United States Department of Agriculture

Soil Conservation Service

Northeast NTC
150 E. 7th Street
Chester, PA 19013

Subject: ENG - GPR Survey, RAMP

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To: James H. Olson
State Conservationist
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PURPOSE

To investigate subsidence problem areas at RAMP sites in Northumberland, Luzerne, and Lackawanna counties.

PARTICIPANTS

Bruce A. Benton, Geologist, SCS, Harrisburg, PA
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EQUIPMENT

The equipment utilized during this field trip was the SIR system-8 with microprocessor, the ADTEK SR-8004H graphic recorder, and the ADTEK DT-6000 tape recorder. During calibration experiment, both the 80 and 120 MH$_z$ antennas were used. However the 120MH$_z$ antenna with the Model 705DA transceiver provided the best balance of probing depth and resolution, and was preferred for field work. The scanning time in the control unit was 150 nanoseconds; the scanning rate was 25.6 scans/sec. The equipment operated well.

ACTIVITIES

The GPR unit travelled from Chester to Frackville, Pennsylvania on the morning of January 6, 1986. The equipment was calibrated and tested on the Lazarski RAMP site in Northumberland County during the afternoon of January 6, 1986. On January 7 field testing was completed at the Lazerski Site. Multiple transects were completed with the GPR on January 8, 1986 at the Zakowski Site in Luzerne County and the Rogers Site in Lackawanna County. Exploratory work was completed at the Lackawanna County Commissioner Site during the morning of January 9, 1986. The unit returned to Chester during the afternoon of January 9, 1986.

RESULTS

The continuous spatial measurements of the GPR appear to afford significant benefits when applied to the evaluation of RAMP sites. This study represented the first attempt by SCS personnel to use GPR techniques to detect and delineate shallow mine cavities.

The probing depth of the radar is related to the conductivity of the earthen material. Admittedly, the physical and mineralogical properties of sedimentary rocks and in particular, coal and shale, restrict the depth of penetration. However, in the areas investigated, depths of 10 to 20 feet were commonly and routinely attained through soil and predominantly sandstone bedrock. While satisfactory for this investigation, the restricted probing depth of the GPR may be a limitation for deeper investigations.

During this initial attempt to define and delineate mining cavities, it was, at times, difficult to identify the graphic signatures of these features. Improved interpretations come with experience. However, several cavities were identified as well as zones of highly fractured bedrock. These features have been identified on the graphic record of this field study.

The area investigated posed several problems to the interpreter. Cavities and tunnels are most easily identified in earthen materials when the medium is relatively homogeneous, the features are relatively large, and the boundary conditions are strongly contrasting. It is easier to define a cavity in a massive, homogenous rock than it is in a thinly bedded, contorted or highly folded rock. In the study areas, multiple reflections from bedding and fracture planes confused interpretations and masked the location of some possible cavities.

The cavity must be of substantial size to create a favorable size to depth ratio. As a general rule, the deeper the feature, the larger its size must be in order for it to be discerned by the radar. This is related to the expanding arc of radiation and the dissipation of the radar's energy with increasing depth. Smaller cavities which may be discernable at shallow depths are often undectable at deeper depths.

The cavity must be electromagnetically contrasting. Generally, the contrast between rock and an air filled cavity is great. However, the cavity may be partially filled with earthen materials and have boundaries that are too transitional or too weakly expressed for the radar to discern. The cavity may have highly irregular walls which complicates the radar image and make interpretations difficult.

Conventional drilling methods, the "classic approach", are expensive and provide absolute information only at the probing site. Drilling sites are limited in number, widely spaced, and provide data on an exceedingly small area and volume of earthen materials. The continuous measurements of the GPR can help to overcome the limitations imposed by conventional drilling methods. The ground-penetrating radar is many times faster, provides high resolution graphic pictures of subsurface conditions, provides greater coverage per unit cost, and is less likely to miss a cavity. With the radar, site assessment can be performed before expensive drilling operations. Reviewing the graphic profile, a minimum number of drilling sites can be selected to provide the maximum amount of information. Risk can be reduced as radar imagery will yield a greater overview of the site and increased levels of confidence.

A complete record of the graphic profiles with explanatory remarks has been returned to Bruce A. Benton, geologist, under a separate cover letter. Kind regards to you and your staff for this opportunity to explore another possible application of the GPR.

James A. Doolittle
Soil Specialist (GPR)

cc:
A. Holland, Director

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