United States Department of Agriculture

Soil Conservation Service

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

Subject: SOI - Ground-penetrating Radar (GPR) Field Study - Niobrara County, Wyoming; September 28-30, 1986

Date: October 20, 1986

To:

Frank S. Dickson, Jr.
State Conservationist
Soil Conservation Service
Casper, Wyoming 82601

File code: 430

PURPOSE

To explore the potential of using ground-penetrating radar (GPR) to characterize soil features in eastern Wyoming.

PARTICIPANTS

Bob Baumgartner, Area Range Conservationists, SCS, Torrington, WY
Jim Doolittle, Soil Specialists (GPR), SCS, NENTC, Chester, PA
George Hartman, State Soil Scientist, SCS, Casper, WY
Gordon Kee, Party Leader, SCS, Lusk, WY
Stan Mitchem, Geologist, SCS, Casper, WY
Ed Rapp, Soil Conservation Tech., SCS, Lusk, WY
Paul Shields, Soil Scientist, SCS, Wheatland, WY
Abe Stevenson, Soil Scientist, SCS, Cheyenne, WY
James Westerman, Soil Scientist, SCS, Lusk, WY

Equipment:

The radar unit is the SIR System-8. Components of the SIR System-8 include the Model 4800 control unit, the ADTEK Model DT-6000 tape recorder and the Model 8004H graphic recorder. The ADTEK Model DT-6000 tape recorder was malfunctioning and was not used. The 120 MH_z antenna with the Models 705DA and 705DA2 transceivers was used.

DISCUSSION

The soils examined during this field trip include Draknab (sandy, mixed, mesic Ustic Torrifluvents), Recluse (fine-loamy, mixed, mesic Aridic Argiustolls), and Savageton (fine, montmorillonitic, mesic Ustollic Camborthids). In areas of coarse textured Draknab soils, the GPR provided clear, consistent, and interpretable imagery of soil and

stratigraphic features to depths of 1.5 meters. However, in areas of medium and moderately-fine textured Recluse soils, the imagery was less clear and was restricted to depths of less than 16 inches. Features evident on graphic profiles of Recluse soils include strong surface reflections (which often masked near surface soil features), and near surface features relating to differences in moisture, consistency, and/or density.

The GPR was exceedingly depth restricted in selected areas of loamy and clayey soils within Niobara County. The maximum probing depth of the GPR is determined by the electrical conductivity of earthen materials. Soils having high electrical conductivities rapidly absorb the radar's energy and severely limit the radar's probing depth. The electrical conductivity of soils increase with moisture, the concentration of dissolved salts in the soil solution, and the amount and type of clays.

Conductivity is essentially an electrolytic process that takes place through moisture-filled pores. As the soil becomes more saturated, the rate of signal attenuation increases and the probing depth is restricted. The selected soils were, compared with soils examined in Utah and Idaho, relatively moist. However, it is doubtful that the probing depth of the GPR would be significantly improved by returning to the selected sites during a drier period.

The conductivity of soils is proportional to the total number of ions in solution. Calcium carbonate is a conspicuous component of the soils within Niobara County, and restricts the radars probing depth.

Ions absorbed on the surface of clay particles can become partially dissociated or exchanged, and contribute to the conductivity of soils. Expanding 2:1 lattice clays, having higher exchange capacities than 1:1 lattice clays, exhibit high electrical conductivities and are more restrictive to the radar.

RESULTS

This study has contributed to our knowledge of where and under what conditions the GPR will and will not perform well. The present GPR system is poorly suited for soil and on-site engineering or geologic investigations in most areas of Niobara County. High concentrations of carbonates and the prevalence of 2:1 expanding lattice clays adds to the electrical conductivity of soils and severely restricts the probing depth and the effectiveness of the GPR in fine and moderately-fine textured soils.

The GPR is suitable for the investigation of coarse textures soils. However, these soils comprise a minor proportion of the acreage in Niobara County and are generally restricted to flood plains. These soils often contain strata of finer texture materials which restrict the probing depth of the GPR to the upper 1.5 meters of the profile.

This field study has provided an opportunity for field and staff specialists to observe and evaluate the performance of the GPR on selected soils within Wyoming. Their impressions of the radar are beneficial for the proper evaluation and direction of GPR within SCS.

An annotated record of the graphic profiles has been returned to George Hartman under a separate cover letter.

I wish to convey my appreciation to members of your staff for their spirit, cooperation, and enthusiasm.

With kind regards.

JAMES A. DOOLITTLE
Soil Specialist (GPR)

cc:
A. Holland, Director, NENTC, Chester, PA
T. Shiflet, Director, MWNTC, Lincoln, NE
R. Arnold, Director Soil Survey Division, NHQ, Washington, DC

JADoolittle/ef