United States Department of Agriculture

Soil Conservation Service

Northeast NTC
160 East 7th Street
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Subject: GPR Field Investigations in Illinois; May 31 - June 2, 1988

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To: Rodney F. Harner
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Purpose:

To evaluate the potential of using ground-penetrating radar (GPR) techniques for soil and geologic investigations in Illinois.

Participants:

Thomas Bicki, Ass't. Professor, U. of Illinois, Champaign, IL
David Brutcher, Illinois St. Geol. Survey, Champaign, IL
Robert Darmody, Ass't. Professor, U. of Illinois, Champaign, IL
James Doolittle, Soil Specialist (GPR), SCS, Chester, PA
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John Sawyer, Manager, Brownstown Res. Station, Brownstown, IL
Stan Sipp, Manager, Sand Farm Res. Station, Kilbourne, IL
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Activities:

The GPR unit travelled from Chester, Pennsylvania, to Champaign, Illinois, on 31 May. On the morning of 1 June, following a working breakfast of the principal participants, GPR field studies were conducted at the Sand Farm Research Station near Kilbourne. On the afternoon of 1 June, GPR field studies were completed at the Brownstown Research Station near Brownstown. Ground-penetrating radar field studies were continued on 2 June: in the morning at Read Lake near Sesser; and in the afternoon, at a landslide site in Chester. After completing field work, the GPR unit departed Chester and travelled to Columbia, Missouri, enroute to Manhattan, Kansas.

Discussion:

Sand Farm Research Station

At the Sand Farm Research Station, soil investigations were confined to areas of Plainfield (mixed, mesic Typic Udipsamments) soils. The purpose of this investigation was to evaluate whether the GPR could detect lamellae and strata which influence the through flow of water within the upper 7.5 meters of the profile. The 500 MHz antenna was used for this study. The velocity of propagation through the upper part of the soil profile was calculated to be 0.402 ft/ns. The scanning time was set at 80 nanoseconds (ns). This scanning time provide a probing depth of about 16.00 feet.

The radar imagery from this site was exceptional and correlated well with ground-truth auger measurements. Unique and identifiable images were discerned for lamellae, finer textured layers, the water table, and buried artifacts. In the areas transected with the GPR, a distinct and continuous zone of lamellae was identified between depths of 3.6 and 10.5 feet. This zone appeared to be variable in expression and composed of dispersed masses and lamellae of finer textured materials within a sandy matrix.

Professor Bicki was encouraged by the results and plans to conduct further research with GPR. Research will be directed toward defining the paths of water infiltration and possible ground water contamination in areas of coarse textured soils. I encouraged Dr Bicki to contact and exchange ideas with Dr Fred Madison of the University of Wisconsin and Dr John Greenhouse of the University of Waterloo (Ontario). These professors are conducting similar research with the GPR.

Brownstown Research Station

The 120 Mhz antenna was used at the Brownstown Research Station to distinguish and characterize mapped areas of Cisne (fine, montmorillonitic, mesic, Mollic Albaqualfs), Hoyleton (fine, montmorillonitic, mesic Aquollic Hapludalfs), and Huey (fine-silty, mixed, mesic Typic Natraqualfs) soils.

During the coarse of field work, it was noted that all soils had fine textured control sections and similar surface textures and colors. These soils appear to have been separated in mapping on the basis of the depth to the argillic horizon and the presence and thickness of an E/Bt horizon. Areas mapped as Huey soils had a noticeably thinner surface layers (< 16 inches) but lacked morphological evidence of natric properties.

The velocity of propagation through the upper part of these soils was calculated to be 0.24 ft/ns. The scanning time was set at 50 ns. This scanning time provide a probing depth of about 6.00 feet. However, fine

textured argillic horizons rapidly attenuated the radar signals and restricted the depth of profiling to the upper part of the subsoil. Within the areas surveyed with the GPR, the argillic horizon varied in depth from 13 to 27 inches.

Though restricted in profiling depth, the GPR distinguished areas delineated on the detailed soil survey map of the research station. Areas of Cisne soils were discriminated on the radar profiles on the basis of their abrupt textural boundary (A/Bt) which strongly reflected the transmitted electromagnetic energy. This strong reflection resulted in an exceptionally black and continuous interface image. Hoyleton soils have a relative thick (6-8 inch) transitional E/Bt horizon. This layer represents a weak electromagnetic gradient and produced a less intense, gray interface image. Areas of Huey soils were identified on the radar profiles by relatively shallow or the absent of reflections from the argillic horizon. It had been anticipated that the high concentrations of soluble salts in the Huey soil would attenuated the radar signal and produce higher levels of background noise. No increase in the levels of background noise was observed in areas of Huey soils.

Rend Lake Site

At the Rend Lake Site, the use of the GPR for determining the depth to bedrock and the water table, and for defining stress features within the soil profile was evaluated. Transects were conducted in areas of Bluford (fine, montmorillontic, mesic Aquic Hapludalfs) soils. The 500, 250, and 120 MHz antennas and various processing techniques were used unsuccessfully at this site. High rates of signal attenuation limited the profiling depth to the upper part of the argillic horizon. The velocity of propagation through the upper part of these soils was calculated to be 0.185 ft/ns.

Results from the Rend Lake site were most discouraging. The radar has limited applications in the fine textured Bluford soils. None of the desired features was clearly expressed or recognized on the radar profiles. However, at this study site, the radar was used successfully to determine and define the thickness of fill materials with the subsidence areas.

Chester Landslide Site

A landslide had occurred along the loess covered bluffs to the Mississippi River causing structural damage to a house in Chester, Illinois. The site was selected to test the efficiency of using GPR techniques for determining the depth to bedrock and the thickness of loess, and for defining slippage planes within the landslide area.

Previous studies in loess revealed severe rates of signal attenuation and restricted probing depths. The radar was ineffective at the Chester landslide site. A seismic survey was conducted by Dr Darmody at this site and provided data on the depth to bedrock and the thickness of loess.

Results:

Illinois is recognized as a state having generally unfavorable soil conditions for the use of GPR techniques. However, some areas of this state have favorable soil environments for the use of GPR techniques. Results from the Sand Farm Research Station have encouraged further interest and possible use of GPR techniques within Illinois. The studies at the Brownstown Research Station demonstrated the radars potential for defining soils and estimating the composition of map units. Results from Rend Lake and Chester have fostered a greater appreciation for the limitations of GPR techniques within Illinois.

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