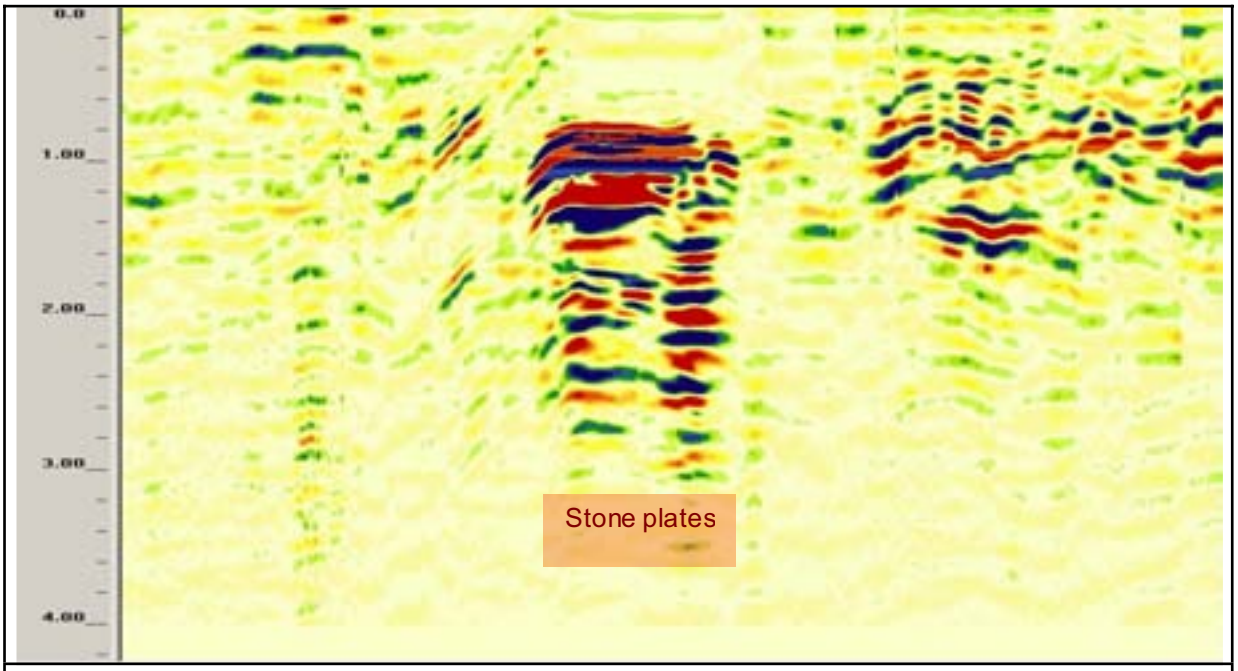

figure 87: radargram of a measuring along measuring line 13 (length: 11 m, GSSI, f = 270 MHz) stone plates in the middle of the line and some inhomogenities

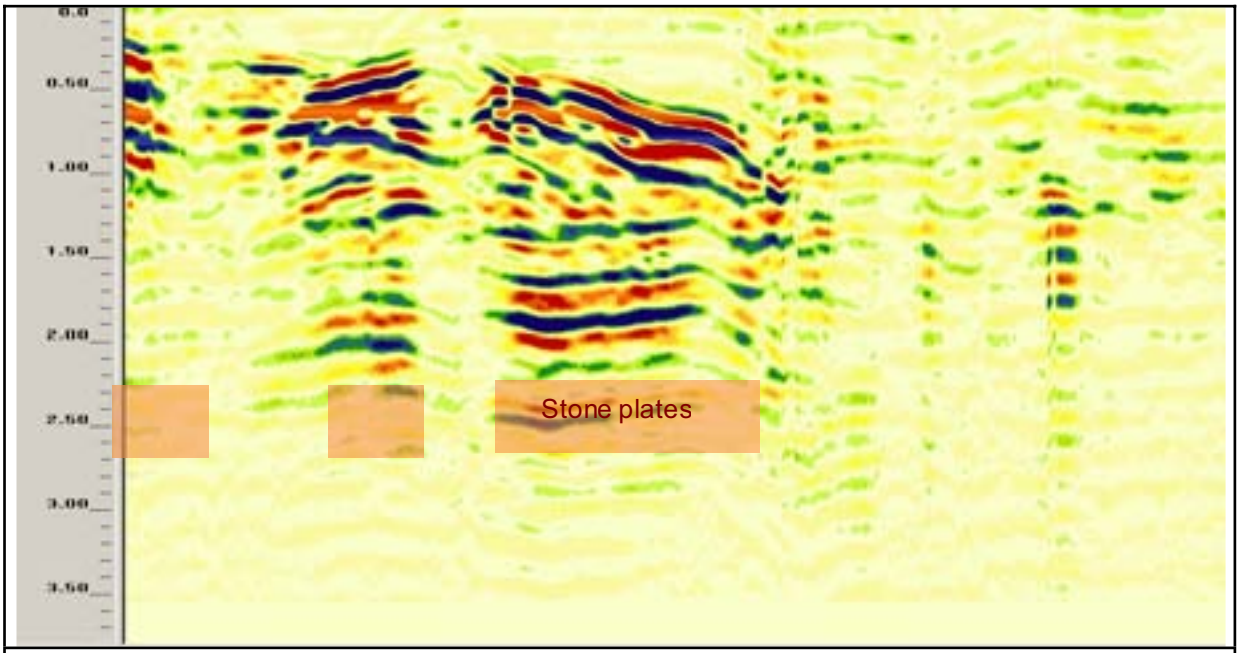

figure 88: radargram of a measuring along measuring line 14 (length: 11 m, GSSI, f = 270 MHz) with echo of stone plates

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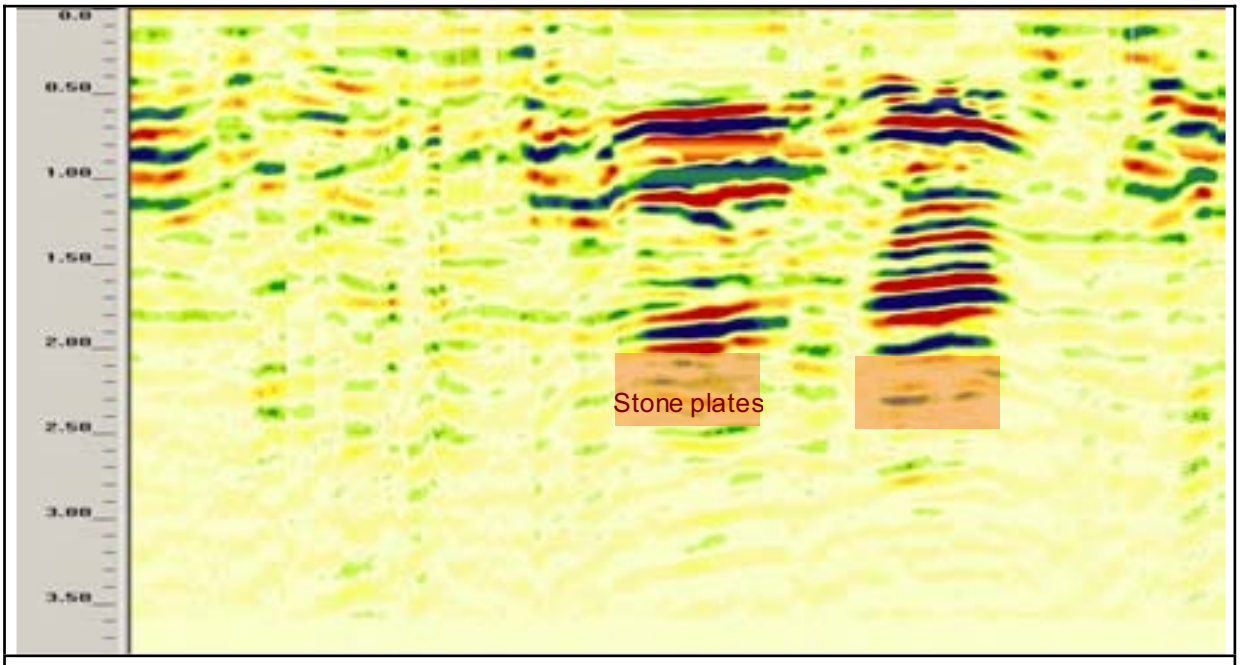

figure 89: radargram of a measuring along measuring line 15 (length: 10 m, GSSI, f = 270 MHz) with echo of stone plates

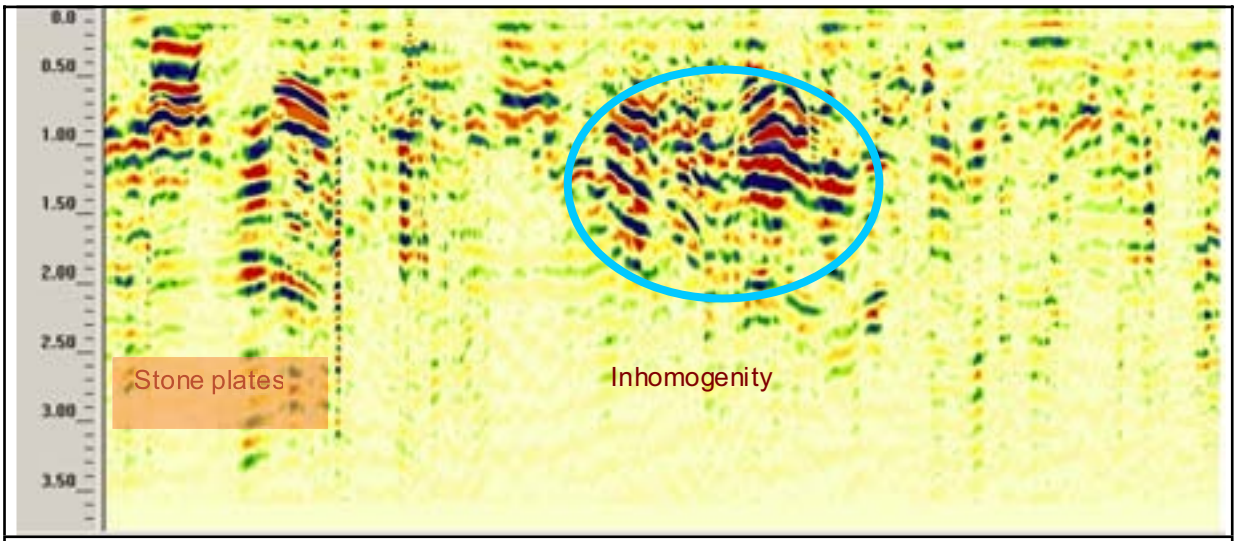

figure 90: radargram of a measuring along measuring line 16 (length: 28 m, GSSI, f = 270 MHz) stone plates on the left side, inhomogenity on the right side(strong reflector)

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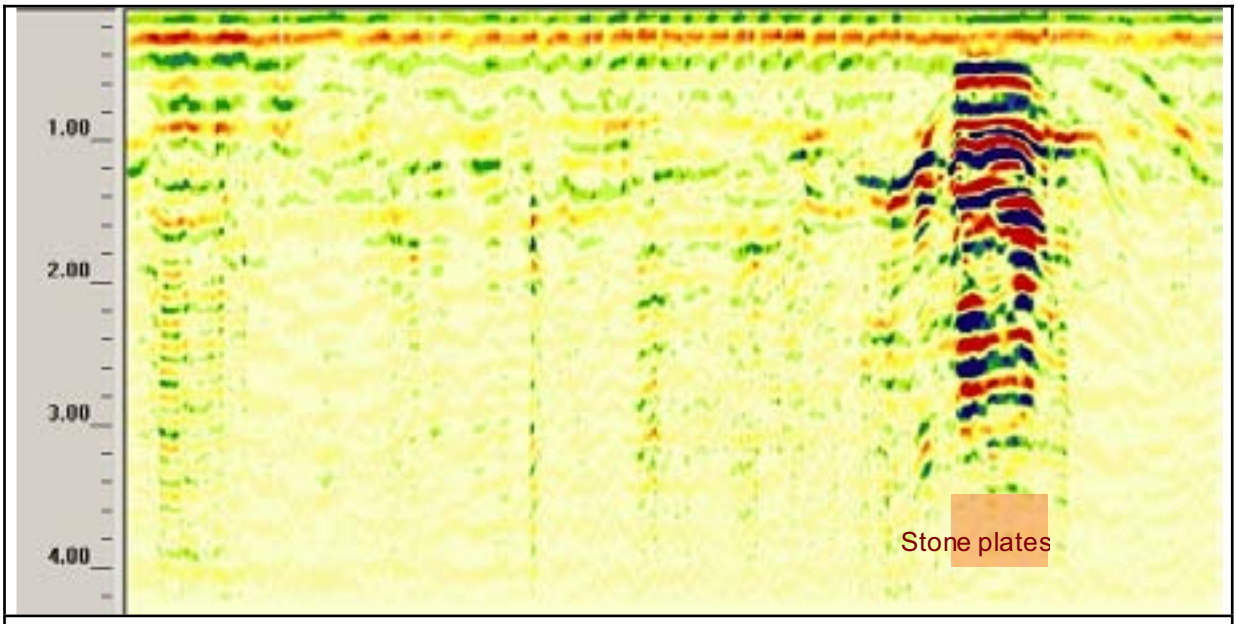

figure 91: radargram of a measuring along measuring line 17 (length: 22 m, GSSI, f = 270 MHz)

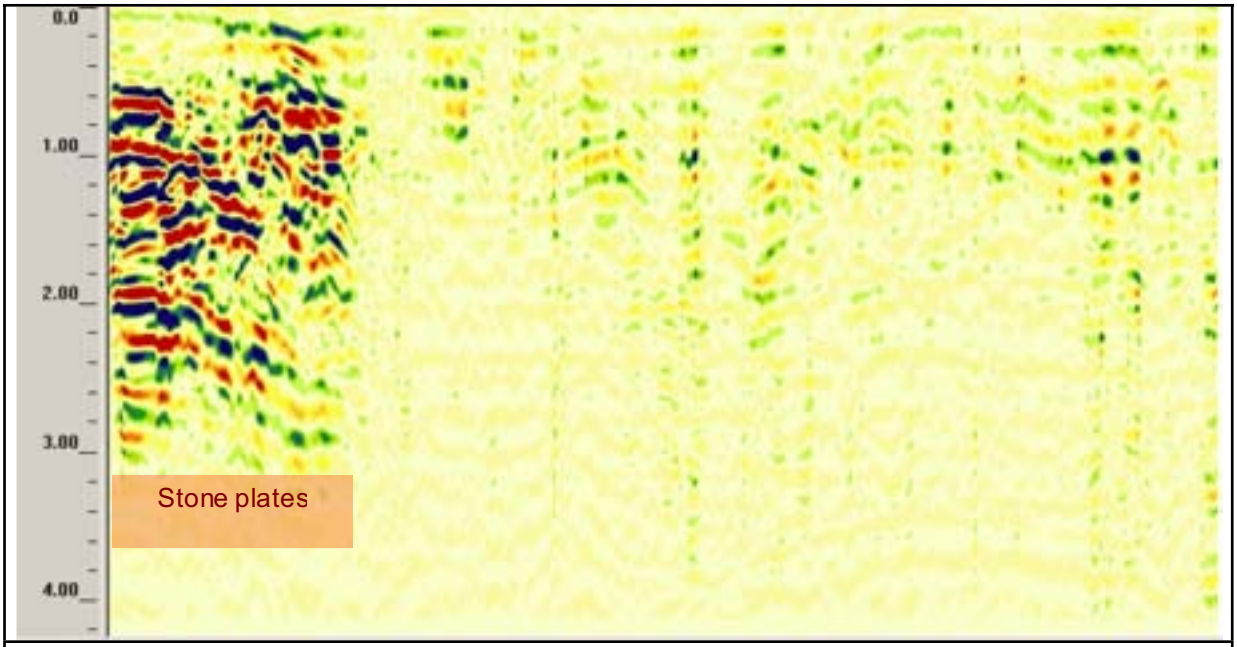

figure 92: radargram of a measuring along measuring line 18 (length: 26 m, GSSI, f = 270 MHz) stone plates on the left side

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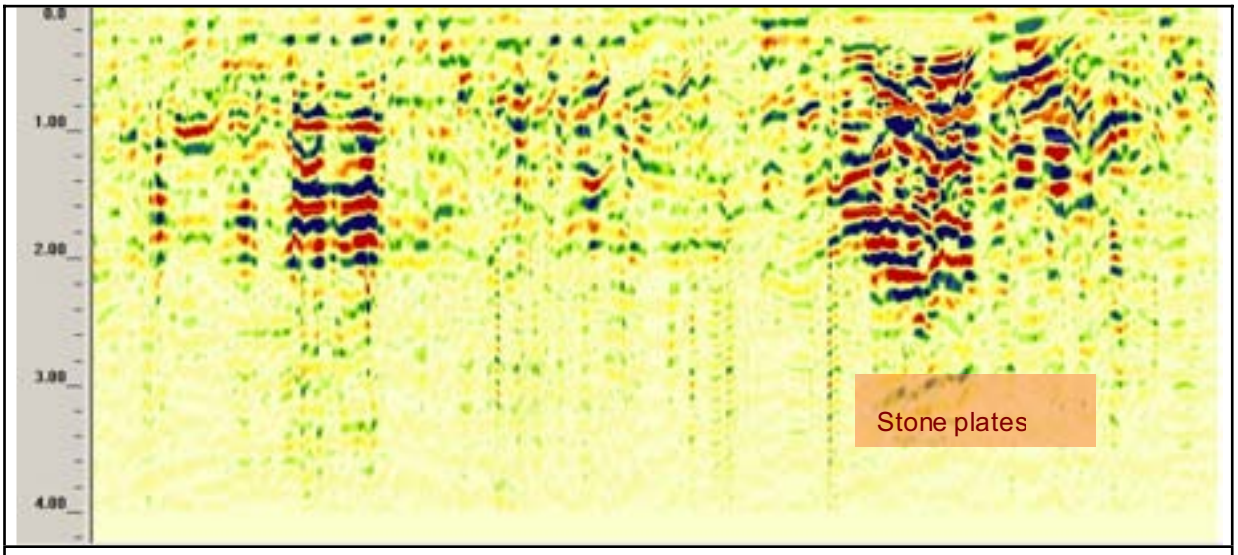

figure 93: radargram of a measuring along measuring line 19 (length: 31 m, GSSI, f = 270 MHz) stone plates on the right side, inhomogenity on the left side

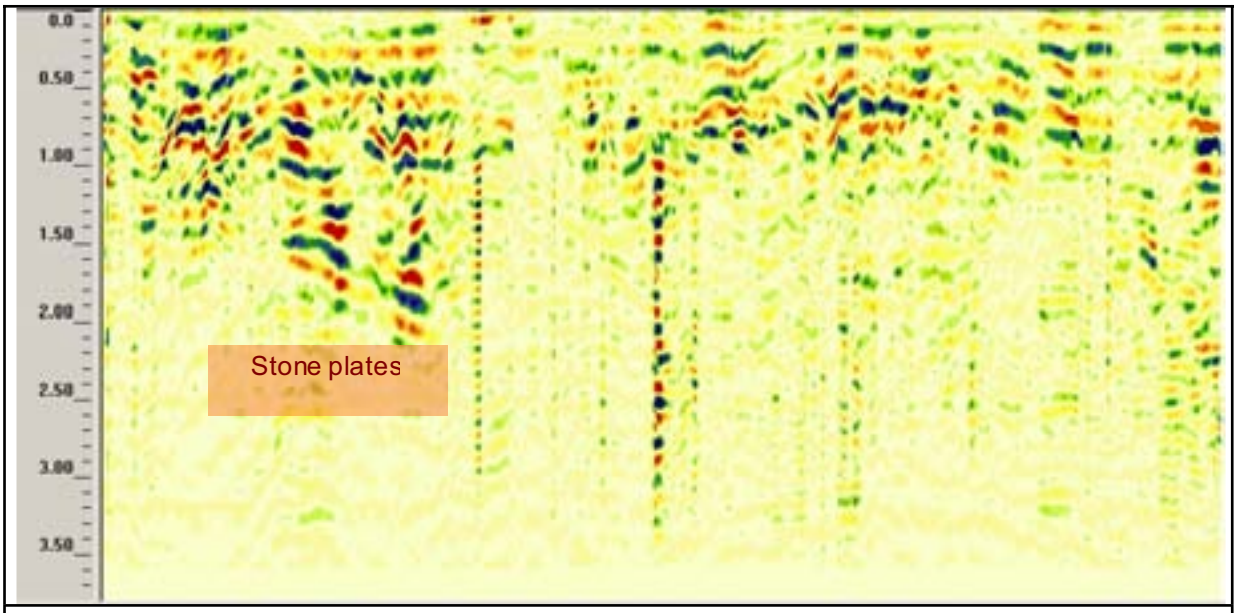

figure 94: radargram of a measuring along measuring line 21 (length: 28 m, GSSI, f = 270 MHz) stone plates on the left side

