NDE/NDT for Highways and Bridges:

Structural Materials Technology (SMT)

Three Dimensional Imaging of Concrete Structures Using Ultrasonic Shear Waves

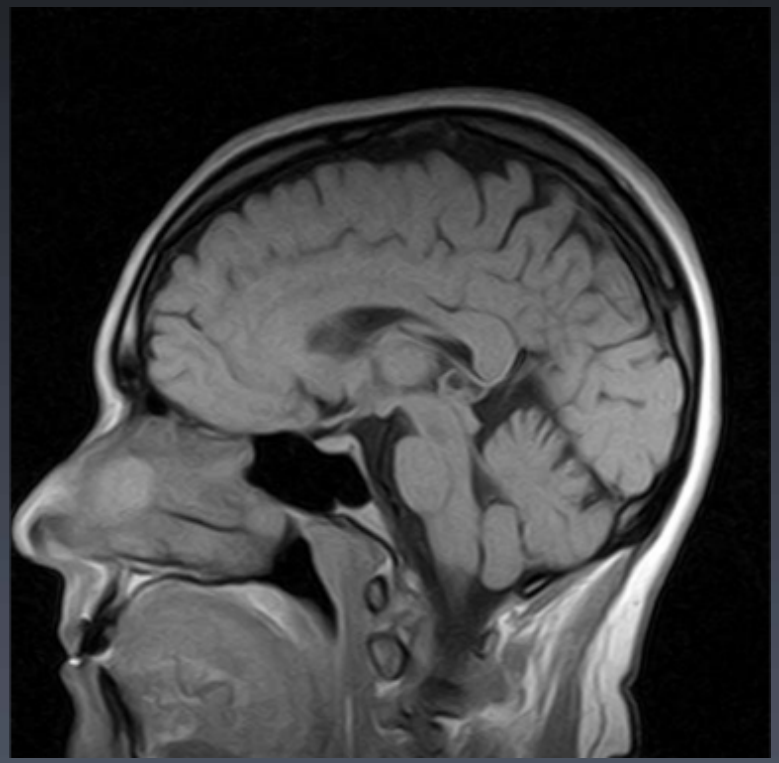
Advanced NDE of Concrete Structures Workshop: Ultrasonic Imaging of Concrete
September 12, 2008

Aldo O. De La Haza

WJE

Medical Radiology Profession

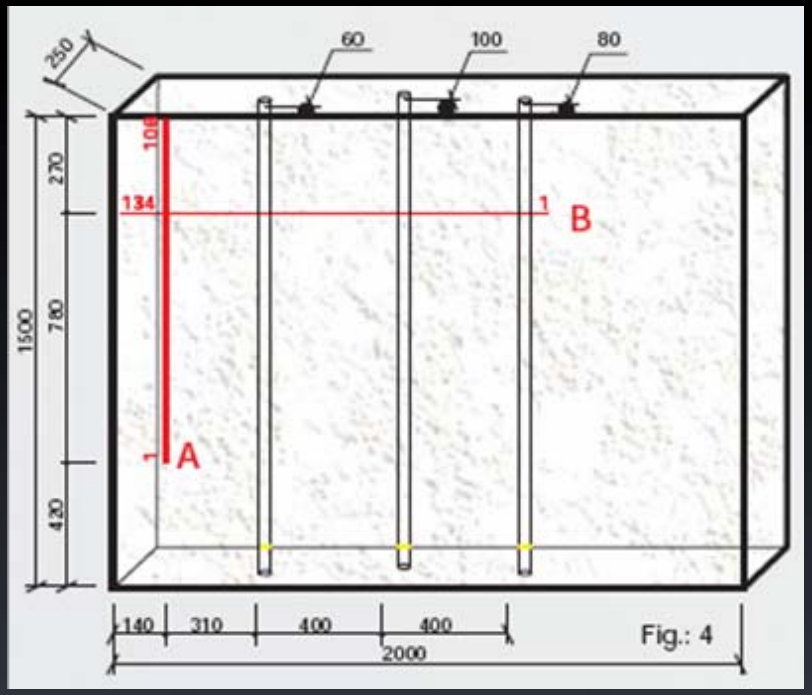
- **Magnetic Resonance Imaging (MRI)**

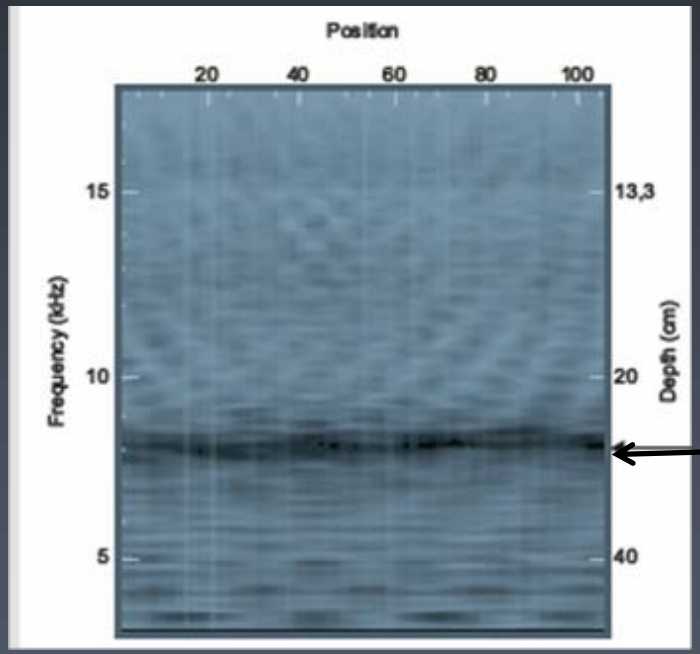


NDT Methods

- Scanning Impact-echo (SIE)
- Ground-Penetrating Radar (GPR)
- Ultrasonic pulse velocity (UPV)

