

I.Industrial (technical) applications of geophysical methods used by the Archeo-geophysics laboratory in construction, plumbing, geotechnical engineering, engineering geology, mining, electricity power supply, transportation, military, criminology, security and ecology.

The fields of application of the Ground Penetrating Radar (GPR) are:

CONSTRUCTION APPLICATIONS

Designing buildings, roads, airports, oil and gas pipelines requires comprehensive study the geological structure of the ground and rocks in the area for construction. Using of geophysical methods for exploration for construction, especially in complex engineering geological conditions of the construction site, provides additional information about the structure of the ground and improves the quality of project solutions.

Non-destructive location, determination of the depth and mapping of:

- Gaps (fig.1, 2) and defects in buildings
- landslides, failures, subsidence (Figure 3), faults and other hazards (Figure 4) for buildings in the design of new residential complexes and buildings
- Invisible cracks in buildings
- Areas of degradation of reinforced concrete due to corrosion of reinforcement
- Corrosion of the connections of the panels
- Wiring and reinforcement (Figure 11) in the floors, walls and ceilings
- Elements of floor heating
- Septic tanks and channels (Figure 20);
- Caves (Figure 5), caverns (Figure 6) and other karst formations causing subsidence of the ground
- Underground reservoirs (fig.30)
- Buried and build in tubes (Figure 20), cables (Figure 21), etc .;
- Tunnels (Figure 7), catacombs and channels
- Underground power, telephone or other cables that could be damaged in excavations for constructions or repair, which would lead to a short circuit, cable breaks or even accidents at work. This prevents their destruction during construction works and accidents with them.

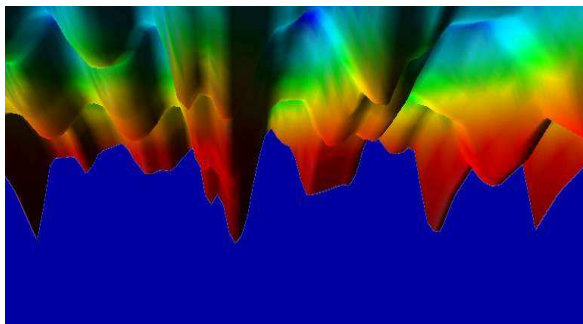


fig.I.1. Intensity of the reflected radar signal from the ceiling of 4 floor of Building B of the Faculty of Physics (Figure 2) measured from 5th floor over concrete slab over them.

Y. Shopov, D. Stoykova (Lab. Archeo- geophysics)

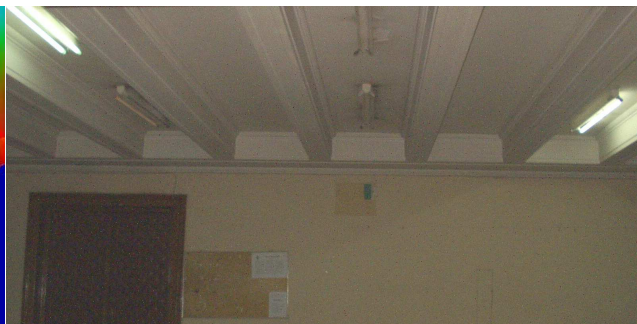


FIG. I.2. Photography of buttresses (concrete beams) of the 4th floor ceiling of Building B of the Faculty of Physics measured with Ground Penetrating Radar (GPR) on Figure 1. photo byY.

Shopov

Non-destructive localization and identification of underground pipes of metal, plastic, ceramics, concrete and asbestos concrete.

Non-destructive evaluation of the status and monitoring of the stability of the ground, floors and foundations.

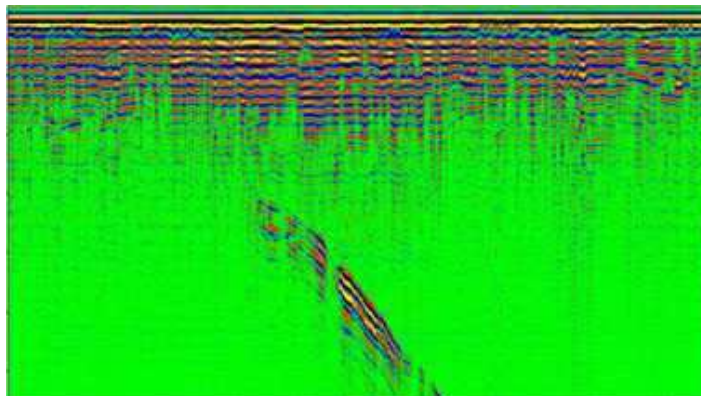


FIG. I.3. Localization of landslide on fault, Radar Systems inc

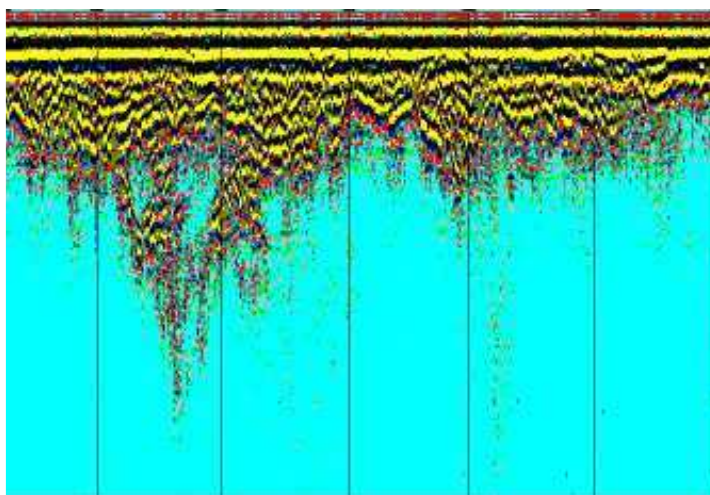


fig.I.4. Localization of the bed of an ancient river, which is not visible at the surface, Radar Systems inc