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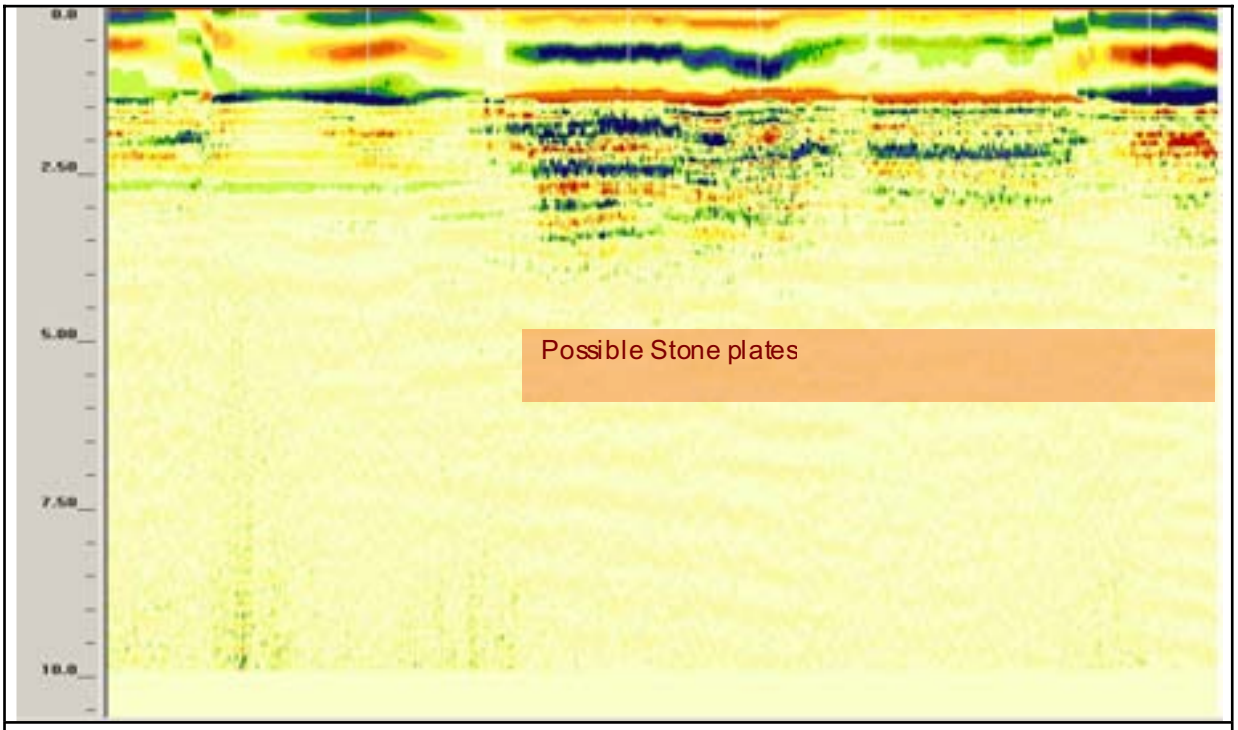

figure 95: radargram of a measuring along measuring line 23 parallel to line 3 (length: 8,5 m, GSSI, f = 100 MHz) stone plates on the right side

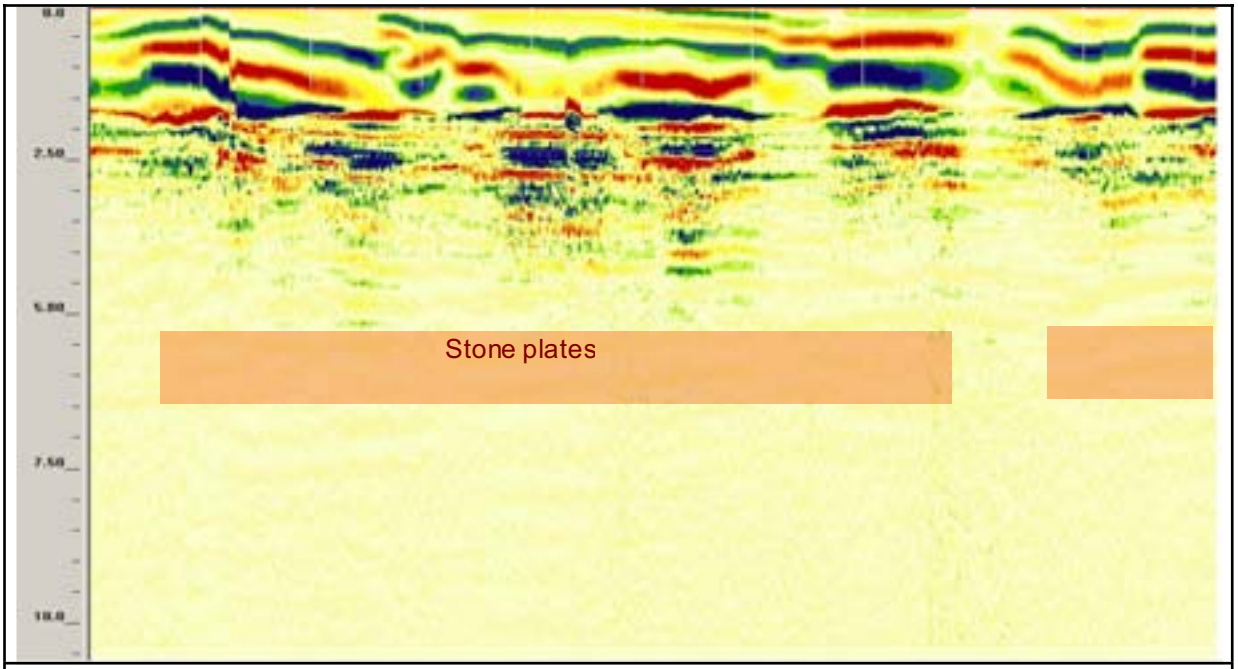

figure 96: radargram of a measuring along measuring line 24, parallel to line 4(length: 10 m, GSSI, f = 100 MHz) with stone plates

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6 MEASUREMENTS AT SONDE 12

6.1 Local conditions

The measurements where carried out at the Sonde 12 with tent.

figure 97: view of measurements at Sonde 12

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6.2 RESULTS OF THE MEASUREMENTS

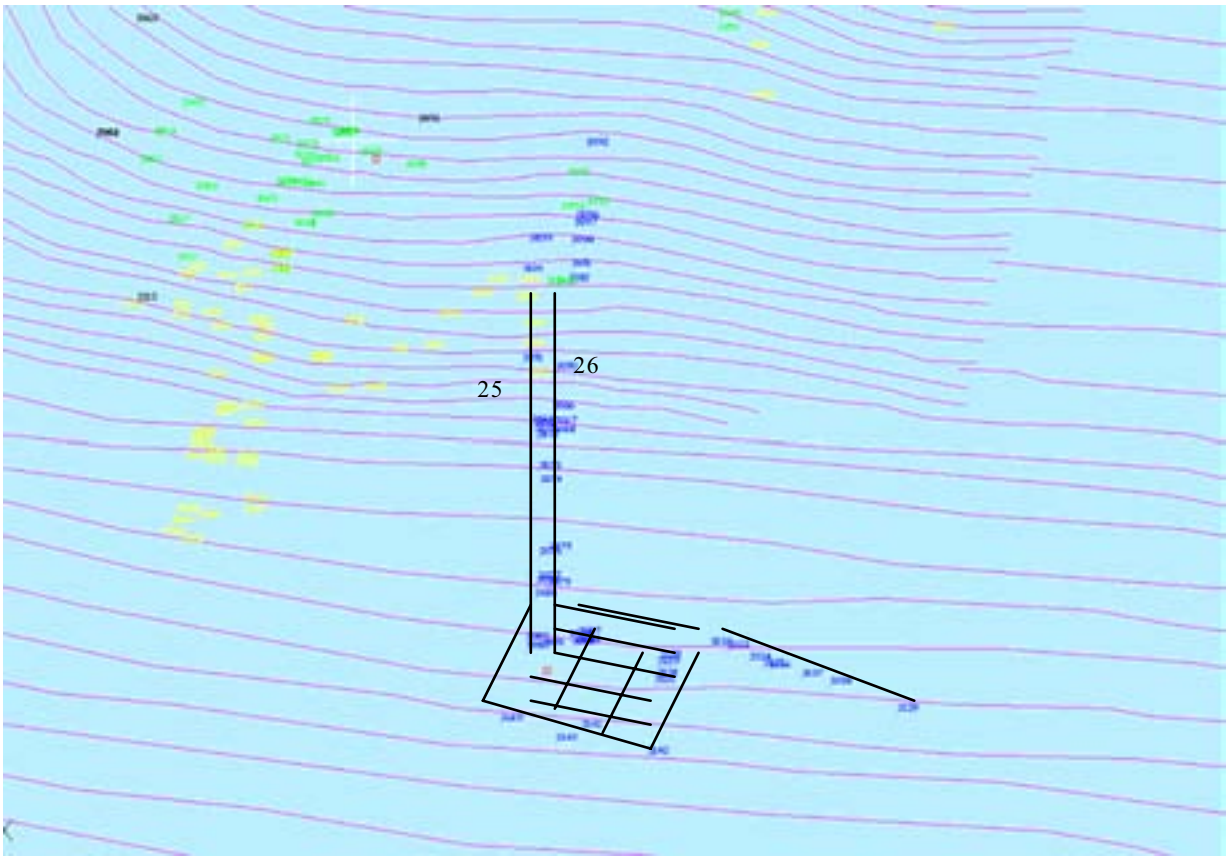

figure 98: overview of position of measuring lines

The measurements were done with a 270 MHz radar antenna. At Sonde 12 and in the forest the measuring area was so small, that it was not possible to use the larger 100 MHz antenna. In the forest the ground has been wet what results in a high damping of signals. Anywhere the results of the measurements were in the first 4 m very good.

Following the results of measurements at the area of Sonde 12 are shown.

LGA Bautechnik GmbH • Tillystraße 2 • 90431 Nürnberg
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E-Mail: andreas.hasenstab@lga.de • http://www.lga.de

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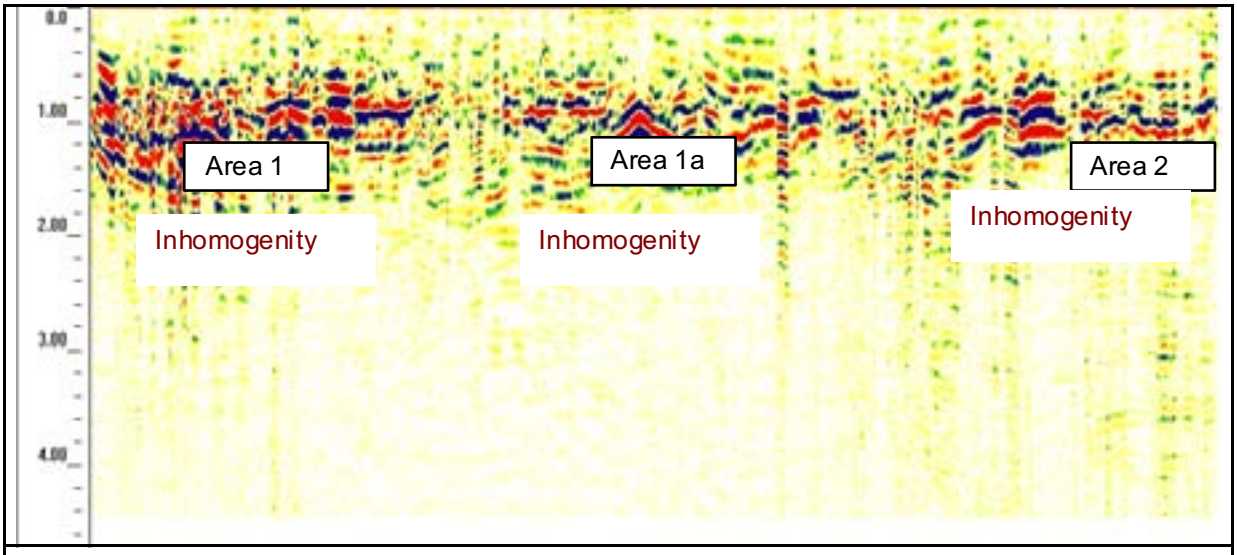

figure 99: radargram of a measuring along measuring line 25 (GSSI, f = 270 MHz) with inhomogenities

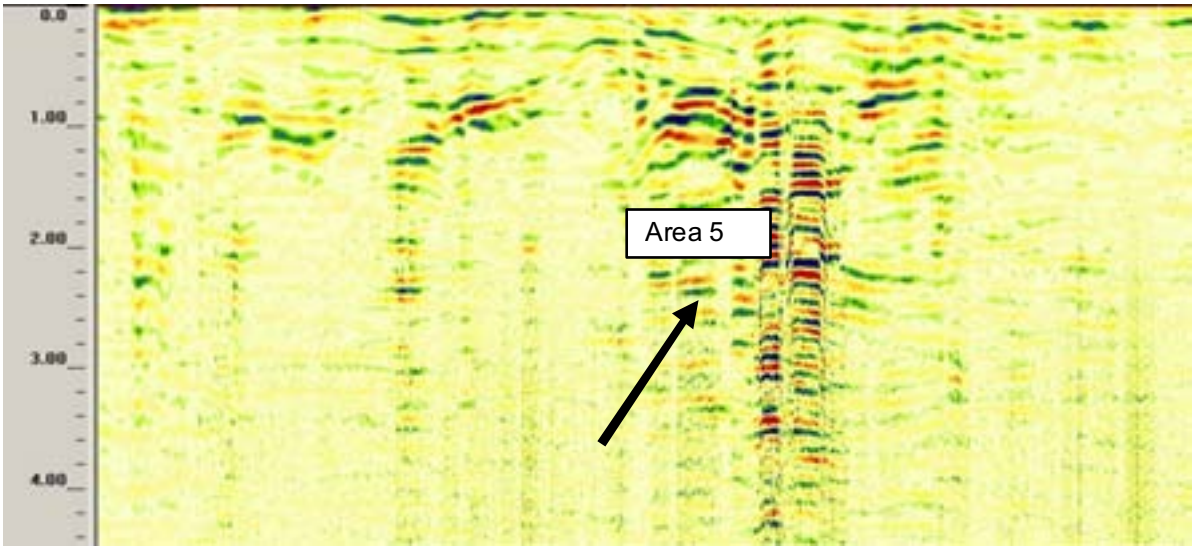

figure 100: radargram of a measuring along measuring line 27 (GSSI, f = 270 MHz) with position of cavity in ground

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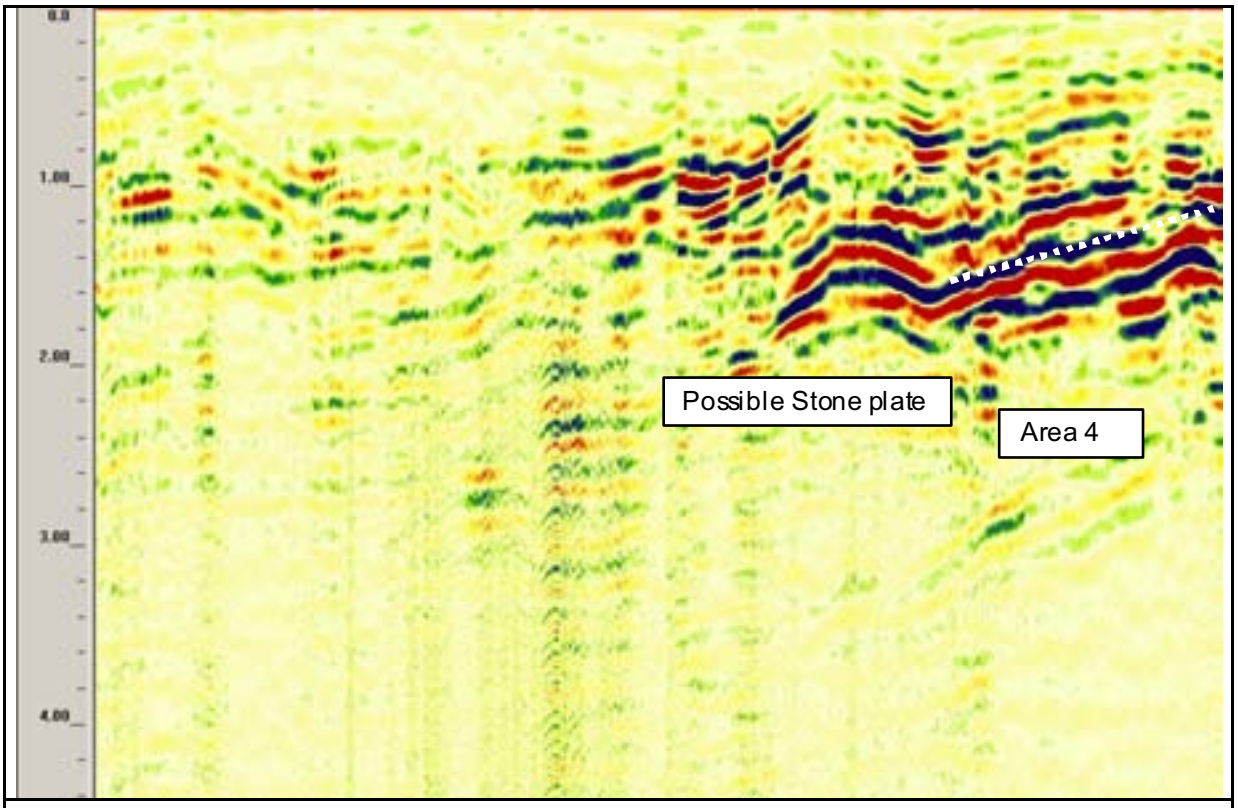

figure 101: radargram of a measuring along measuring line 30 (GSSI, f = 270 MHz) with inhomogenities

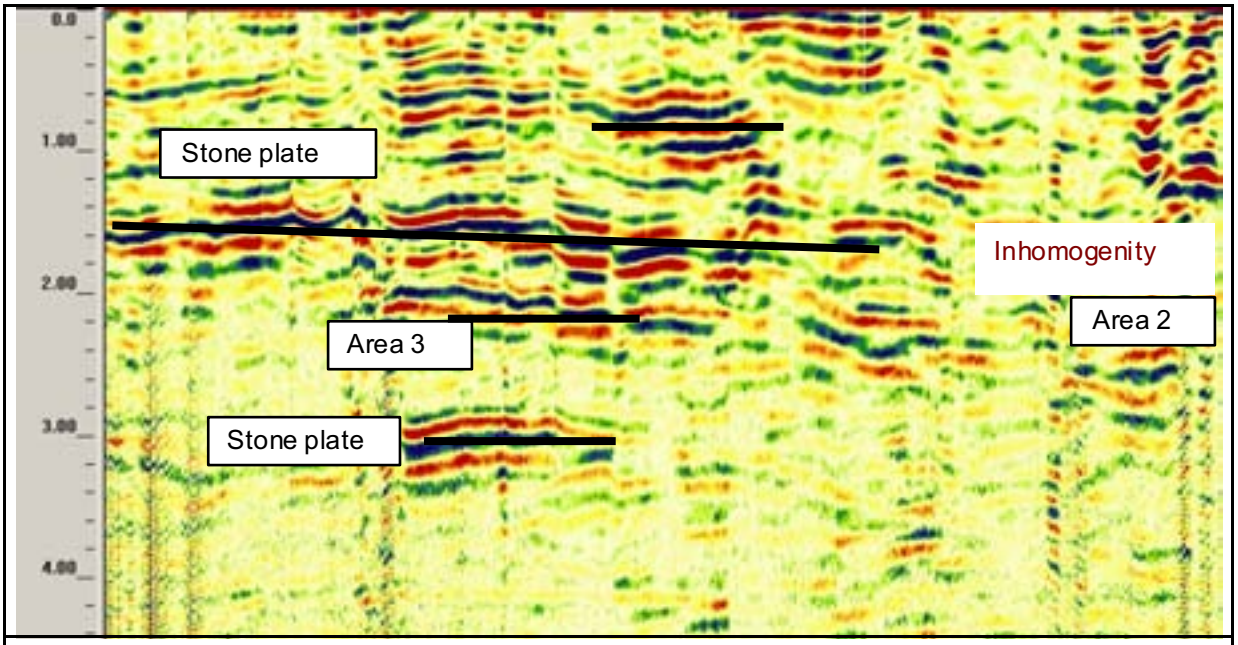

figure 102: radargram of a measuring along measuring line 31 (GSSI, f = 270 MHz) with inhomogenities

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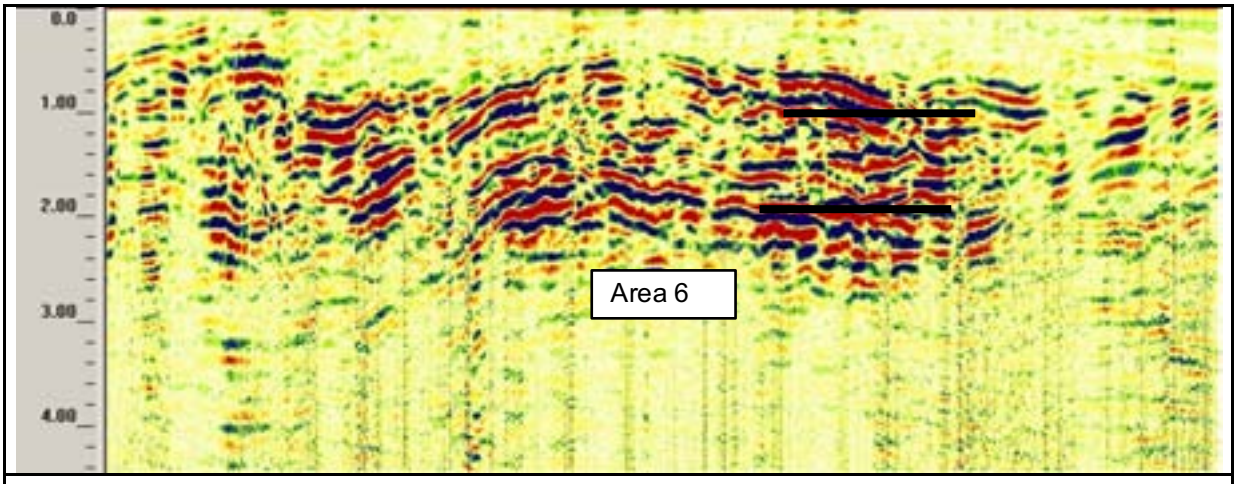

figure 103: radargram of a measuring along measuring line 32 (GSSI, f = 270 MHz) with inhomogenities