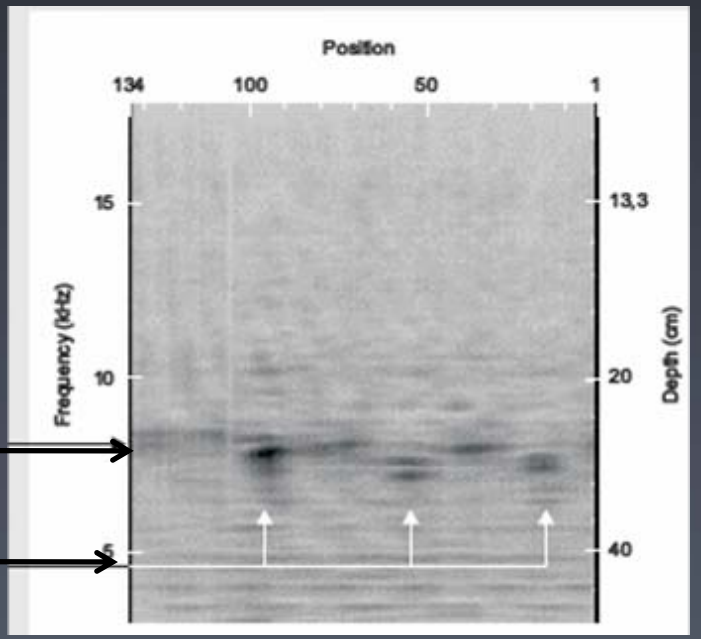
Scanning IES





Backwall

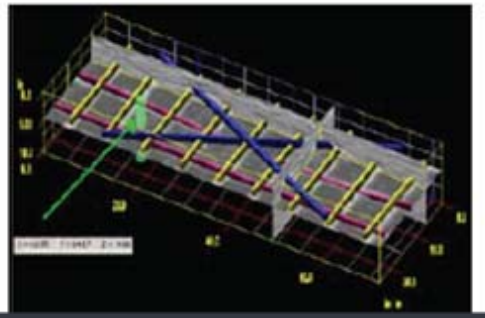
Ducts



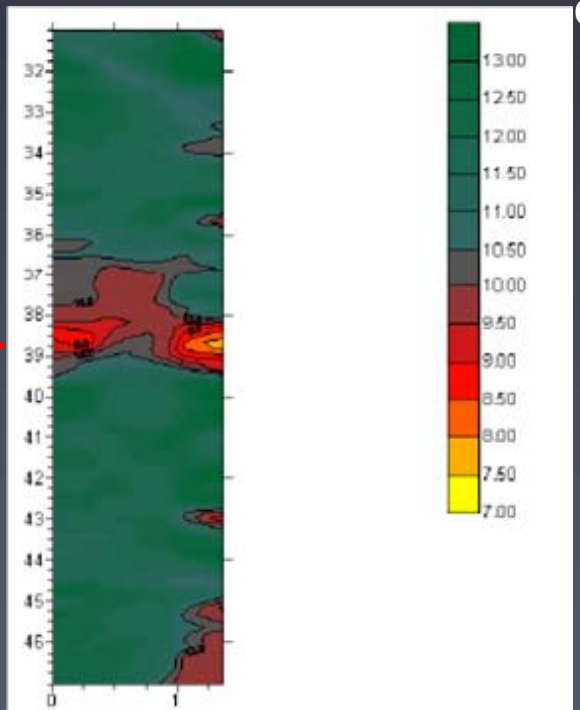
Courtesy of BAM

Before concrete pour

StructureScan C-scan data image



Courtesy of GSSI



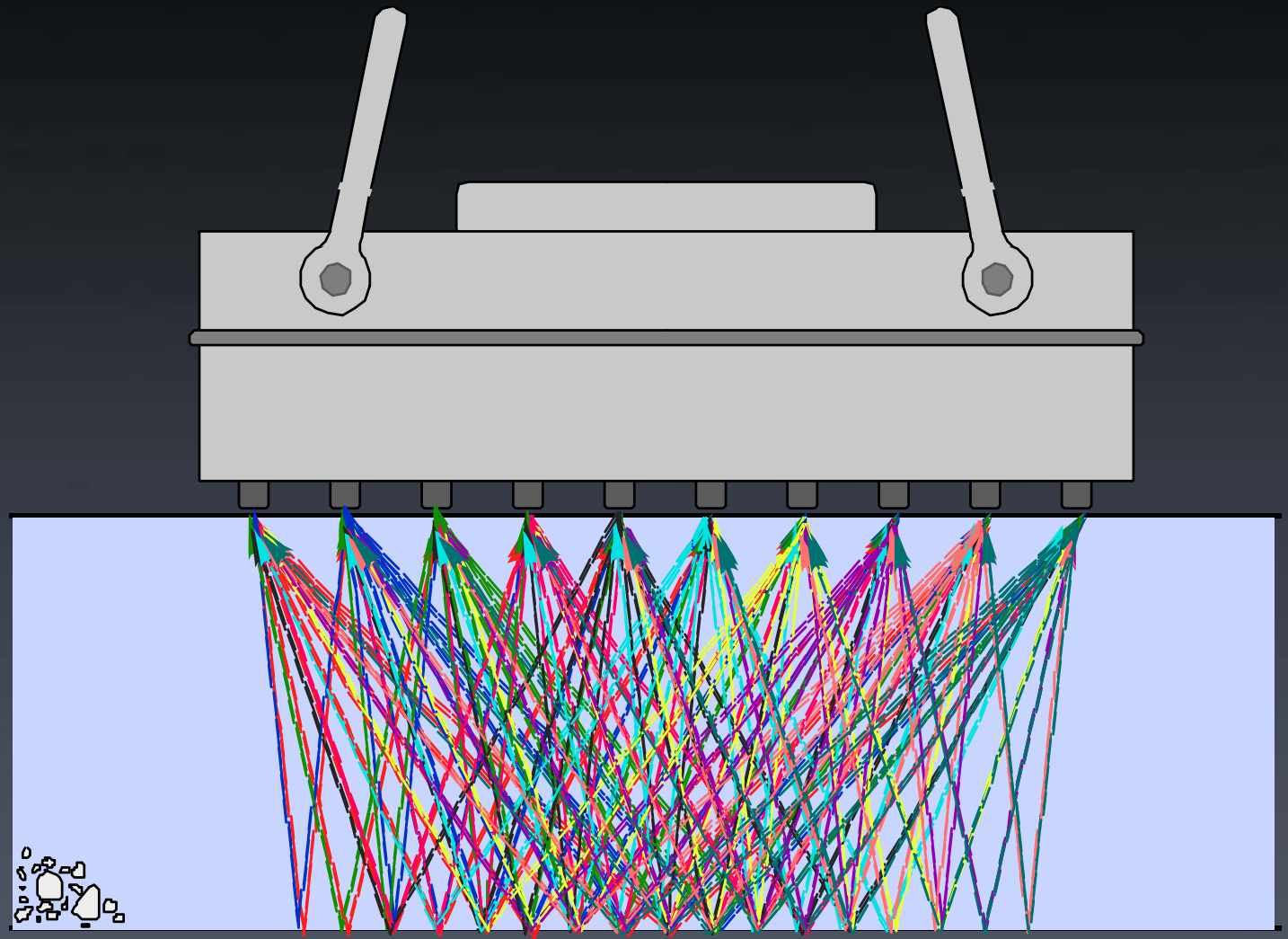
Ultrasonic Shear Wave Devices

MIRA

Eyecon

Surfer


TD 20
20 kHz
LD 10
10 kHz



Single scan: 350 ms

PULSE-ECHO METHOD

Is a single-sided method that measures the two-way travel time and signal amplitude of a sound wave travelling through the test sample

Advantage

Access only from one side to the test object is needed

Ultrasonic Transducers

25 – 200 kHz

Dry point contact: compression waves, shear waves, Rayleigh waves

BANDWIDTH UP TO 100%

Patent RF № 2082163

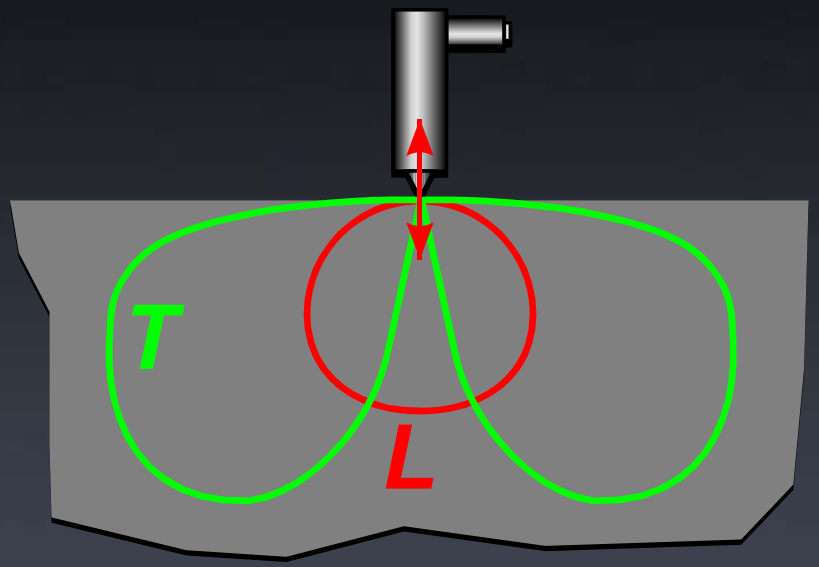
DPC Transducers

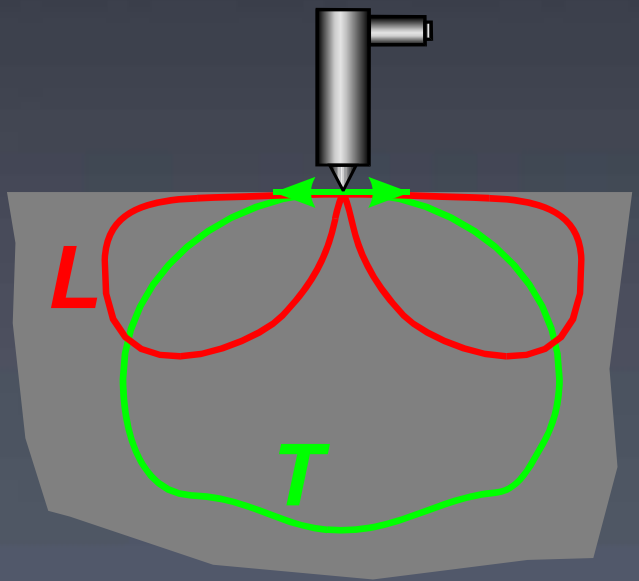
CHARACTERISTICS AND SPECIAL FEATURES:

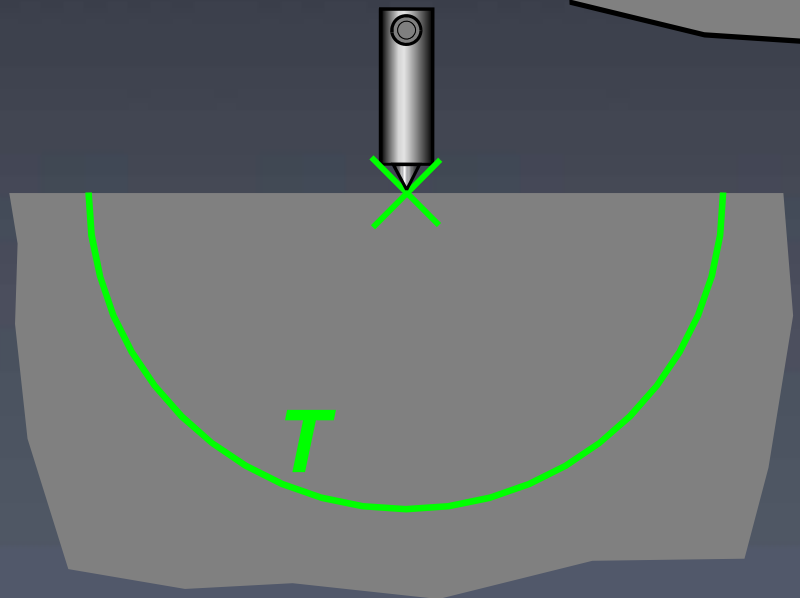
- **Point acoustic contact:**
  Reliable acoustic connection without coupling material
- **All basic types of acoustic waves:**
  Longitudinal waves, Rayleigh waves, Shear waves
- **Possible electronic switching of wave types**
  P-waves, S-waves, R-waves
- **Broadband:**
  Longitudinal waves 20-100 KHz
- **Damping**
  Proprietary composite material

DPC Transducers

TRANSDUCERS WITH DRY POINT CONTACT (DPC)





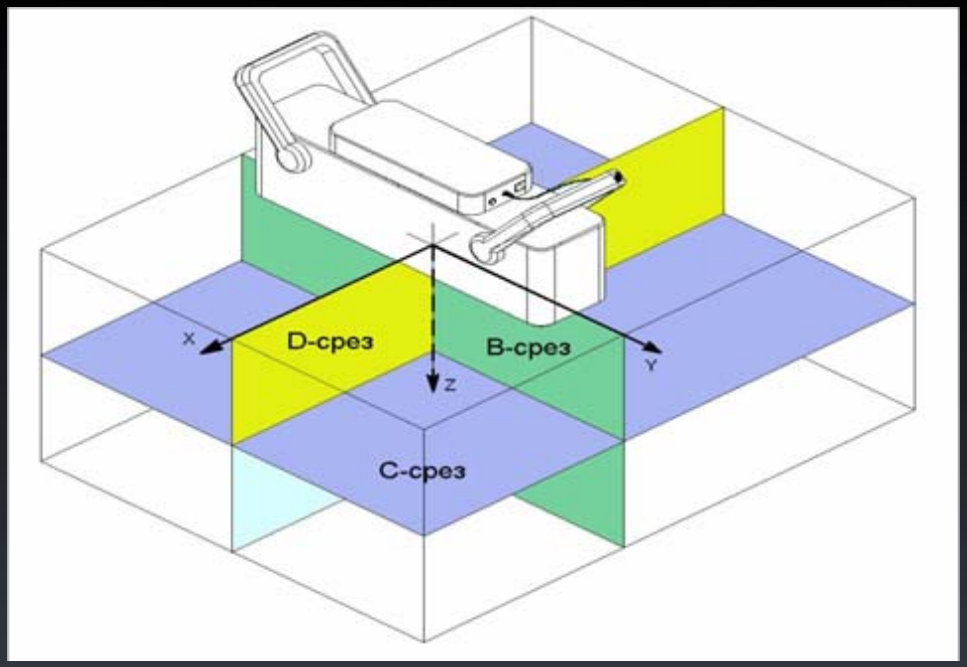


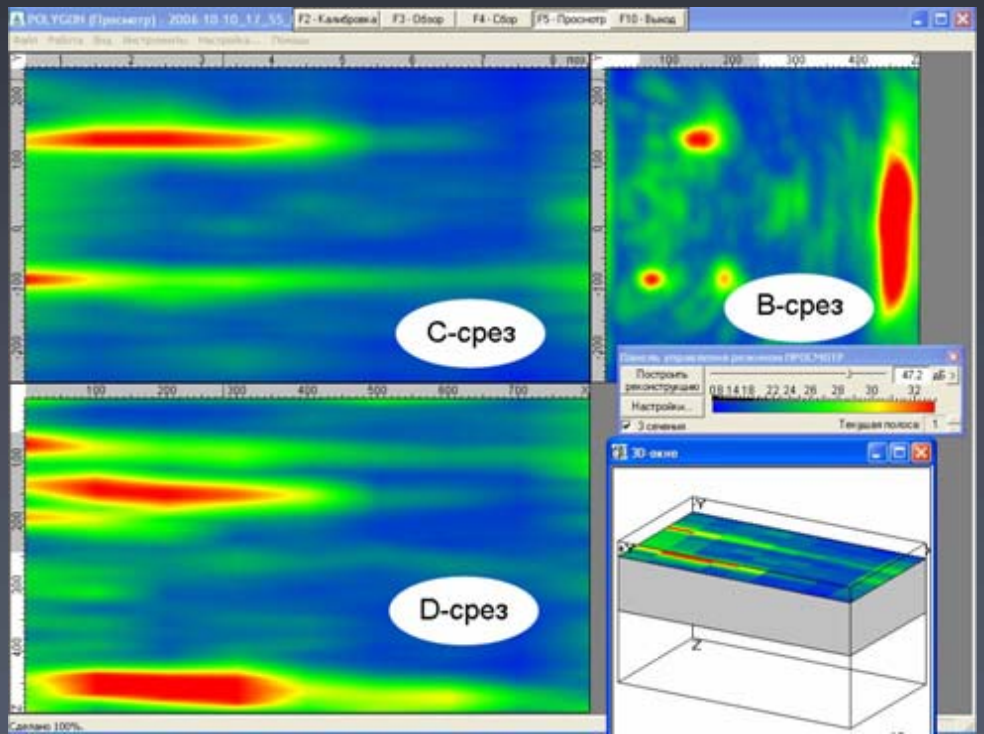
On diagrams:

L – Longitudinal wave

T – Shear wave

Data Processing





- **Synthetic Aperture Focusing Technique (SAFT) Reconstruction**
- **Data Imaged as B, C, D Scans**
- **The coordinates and signal levels at any point at any point along the scan are reconstructed in the images**
- **Different color schemes are used to represent the significance of the data**
- **Choice of cross-section and 3D isometric views are possible**

Case Studies

- **Laboratory Studies**
  - ✓R/C block with tendon duct (*MIRA*)
  - ✓R/C notched beam (*MIRA* + *Eyecon*)
  - ✓Variable thickness wall with empty tendon ducts (MIRA + Eyecon)
  - ✓R/C mat foundation
- **Field Studies**
  - ✓Underground pedestrian tunnel
  - ✓Precast concrete spandrel walls
  - ✓R/C columns with grouted metal ducts
  - ✓Segmental box-girder bridge with P/T ducts

➢Laboratory Studies

- ✓R/C block with tendon duct (*MIRA*)
- ✓R/C notched beam (*MIRA* + *Eyecon*)
- ✓Variable thickness wall with empty tendon ducts (MIRA + Eyecon)
- ✓R/C mat foundation


OCT 16 2007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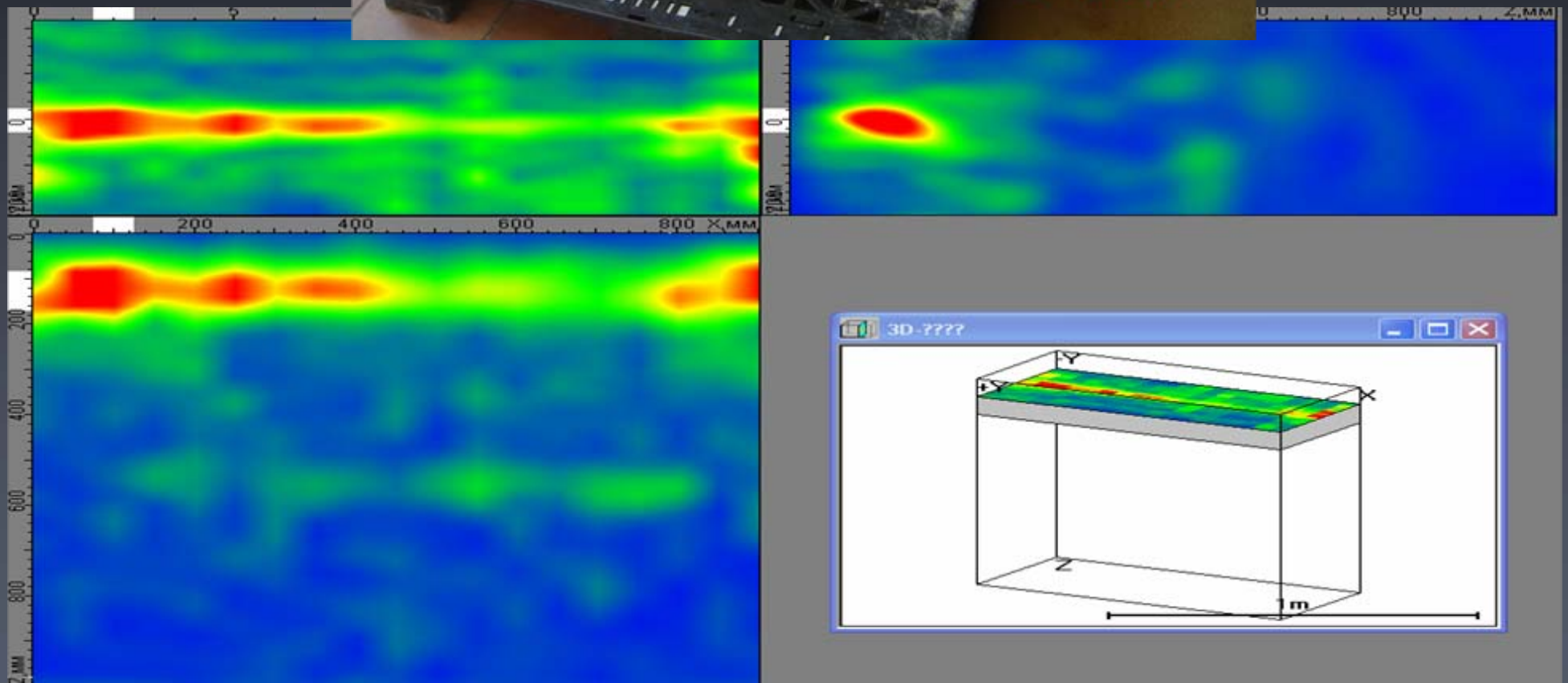
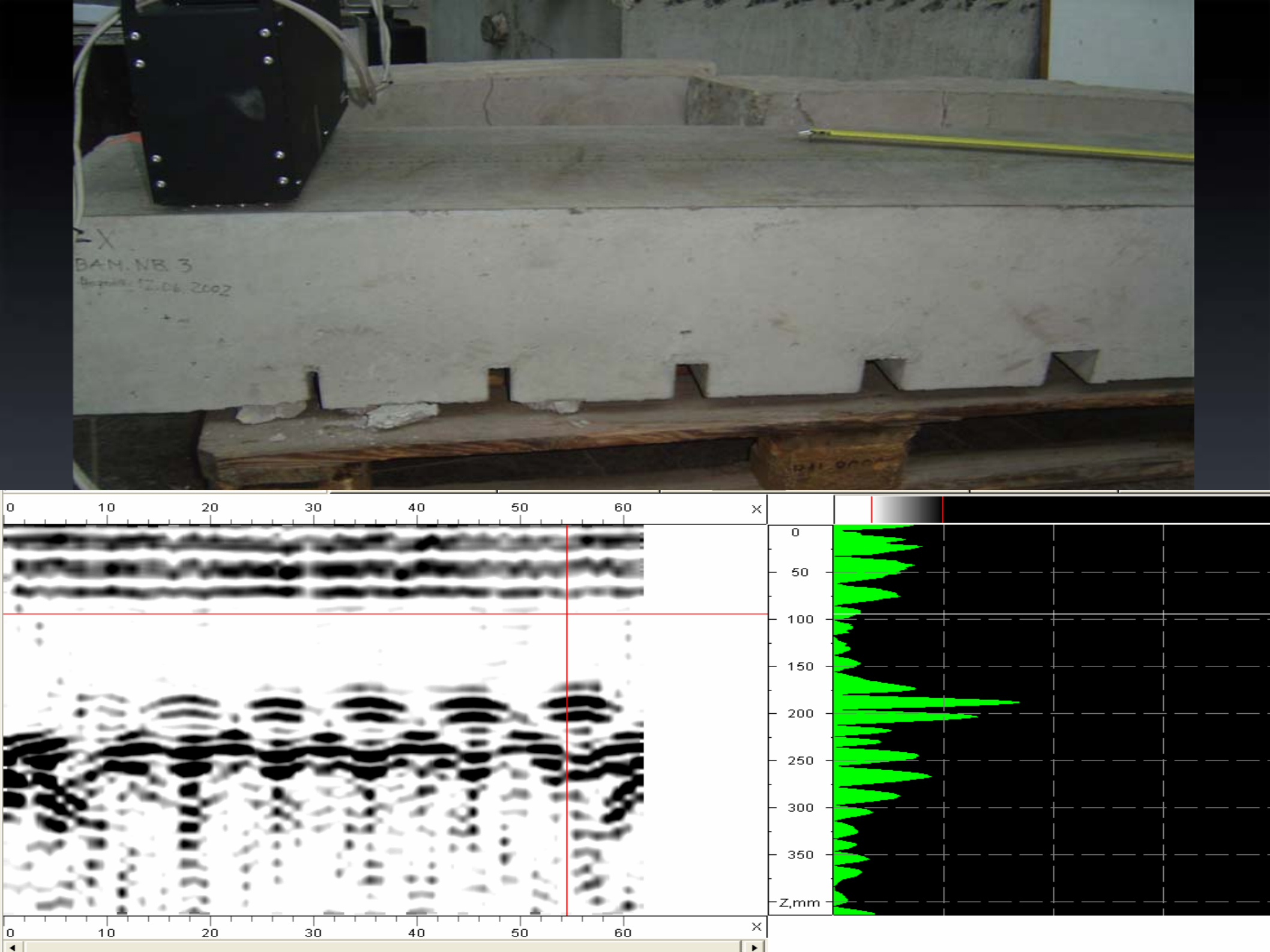
OCT 15 2007