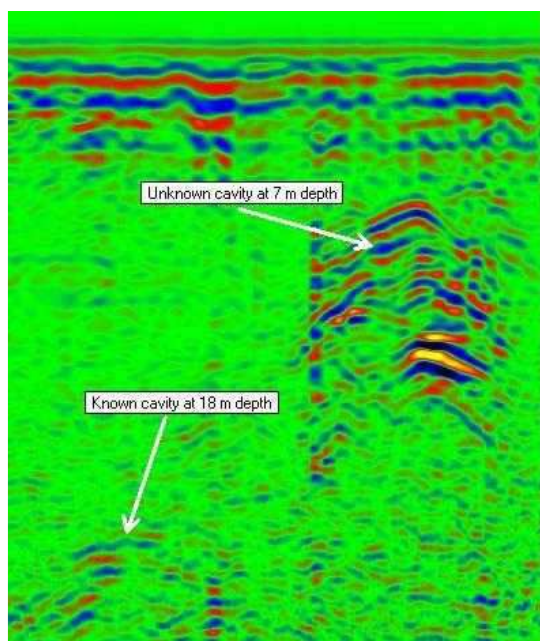


FIG. I.5. Localization of caves in the limestone of 7 and 18 m depth, Radar Systems inc

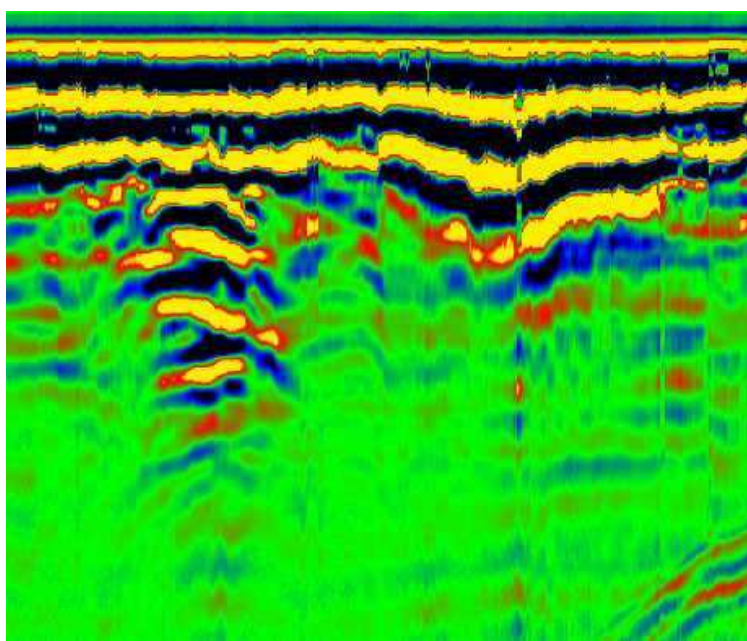


FIG. I.6. Localization of the cavern (left) in the limestone under a layer of clay (above), Radar Systems inc

Assessment of amortization of:

buildings, towers, terraces, garages, balconies, panels, iron and concrete structures.

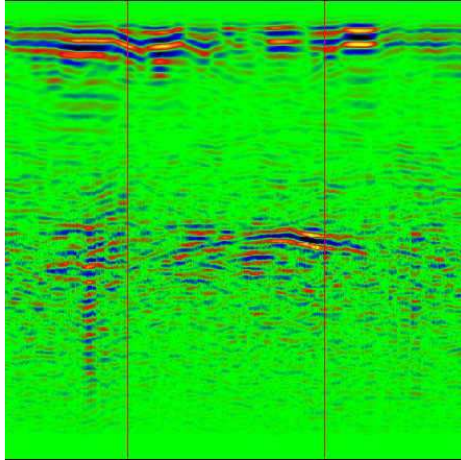


FIG. I.7. Railway tunnel 15 meters deep in the limestone.
Radar Systems inc

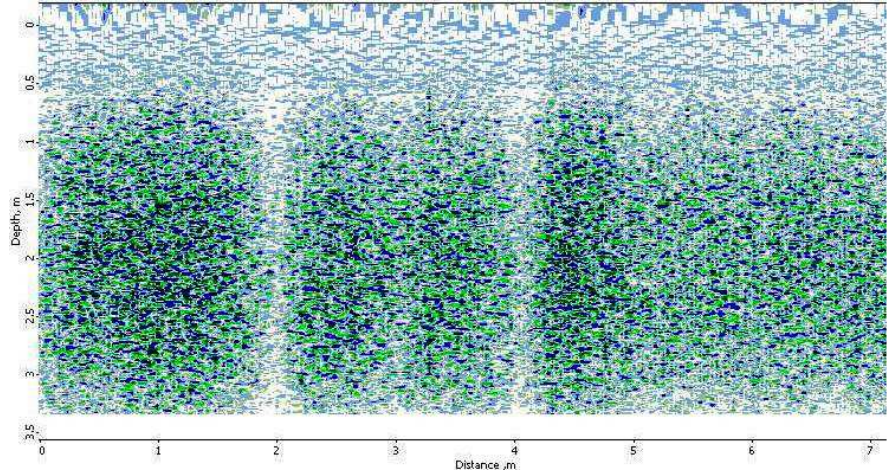


FIG. I.8. Extreme GPR profile of two walls on the 5th floor of Building B of the Faculty of Physics measured from the sixth floor through the concrete slab over them. Y. Shopov (Lab. Archeo- geophysics)