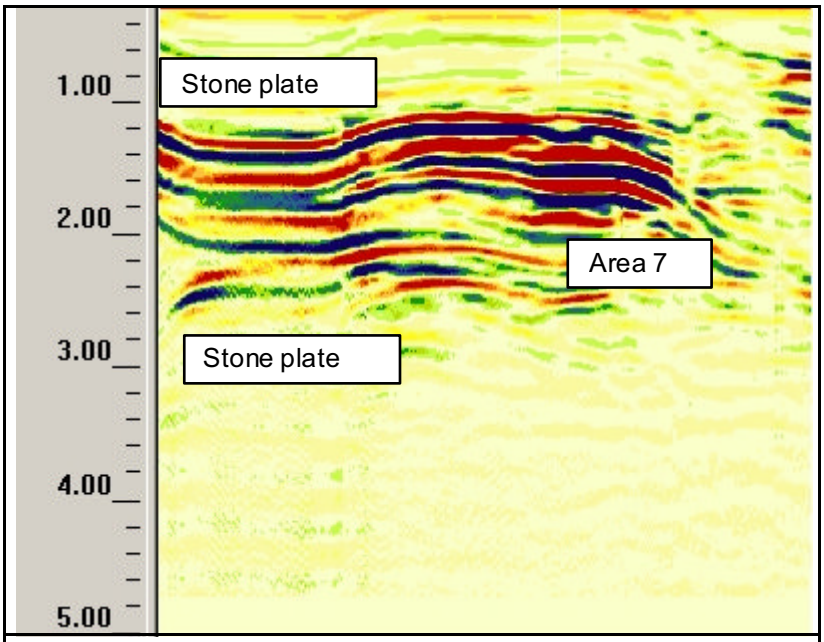

figure 104: radargram of a measuring along measuring line 33 (GSSI, f = 270 MHz) with very strong reflector (perhaps air under it)

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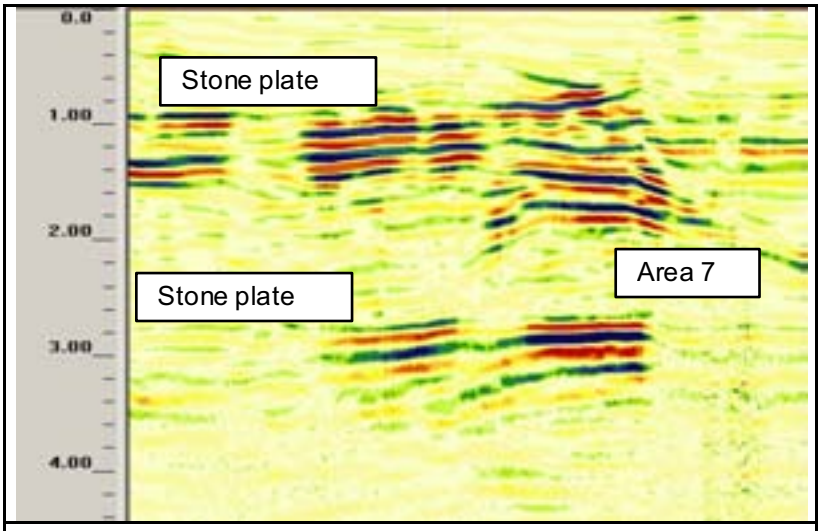

figure 105: radargram of a measuring along measuring line 36 (GSSI, f = 270 MHz) with inhomogenities

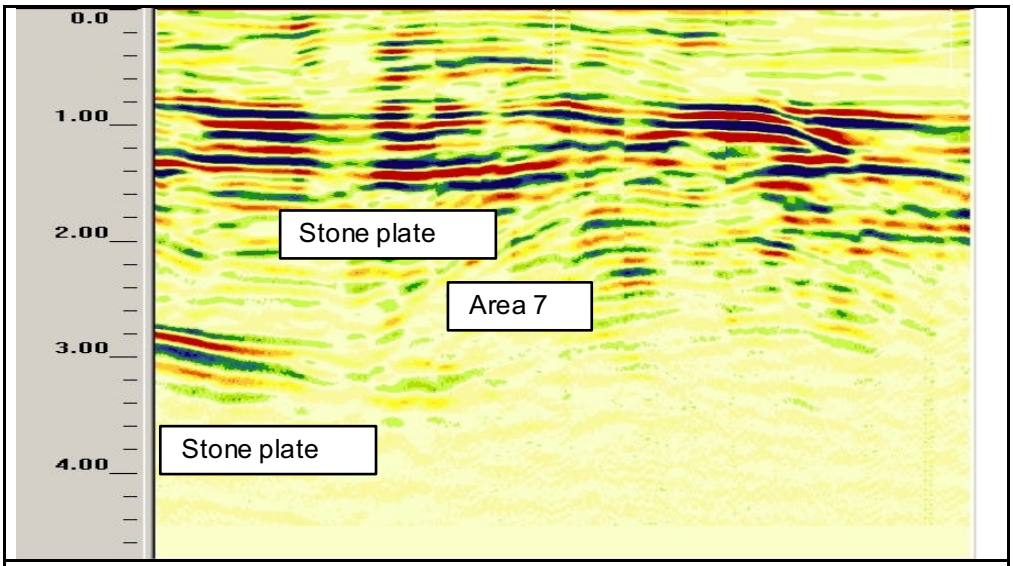

figure 106: radargram of a measuring along measuring line 39 (GSSI, f = 270 MHz) with inhomogenities

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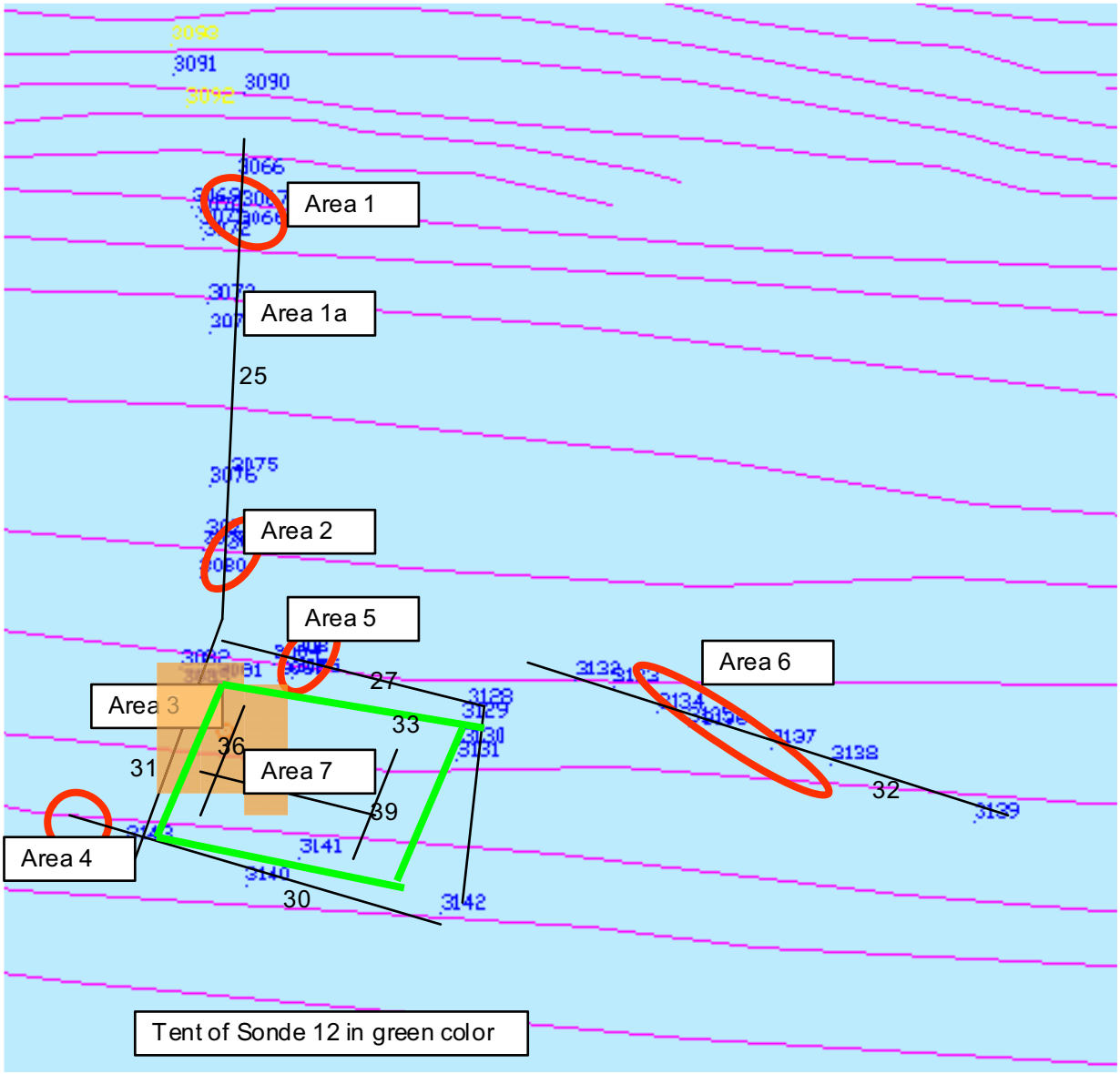
6.3 EVALUATION OF RESULTS



In the picture above the measuring lines and the areas with inhomogenities are shown.

LGA Bautechnik GmbH Tillystraße 2 90431 Nürnberg
Tel.: +49 (0) 911 655-5561 Fax: +49 (0) 911 655-5536
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Area 1, Area 1a:	inhomogenity along the measuring line in depth of: 1,0 – 1,2m
Area 2	Top of Area 1 Depth of inhomogenity: 1,0 – 1,2m
Area 3:	Different layers of stone plates Depth of stone pates 0,8m; 1,3m; 3,0m
Area 4:	Stone plates in depth of 1,3 m – 1,6m
Area 5:	Crack going from Sonde 12 Depth: 0,9 - 1,0m
Area 6:	Two different Layers In depth of 0,9-1,1 m and 1,9 – 2,1m
Area 7:	In the tent of Sonde 12 One up to four layers of stone plates (ore cracked stone plates) Depth of: 0,9m; 1,4m; 1,8m; 3,0m

LGA Bautechnik GmbH • Tillystraße 2 • 90431 Nürnberg
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7 MEASUREMENTS AT PLATEAU A AND B

7.1 Local conditions

figure 107: view of measurements at Plateau (grassland)

7.2 RESULTS OF THE MEASUREMENTS

The measurements were done with a 270 MHz and a 100 MHz radar antenna at the Plateau.
The ground has been wet what results in a high damping of signals.
Anywhere the results of the measurements were in the first 4 m very good. The results of measurements with the 100 MHz antenna brought no information.

Following the results of measurements at the plateau are shown.

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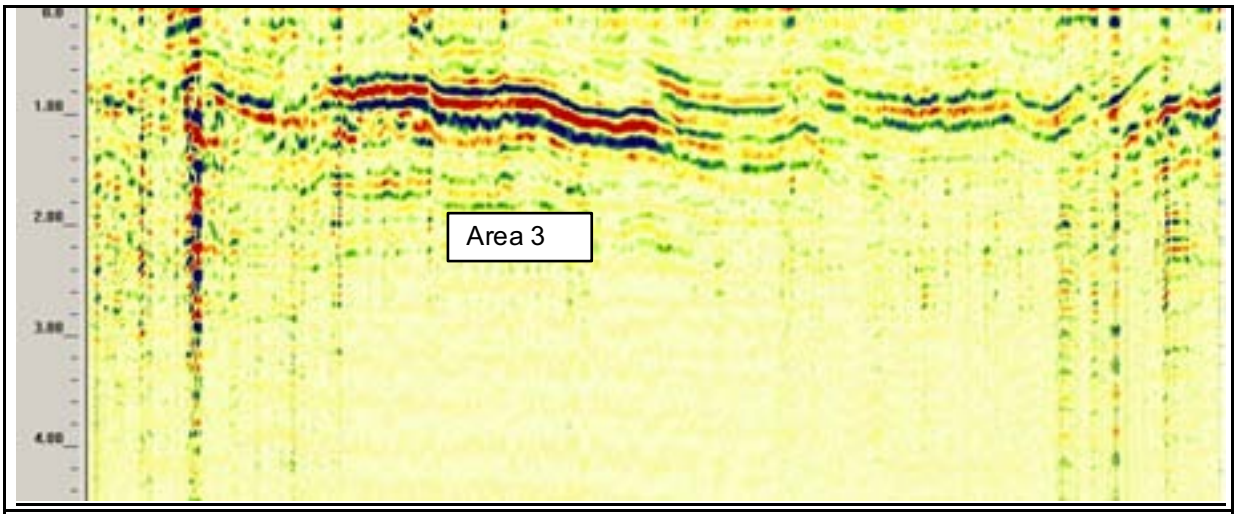

figure 108: radargram of a measuring along measuring line 42 (GSSI, f = 270 MHz) with inhomogenities

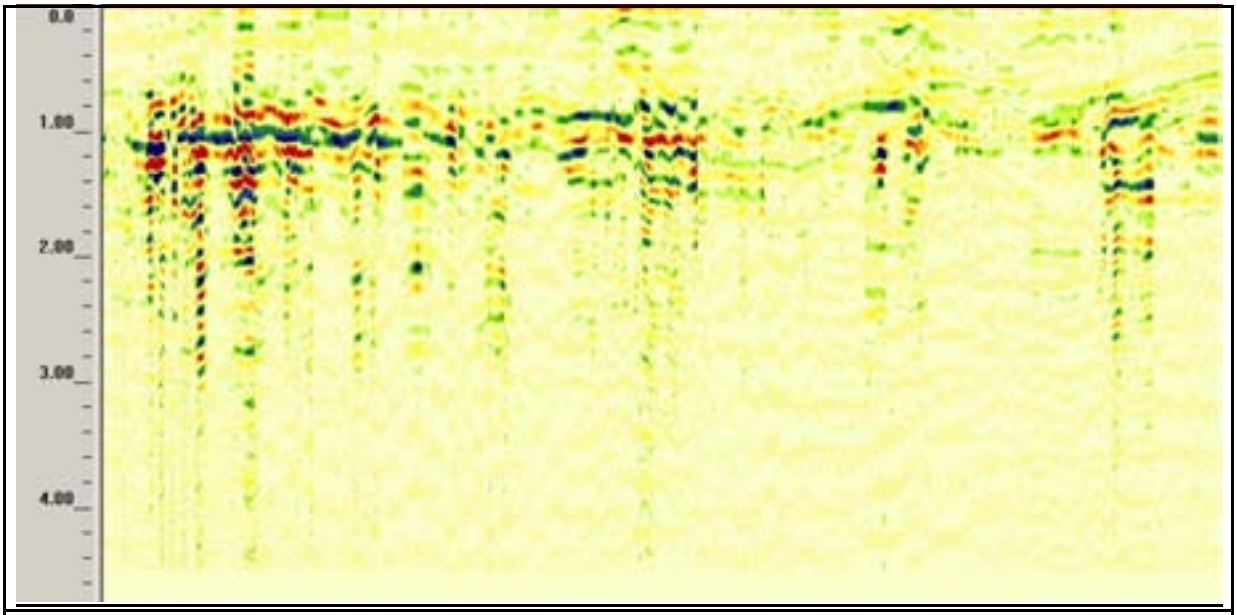

figure 109: radargram of a measuring along measuring line 44 along way (GSSI, f = 270 MHz) with inhomogenities

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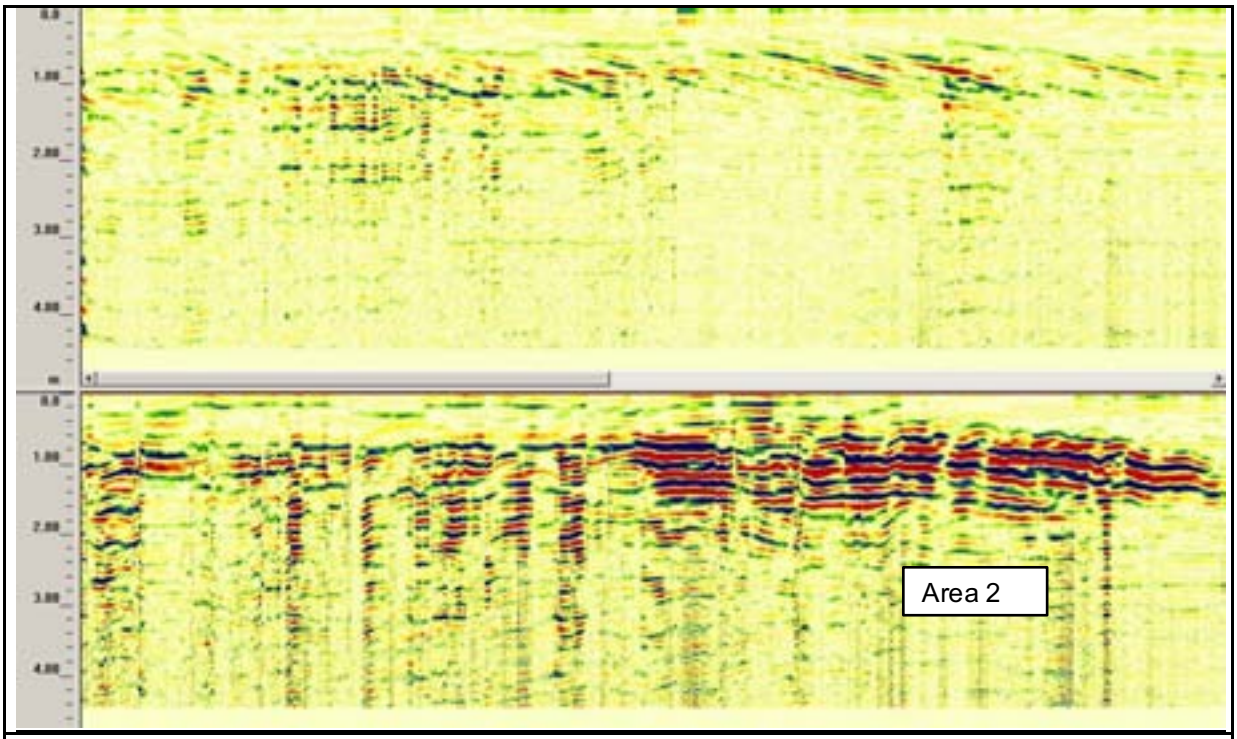

figure 110: radargram of a measuring along measuring line 49 (GSSI, f = 270 MHz) with inhomogenities

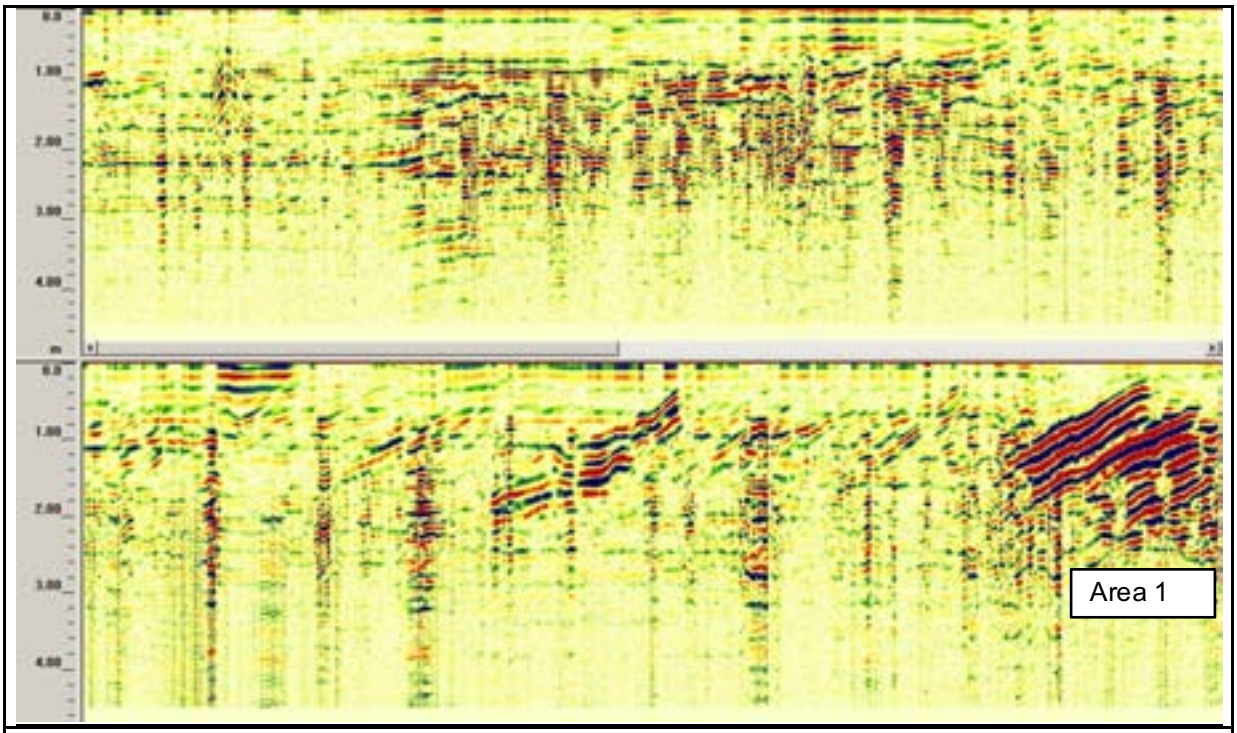

figure 111: radargram of a measuring along measuring line 54 (GSSI, f = 270 MHz) with inhomogenities

