United States Department of Agriculture
Soil Conservation Service

Northeast NTC
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Subject: SOI - Ground-Penetrating Radar (GPR) Field Studies; August 4-16, 1986

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To: Eugene E. Andreuccetti
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PURPOSE

To demonstrate, explore, and assess the potential of using ground-penetrating radar in California.

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EQUIPMENT

The equipment used during this field study was the SIR System-8 with the ADTEK SR-8004H graphic recorder and the ADTEK DT-6000 tape recorder. The 80, 120, and 300 MH_z antennas were used at various times and under differing soil conditions. The 120 MH_z antenna, with either the 705DA or the 705DA2 transceiver consistently provided the greatest probing depths and the best resolution of subsurface features, and is the preferred unit. The radar operated well with no observed malfunctions.

ACTIVITIES

The GPR was used to investigate the depths to meta-sedimentary materials near the town of Challenge in Yuba County on August 4 through 6. The unit was relocated to Stockton on the afternoon of 6 August. During the period of August 7 through 14, GPR techniques were evaluated on a wide diversity of soils in San Joaquin County. On 15 August, the GPR was used to chart the depth to bedrock in the area of Lake Tahoe. This trip report was completed on 16 August. The unit left California for Oregon on 17 August.

DISCUSSION

General rules of radar application learned in Eastern states apply to California. The probing depth of the GPR and the quality of the graphic images are influenced by the amount of water, clay, and salts in the soil. As these factors increase (alone or in combination) in soils, the probing depth of the radar is restricted and the quality of the graphic image is lessened.

This study represents the first occasion for SCS to operate the radar in a xeric moisture regime. At the time of this field study, the soils were unquestionably dry. Results obtained during this field study may not be repeatable during the moister, winter months. The effects of soil moisture will be more limiting during the winter months especially in areas of moderately-fine and fine textured soils.

The proportion of clay and the type of clays within the soil determines the probing depth of the GPR. As a general rule, the lower the clay content the greater the depth of radar penetration. During this field study, the effective probing depth of the GPR ranged from 10 to 24 feet in coarse textured soils to less than 3 feet in most moderately-fine and fine textured soils. These results are comparable with results obtained from other areas of the country.

The GPR is not only influenced by the amount of clay within the soil, but also by the types of clay. The relatively high proportion and amounts expanding 2:1 lattice clays, in particular smectites, in the San Joaquin Valley, limit the probing depth of the GPR to depths of less than 3 feet in many areas.

This trip provided SCS with its first opportunity to operate the GPR in an area of clayey soils having an oxidic mineralogy. In areas of Sites (clayey, oxidic, mesic Xeric Haplohumults) soils the radar effectively and consistently probed to depths of 17 feet. The relatively high proportion of low activity clays within Sites soils is responsible for this most remarkable depth of penetration with the radar.

The probing depth of the radar and the quality of the graphic images are related to the amounts of salts in the soil. It was observed in this study that probing depths were more restricted and the imagery was more diffused and blurred in areas having recent applications of fertilizer.

In an area of Tinnin (sandy, mixed, thermic Entic Haploxerolls) soils, probing was restricted to depths of less than 5 feet along the borders to corn fields while depths greater than 10 feet were recorded within a vineyard. It is assumed that the former area had either been more heavily or recently fertilized, or had been fertilized with a more limiting chemical (to the radar) than the latter area.

During this field trip, the GPR was used on a wide variety of soils. Included in this study were areas of Cometa (fine, mixed, thermic Typic Palexeralfs), Delhi (mixed, thermic Typic Xeropsamments), DeVries (coarse-loamy, mixed, thermic Typic Duraquolls), Hedge (fine-loamy, mixed, thermic Haplic Durixeralfs), Montpellier (fine-loamy, mixed, thermic Typic Haploxeralfs), Pentz (loamy, mixed, thermic, shallow Ultic Haploxerolls), Redding (fine, mixed, thermic Abruptic Durixeralfs), Rindge (euic, thermic Typic Medisaprists), Rocklin (fine-loamy, mixed, thermic Typic Durixeralfs), Sites (clayey, oxidic, mesic Xeric Haplohumults), Tinnin (sandy, mixed, thermic Entic Haploxerolls), and Veritas (coarse-loamy, mixed, thermic Typic Haploxerolls) soils.

The GPR provided interpretable imagery at all but the Rindge site. Rindge are organic soils that contain as much as 55 percent clay. The high clay content and alkaline conditions of this soil restricted the effective probing depth of the radar to less than 3 feet. In most areas of Rindge soils examined with the GPR, the depth to the organic/mineral contact was deeper than 3 feet.

In moderately-fine and fine textures soils the effective probing depth of the GPR is less then 3 feet or to the argillic horizon. Compared with results from coarser textured soils, these depths are limiting but not discouraging. Useful information can be gleaned from the graphic profiles of fine and and moderately-fine textured soils. Where present, the GPR charted the depth to, lateral extent, and variability of the argillic horizon. The GPR detected traffic pans; duripans; differences in consistency, texture, and density; areas of contrasting soils; soil stratigraphic relationships; and buried artifacts such as irrigation pipes or conduits and utility lines. In the upper part of some soils, the GPR was able to discern horizons having absolute differences in clay content of as little as 6 percent or differences in consistency of from slightly hard to hard.

Except in soils lacking an argillic horizon or having a thin, finer textured layer (less than 1 inch thick), duripans were seldom observed on graphic profiles. In fine and moderately-fine textured soils, the high clay content of argillic horizons absorbs so much of the radar's energy that little remains to reflect off of a duripan. However, duripans and argillic horizons were observed alone or together in some areas. As duripans and argillic horizons have distinct and identifiable graphic signatures, these features can be distinguished on graphic profiles.

RESULTS

Ground-penetrating radar (GPR) technology has been introduced into the West Region. This field study has provided an opportunity for field and staff specialist to observe and evaluate the radar's performance on selected soils within California. I have been encouraged by their enthusiasm and receptiveness. If motivation alone is the key for the radar's success, I doubt that it would fail among those who participated in this study.

The "Great Valley" of California, because of its high effective ground conductivities, is recognized as one of the most inhospitable environments for the use of GPR. As an area, the valley has perhaps the lowest potential in California for deep probing with the GPR. In fine and moderately-fine textured soils the probing depth of the radar is restricted to the argillic (Bt) horizon or to depths of less than 3 feet. However, even in these soils, the GPR provided detailed and meaningful information concerning soil features occurring within the upper part of the profile. As the clay content of the soils decrease, the depth of penetration increased to about 24 feet in areas of sandy soils.

California is too large and diverse a state for GPR techniques not to work exceptionally well (in terms of depth penetration) in some areas. In the Sierra Nevada Mountains, along the shores of Lake Tahoe, the radar probed to depths of 15 to 24 feet and charted the depth to and the topography of the bedrock surface. Along the foothills of the Sierra's GPR probed to depths of 17 feet in areas of fine textured soils which are dominated by low activity clays. These depths are astonishing and will undoubtedly have consequences for the use of GPR techniques in areas of highly weathered soils.

This trip has demonstrated that the radar can be used effectively in California. Further use of GPR technology will depend upon need, applications, and program development.

An annotated record of the graphic profiles has been returned to Ron Hoppes and each of the soil survey party leaders under a separate cover letter.

A special thanks is extended to Dennis Lytle and Mike McElhiney for their thorough preparation for this trip. The sites which they selected were representative of the diversity of the area and served as an excellent basis upon which to evaluate the radar's performance.

With kind regards.

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