ENGINEERING APPLICATIONS

GPR replaced the X-ray in flaw detection of large constructions due to harming, high price, time consuming and limitations of X-ray flaw detection.

Non-destructive locating, determination the depth and mapping of:

- Walls (Figure 8), supports (Fig 1, 2, 9, 10), reinforcement (Figure 11), and other supporting structures;
- Built-in components and systems in structures (Figure 8, 13-14).
- Gaps (fig.1,2) and defects in structures;
- Tubes (Figure 15, 16), cables and wires in structures (Fig. 17)

Determination of:

- Thickness of pavement, foundations, asphalt, concrete, etc .;
- Thinning, distortion and other types of wearing of surfaces, foundations, etc .;
- network of wires, metal or plastic pipes

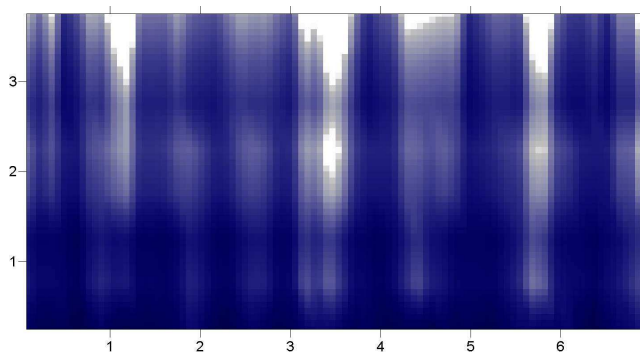


FIG. I.9. 2-Dimensional map (in meters) of the radar signal from concrete ceiling beams (25 cm thick) and gaps between them - 80 cm. Due to the scattering of the signal, radar "sees" 7.46 m instead of 7 meters which it scanned. Fluorescent lamps are also visible (Figure 5) between 3th and 4th and 4th and 5th meter of the scan.

Y. Shopov, D. Stoykova (Lab. Archeo- geophysics)



FIG. I.10. Photography of the buttresses (concrete beams) of the ceiling on the 4th floor of Building B of the Faculty of Physics (measured with GPR on Figure 1, 9). The same object is presented in Figure 1, 2, 9. Photo by Y.Shopov (Lab.Archeo-geophysics)

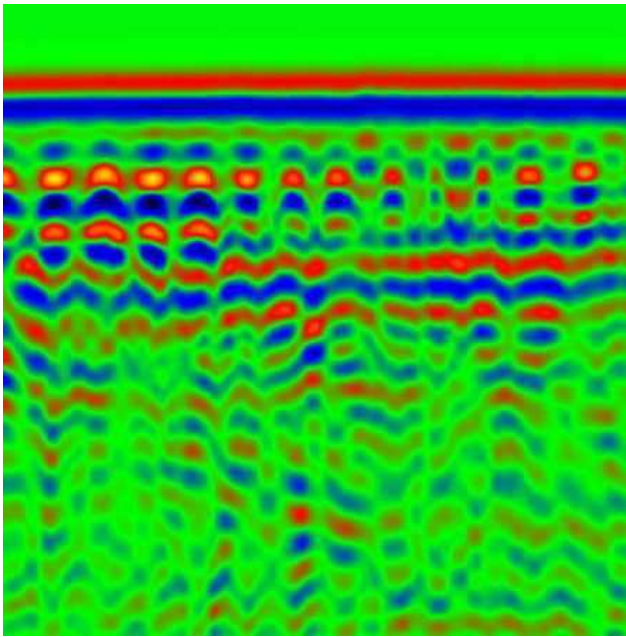


FIG. I.11. Locating of fitting in reinforced concrete floor. Radar Systems inc

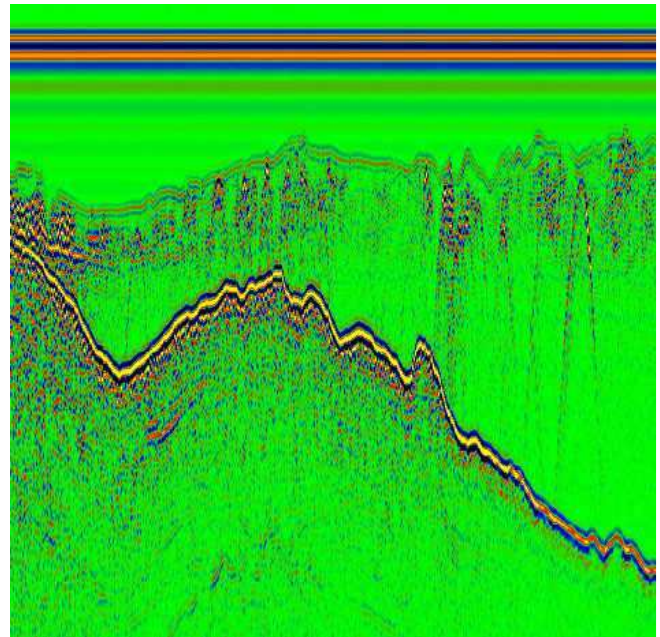


FIG. I.12. Profiling of the lake from the bottom of a plastic boat. Several metal objects are localized, which are very well visible in the silt layer as hyperbola. Radar Systems inc