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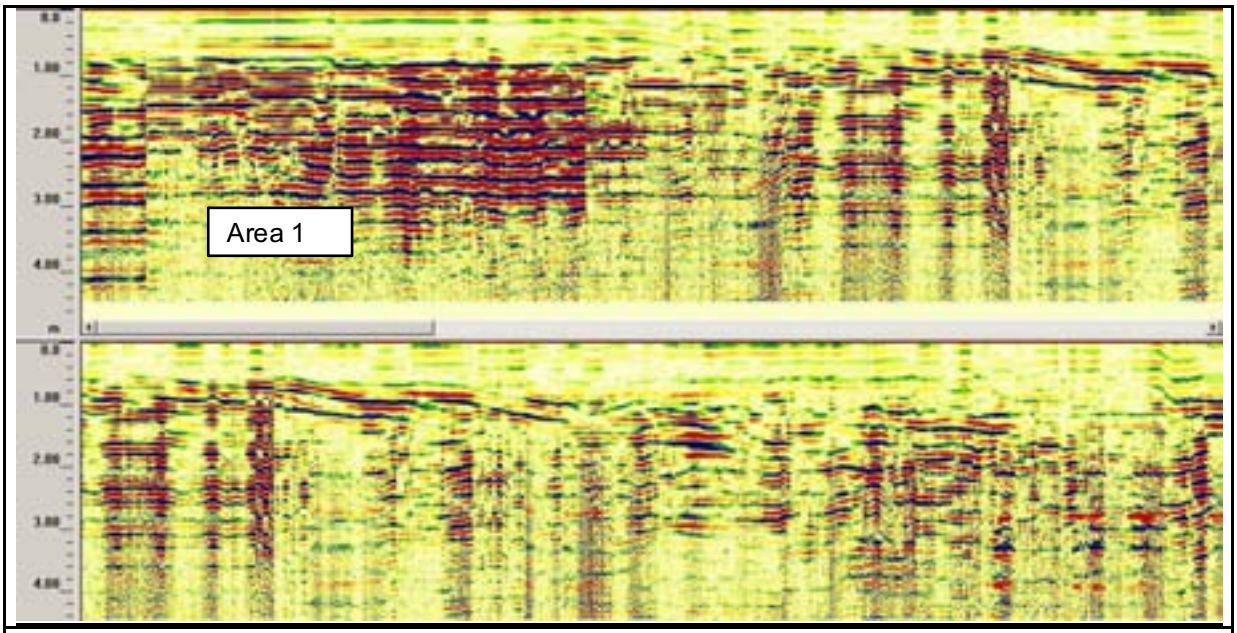
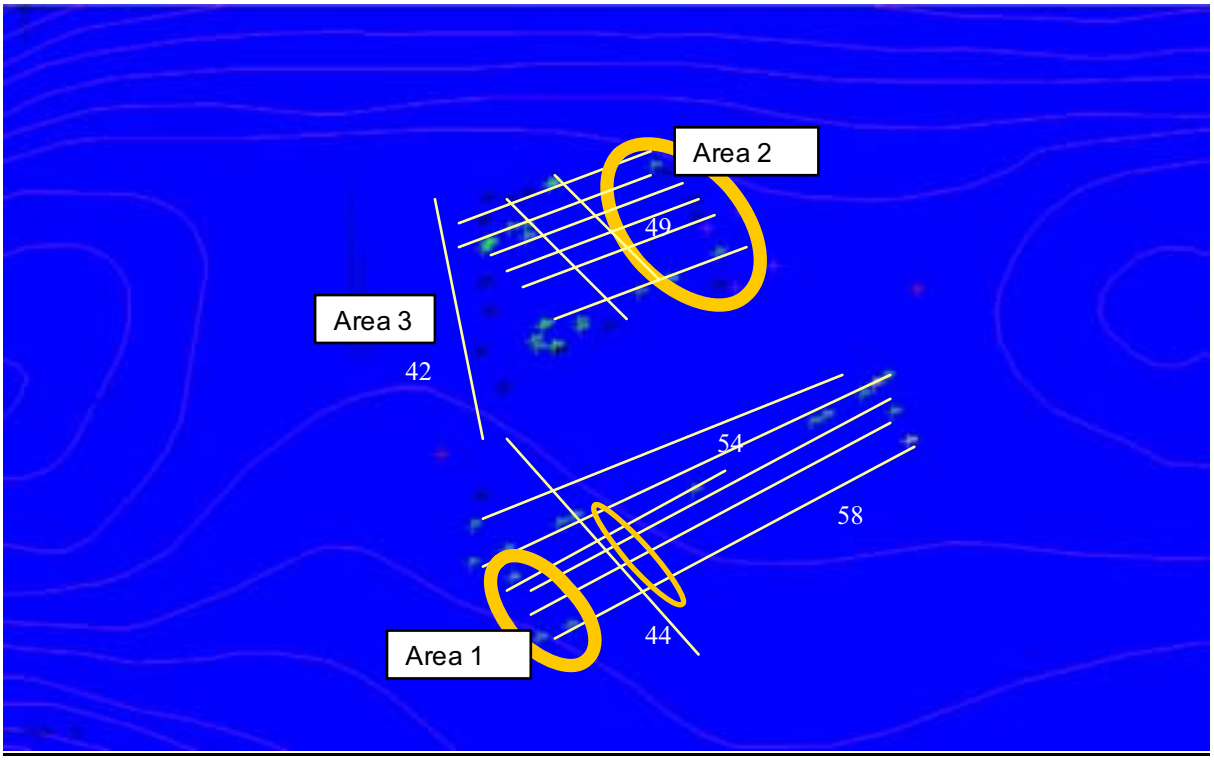


figure 112: radargram of a measuring along measuring line 58 (GSSI, f = 270 MHz) with inhomogenities

7.3 CONCLUSSION OF RESULTS



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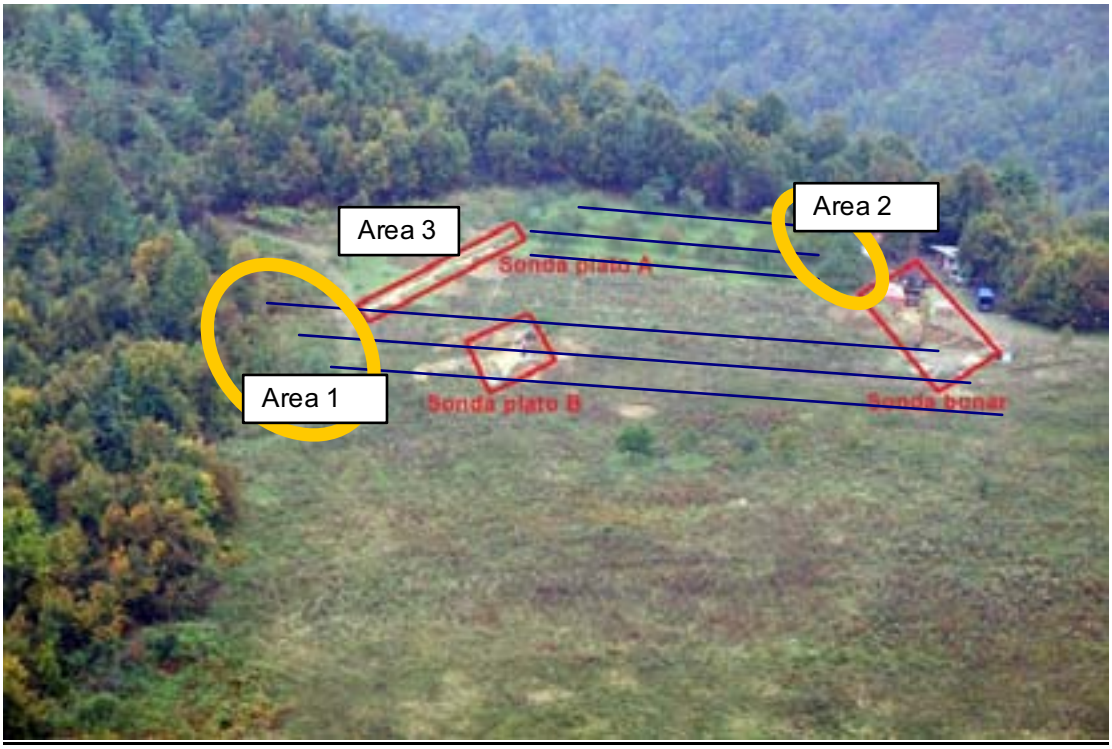

Area 1	At the end of grassland in depth of: 0,5 – 2,0m
Area 2	At the end of grassland with trees Depth of inhomogenity: 0,7 – 1,3m
Area 3:	Parallel to stone plates Depth of inhomogenity: 1,0 – 1,2m

LGA Bautechnik GmbH • Tillystraße 2 • 90431 Nürnberg
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8 MEASUREMENTS AT PLATEAU AND PYRAMIDE

8.1 Local conditions

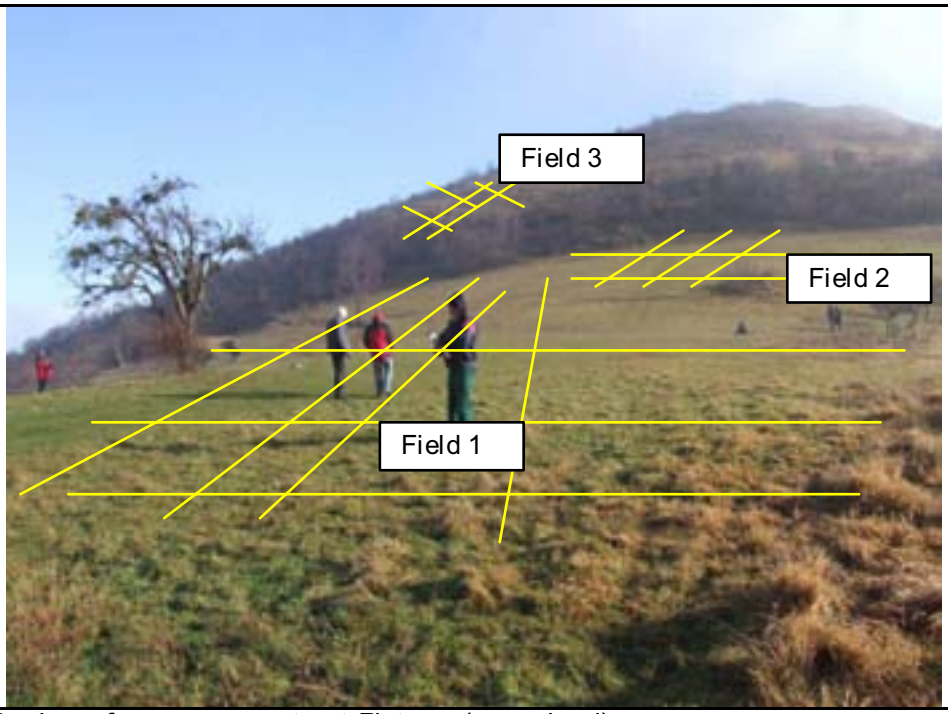

figure 113: view of measurements at Plateau (grassland)

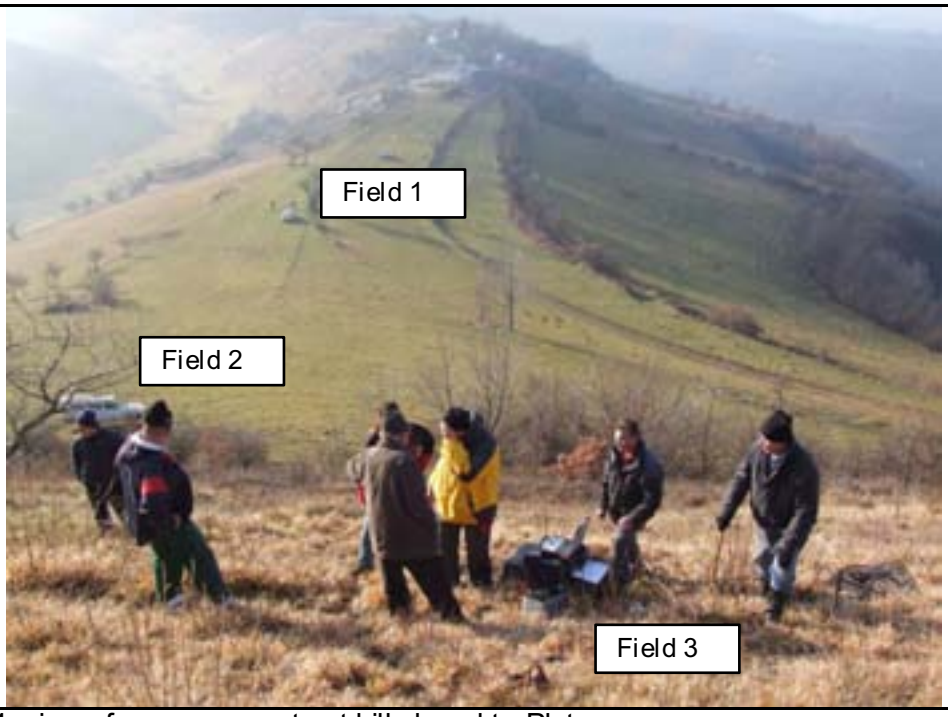

figure 114: view of measurements at hill closed to Plateau

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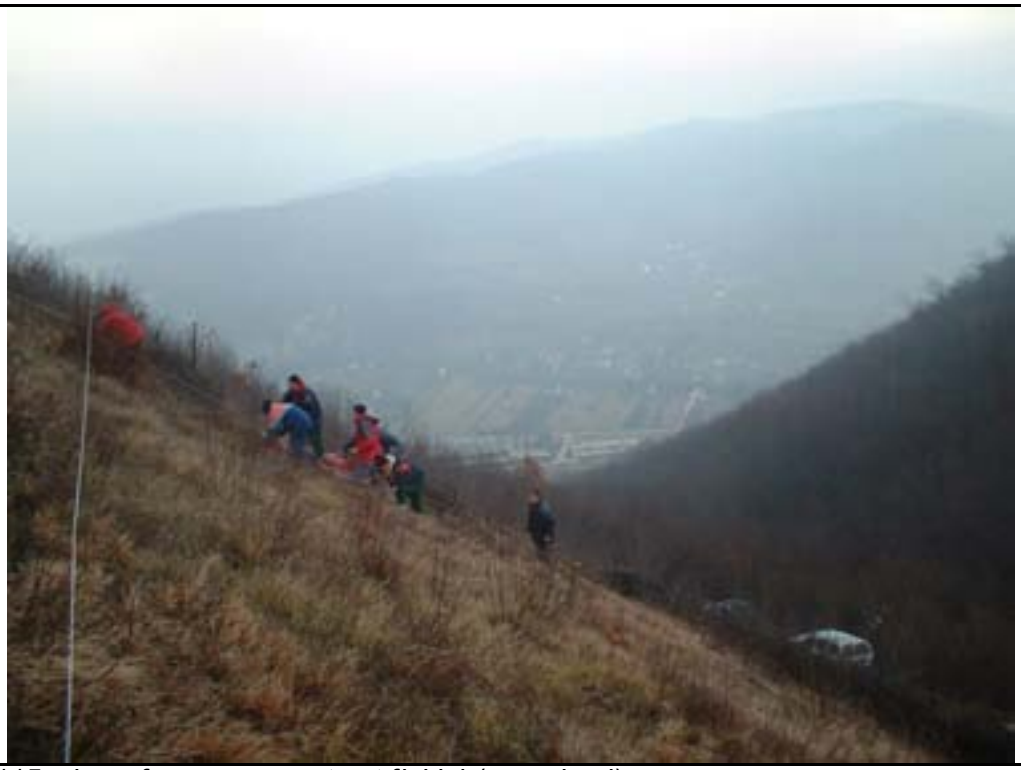

figure 115: view of measurements at field 4 (grassland)

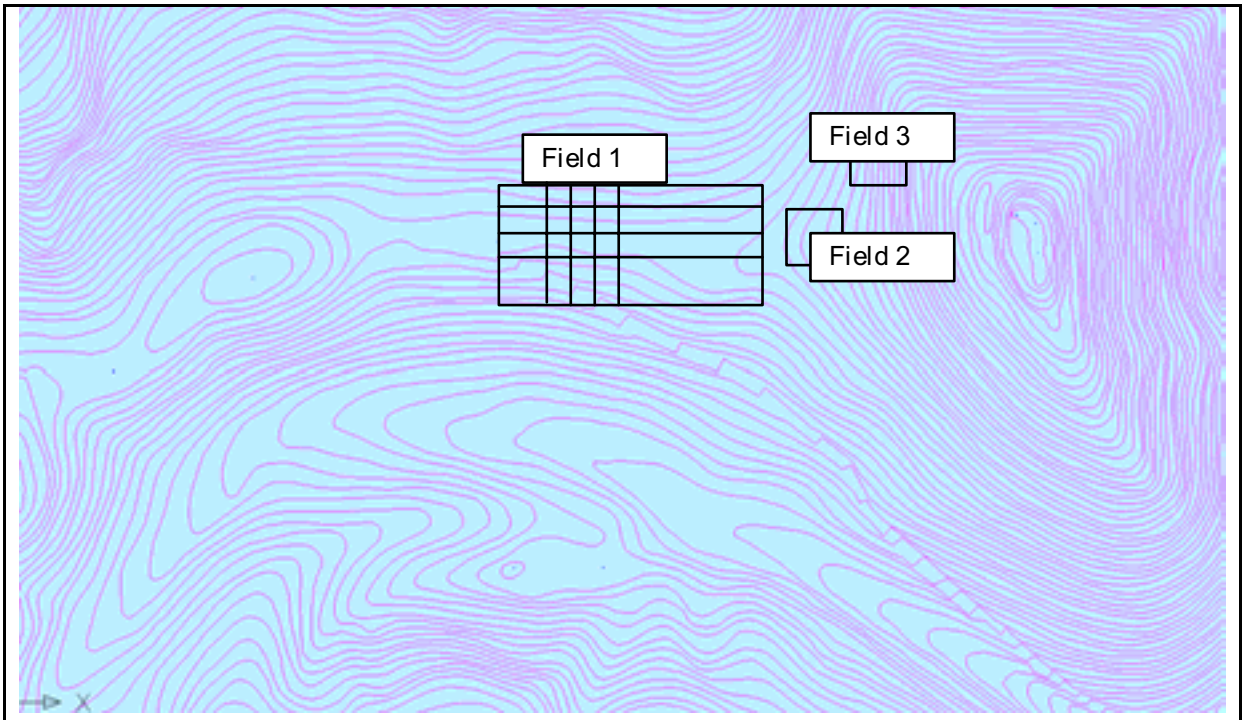

figure 116: view measuring fields, field 1: 4 long lines, 20 short lines

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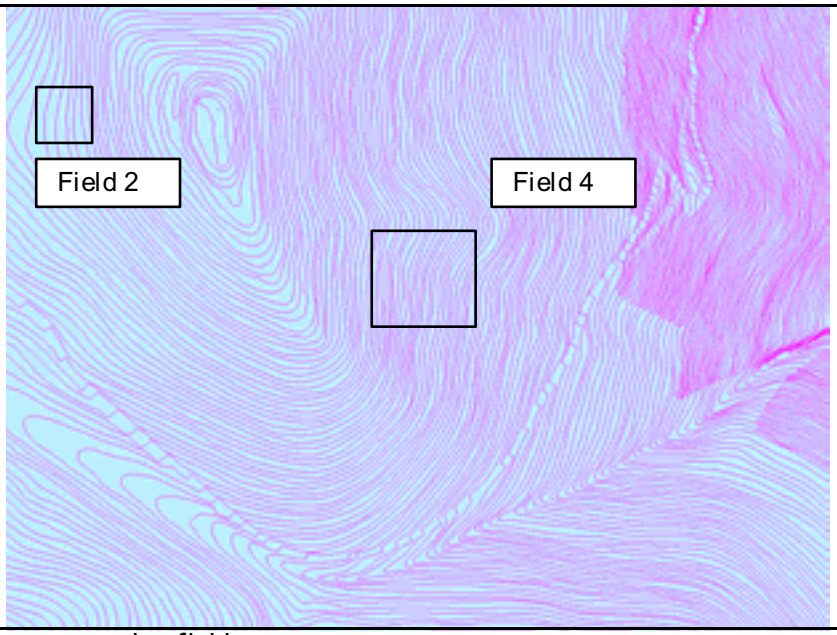

figure 117: view measuring fields

8.2 RESULTS OF THE MEASUREMENTS

The measurements were done with a 100 MHz radar antenna at the Plateau. The ground has been wet what results in a high damping of signals. Anywhere the results of the measurements were in the first 4 m very good.

Following the results of measurements at the plateau are shown.

