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Ground Penetrating Radar

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ABSTRACT: Ground-penetrating radar (GPR) is a geophysical method that uses radar pulses to image the subsurface. This nondestructive method uses electromagnetic radiation in the microwave band (UHF/VHF frequencies) of the radio spectrum, and detects the reflected signals from subsurface structures. These GPR has many applications in many fields. In earth sciences it is used to study bedrock ice and soils. In engineering applications include non-destructive testing (NDT) of structures and pavements and locating buried structures etc.

KEYWORDS: Ground-penetrating radar, Non-destructive testing

I. BACKGROUND

Ground Penetrating Radar (GPR) was invented in the 1970's, originally for military purposes such as locating land-mines and underground military tunnels. Soon public utility companies began to be keenly interested in such radars in hopes they would provide a practical method for mapping pipes and utility lines under city streets, and for locating cavities and voids. Most recently radars of this type have been used from aircraft for mapping the surface of the earth through jungle or forest cover. GPR technologies have proven to be of great usefulness in archaeology, especially in Israel. Radar from the air is seldom of use to the archaeologist these days except for large sites covered by jungle such as are found in the Yucatan or Central America. Foliage-penetrating radars are now used widely for topographic mapping of the land surface beneath jungle canopy.

Thermal-infrared imaging methods measure the surface temperature of the earth to an accuracy of a fraction of one degree. The electronic scanning equipment necessary for such measurements was originally available Only to the military and the instruments cost from $100,000 to $1,000,000. In recent years Portable instruments of great sensitivity have become commercially available at greatly reduced prices. These instruments can be used from a tripod on the ground, or from helicopter or airplane by viewing through a hole in the fuselage.

Borehole technology, Radars, seismic and resistivity other probes are often lowered into holes drilled into an archaeological site, to permit geophysical probing at depth. Core drill soil samples can be a big help in identifying the various historic levels and strata at a layered archaeological site. When chambers or voids are encountered while drilling, these can be explored (and videotaped) using a down-hole television camera equipped with lights. Holes drilled into an archaeological site are obviously much less damaging than trenches or tunnels and they can either be filled or capped after use.

Not all individuals or companies who offer geophysical assistance to the archaeologist are reputable or professionally competent. Fraudulent self-made experts---whose instruments may be little more than electronic water dowsing rods-commonly offered services, are of little value. Some geophysical instruments on the market may promise amazing results in identifying metals at great depth by type and quantity but many of these operate by methods unknown to reputable science. Geophysical records, even when made using legitimate instruments, are also of little value unless the data is collected and interpreted correctly. Archaeologists should not expect his geophysicist to work wonders for him at all sites. In some cases a combination of instruments may be appropriate, in other cases no known method may prove really very useful or cost effective.

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II. RELATED WORK

GPR is a technology that allows for the noninvasive study of subsurface stratigraphy (layering) and underground phenomena, among other uses Similar to the technologies of GPS and satellite imagery, GPR provides yet another effective method of exploration. Though GPR as a technique is used far less than GPS and satellite imaging, its advantages are becoming more widely known with each new application. An example is the research Dr. Harry Jol has done in the field of archeology in Israel investigating ancient bath houses an application many would not
Have thought of but can now learn from.[1] GPR is capable of imaging large-scale glaciotectonic structures, resulting in a factual model of the eastern Veluwe push-moraine architecture and better insight into postglacial denudation amounts and push-moraine genesis [2].

III. STATEMENT OF PROBLEM

The most significant performance limitation of GPR is in high-conductivity materials such as clay soils and soils that are salt contaminated. Performance is also limited by signal scattering in heterogeneous conditions (e.g. rocky soils).
Other disadvantages of currently available GPR systems include:

- Interpretation of radar grams is generally non-intuitive to the novice.
- Considerable expertise is necessary to effectively design, conduct, and interpret GPR surveys.
- Relatively high energy consumption can be problematic for extensive field surveys.
- Ineffective in the soils where the moisture content is hig

IV. RESEARCH

Recent advances in GPR hardware and software have done much to ameliorate these disadvantages, and further improvement can be expected with ongoing development.