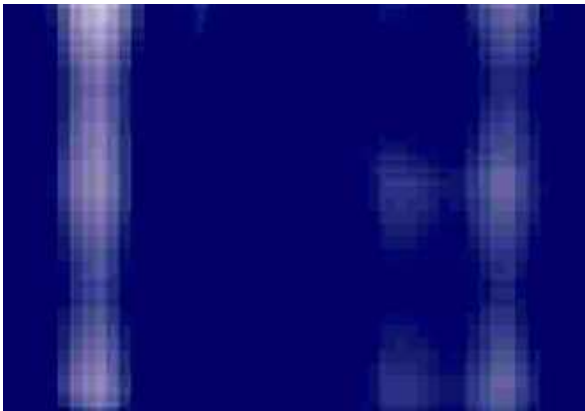


FIG. I.13. The radar signal from the two concrete beams in the middle of the ceiling of the basement of the building B of the Physics department, measured at 17,11-17.38 m depth from the 5th floor, through 5 concrete slabs with a total thickness of 3.25 m! This depth is 70% greater than the manufacturer's specified maximum working depth of the device !!!

Y. Shopov, D. Stoykova (Lab. Archeo- geophysics)



FIG. I.14. Photography of the buttresses (concrete beams) at the ceiling of the basement of Building B of the Faculty of Physics, measured with GPR on Figure 13.

Photo by. Y. Shopov (Lab. Archeo- geophysics)

Non-destructive testing, evaluation of the situation and monitoring of:

pavement, platforms, foundations, plates, supporting and bearing constructions and others structures.

COMMUNICATIONS, OIL AND GAS LINES, PIPELINES, WATER-CONDUIT AND SEWERAGE

Non-destructive locating, determination of the depth and mapping of:

- Buried and build in tubes (Figure 15, 16), channels (fig.16,18), cables (Figure 17), tunnels (Figure 7),etc.;
- Underwater pipes, cables, etc.
- Leaks in pipes (water, gas, etc.).

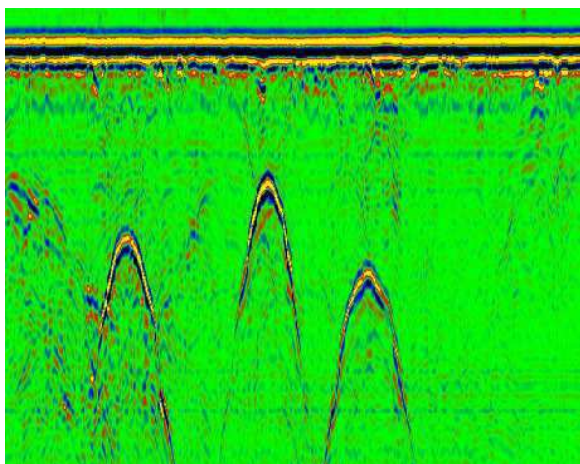


FIG. I.15. Localization of three metal oil pipelines buried in the ground at 1-1.5 m depth. Each pipeline gives hyperbolic signal. Radar Systems inc

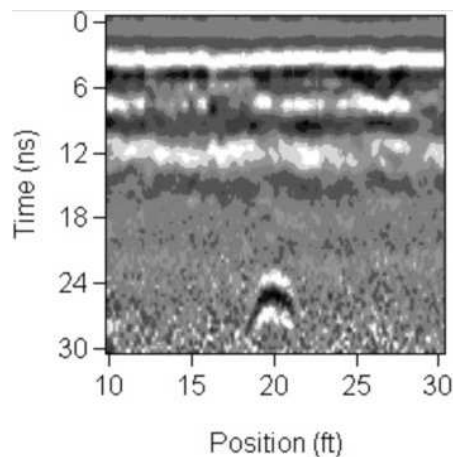


FIG. I.16. Localization of sewerage pipe (below) passing perpendicularly under a metal pipe (above) Sensors & Software inc

