United States Department of Agriculture

Soil Conservation Service

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

Subject: SOI - GPR Plow Pan Study - Presque Isle, Maine; May 6-10, 1985

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To: Ronald E. Hendricks
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PURPOSE

To explore the potential of using Ground-Penetrating Radar (GPR) to detect the presence and measure the development of plow pans in a dominant soil of Aroostook County.

PARTICIPANTS

Richard Babcock, State Soil Scientist, SCS, Orono, ME
James Doolittle, Soil Specialist (GPR), SCS, Chester, PA
Robert Joslin, Assistant State Soil Scientist, SCS, Orono, ME
Ronald Olson, Soil Scientist, SCS, Presque Isle, ME
James Park, Technician, Central Aroostook SWCD, Presque Isle, ME
Robert Rourke, Senior Soil Scientist, University of Maine, Orono, ME
Mike White, District Conservationist, SCS, Presque Isle, ME

Equipment

The equipment utilized during this field study was the SIR System-8, the ADTEK SR-8004M graphic recorder, and the ADTEK DT-6000 tape recorder. Although the 120 MH_z antenna provided the best imagery, calibration trials were also conducted with the 80 and 300 MH_z antennas. The equipment, completing its first month of field tests, operated well with the exception of the 80 MH_z antenna and the high power, model 765HP transmitter. The 80 MH_z antenna produced poor quality graphic images and appeared to be extremely depth restricted. The model 765HP transmitter produced high levels of background noise which obscured the imagery of the desired signals. Both units were overhauled the following week by the manufacturer in New Hampshire. The 80MH_z antenna had a bad resistor and separated antenna plates; the high power, model 765HP transmitter was incompatible with current antenna configurations and was replaced with a newly modified system.

ACTIVITIES

Test plots were selected prior to the arrival of the GPR. Each plot varied in management treatments. Plots had been prepared with moldboard plow, offset disc, chisel plow (twisted or straight shanks), or left untilled. Initial field trials were conducted at the Maine Agricultural

Experiment Station's test plots, adjoining fields, and neighboring farms on May 7 and 8. During this period, the equipment was calibrated and antennas were selected.

Snow and inclement weather slowed field work on May 7 and 8. Multiple transects were conducted on Central Aroostook Soil and Water Conservation Districts demonstration plots on May 9. During the morning of May 10, a final review of the field work was conducted in the field office. All graphic profiles have been labeled and returned to Bob Joslin.

DISCUSSION

The GPR is a broad bandwidth impulse radar system that has been specifically designed to penetrate earthen materials. Relatively high frequency, short duration pulses of energy are transmitted into the ground from a coupled antenna. When a pulse strikes an interface (boundary) separating layers of differing electromagnetic properties a portion of the pulse's energy is reflected back to the receiving antenna.

Each interface reflects energy which is displayed as dark bands on graphic profiles. These bands, often appearing in groups of three, are reflections from a single interface between two materials. The multiple bands are caused by oscillations in the reflection of the pulse. This oscillation or banding limits the ability of the GPR to distinquish (to display) closely spaced interfaces. Accordingly, it was considered improbable that the GPR could define a feature, such as the plow pan, that was near and closely paralleled the ground surface.

Strong reflections from the ground surface are superimposed upon and obscure the initial reflections of the plow pan. When reflections from two interfaces are superpositioned, the resulting image is a composite of the additive or subtractive interference patterns. In the enclosed figure, the distinct "whiteout" zone immediately below the strong images of the ground surface is caused by signal interference and cancellation.

It is believed that the plow pan is not completely obscured by the strong surface reflections. The lowermost band caused by oscillations in the reflection from the plow pan is believed to be expressed immediately below the "whiteout" zone. If this assumption is true, signature and intensity (lightness or darkness) of this band can be used to measure the expression or development of the plow pan.

The ground-penetrating radar has not been used extensively to investigate plow pans. Observations made in Alabama and Florida on the radar's potential application to traffic pan or plow pan studies are inconclusive. Unfortunately, the GPR has been accepted by most manufacturers and researchers as being a relatively poor tool for investigating surface and near surface features of soils. Although the GPR has been used successfully to locate shallow, buried artifacts such as utility lines, cables, and foundations; these features, unlike plow pans, often represent strongly contrasting reflectors of electromagnetic energy and are more clearly expressed on most graphic profiles.

During the first day of field experimentation with the GPR, no consistent pattern of plow pan expression was observed. Following antenna selection and optimalization of range, gain, and filtration settings on the control unit, results improved. Several experiments were conducted with the GPR to confirm the imagery of the plow pan. These experiments included running radar traverses over buried reflectors (metal pipes or shovel blades), pits exhumed to or through the plow pan, and filled pits.