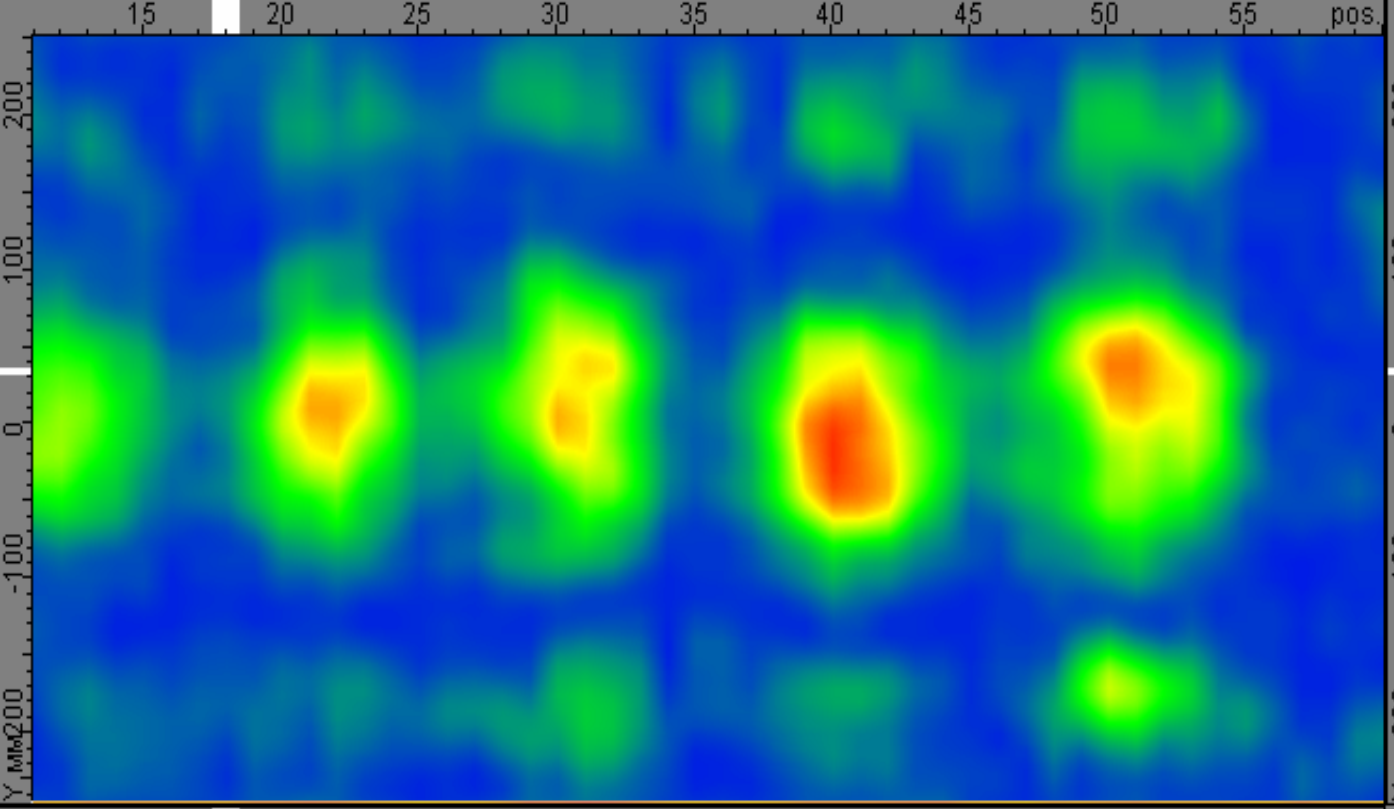

OCT 15 2007

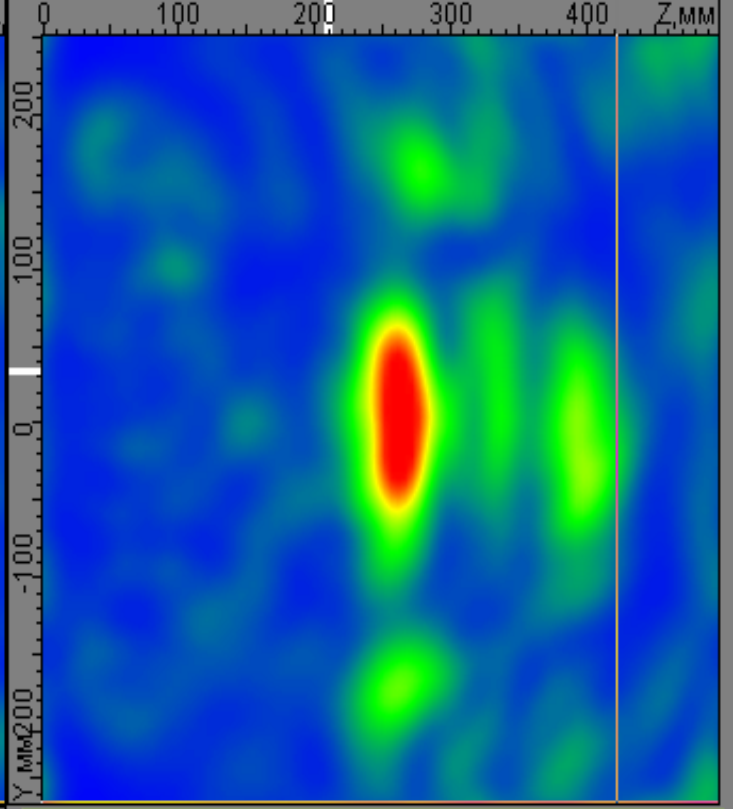

0
200
400
600
800 X,мм
0
200
400
600
800 Z,мм

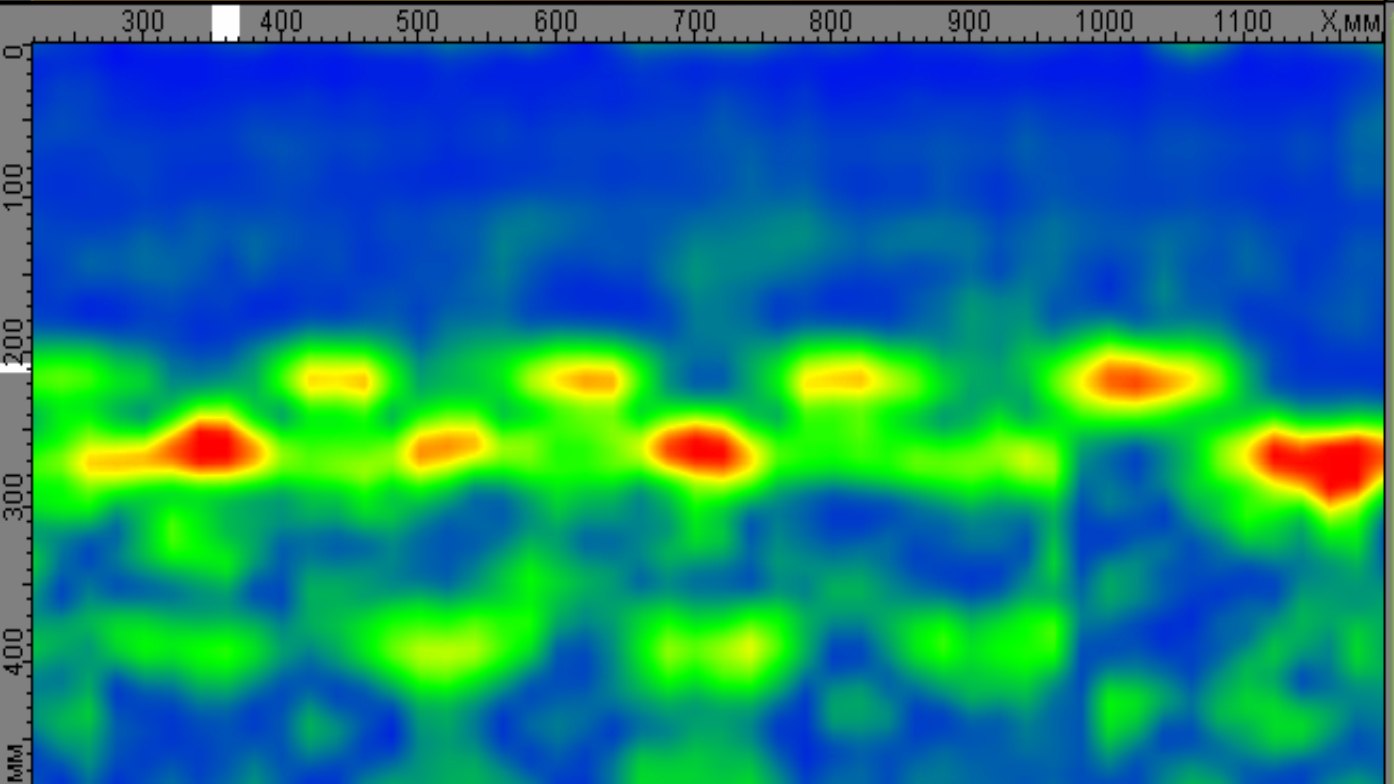
3D-????
Y
X
Z
1m

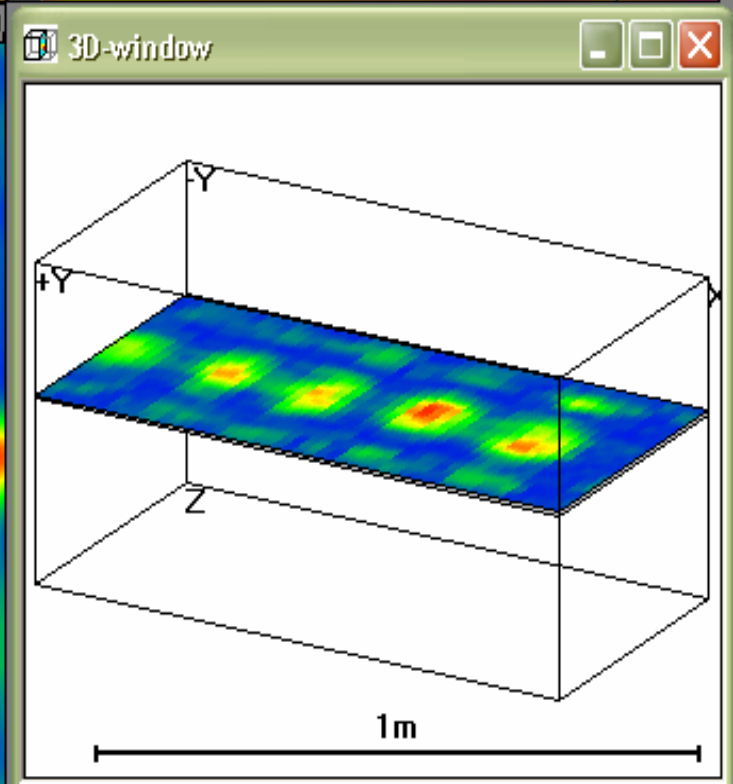

Automatisierung
AUG 26 2008


BAN. NR 3
0
10
20
30
40
50
60
0
50
100
150
200
250
300
350
Z,mm


15
20
25
30
35
40
45
50
55
pos.
200
100
0
-100
-200
Y, мм


0
100
200
300
400
Z, мм
200
100
0
-100
-200
Y, мм


300
400
500
600
700
800
900
1000