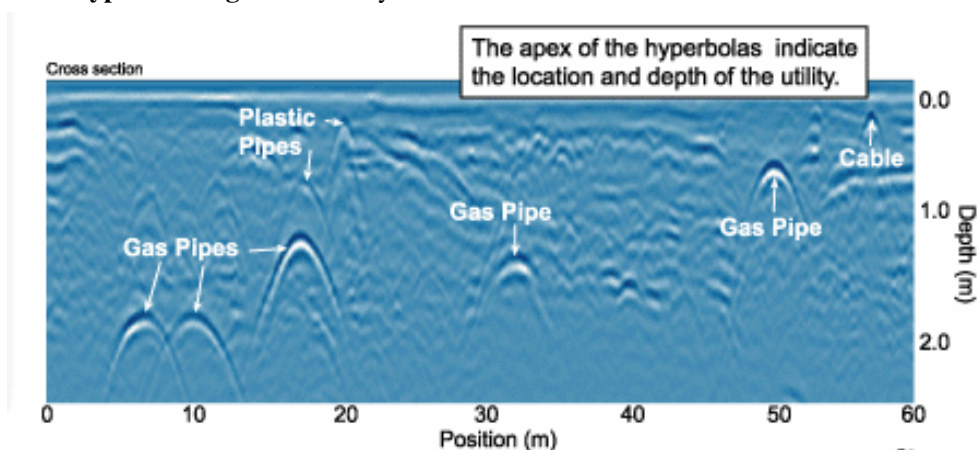


Fig. I.17. Localization of plastic and metal pipes and cables buried in the ground. Each pipe and cable gives hyperbolic shadow under it. Sensors & Software inc



Fig. I.18. Scanning urban terrain with GPR for search of sewerage pipes by a team of archaeo-geophysics laboratory.

APPLICATIONS IN TRANSPORT

Non-destructive locating, determination of the depth and mapping of:

- Cracks, collapses, cavities and other defects in the foundation and pavement of roads, runways, railway lines and other transportation constructions;
- Cracks, collapses, cavities and other defects in tunnels and tunnel structures;
- Thinning, distortion, cracks, voids, and other defects in bridges and bridge constructions.

Non-destructive thickness measurement of:

bridge roadways, pavements, new and old asphalt, foundations, drainage and others.

Non-destructive testing, evaluation and monitoring of the state of:

roads, runways, railway lines, tunnels, bridges, etc. constructions.

Evaluation of amortization of bridges, runways, tunnels, overpasses, multi- level parking, etc.

HYDROLOGICAL APPLICATIONS

Non-destructive locating, determination of the depth and mapping of:

- Underground rivers
- Groundwater (Figure 19)

Non-destructive determination of the depth of the water level of groundwater.

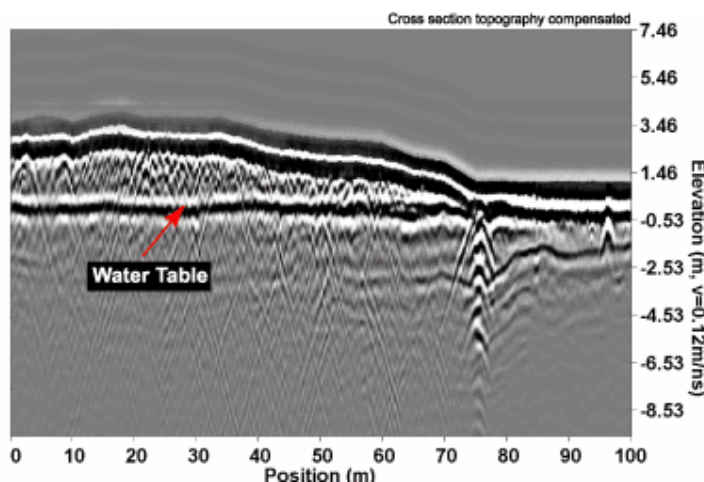


Fig. I.19. Determination of the depth of the water level of groundwater by GPR. Sensors & Software inc

GEOLOGICAL AND GEOTECHNICAL APPLICATIONS

The use of the method of subsurface radar sounding (GPR) in engineering geology explorations increased dramatically in the practice of over the past decade.

Unlike the traditional geophysical methods (electric resistivity survey, seismic survey, etc.), GPR survey allows extremely high resolution along the trace and in depth, highly-detailed surveys, along with possibility to obtain information about the structure of the studied section and visualization of results during the measurement. All this is resulting in high performance of the GPR exploration.

Mapping of sections and study the structure of:

- Rocks;
- Sediments;
- Underwater sediments;
- Rock surfaces in sedimentary rocks
- Rock-bottom and bottom deposits in fresh water bodies (lakes and rivers) - Figure 12
- Soils;
- Groundwater;
- Water horizons (Figure 19);
- Karst formations (caves (Figure 5), caverns (Figure 6), whirlpools, potholes, etc.);
- Failures, faults, landslides (Figure 3), etc .;

Non-destructive stratification and stratigraphic mapping of:

- Sediments;
- Soils;
- Water horizons (Figure 19);

Detection and mapping of the structural discontinuities in a section (karst, tectonic discontinuities, contact between lithological different rocks, areas of wedging of the rock layers, rock inclusions in sedimentary environment, etc.);

Sounding and measurement of peat and sapropel deposits

Non-destructive testing, evaluation and monitoring of the status of groundwater resources, geological and hydrogeological situation

Non-destructive determination of:

- Thickness and density of the snow and ice cover
- Depth of bedrock

Characterization of cracks and faults

MINING APPLICATIONS

Non-destructive localization and mapping:

- Hazardous areas in open pits and mine galleries.
- Old underground mining galleries.
- Coal layers;
- Ore deposits;
- Salt deposits;
- Bauxites;

Non-destructive testing, evaluation and monitoring of the deposits and hazardous areas.

