United States Department of Agriculture

Soil Conservation Service

Northeast NTC
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Subject: SOI - Ground-penetrating Radar (GPR) Field Study in Idaho; September 17-20, 1986

Date: October 15, 1986

To: Stanley N. Hobson
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File code: 430

PURPOSE

To explore the potential of using ground-penetrating radar to characterize selected soils in Idaho and to acquaint field and staff soil scientist with GPR techniques.

PARTICIPANTS

Peter Biggan, Soil Scientist, SCS, Lewiston, ID
James Doolittle, Soil Specialist (GPR), SCS, Chester, PA
Tom Hahn, Party Leader, SCS, Lewiston, ID
Doug Harrison, Soil Specialist, SCS, Boise, ID
Mark Keller, Soil Scientist, SCS, Orofino, ID
Larry Wright, Soil Scientist, SCS, Lewiston, ID

EQUIPMENT

The radar unit is the SIR System-8. Components of the SIR System-8 include the Model 4800 control unit, the ADTEK DT-6000 tape recorder, and the Model 8004H graphic recorder. The 80 and 120 MHz antennas were used interchangeably with the Models 705, 705DA, and 705DA2 transceivers. The high electrical conductivities of the selected soils severely limited the depth of penetration of both antennas. However, the 120 MHz antenna with the Model 705 transceiver provided the best balance of probing depth and image resolution. The surface layers of the selected soil absorbed and reflected large amounts of the applied electromgenetic energy. Surface reflections often masked near surface features when pulses of greater amplification were applied through the Model 705DA and 705DA2 transceivers. The Model 705 transceiver produced greater clarity of near surface features with no apparent reduction in probing depth.

The tape recorder continued to skip data and its use was discontinued. With this exception, the equipment operated well.

ACTIVITIES

The radar unit arrived in Lewiston on the morning of 17 September. Field studies were conducted in the Lewiston area on 17 and 18 September and in the Orofino areas on 19 September. The unit was relocated to Boise on

the night of 19 September. On 20 September, graphic profiles collected during the field studies were submitted to image analysis techniques. The radar unit departed Idaho on the morning of 21 September.

RESULTS

Compared with other areas of the United States, the potential for successful GPR applications in Nez Perce, Lewis, and Clearwater counties is low. With the GPR, success is measured first, in terms of its effective probing depth, and second, by the quality of results. Areas blanketed by loess in western Idaho and eastern Oregon and Washington have high effective ground conductivities which rapidly dissipate the radar signals and severely limit the probing depth of the GPR. Generally, interpretable radar images of soil or geologic features were limited to either the upper 30 inches of the profile or to the upper part of the argillic horizon.

During this brief study, the GPR was used on a wide variety of soils which included Bryden (fine-silty, mixed, mesic Typic Durixerolls), Endicott (coarse-silty, mixed, mesic Haplic Durixerolls), Johnson (fine-loamy, mixed, frigid Ultic Argixerolls), Kruse (fine-loamy, mixed, frigid Ultic Haploxeralfs), Latahco (fine-silty, mixed, frigid Argiaquic Xeric Argialbolls), Nez Perce (fine, montmorillonitic, mesic Xeric Argialbolls), Reggear (fine-silty, mixed Typic Fragiboralfs), Spokane (coarse-loamy, mixed, mesic Ultic Haploxerolls) and Uhlorn (fine-silty, mixed, mesic Ultic Argixerolls). Multiple transects were completed in areas of each soil with various combinations of antennas, transceivers, and control settings. Objectives of field work were to optimize the depth of penetration and to produce the clearest and most interpretable radar imagery.

While the effective depth of penetration was restricted, significant and meaningful information was obtained with the radar at each site. In an area of Bryden and Endicott soils, the GPR was used to determine the proportion of each soil along transect lines. The radar determined the presence and extent of Bryden soils, which had natric horizons and cloddy and dispersed surface layers. High concentrations of sodium salts in the surface layers produced a grayer, more diffused image. This work represented the first opportunity for SCS field specialists to explore the GPR's potential in areas of sodium affected soils. The GPR also provided meaningful information concerning plow pan development and/or moisture gradients in cultivated areas of Bryden and Endicott soils.

The presence of an albic horizon and an abrupt textural change is used in the field to distinguish Nez Perce from Uhlorn soils. These features were manifested on the radar's graphic profiles. Abrupt and contrasting horizon boundaries reflect greater amounts of radar energy and produce darker images on graphic profiles than do gradational or more transitional horizon boundaries. On the basis of this principle, areas of Nez Perce were distinguished from areas of Uhlorn soils. Within the study sites, proportions varied from 75-percent Nez Perce and 25-percent Uhlorn soils to 75-percent Uhlorn, 17-percent Latahco, and 8-percent Nez Perce soils.

In areas underlain by saprolite, the soil/bedrock interface is often too gradational for the radar to discern. However, with optimal antenna selection and control setting adjustments, it is often possible to chart this interface. In an area of Johnson soils, relatively unweathered bedrock was charted to depth or more than 10 feet. However, this observation was the exception rather than the rule in this area of predominantly soft, disintegrated bedrock. Typically, the image of the soil/saprolite interface was less clear and its interpretation more questionable.

The graphic recorder is a gray-scale recorder which prints images in seven shades ranging from light gray to black. During this field trip, the compatibility of image analysis and GPR techniques was explored.

Interpretations and quantification of GPR data can be significantly improved and increased through image analysis processes. As an experiment, the image of an argillic horizon was successfully partitioned into segments varying in texture, moisture, or density.

This field study provided an opportunity for field and staff soil scientists to observe, understand, and evaluate a relatively new geophysical tool. Their impressions of the GPR are important to the direction of radar development and use in SCS.

Annotated copies of the graphic profiles have been returned to Doug Harrison under a separate cover letter.

I wish to extend my appreciation for the spirited cooperation and enthusiasm that members of your staff extended to me.

With kind regards.

JAMES A. DOOLITTLE
Soil Specialist (GPR)

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