1100
X, мм
0
100
200
300
400
мм


3D-window
Y
+Y
X
Z
1m


29
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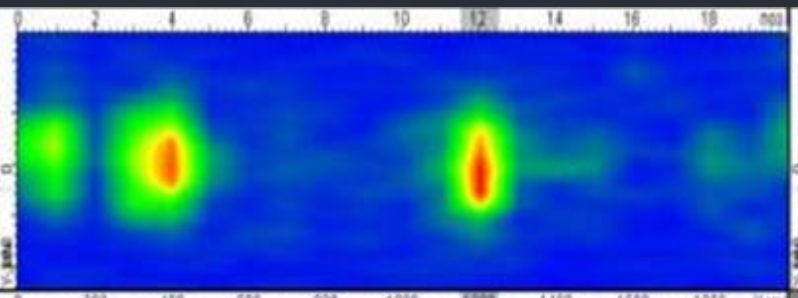
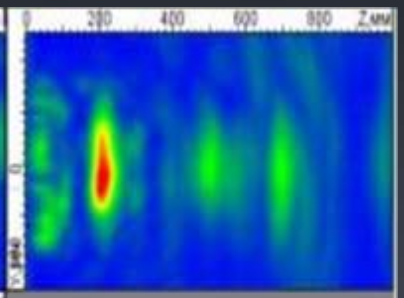
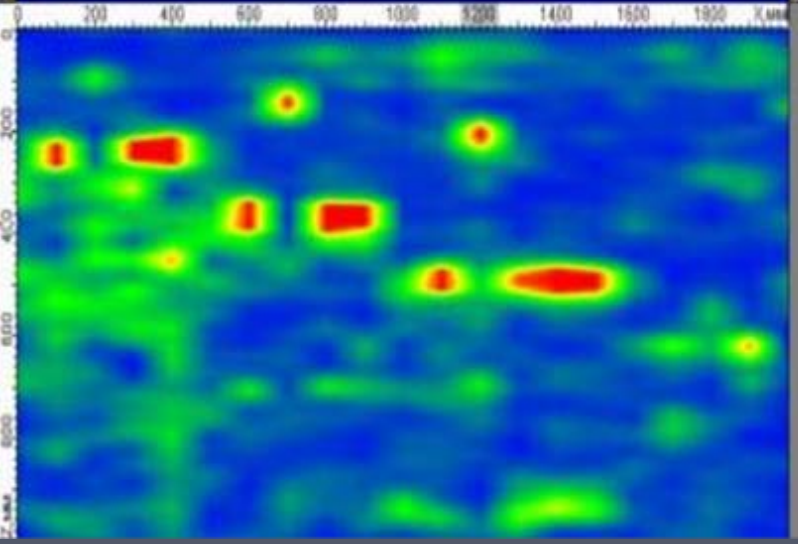
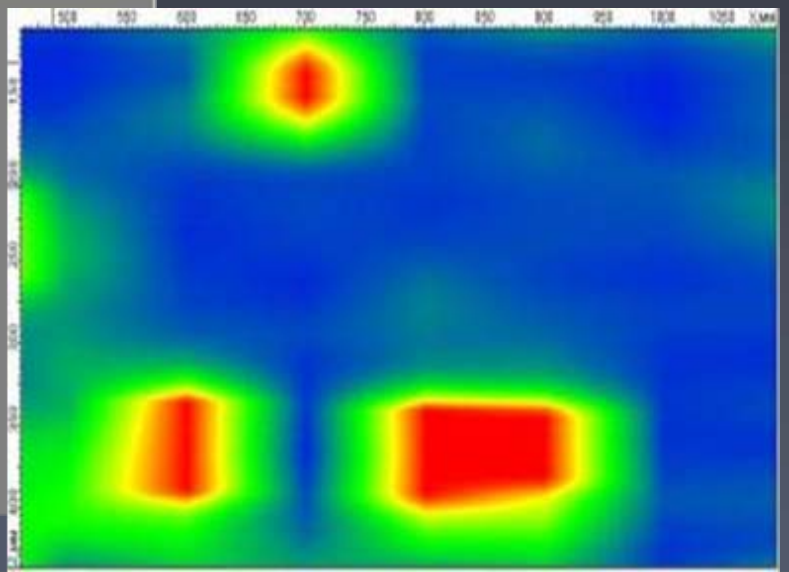
Concrete plate of variable thickness and empty cable ducts:

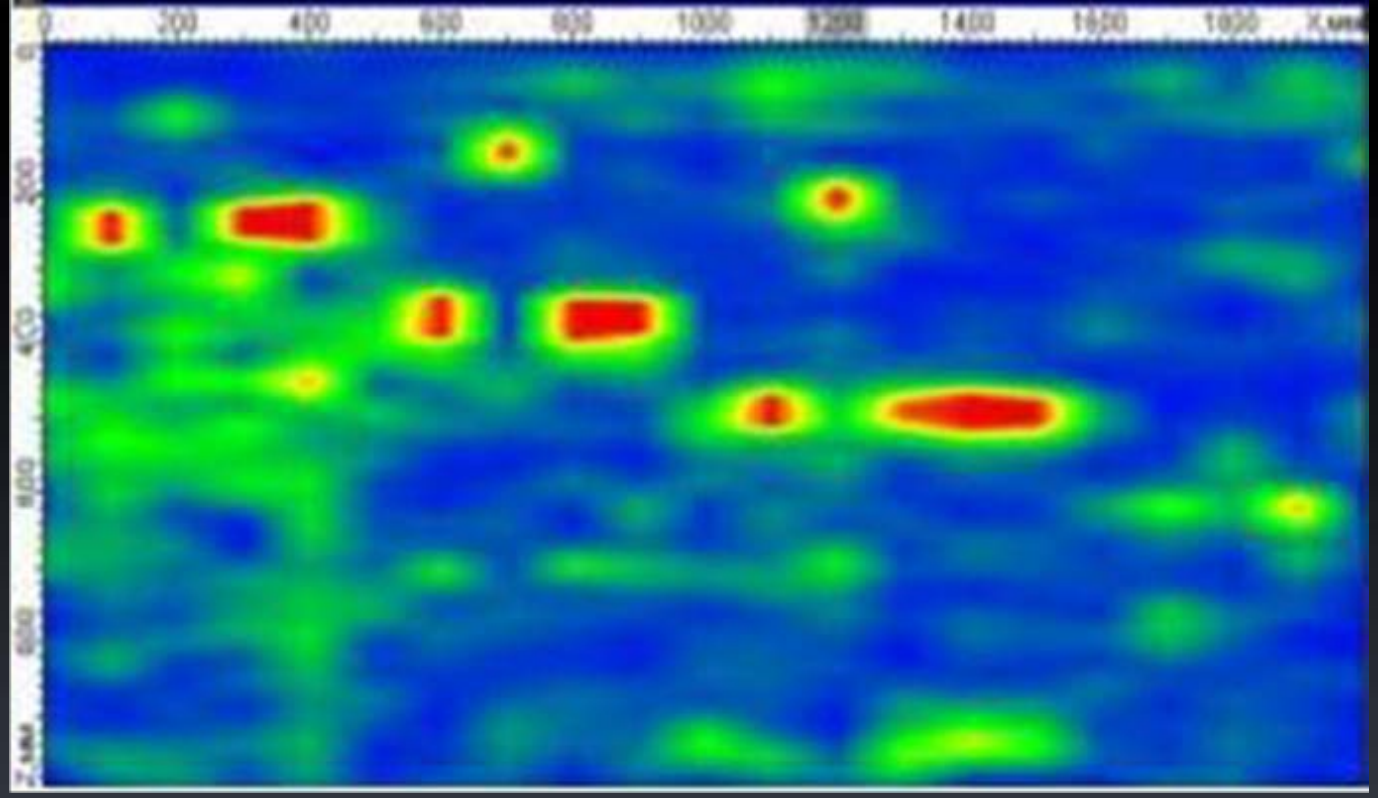
Length of each step - 500 mm
Total plate length – 2000 mm
Thickness of steps – 250, 350, 450, 550 mm