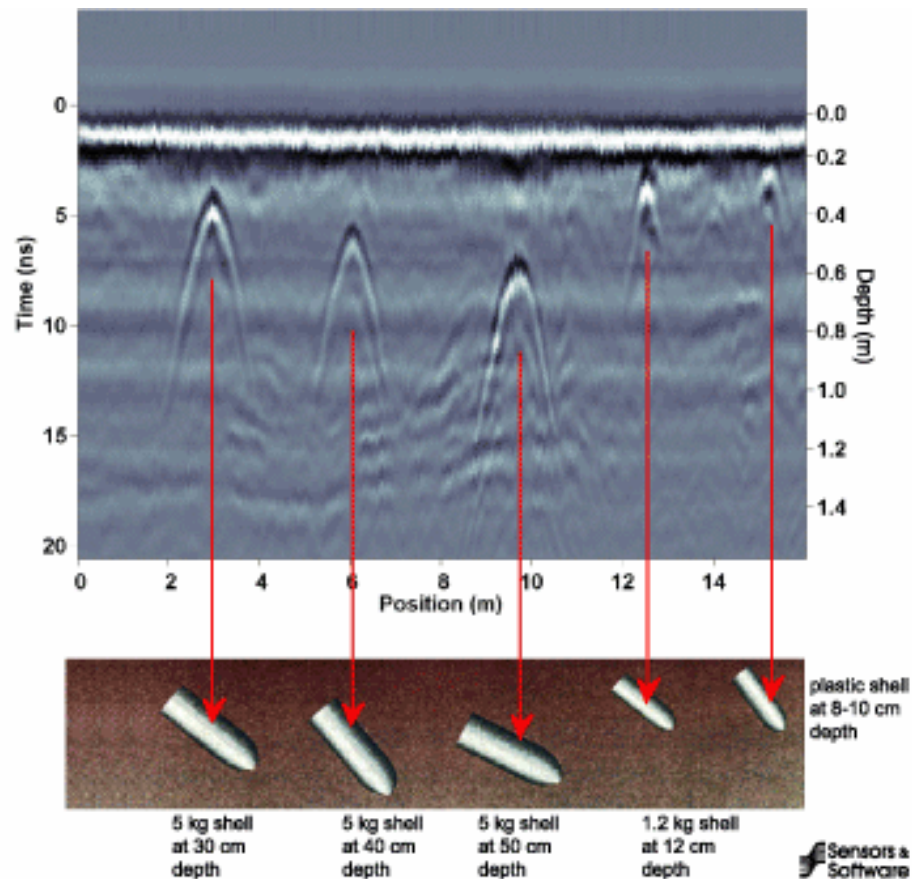


Fig. I.20. Locating of unexploded shells of different depths Sensors & Software inc

MILITARY APPLICATIONS

Non-destructive locating, determination of the depth and mapping of:

- Bunkers, shelters, underground warehouses, caves and other strategic underground sites;
- Anti-infantry and antitank mines;
- Unexploded mines, shells (Figure 20) and grenades;
- Defects in bunkers, polygons, tunnels, roads, runways, bridges, etc. strategic sites
- Cables (Figure 17), pipelines (fig.15-16) tunnels (Figure 7) and other communications;

Geophysical methods are applied effectively even in intelligence!

CRIMINOLOGY (FORENSIC) AND SECURITY APPLICATIONS

Non-destructive locating, determination of the depth and mapping of:

- Walled in safes, (Figure 21) and hideouts
- Hidden single and mass graves (Figure 22, 23);
- Tunnels dug under banks, prisons, vaults, galleries, museums, warehouses (Figure 24) and other buildings for robbery or escape from prison
- Buried, built in, and otherwise hidden clues, weapons (Figure 25), ammunition (Figure 20), hazardous substances and others.
- bugging devices

Non-destructive testing, evaluation and monitoring of the status of objects, subject to criminal investigation or special security measures.

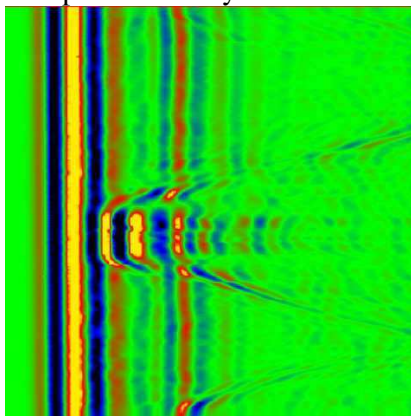


Fig. I.21. Scan of a brick wall. Central part of the profile clearly shows a signal from walled in safe. Radar Systems inc