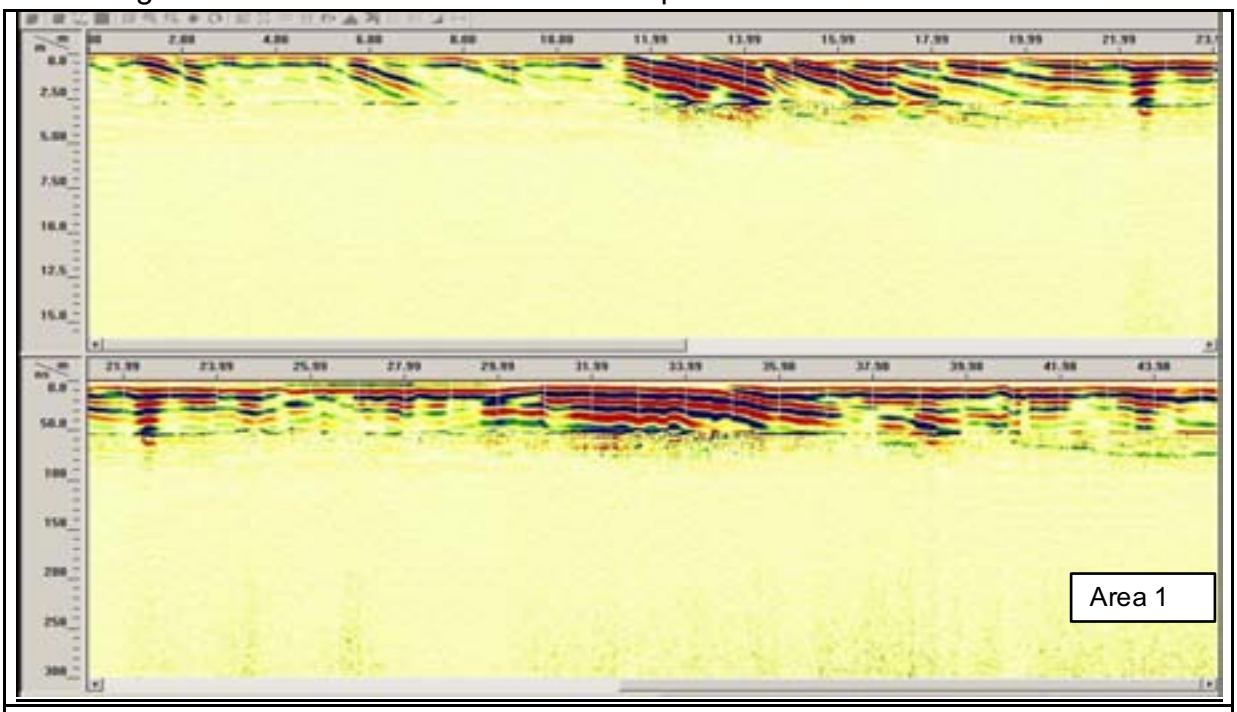

figure 118: radargram of a measuring along measuring line 1 (GSSI, f = 100 MHz) with inhomogenities

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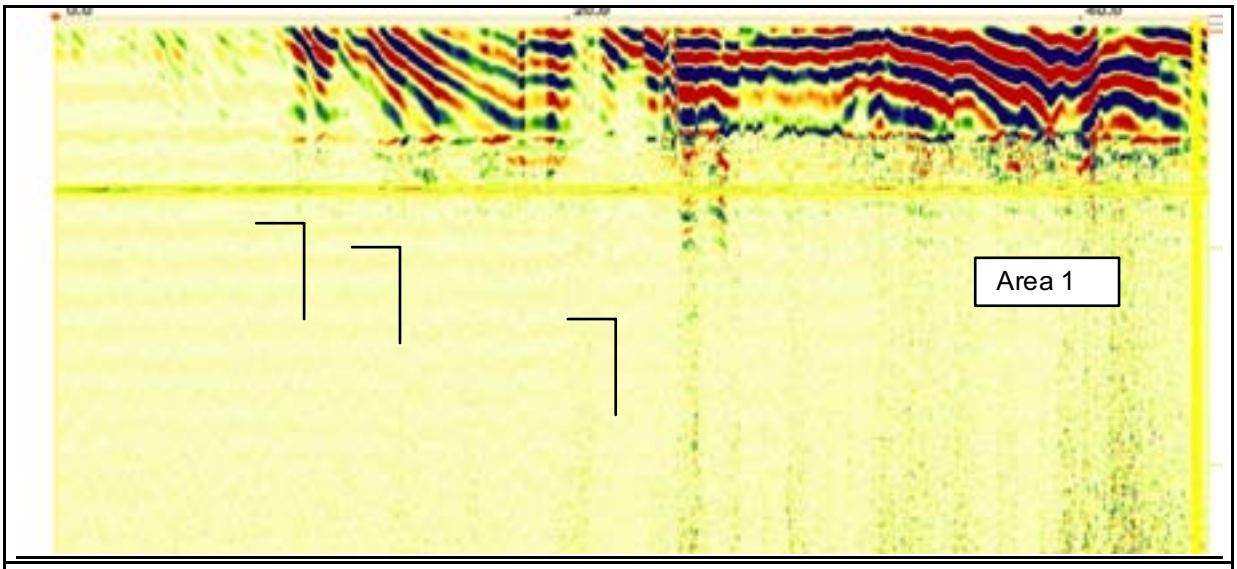

figure 119: radargram of a measuring along measuring line 3 (GSSI, f = 100 MHz) in field 1 with inhomogenities caused by stairs of stone

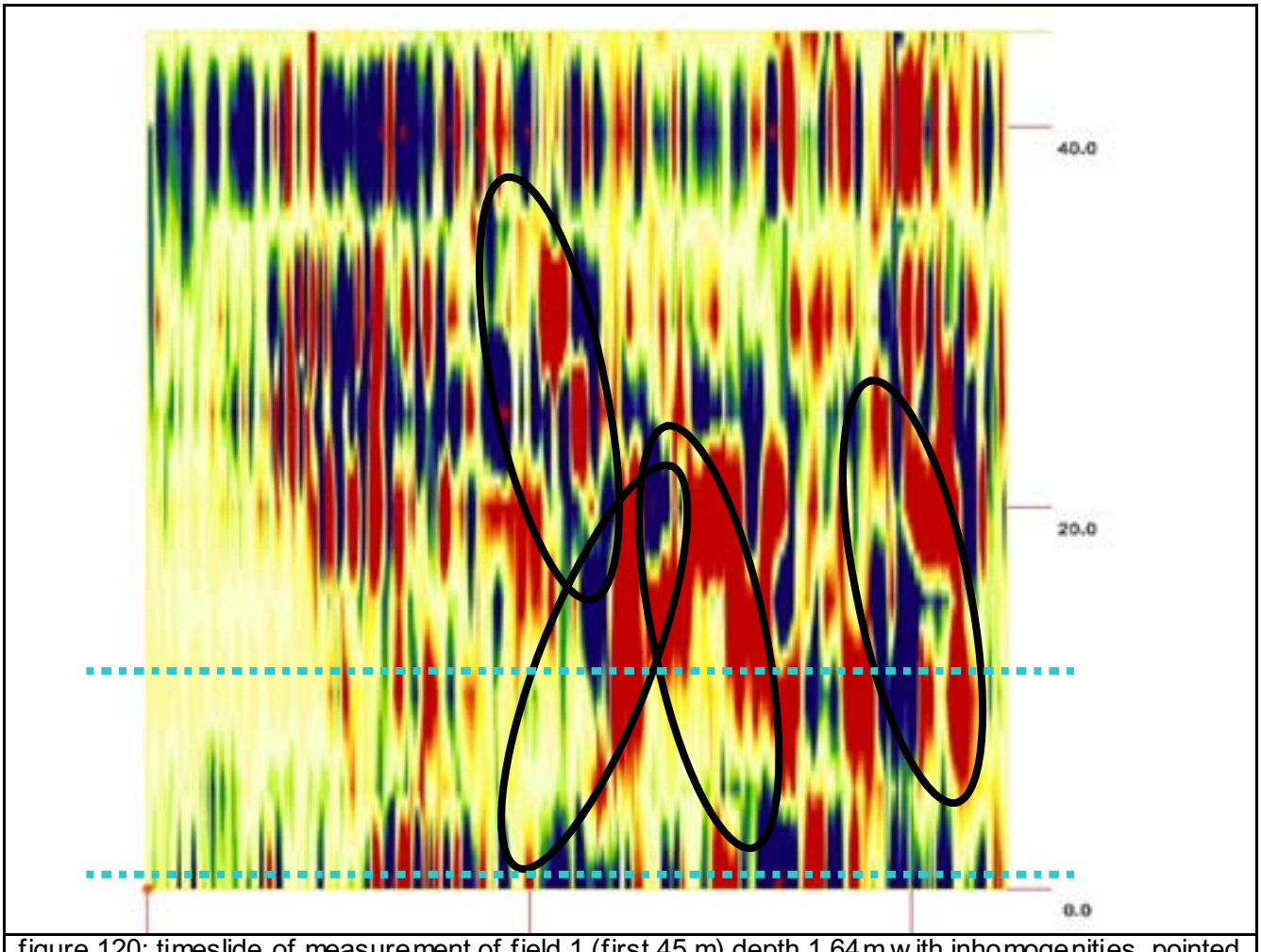

figure 120: timeslide of measurement of field 1 (first 45 m) depth 1,64 m with inhomogenities, pointed

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lines: bottom line 1, upper – line 3

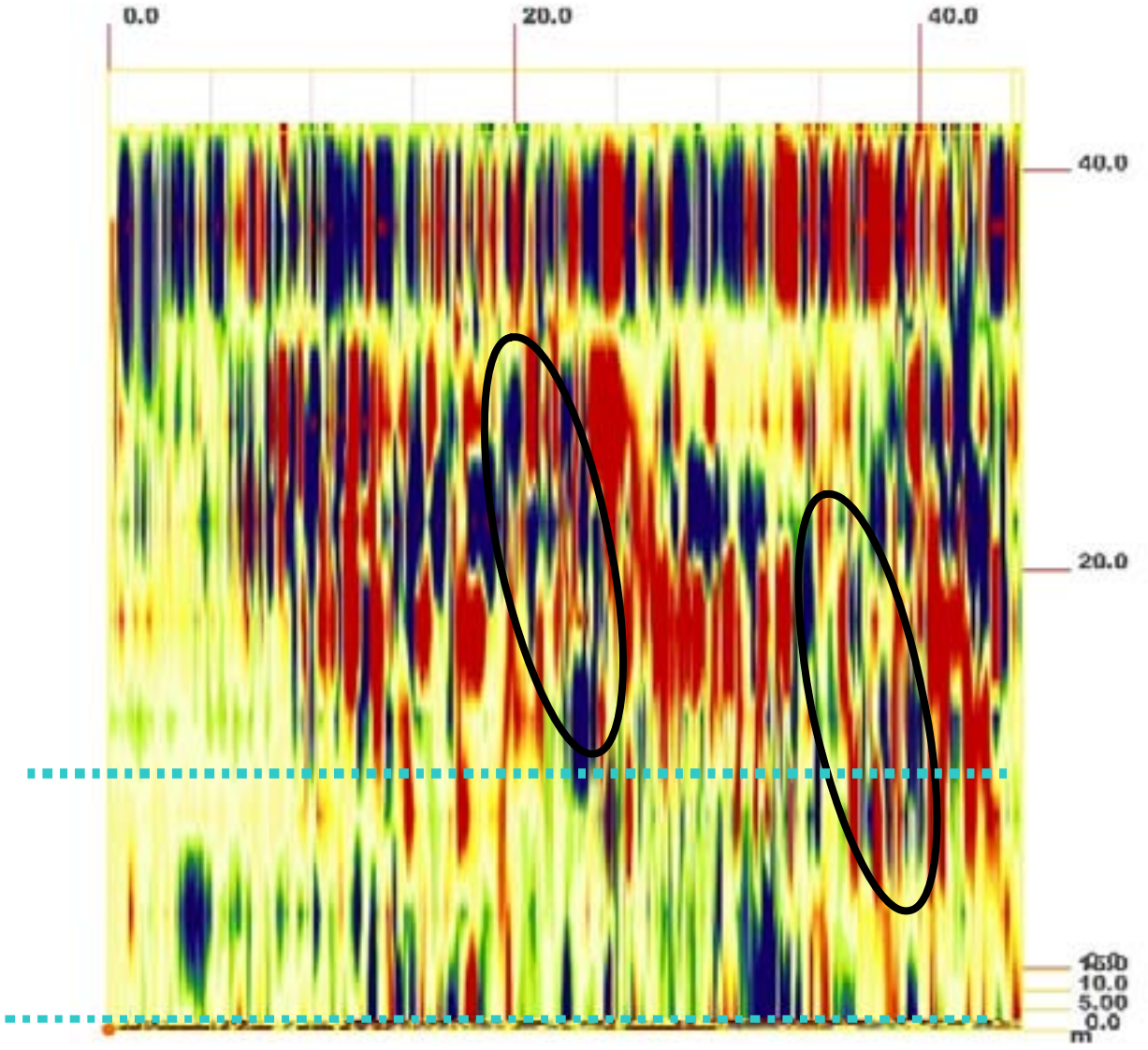

figure 121: timeslide of measurement of field 1 (first 45 m) depth 2,67m with inhomogenities, pointed lines: bottom line 1, upper – line 3

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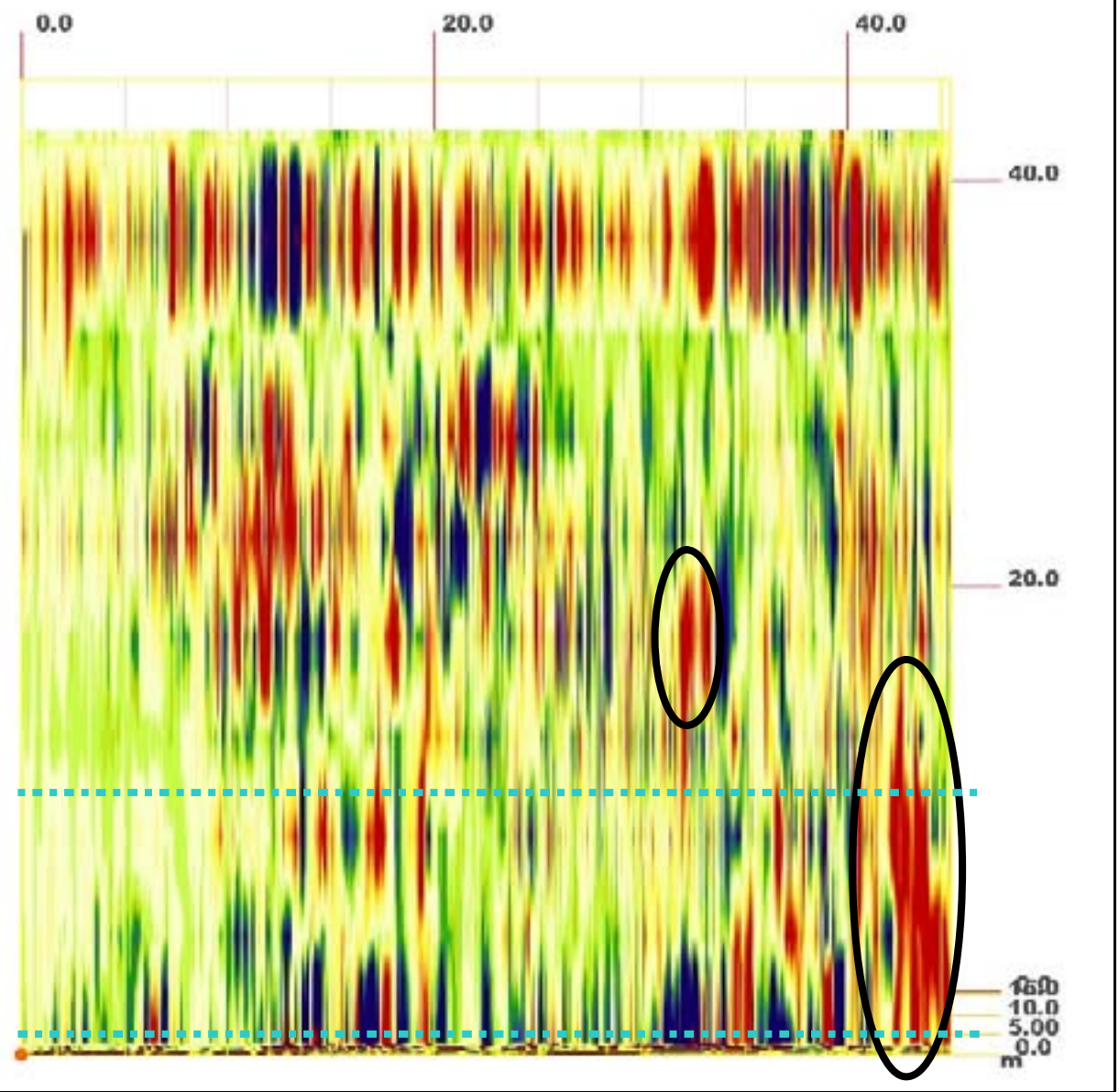

figure 122: timeslide of measurement of field 1 (first 45 m) depth 2,84 m with inhomogenities, pointed lines: bottom line 1, upper – line 3

Inhomogenity go from 2,8 m as a diagonal to 1,6 m with a length of 30 m

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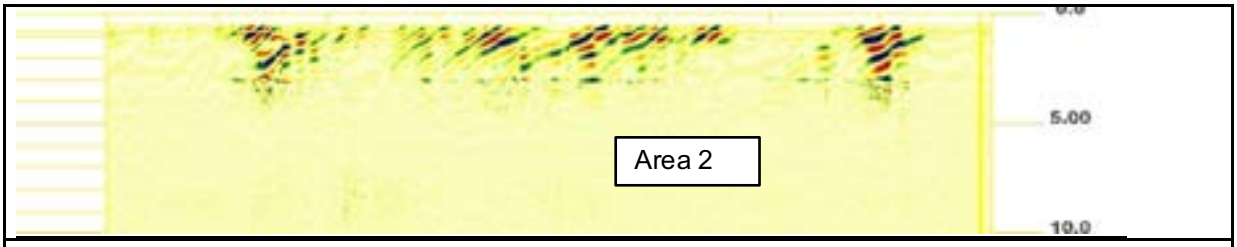

figure 123: radargram of a measuring along measuring line 16 at field 1 the right 45 m (GSSI, f = 270 MHz) with inhomogenities

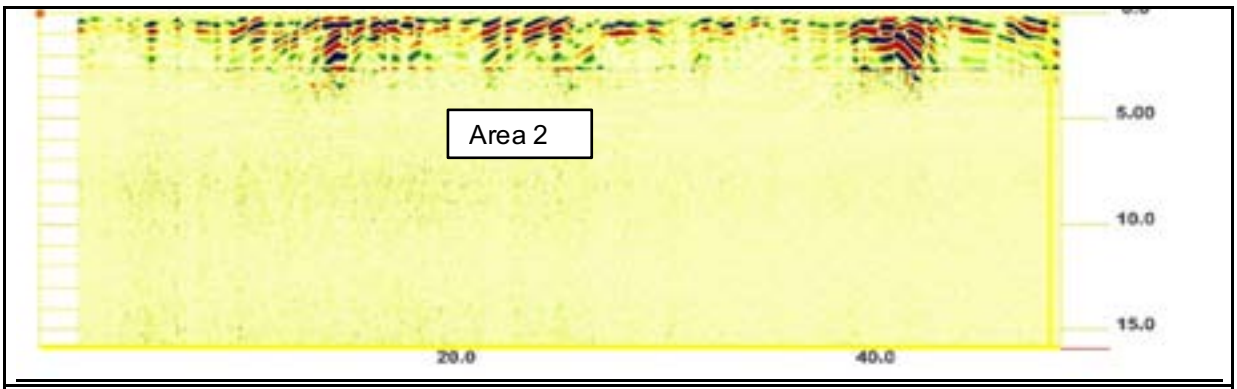

figure 124: radargram of a measuring along measuring line 15 at field 1 the right 45 m (GSSI, f = 270 MHz) with inhomogenities

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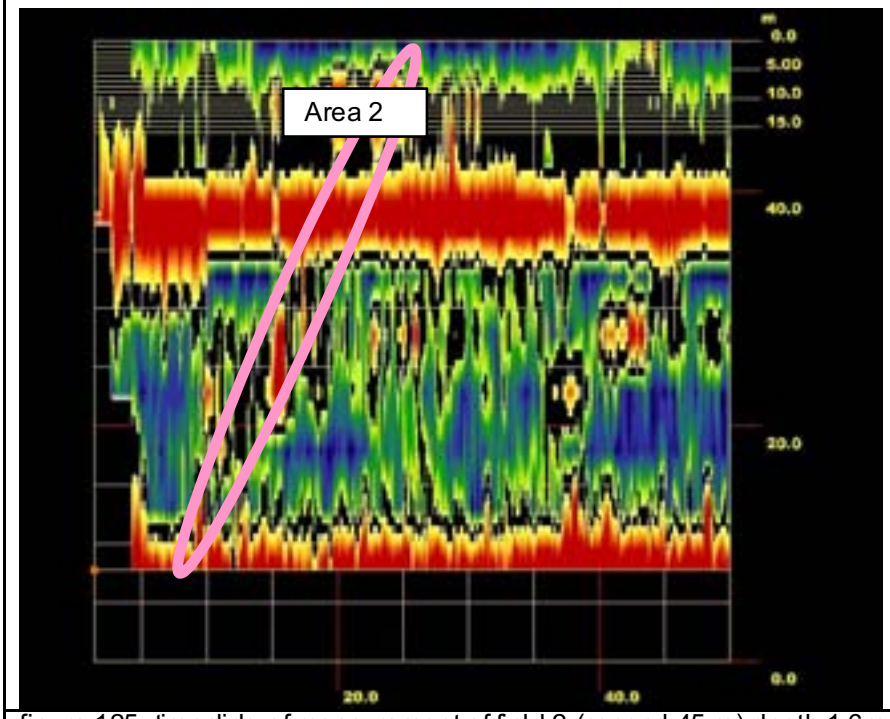

figure 125: timeslide of measurement of field 2 (second 45 m) depth 1,6m with inhomogenities