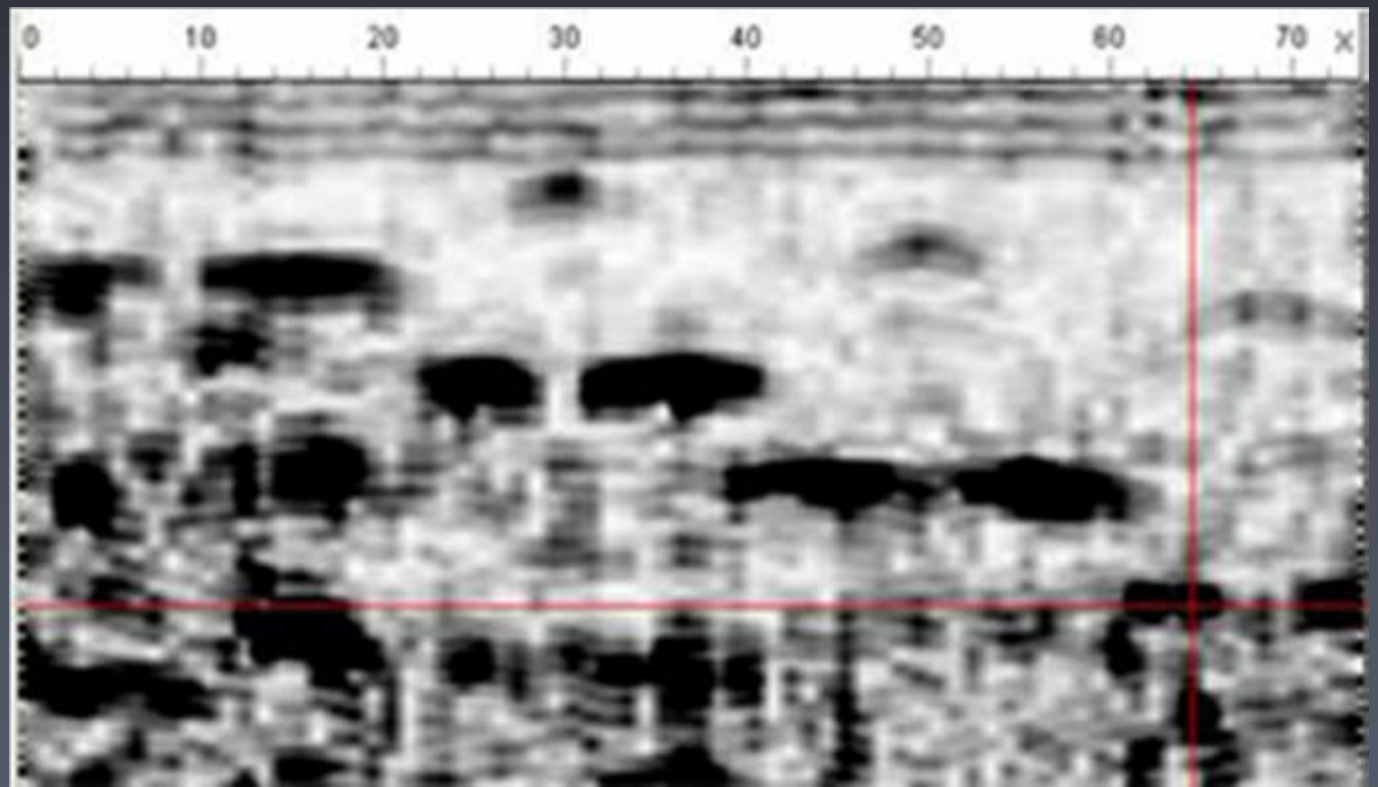









0
200
400
600
800
1000
1200
1400
1600
1800
X, мм
Z, мкм


0
10
20
30
40
50
60
70
X

BAM - Horstwalde, Germany

BAM- Hortswalde, Germany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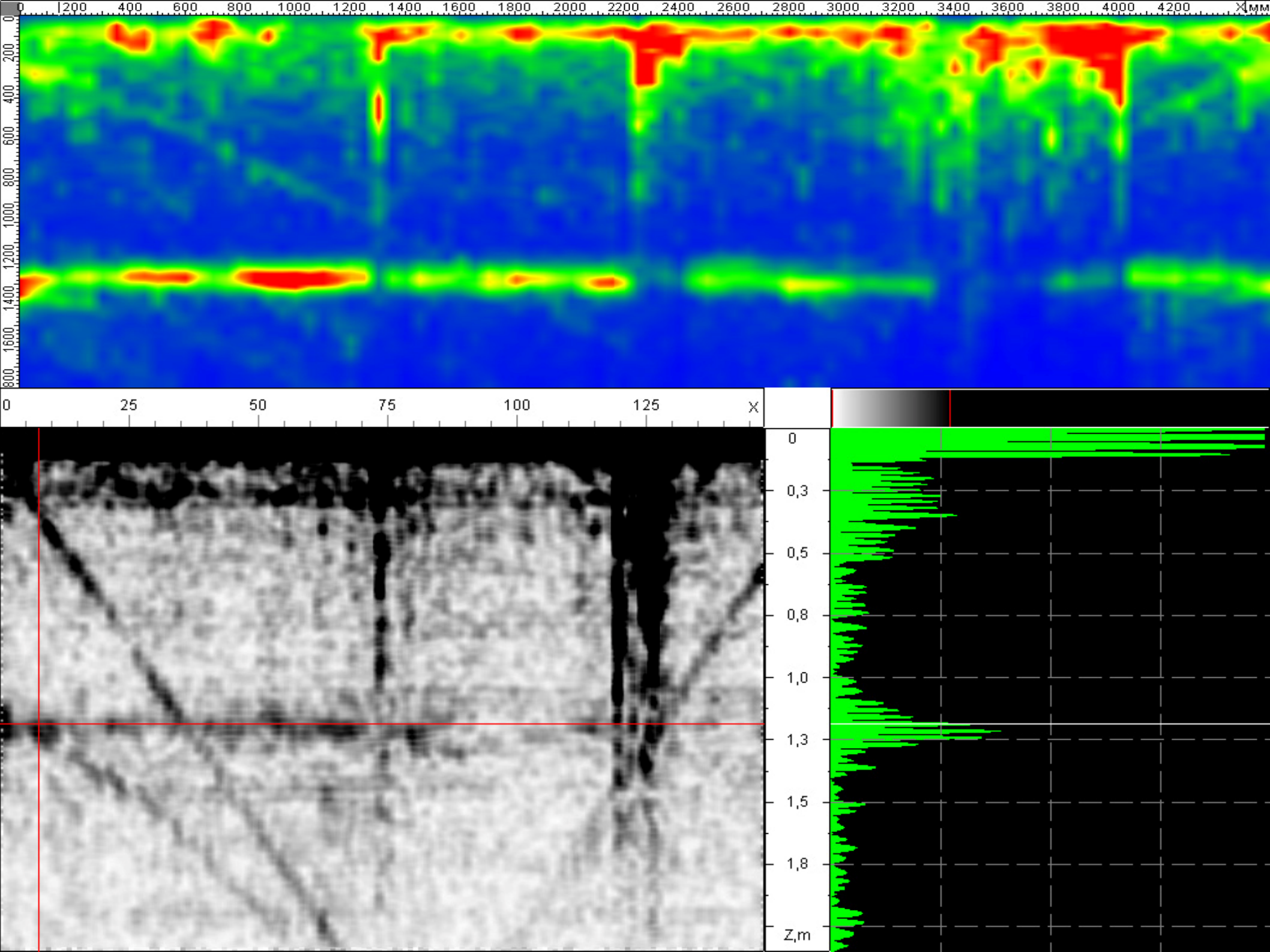
0
200
400
600
800
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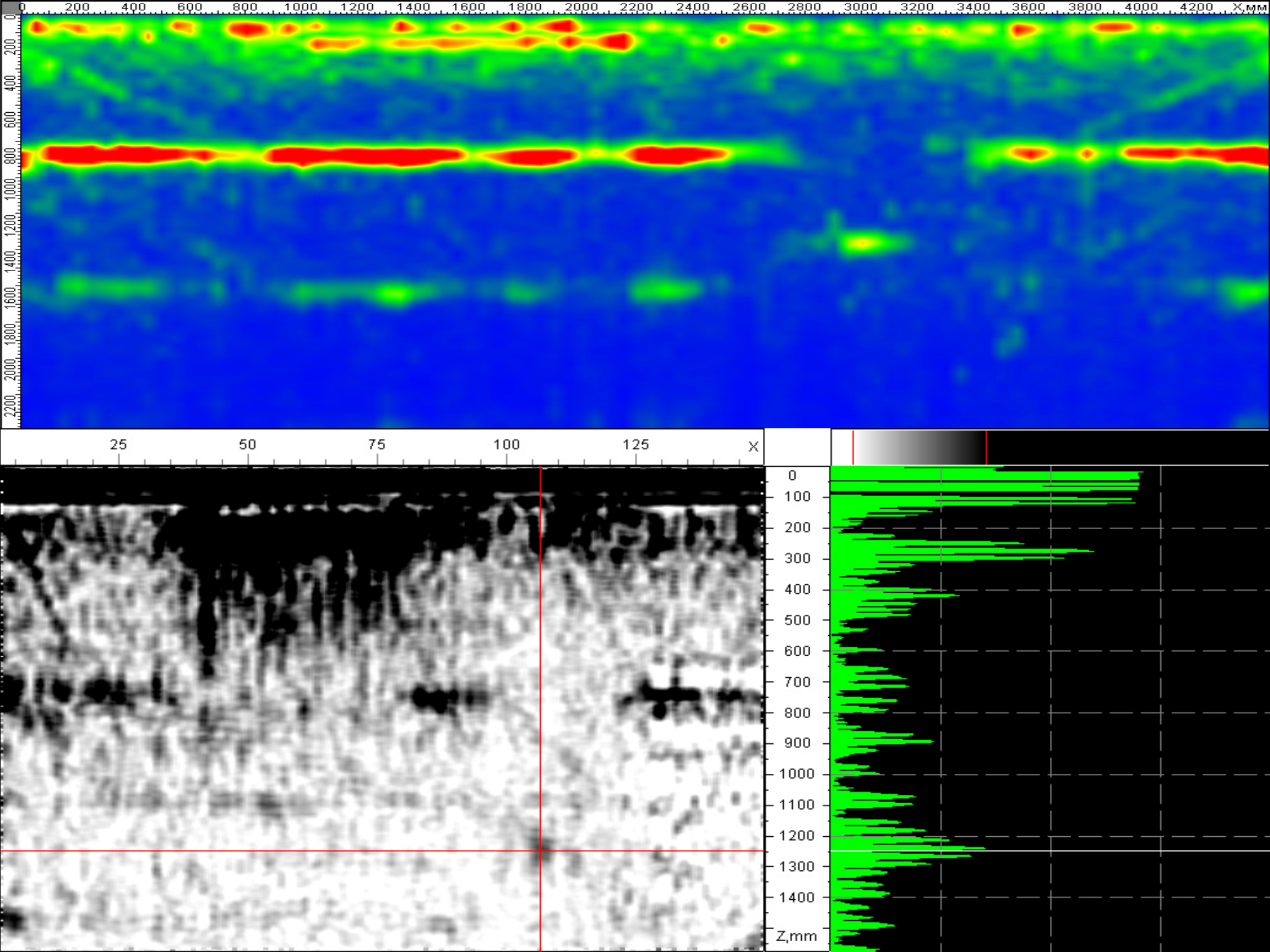
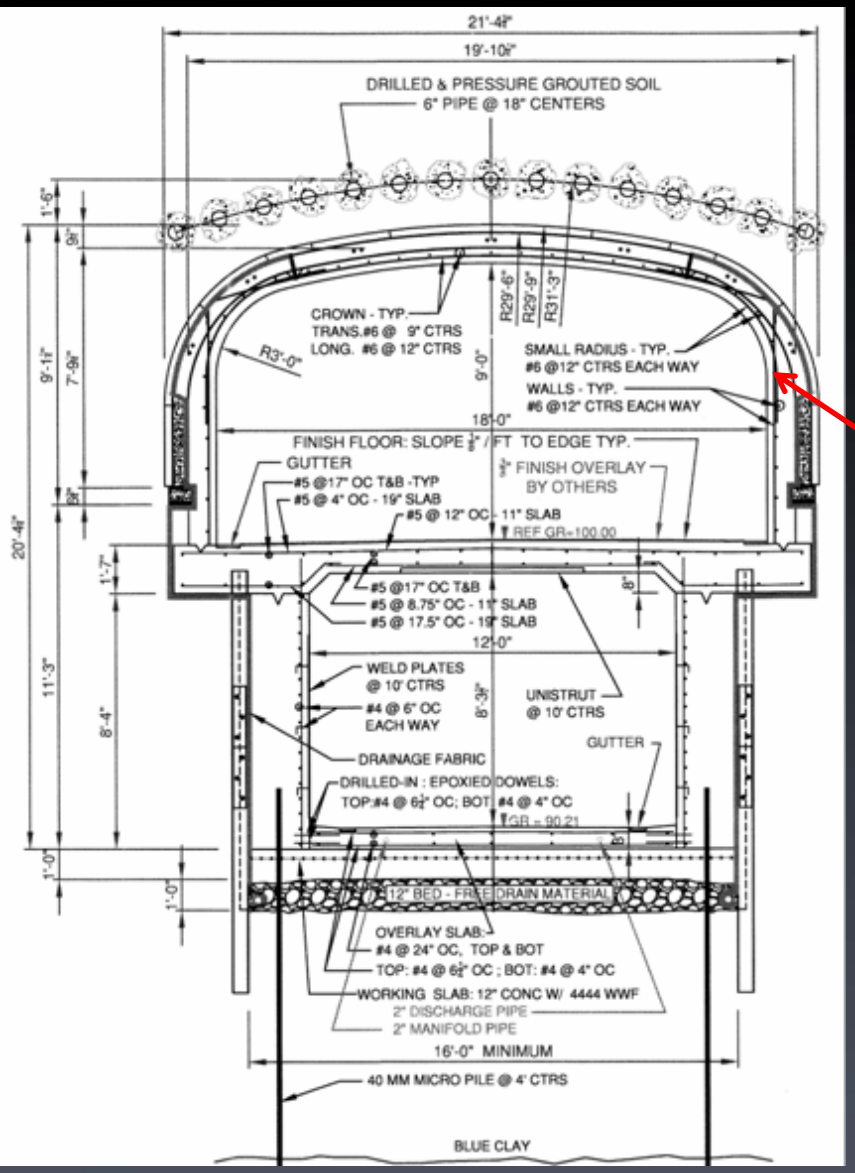
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
3800
4000
4200
мм
0
200
400
600
800
1000
1200
1400
1600
1800
0
25
50
75
100
125
X
0
0,3
0,5
0,8
1,0
1,3
1,5
1,8
Z,m