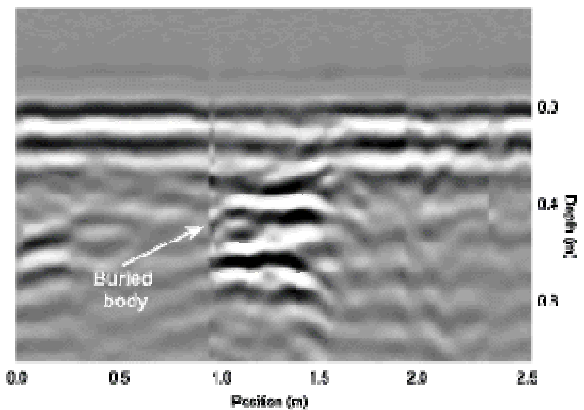


FIG. I. 22. Location of buried human body
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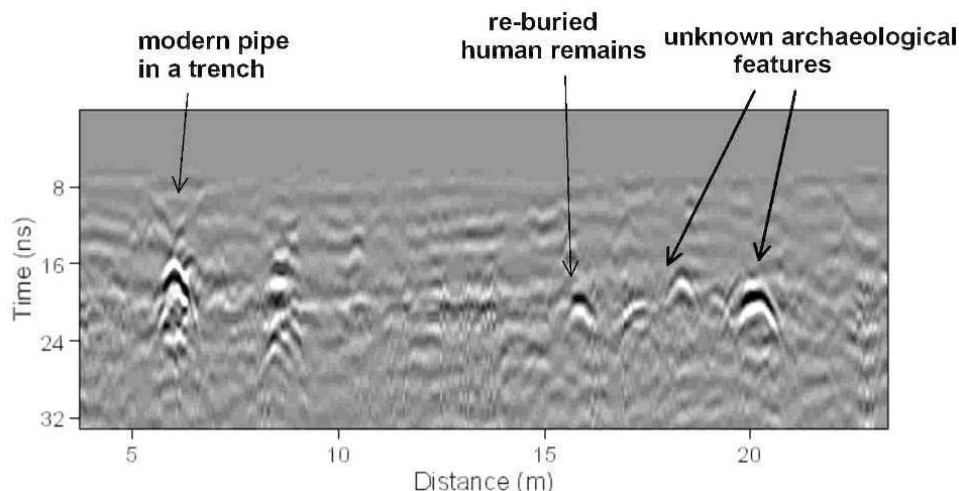
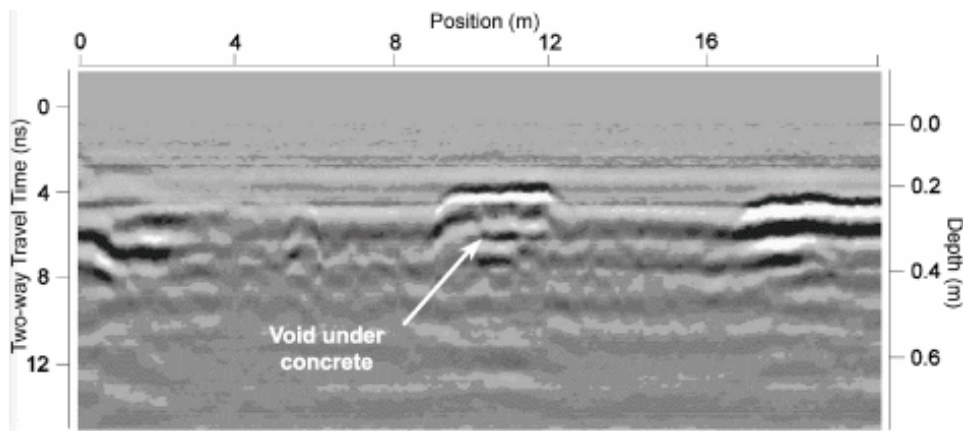


Fig. I.23. Reburial of human remains (center) and pipe in a trench (left) after Conyers (2004)



I.24. Cavity (trench) under the concrete Sensors & Software inc

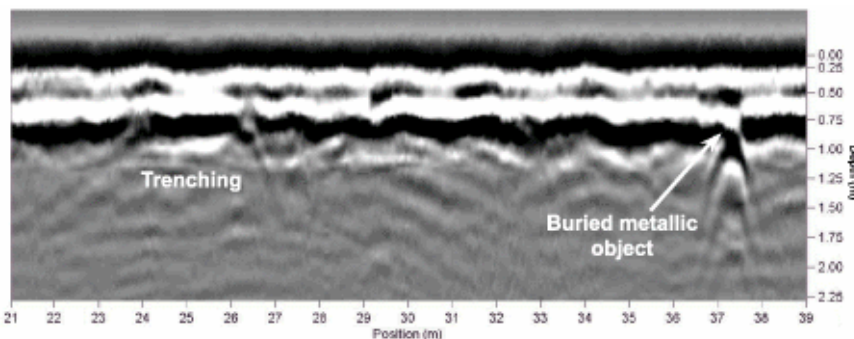


Fig. I.25. Localization of buried plastic container (left) and gun (right) Sensors & Software inc

ENVIRONMENT

Conductive contamination of groundwater strongly absorb signal of GPR, and therefore it is an effective tool for mapping the distribution of such contaminants (Figure 26).

Non-destructive locating, determination of the depth and mapping of:

- Leaks and spills of pollutants (Figure 26);
- Septic tanks and channels;
- Buried, walled in, or submerged pollutants;
- Underground reservoirs (Figure 27) and storage of pollutants;

Non-destructive testing, evaluation of the state and monitoring of contaminated sites, groundwater, reservoirs and storage of hazardous waste, and protected natural sites or monuments.