It was concluded from these experiments that the GPR provides a measurable image representing either a single near-surface feature, the plow pan, or a composite of surface and near-surface features. Differences in the expression of this image are evident on graphic profiles and appear to conform with and be distinguished by applied methods of cultivation (see enclosed figure). This observation is the most intriguing and points to the need for further studies.

The use of the GPR to detect the presence and measure the expression of plow pans requires further research and applications. If the banded image is the plow pan, the intensity of expression is dependent upon the absolute and relative degree of compaction, the moisture state of the upper part of the soil profile, and recent management practices. Assumptions will have to be made concerning the uniformity of surface and near surface soil conditions. In order to more fully appraise the graphic profiles, ground-truth sampling must be carried out in conjuncture with GPR operations.

Bob Joslin proposed that the graphic profiles be grouped and compared according to both landscape position and management practices. Hopefully, his discerning eye will catch some meaningful patterns of variation. I will research the possibility of using densing slicing technique to group the subtle variations in the profiles gray scale. Hopefully, with more ground-truth information we can relate the intensity (lightness or darkness) of the graphic imagery with pan development.

My sincerest appreciation is extended to the participants for their enthusiasm and cooperation in the field.

James A. Doolittle
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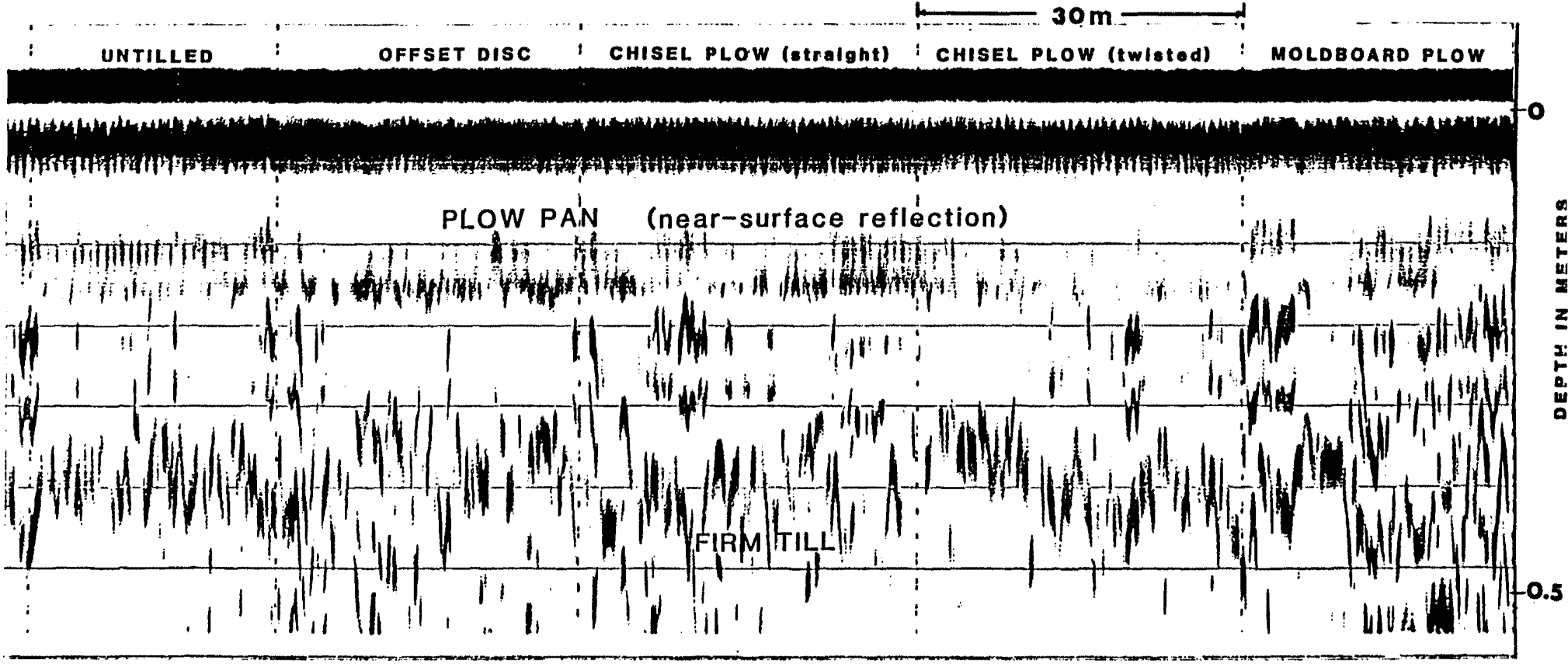
Enclosure

cc:
A. Holland
F. Miller
R. Babcock
R. Rourke

JADoolittle/kmg



GRAPHIC PROFILE FROM A CULTIVATED AREA OF CARIBOU SOIL

FINE-LOAMY,MIXED,FRIGID TYPIC HAPLORTHODS