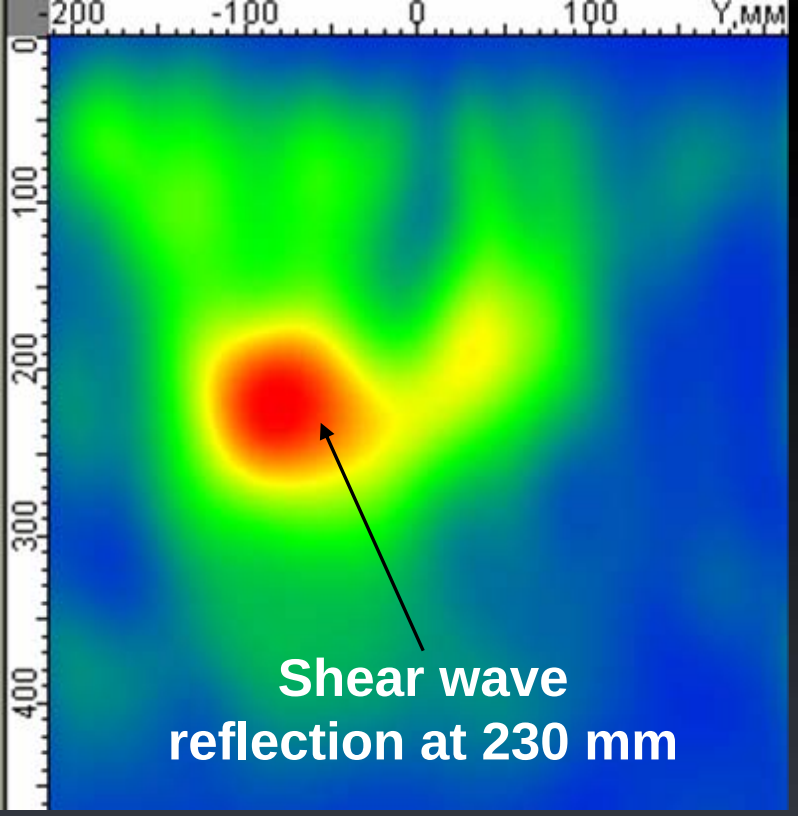

0 200 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400 2600 2800 3000 3200 3400 3600 3800 4000 4200 X,мм
0 200 400 600 800 1000 1200 1400 1600 1800 2000 2200
25 50 75 100 125 X
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 Z,mm

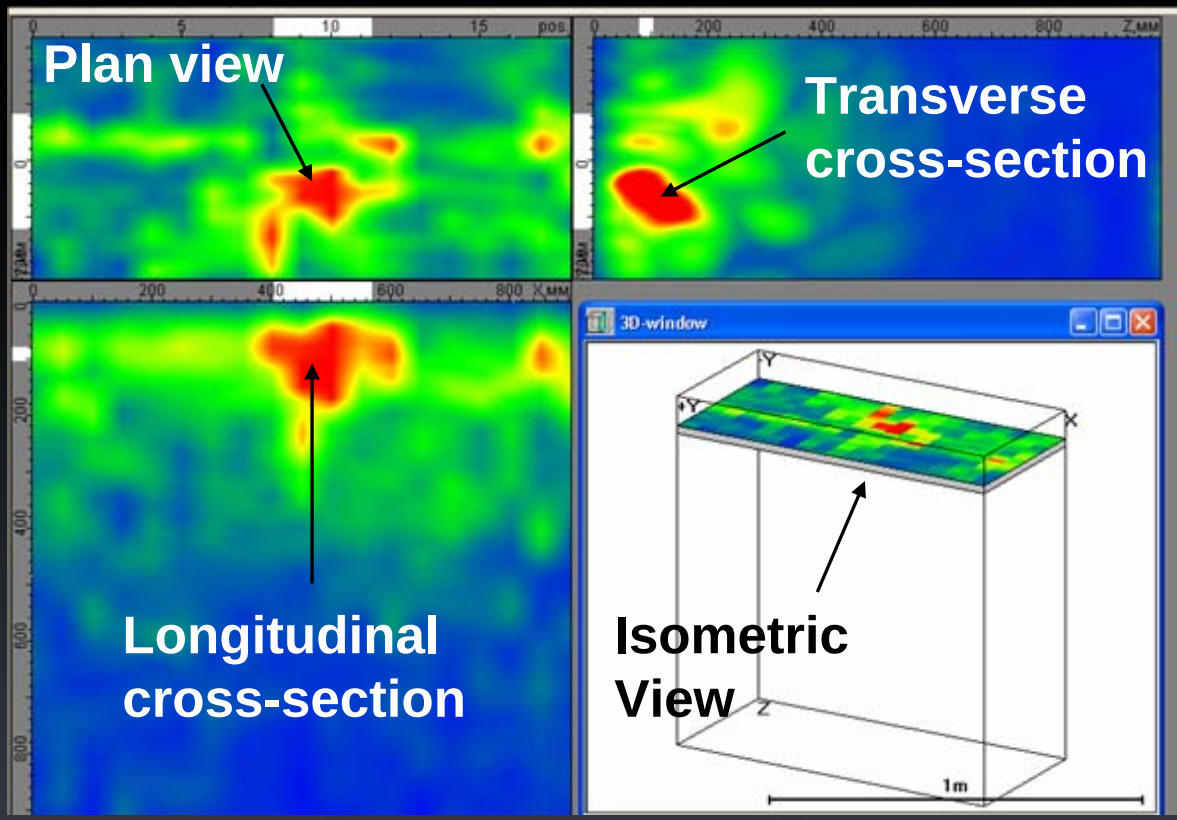
➢Field Studies

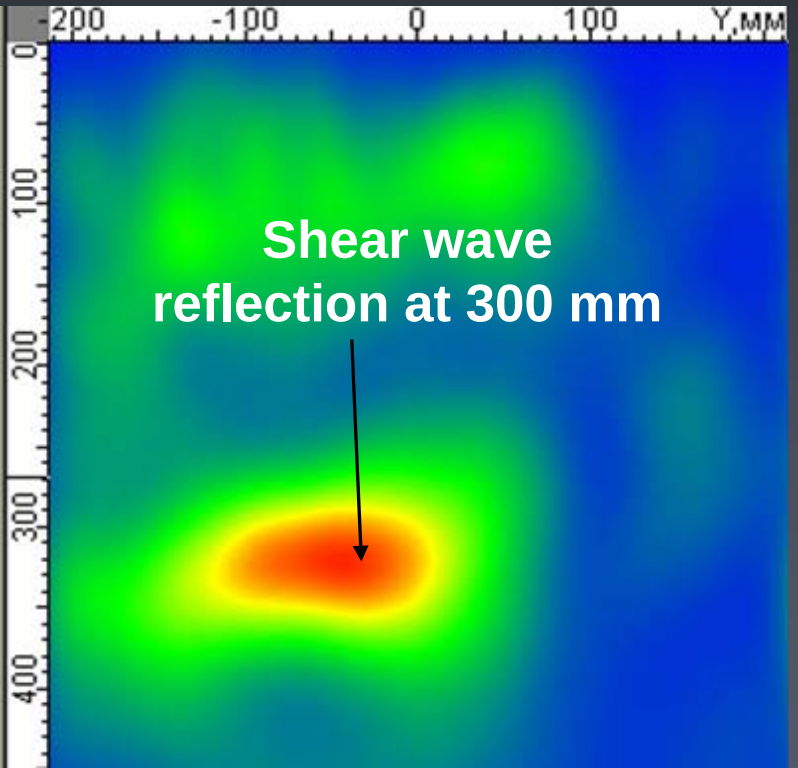
- ✓Underground pedestrian tunnel
- ✓Precast concrete spandrel walls
- ✓R/C columns with grouted metal ducts
- ✓Segmental box-girder bridge with P/T ducts



Reinforced concrete liner

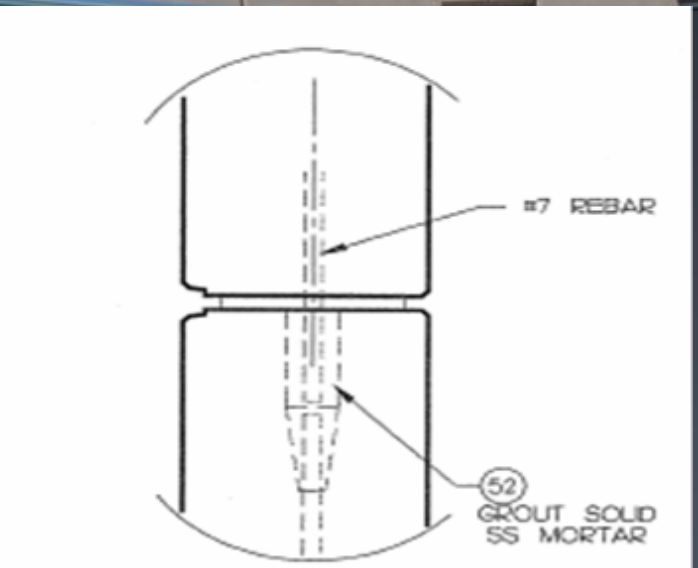

-200
-100
0
100
Y,мм
0
100
200
300
400
Shear wave
reflection at 230 mm


Plan view
Transverse
cross-section
Longitudinal
cross-section
3D-window
Isometric
View
1m