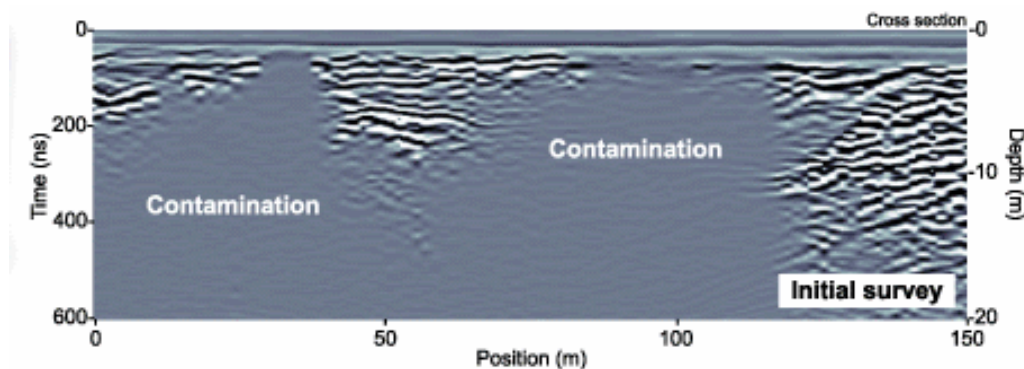


Fig. I.26. Profile of the sand with high conductivity due to the discharge of pollutants causing rapid signal attenuation. Sensors & Software inc

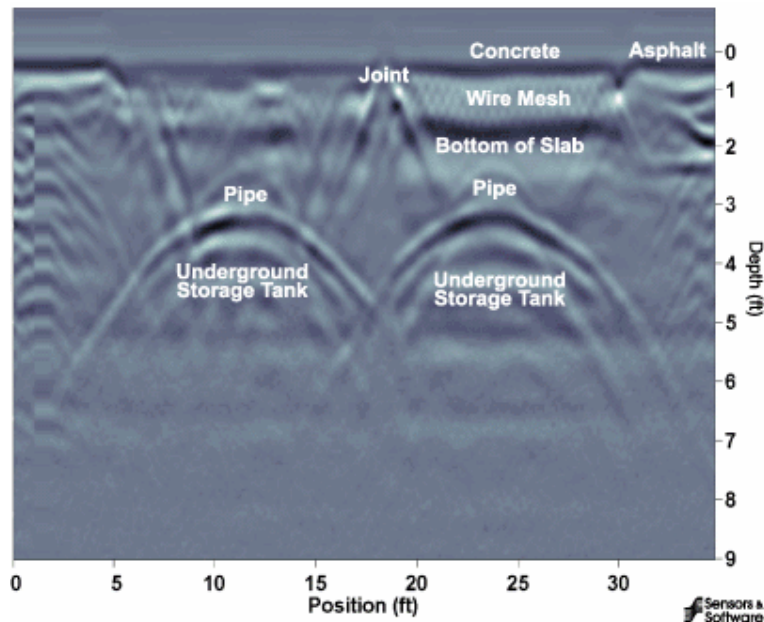


Fig. I.27. Localization of tanks with pipes lying under asphalt, concrete and wires. Sensors & Software inc

AGRICULTURAL APPLICATIONS

Non-destructive locating, determination of the depth and mapping of:

- The level of groundwater (Figure 19)
- Drainage pipes and equipment
- Tree roots

APPLICATIONS FOR RESCUE OPERATIONS

Non-destructive localization of people and objects buried by avalanches.

Equipment applied by the lab.

Most appropriate geophysical method for solving these problems is Ground Penetrating Radar (GPR). Before the creation of GPR, underground objects from plastic, tiles, concrete and asphalt were considered for undetectable. GPR became the main method for locating and mapping of non-conductive, non-metallic and non-magnetic objects.

GPR - the method was developed by NASA to study the lunar ground for the needs of the US space program and is similar to sonar. The GPR is a digital portable device for subsurface scanning, designed to work on a wide range of geotechnical, geological, environmental, engineering, and other tasks that require subsurface monitoring. During scanning the operator sees the radar picture of the computer screen in real time. Data are stored on hard drive memory of the computer for digital processing, printing and interpretation of results.

The principle of operation of the apparatus for subsurface radar sounding (GPR) is based on the emission of ultra-wideband nanosecond pulses in the meter, decimeter and centimeter range of the radio waves, and receiving of signals reflected from the boundaries of the studied medium, which have different electro-physical properties. Such boundaries are contact between dry and moisture-saturated soils - groundwater level, contacts between rocks with different properties, boundaries rock - air, soil- metal, etc.

The GPR is detecting metal objects, tunnels, tombs, wells, bunkers and everything which is different from the surrounding environment. This high-tech radar explores large areas with great precision. Thousands of square meters can be explored for one day.

The GPR we use is working at depths up to 25 meters (fig.14-15) with a resolution of 2 to 15 cm as it scans and visualizes the object in real time (during the study). GPR does not require intrusive contact. It does not damage the studied objects. It allows creating of two-dimensional maps (slices) of underground terrain at

different depths below the surface by additional computer processing. In addition, it allows for creating of three-dimensional reconstructions (3D image) of the exact shape and depth of underground structures.

The GPR is ideal for locating underground electric cables, pipes, channels, gaps, and to determine the thickness of the slab or pavement at study of roads, bridges, sewerage, electric power supply, telephone lines, for tracing underground waterways (natural and artificial), as well as for mapping of urban communication necessary during construction work. It works effectively in locating underground objects and measuring the stability of the ground before the start of excavation work for construction or repair.

The GPR used at our Archaeo-geophysics laboratory can be used for underwater research in freshwater bodies. It is a powerful modern apparatus that can be used for many different applications, and for resolving of comprehensive exploration problems.