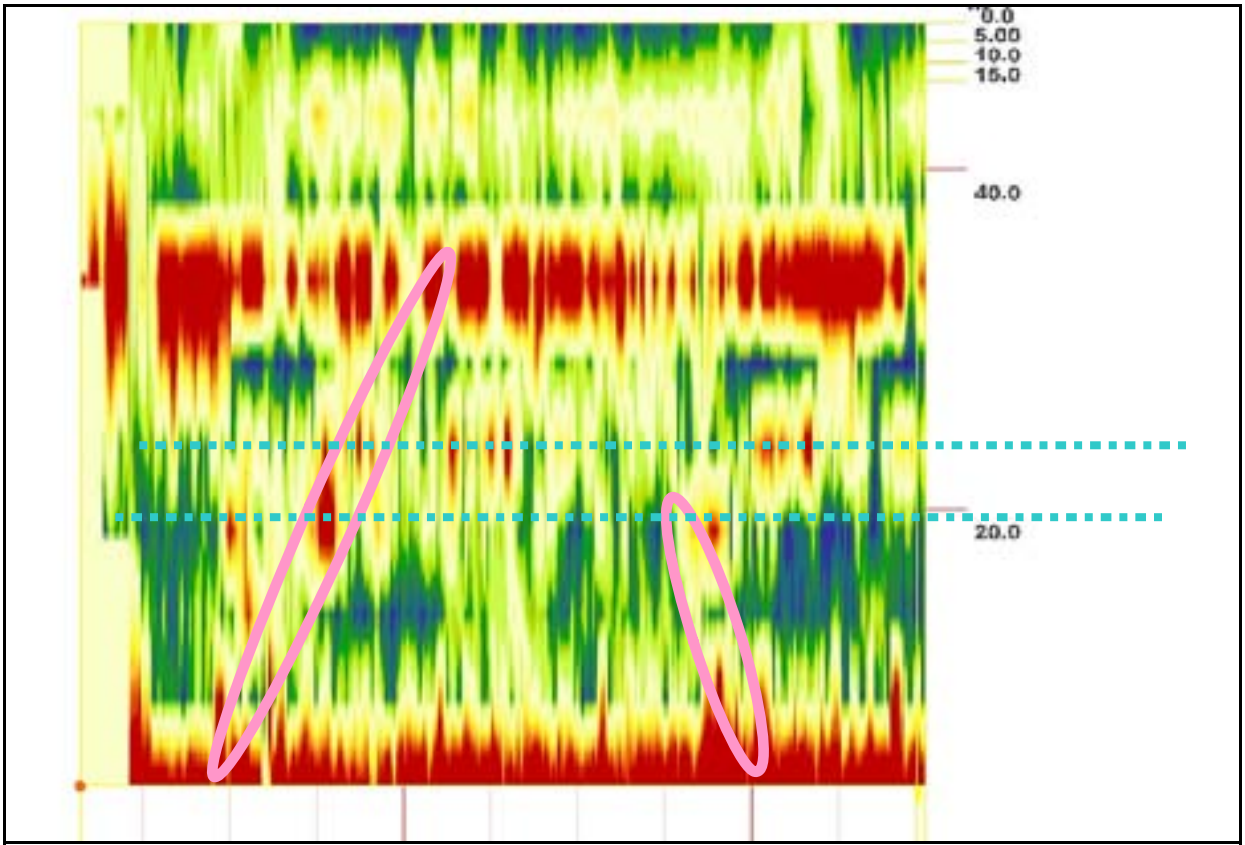

figure 126: timeslide of measurement of field 2 (second 45 m) depth 1,47m with inhomogenities, pointed lines: bottom line 15, upper – line 16

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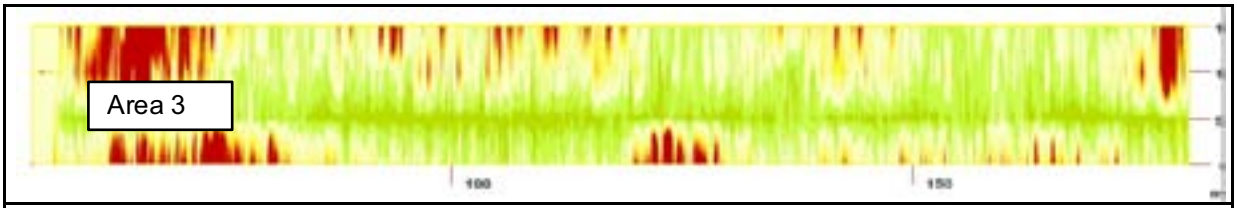

figure 127: timeslide of long lines in depth of 2,8m (GSSI, f = 100 MHz) with inhomogenitie (0,7 – 3,5m)

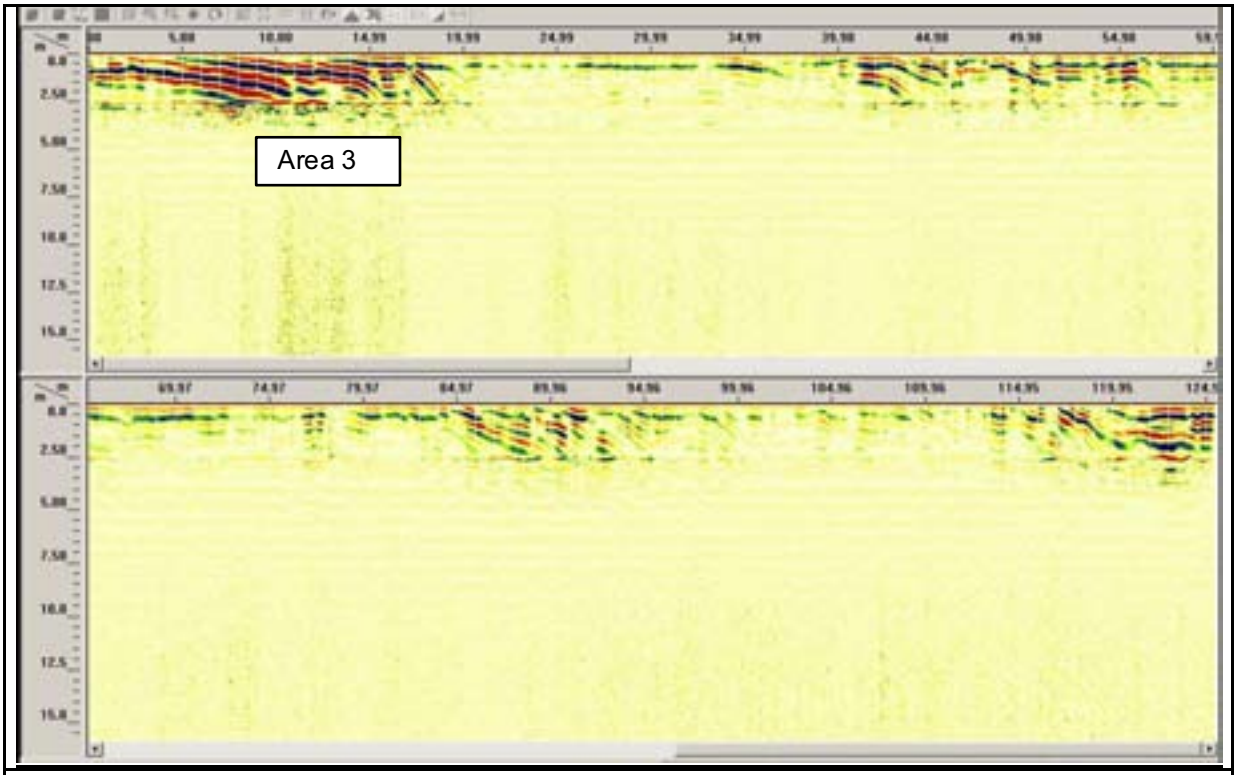

figure 128: radargram of a measuring along measuring line 23 (GSSI, f = 100 MHz) with inhomogenities

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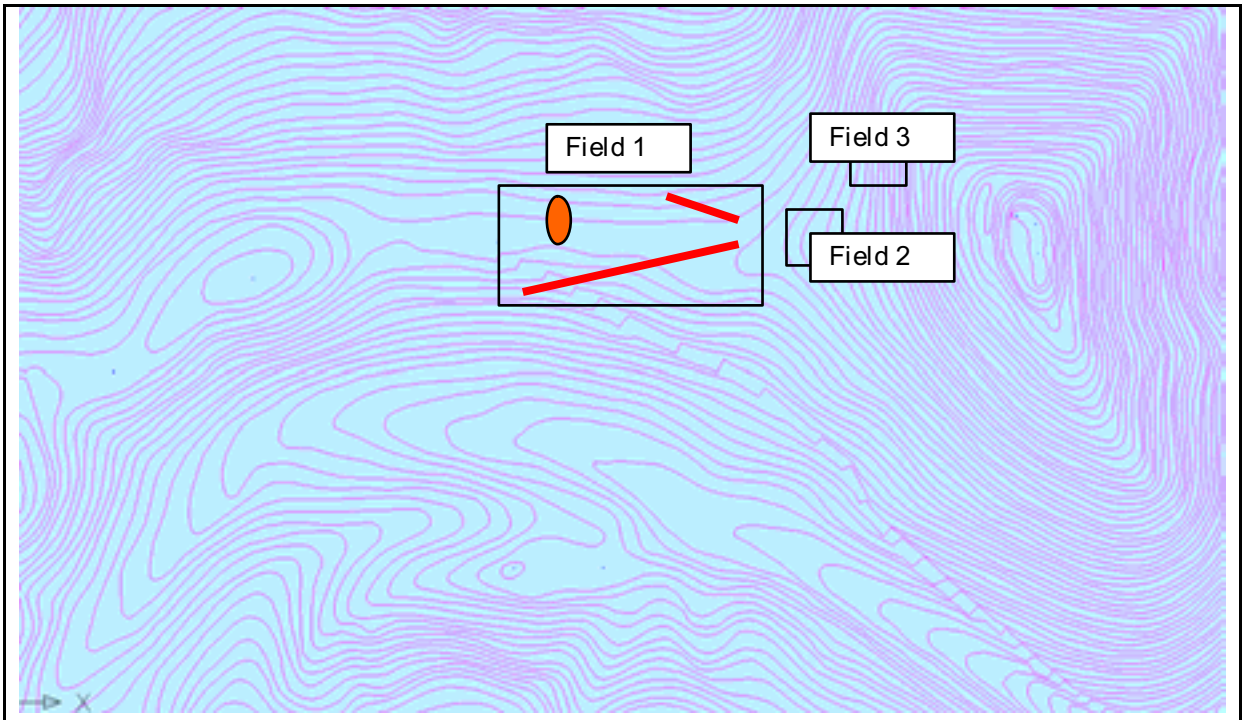

figure 129: view measuring fields

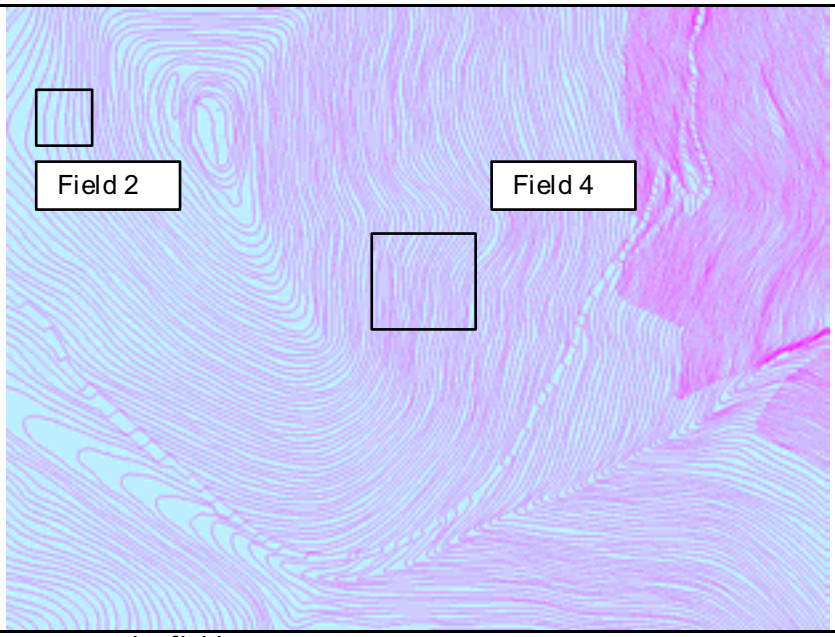

figure 130: view measuringfields

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Field 1	
Area 1	On the right side inhomogenites in depth of: 1,6 – 2,8 m with length of 30 m
Area 2	Inhomogenity in depth of: 0,8 – 2,0m
Area 3	Inhomogenity in depth of: 0,7 – 3,5m
Field 2	
	Very strong damping of signals, few inhomogenities in the first 1-2m
Field 3	Very strong damping of signals, inhomogenities beginning 0,7 m from surface, no structure, no different pictures parallel and right angle to hill
Field 4	
	Grassland with small bushes, no reflections received, possible cause of no reflector or total damping of signal

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9 MEASUREMENTS AT BOTTOM OF VALLEY

9.1 Local conditions

Inhomogene ground wiHt civil structure in it.

9.2 CONCLUSSION OF RESULTS

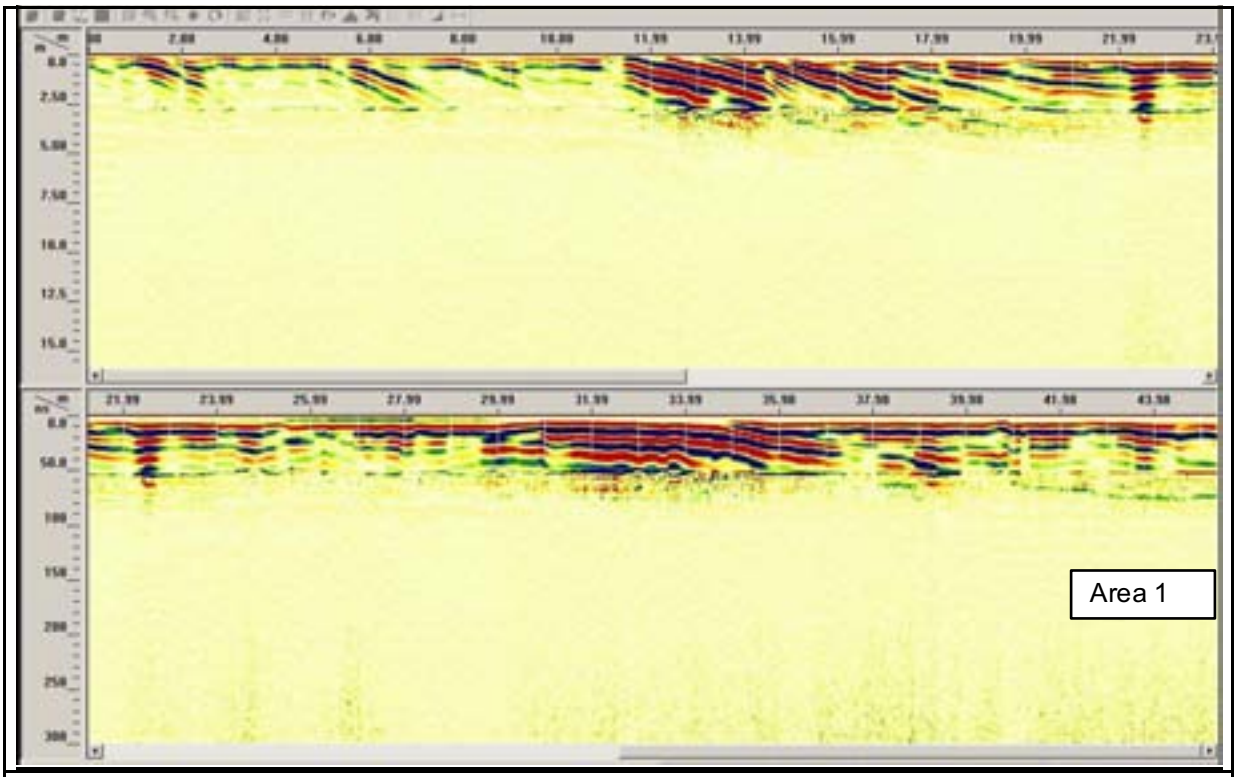

figure 131: radargram of a measuring along measuring line 1 (GSSI, f = 100 MHz) with inhomogenities

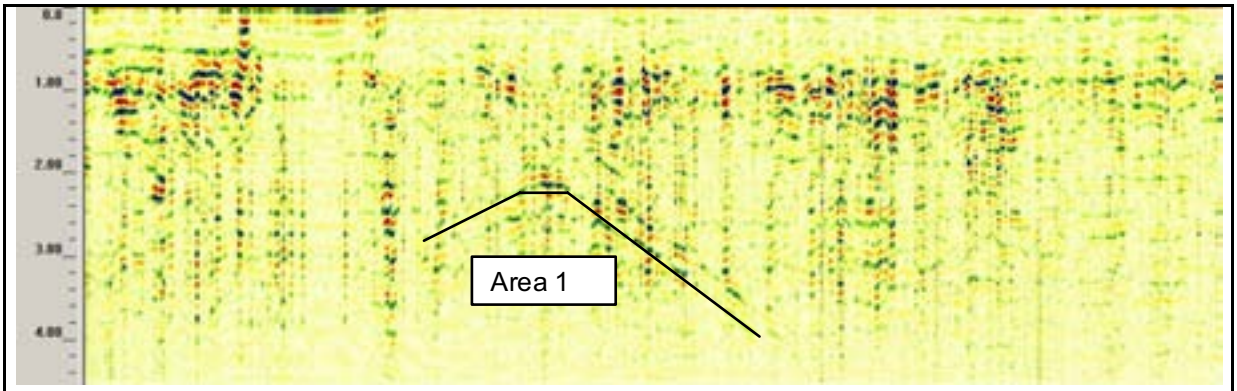

figure 132: radargram of a measuring along measuring line 37 (GSSI, f = 270 MHz) with inhomogenities

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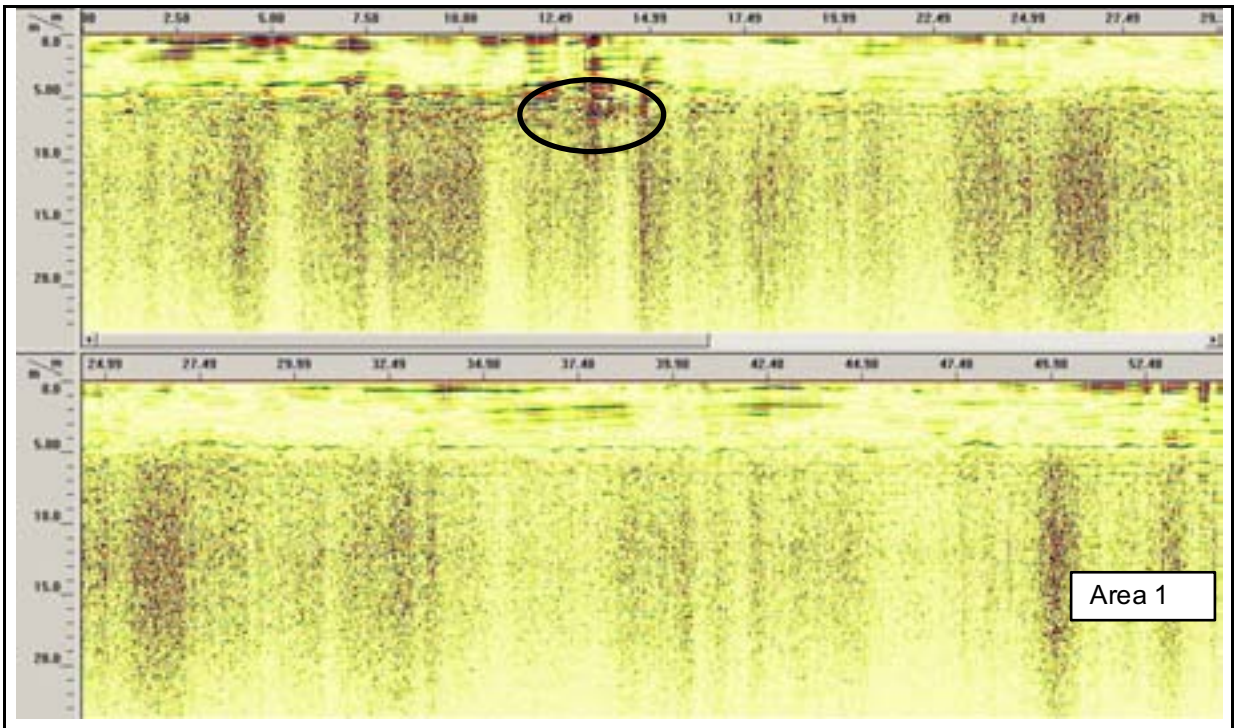

figure 133: radargram of a measuring along measuring line 38 (GSSI, f = 100MHz) with small inhomogenity, but no clear echo