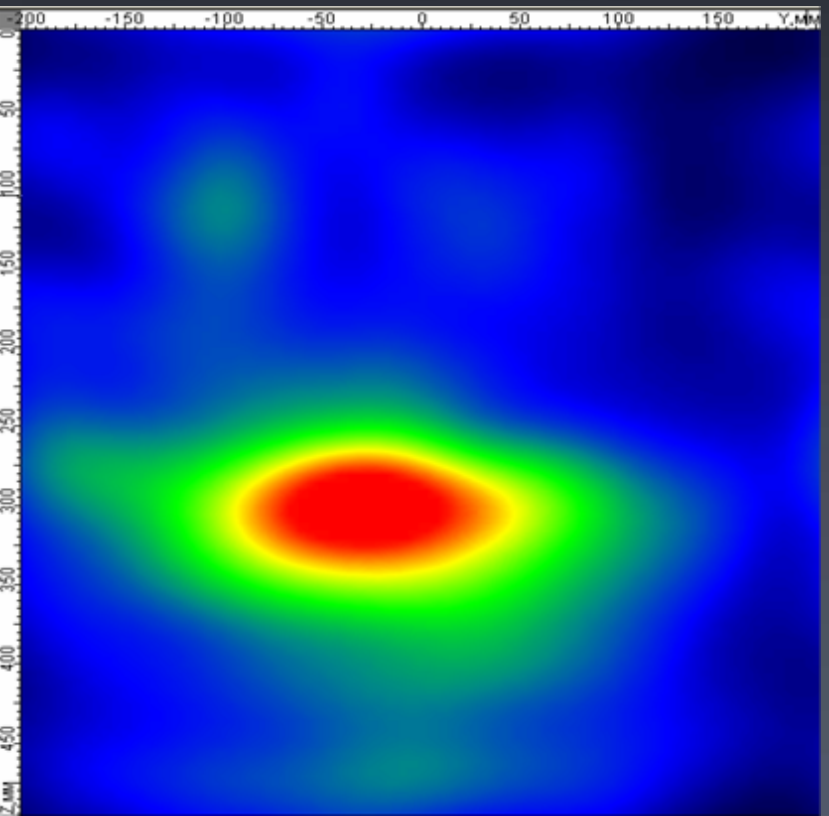

-200
-100
0
100
Y,мм
0
100
200
300
400
Shear wave
reflection at 300 mm

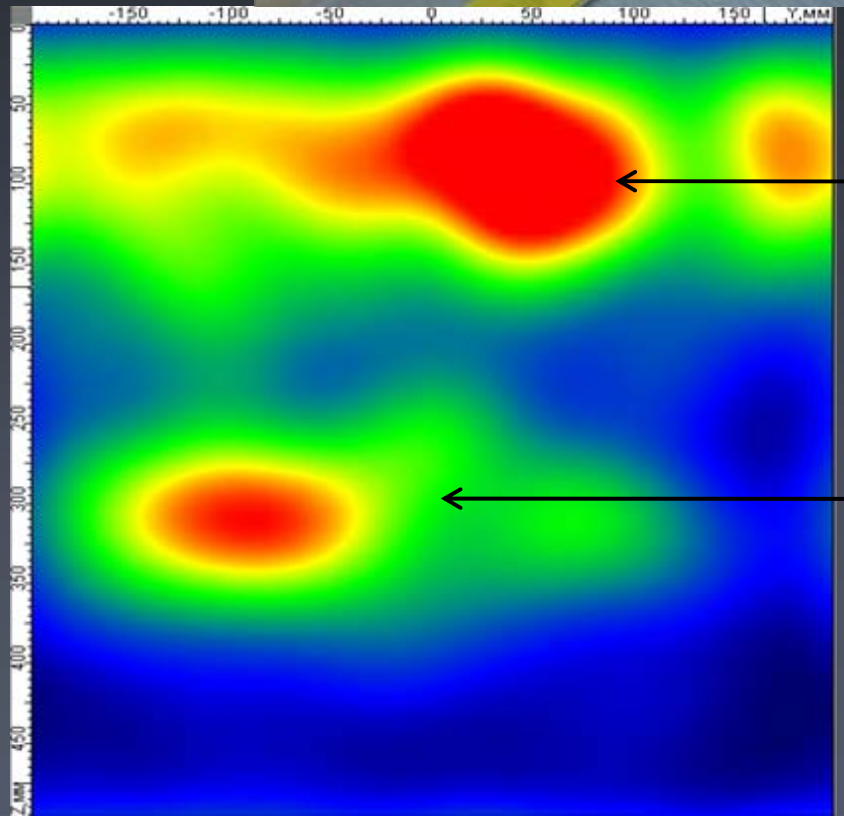

NOV 28 2007

22 mm dia.
splice sleeves



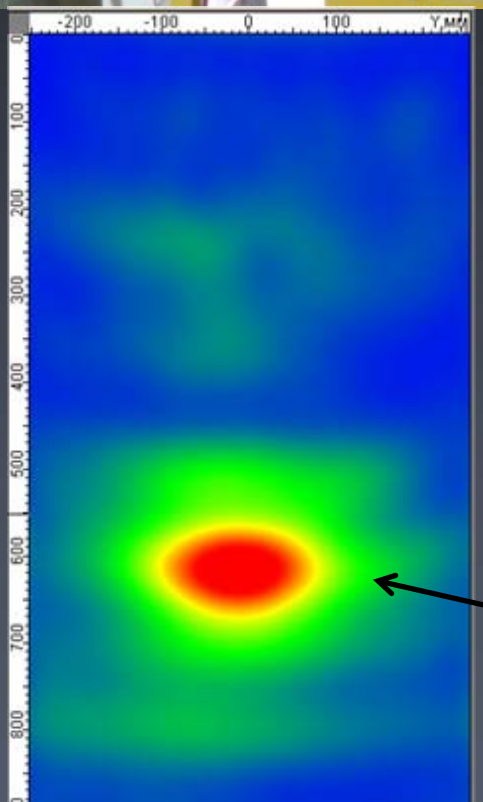
CONNECTION C17



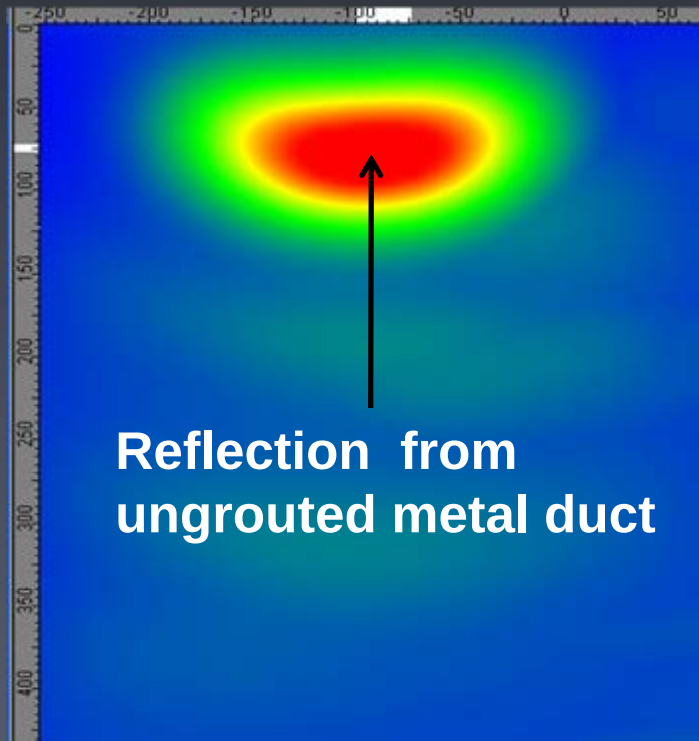


Reflection from the ungrouted splice Sleeve

Backwall reflection at 300 mm

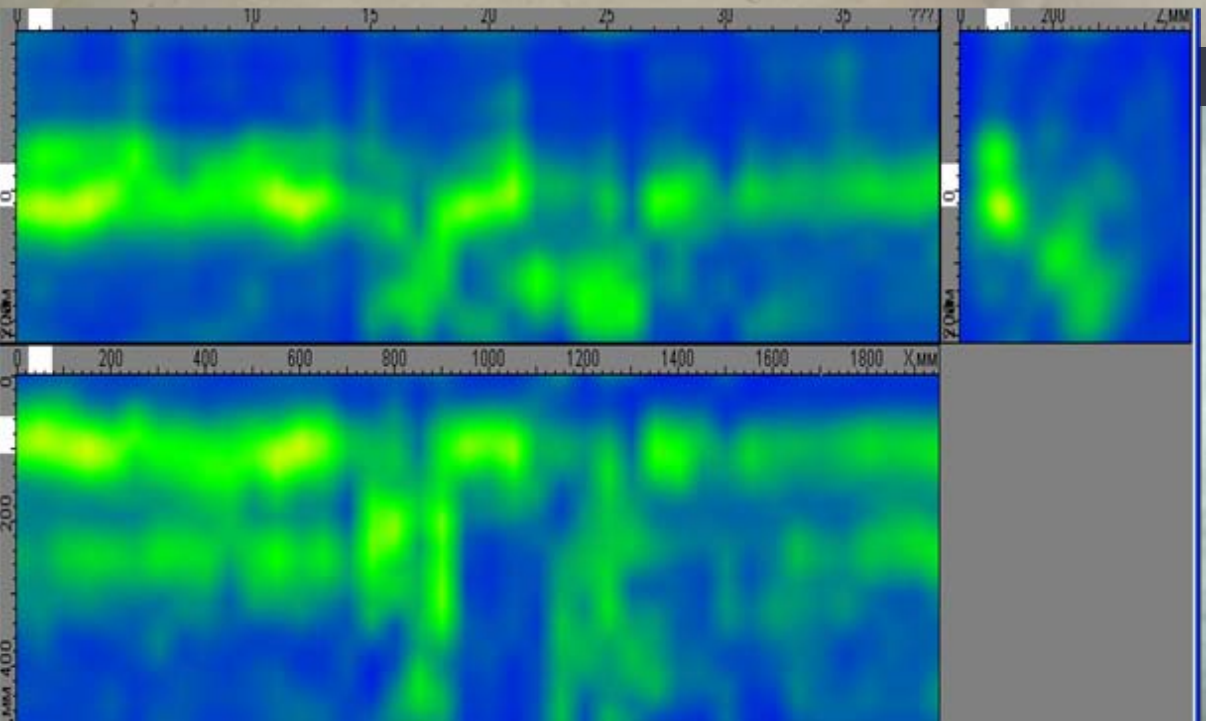


Backwall reflection at 600 mm



Reflection from ungrouted metal duct

Post-tensioned segmental box girders with grouted tendon ducts



Thank You

WJE