A. ARCHAEOLOGY

Ground penetrating radar is commonly used in geophysical and geological research but much less so in soil and hydrological related work. Since 1996 the Department has been working with GPR and we have a dedicated laboratory facility and our own PULSE EKKO 1000a GPR. Most GPR research focuses on finding things with the instrument whereas my GPR research has focused on measuring properties from GPR returns. IN particular I am interested in measuring soil and surface properties (density, stoniness, soil moisture). I have worked alongside Thames Water to identify urban water leaks from GPR returns and through a number of NERC-funded PhD projects, have developed GPR applications in the measurement of soil properties and of soil moisture. In addition work has been carried out on the measurement of soil stoniness in Mediterranean soils using GPR.

B. MILITARY

For the past fifty years, the ESL has carried out extensive research into Ground Penetrating Radars (GPR) for detecting and identifying buried targets such as:

- anti-tank (A-T) mines,
- plastic pipe lines, and
- Tunnels.

Techniques developed at the ESL for detecting A-T mines have been extended and applied successfully by the British in the Falklands.
The ESL is currently developing new sensors and new methods for sub-surface object sensing using active and passive microwave and IR sensors, with emphasis on detection and identification of:

- anti-personnel mines and
- Unexploded ordnance.

V. TECHNICAL REPORT

A. Operation

The impulse Ground Penetrating Radar (geo radar) is a precise transmitting - receiving measuring device, which implements the phenomenon of reflection of electromagnetic waves. The transmitting antenna sends an interrupted sinusoidal impulse of the length of one and a half period. The electromagnetic wave travels with the velocity, which is

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dependent on electromagnetic properties of penetrated material. The second - receiving antenna, mounted at a certain distance, receives reflected signals, which are delayed from the transmitted signals from tens to thousands nanoseconds. The delay results from the distance between the transmitting antenna and underground reflectors(any material with different electrical properties to source material, which reflects a part of the energy of electromagnetic wave) and the receiving antenna.

B. Working

GPR works within the range from 10 MHz to 2 GHz. The frequency depends on eligible penetration depth. The electromagnetic waves are extinguished in loam and clay, while dry sand and gravel do it to lower extent. The strongest fading effect occurs for the highest frequencies. Therefore they can be reduced to 10-300 MHz, when deeper penetration is needed. Lower frequency is the price for accessing high depths. GPR is only able to see bigger objects such as caves, tunnels, casts and the structure of lithological layers. Since we hardly seek cables, pipes or rock crumbs at these depths, this emerges as an advantage. These small objects would produce noise, rather than useful information. The specific examination of very deep parts can be done by placing the antenna in a bore-hole. Through this method, we can obtain information about the smallest objects. The images show how used frequency influences the final resolution. Each profile is for the same depth (even though they are able to depict much deeper parts). The visible anomaly is a vivid part of other type of material, a brick lane in this case.

VI. RESULTS

A. PROS

- In finding land mines in military applications.
- Locating stumps in the below surfaces and in locating graves.

B. CONS

- Interpretation of radar grams is generally non-intuitive to the novice.
- Considerable expertise is necessary to effectively design, conduct, and interpret GPR surveys.
- Relatively high energy consumption can be problematic for extensive field surveys.
- Ineffective in the soils where the moisture content is high
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VII. APPLICATIONS

- In military for antitank and anti-personnel mines.
- In archaeology to find underground pipes and tanks.
- Borehole radars utilizing GPR are used to map the structures from a borehole in underground mining applications.
- One of the other main applications for ground penetration radars to locate underground utilities. Being able to generate 3D underground Images of Pipes, Power, Sewage and Water mains.
- To find the underground stumps and wastes in the sub surfaces.
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