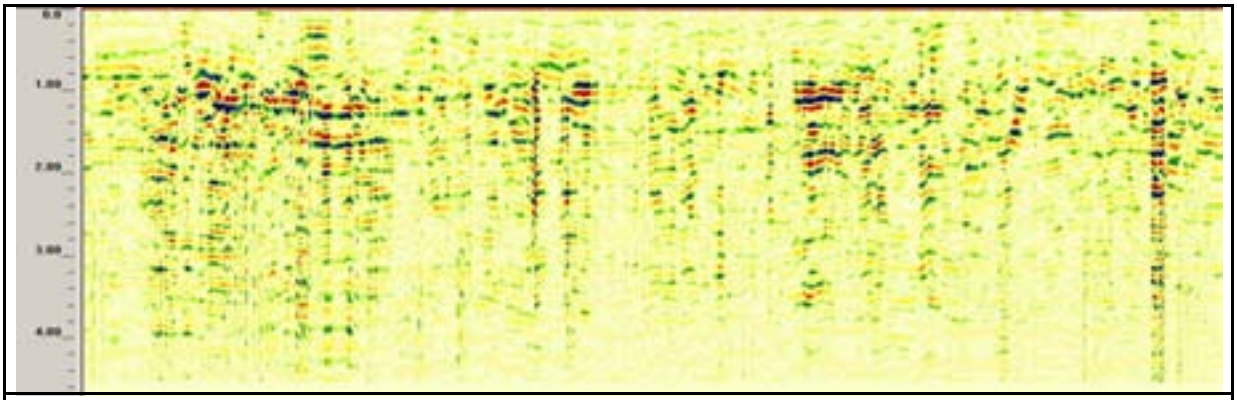

figure 134: radargram of a measuring along measuring line 40 (GSSI, f = 270MHz) with no echo, only inhomogenitiers from closed structure

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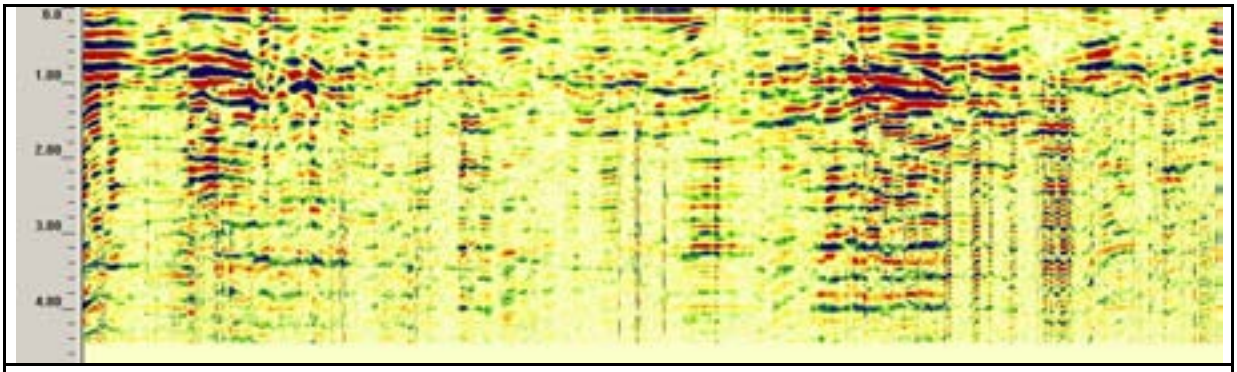
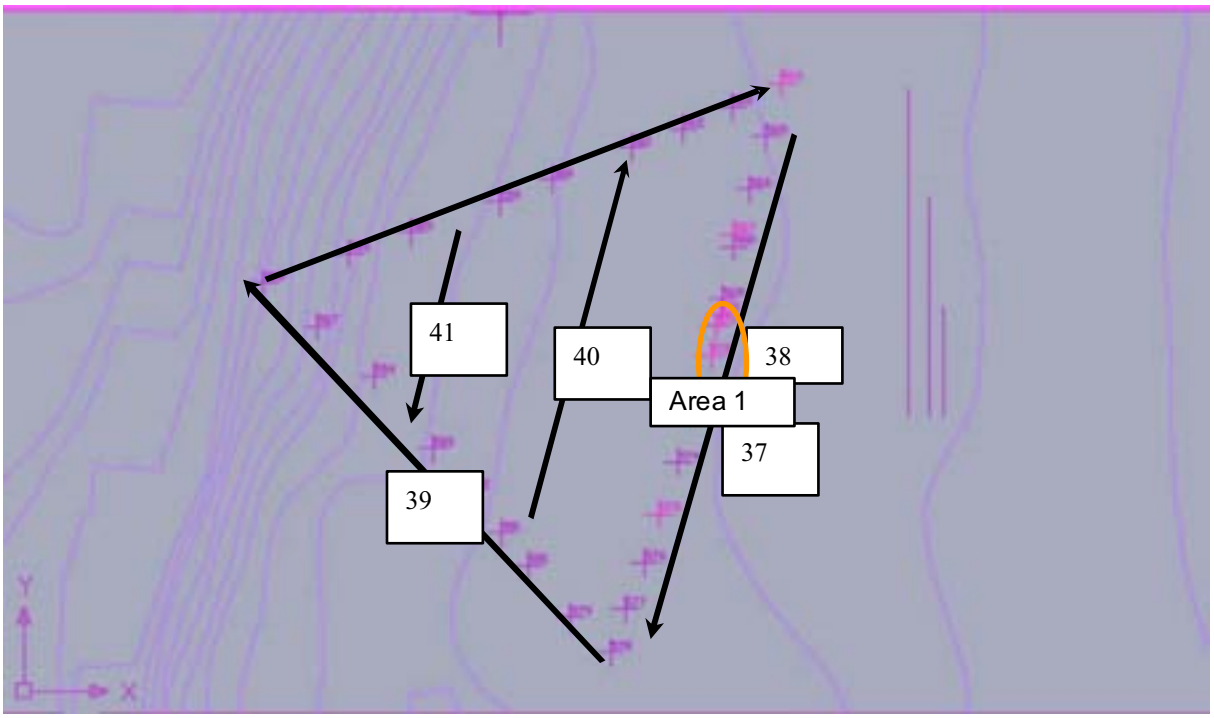


figure 135: radargram of a measuring along measuring line 39 (GSSI, f = 270MHz) with echo from closed structure



The measurements show, that it is very difficult to measure in an area with a lot of built structures – these inhomogenities disturb the radar measurements.
Only in one measuring line were some echo from deeper areas – in line 37. All other measuring lines had no results. The line 40 parallel to line 37 also had no results.

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10 MEASUREMENTS AT VRATNICA KAMENI HRAM AND DOLOVI VALJAK

10.1 Local conditions

The measurements where carried out at two hills.

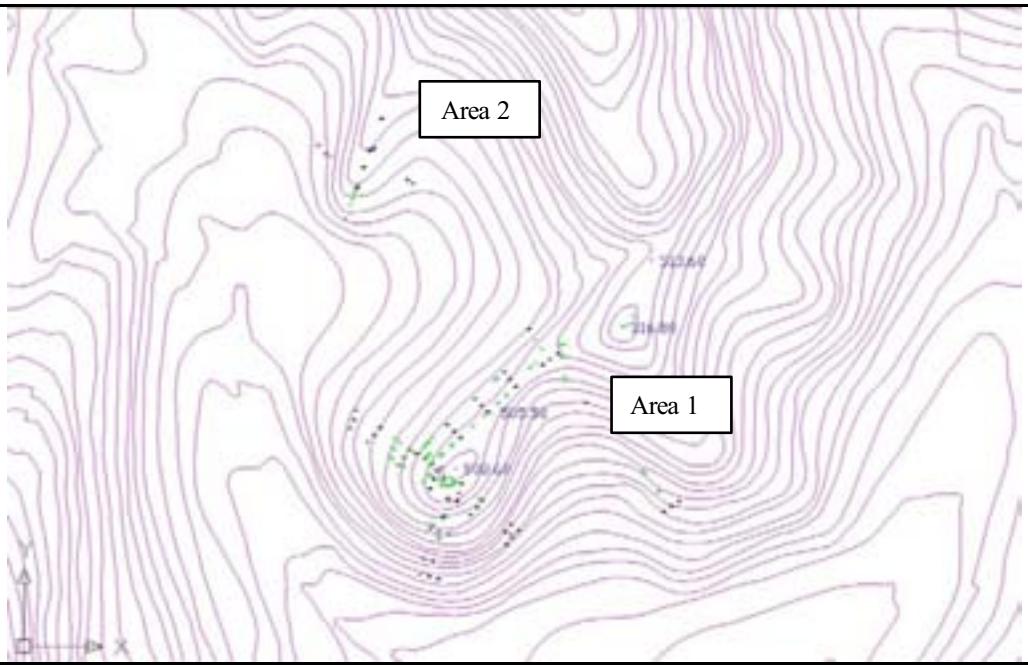

figure 136: view of measurements at Area VRATNICA KAMENI HRAM and DOLOVI VALJAK

figure 137: view of measurements at Area 1

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figure 138: view of measurements at Area 1

figure 139: view of measurements at Area 1

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figure 140: view of measurements at Area 1

figure 141: view of measurements at small hill (Area 2)

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10.2 RESULTS OF THE MEASUREMENTS

The measurements were done with a 270 MHz radar antenna. Because of the weather the ground has been wet what results in a high damping of signals. Anywhere the results of the measurements were in the first 4 m very good.

Following the results of measurements at the area of VRATNICA KAMENI HRAM and DOLOVI VALJAK are shown.

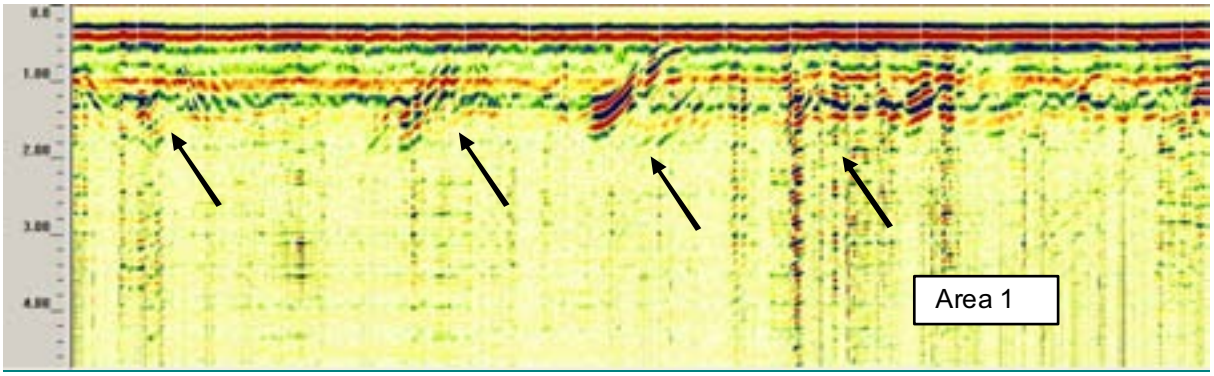

figure 142: radargram of a measuring along measuring line 6 (GSSI, f = 270 MHz) with position of "steps"

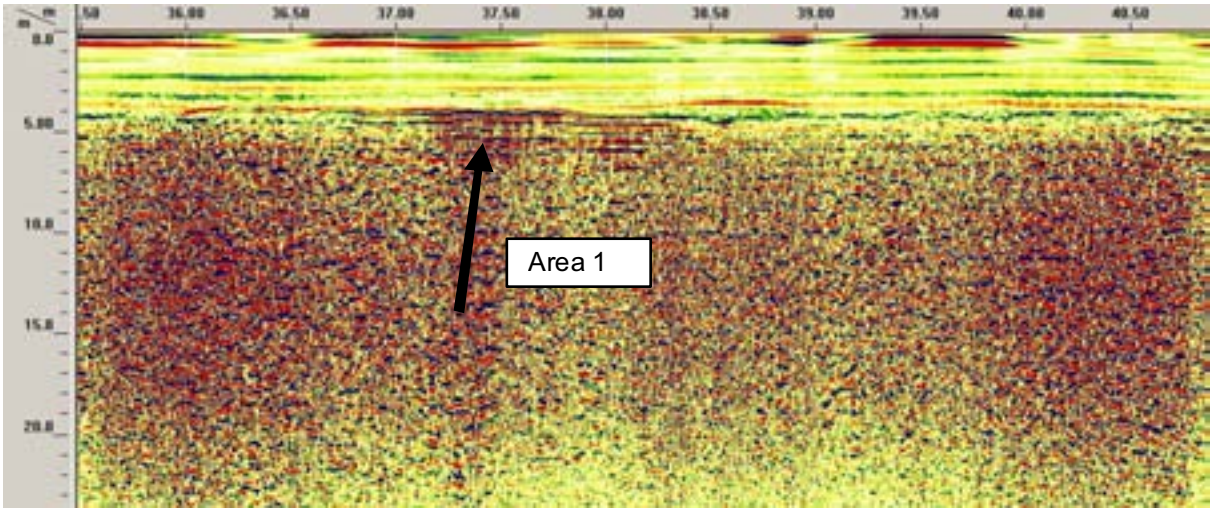

figure 143: radargram of a measuring along measuring line 7 (GSSI, f = 100 MHz) with position of inhomogenity

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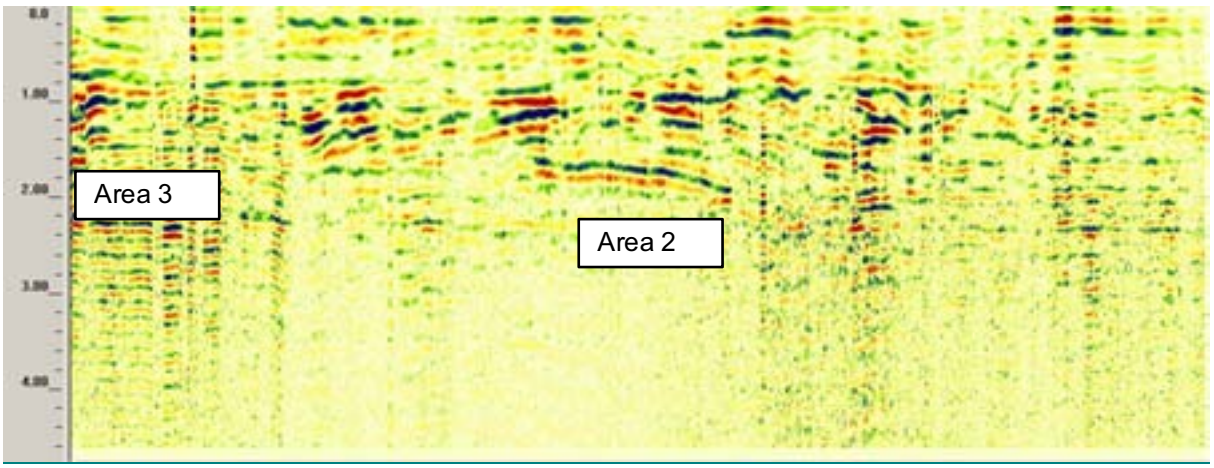

figure 144: radargram of a measuring along measuring line 8 (GSSI, f = 270 MHz) with position of inhomogenity

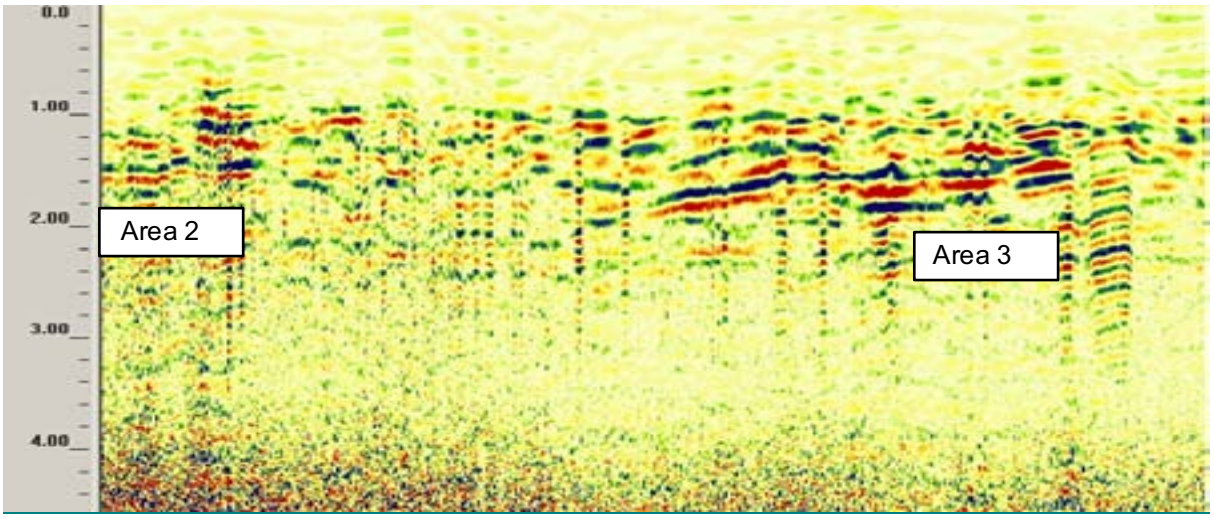

figure 145: radargram of a measuring along measuring line 9 (GSSI, f = 270 MHz) with position of inhomogenity

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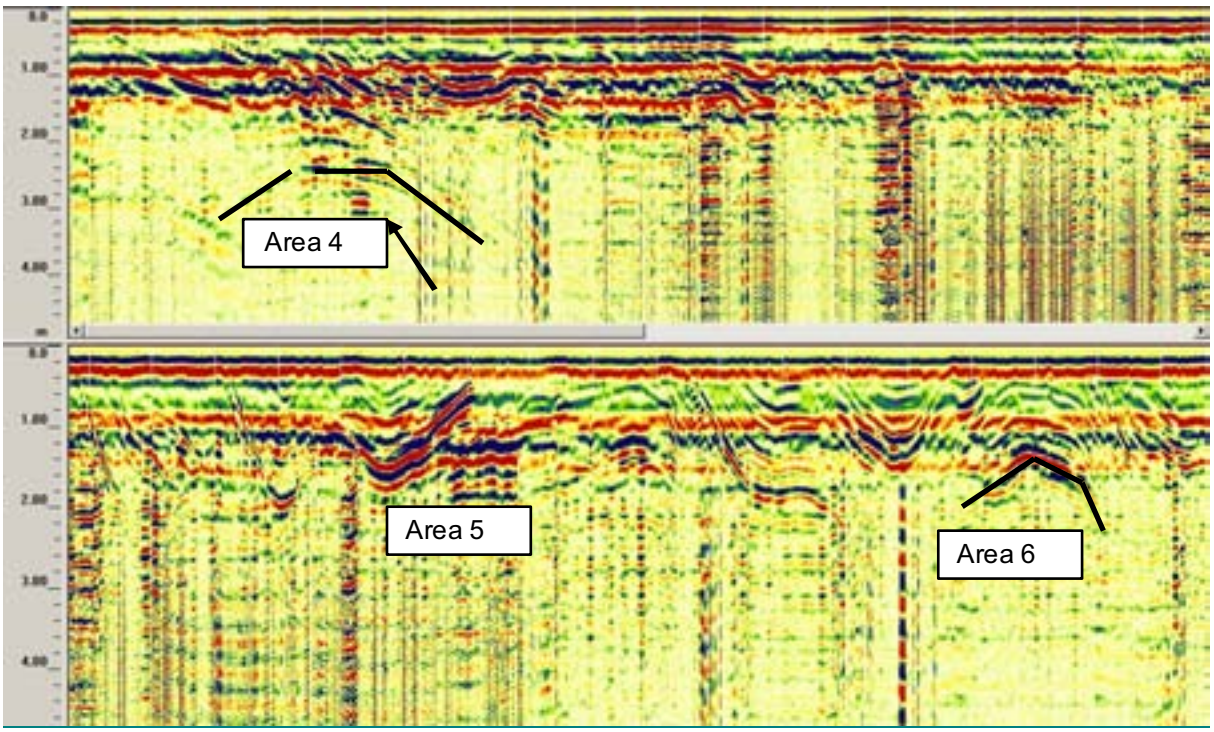

figure 146: radargram of a measuring along measuring line 13 (GSSI, f = 270 MHz) with position of inhomogenity

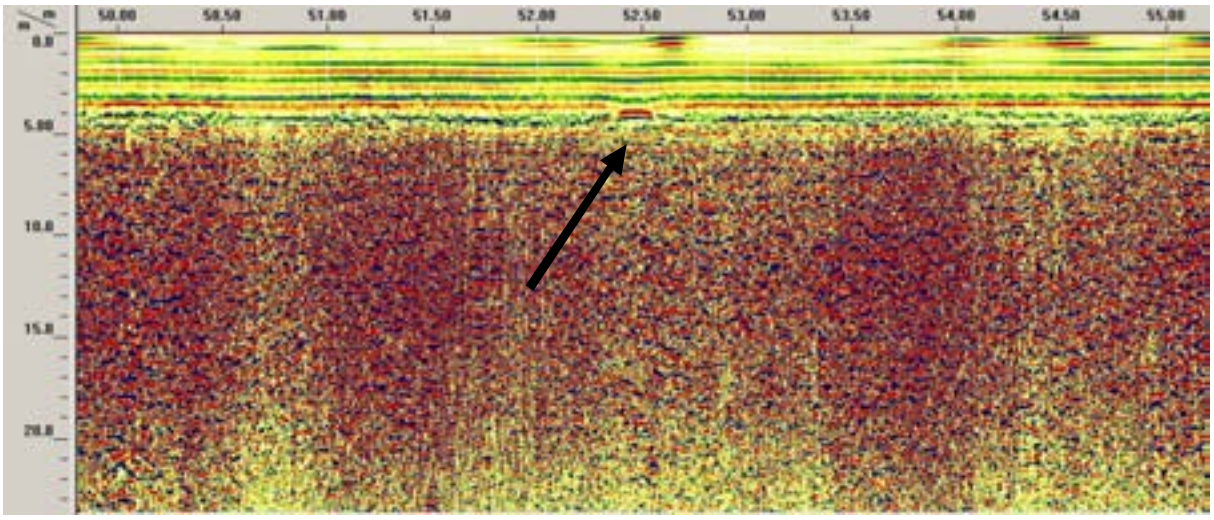

figure 147: radargram of a measuring along measuring line 16 (GSSI, f = 100 MHz) with position of inhomogenity

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Tel.: +49 (0) 911 655-5561 • Fax: +49 (0) 911 655-5536
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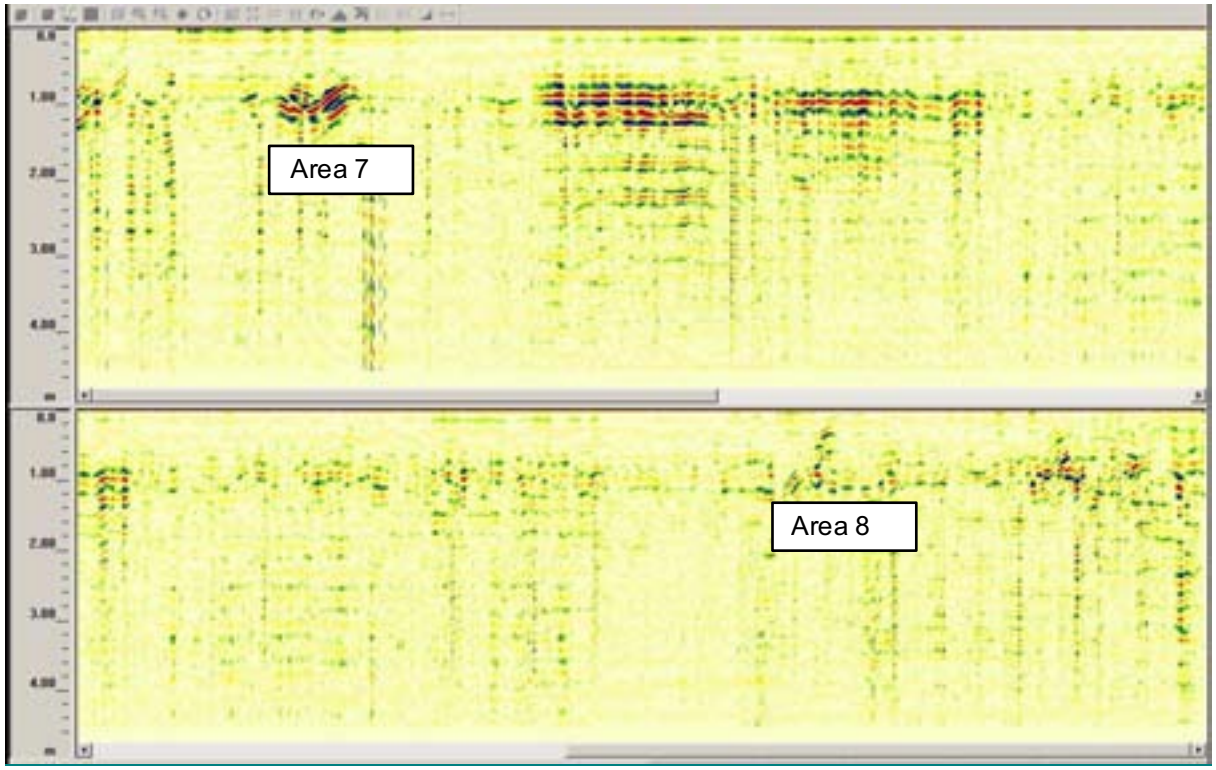

figure 148: radargram of a measuring along measuring line 20 (GSSI, f = 270 MHz) with position of inhomogenity

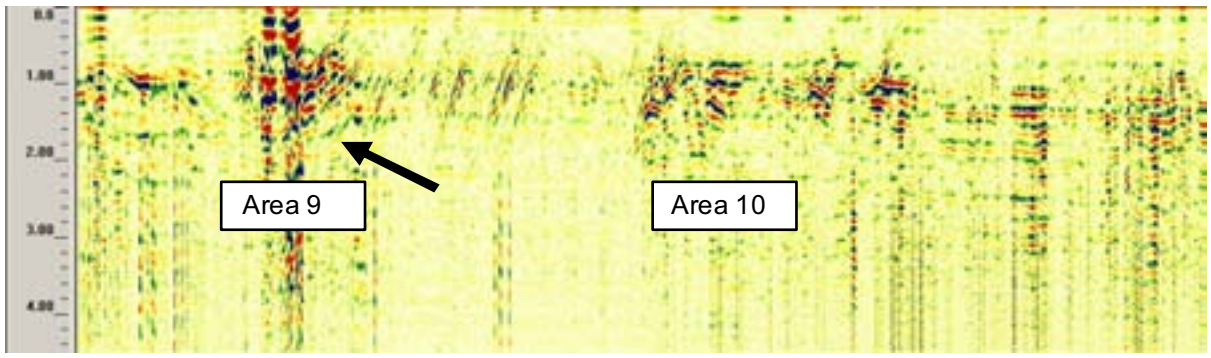

figure 149: radargram of a measuring along measuring line 28 (GSSI, f = 270 MHz) with position of inhomogenity

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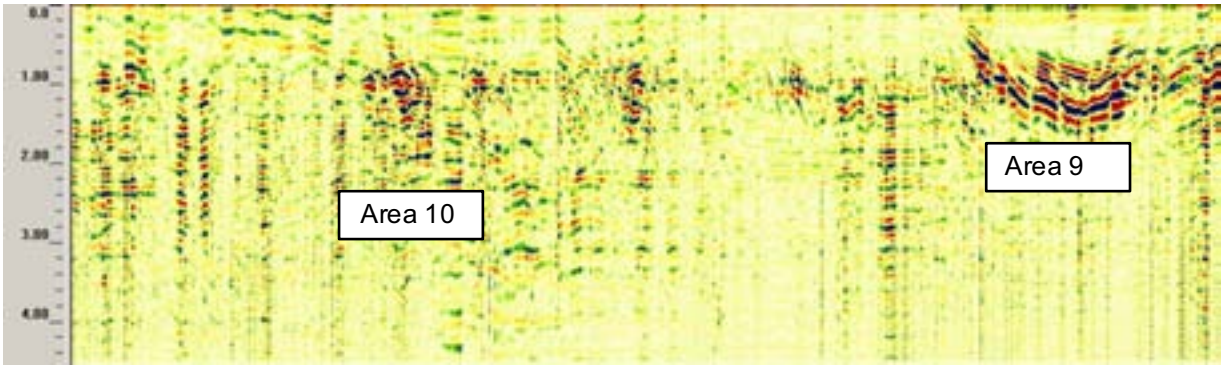

figure 150: radargram of a measuring along measuring line 29 (GSSI, f = 270 MHz) with position of inhomogenity

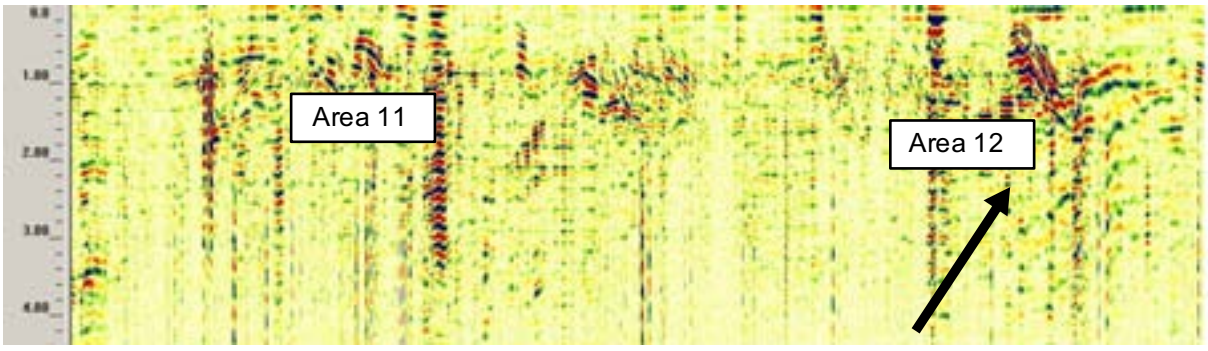

figure 151: radargram of a measuring along measuring line 31 (GSSI, f = 270 MHz) with position of inhomogenity

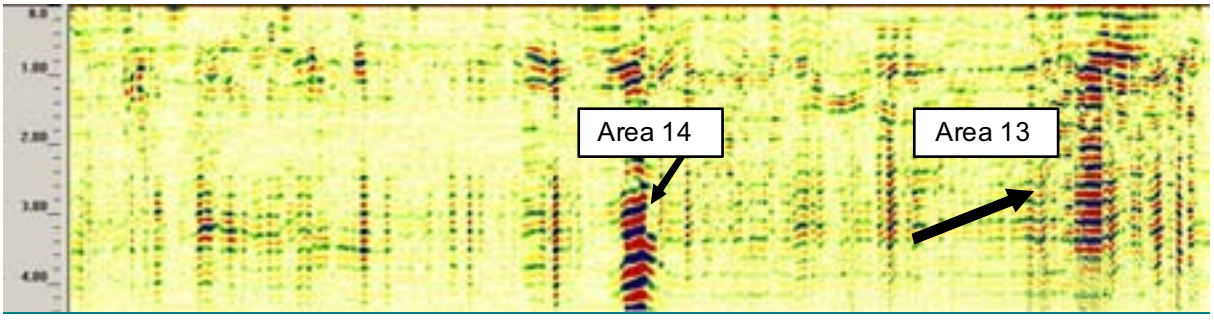

figure 152: radargram of a measuring along measuring line 32 (Field 2) (GSSI, f = 270 MHz) with position of inhomogenity

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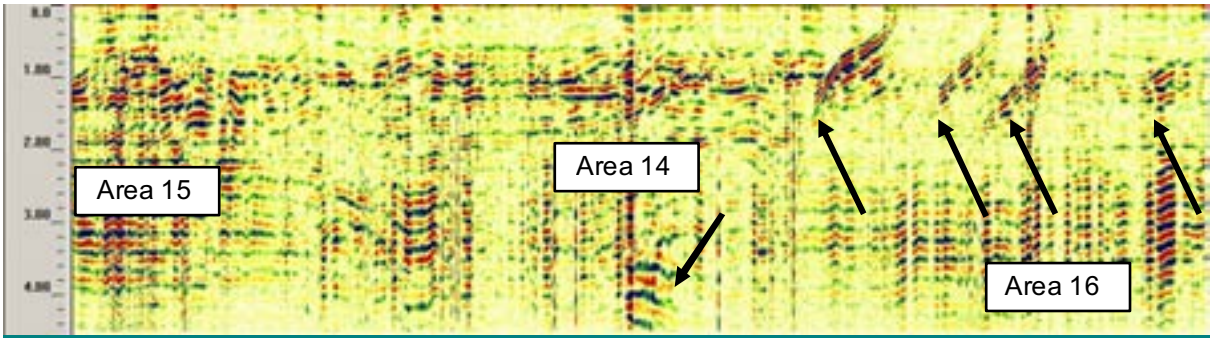

figure 153: radargram of a measuring along measuring line 33 (GSSI, f = 270 MHz) with position of inhomogenity

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10.3 EVALUATION OF RESULTS

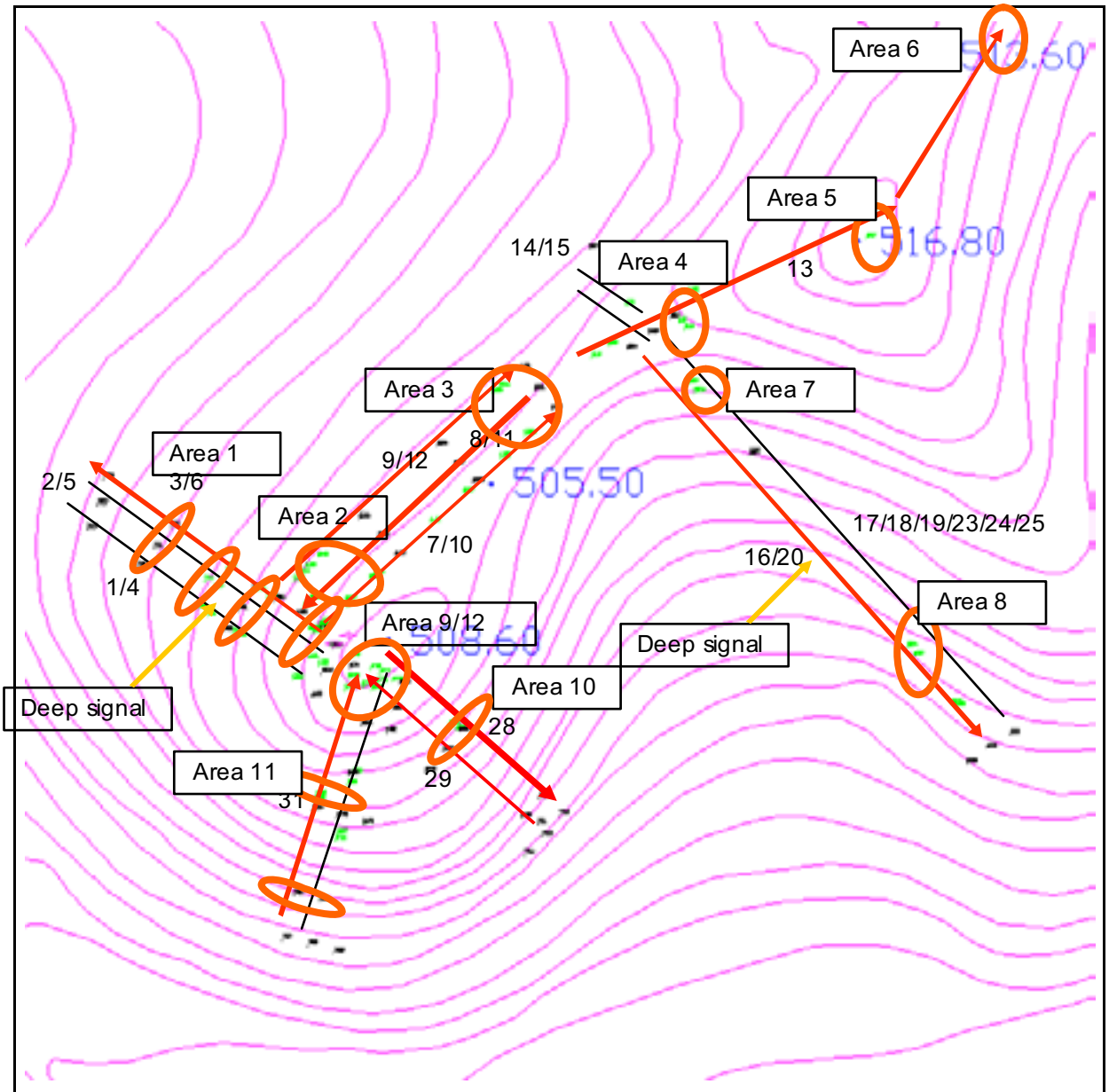

figure 154: radargram of a measuring along measuring line 27 (GSSI, f = 270 MHz) with position of cavity in ground

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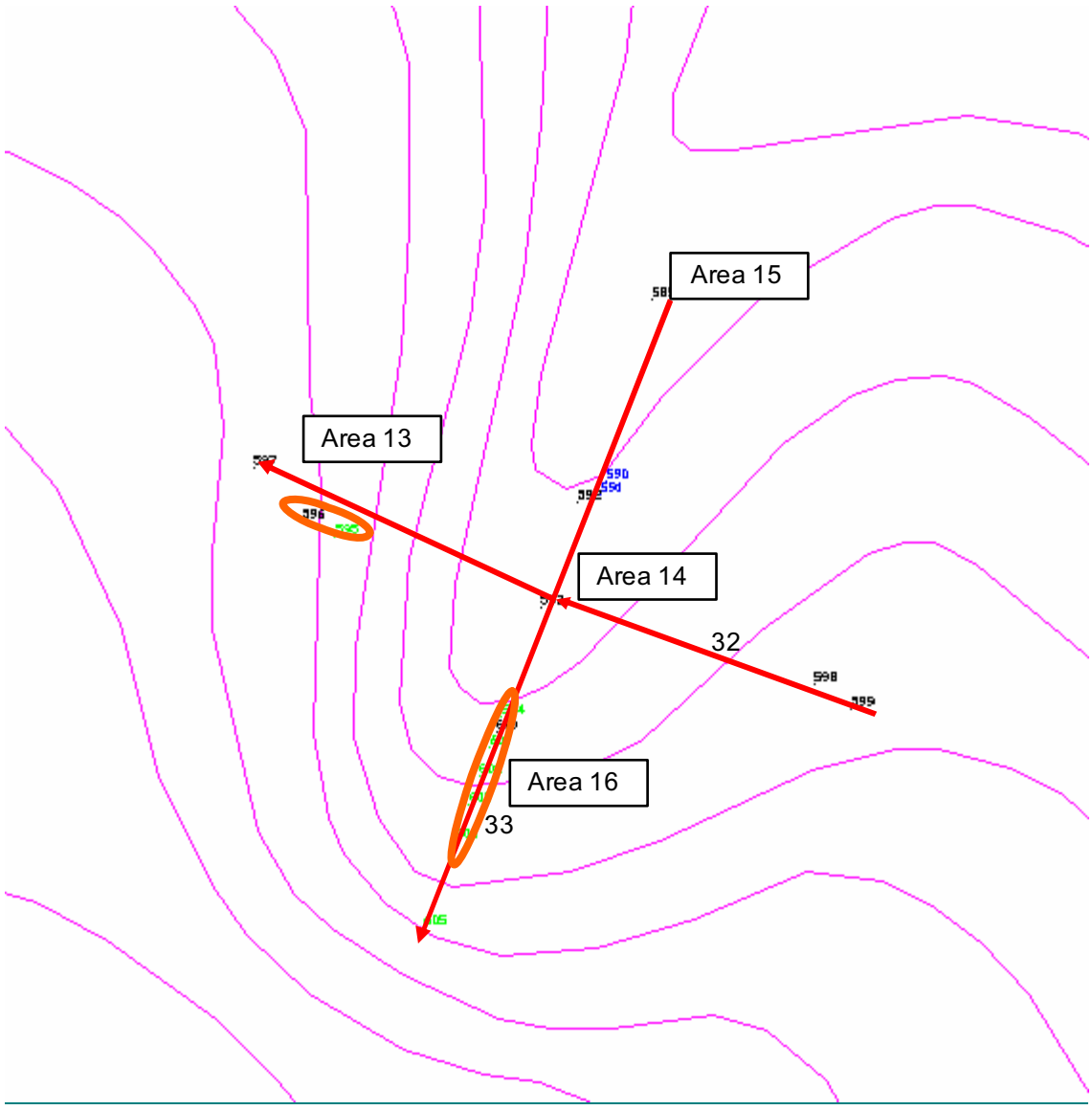

figure 155: radargram of a measuring along measuring line 27 (GSSI, f = 270 MHz) with position of cavity in ground

In the picture above the measuring lines and the areas with inhomogenities are shown.

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Area 1	inhomogenity along the measuring line (steps) in depth of: 0,8 – 1,2m deep reflection from 4,5 – 7m
Area 2	Top of Area 1 Depth of inhomogenity: 1,0 – 1,2m, 1,8-2,0m
Area 3:	Depth of inhomogenity: 1,6-2,0m
Area 4:	Depth of inhomogenity: 2,4 – 3,2m
Area 5:	Depth of inhomogenity: 1,2-1,6m
Area 6:	Depth of inhomogenity: 1,6m
Area 7:	Depth of inhomogenity: 0,8-1,2m
Area 8:	Depth of inhomogenity: 0,8-1,2m
Area 9:	Depth of inhomogenity: 0,6-1,8m
Area 10:	Depth of inhomogenity: 0,8-1,6m
Area 11:	Depth of inhomogenity: 0,6-1,2m
Area 12:	Depth of inhomogenity: 0,4-1,2m
Area 13:	Depth of inhomogenity: 1,0-2,5m
Area 14:	Depth of inhomogenity: 2,8m
Area 15:	Depth of inhomogenity: 0,8-1,4m
Area 16:	Four “steps” Depth of inhomogenity: 1,2-0,6m

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Steuer-Nr. 241/115/90733 Ust-IdNr. DE813835574

LGA Bautechnik GmbH
Bauwerksdiagnose

Bearbeiter:

M.Eng. Sven Homburg

Dr. –Ing. Andreas Hasenstab

LGA Bautechnik GmbH • Tillystraße 2 • 90431 Nürnberg
Tel.: +49 (0) 911 655-5561 • Fax: +49 (0) 911 655-5536
E-Mail: andreas.hasenstab@lga.de • http://www.lga.de

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