United States Department of Agriculture

Soil Conservation Service

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

ject: SOI - Ground-Penetrating Radar (GPR) Field Studies in Kentucky; November 3-9, 1985

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333 Waller Avenue, Room 305
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File Code: 430

PURPOSE

To field test the ground-penetrating radar and evaluate the system's performance and potential applications on minespoils and soils of northwest Kentucky.

PRINCIPAL PARTICIPANTS

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EQUIPMENT

The radar unit is the SIR-System 8 with the ADTEK SR-8004H graphic recorder and the ADTEK DT-6000 tape recorder. Although the 80, 120, and 300 MH_z antennas were used in this field study, the 120 MH_z antenna provided the best balance of depth of penetration and resolution of soil features.

The equipment operated well with the exception of the model 30 program control unit (microprocessor) which was inoperative.

ACTIVITIES

The GPR unit travelled from Chester, PA, to Lexington, KY, on November 3, 1985. On the 4th of November, the unit was demonstrated before SCS staff and University of Kentucky faculty and students at Spindletop Research

Farm near Lexington. The unit was relocated to Owensboro during the evening of November 4. On November 5 and 7, areas of reclaimed coalfields were investigated in Hancock and Mclean, and in Muhlenberg County, respectively. On November 6 and 8, the potential of the GPR on soils formed in loess over residuum and bedrock was assessed in Breckenridge County. The GPR unit returned to the NENTC during the night of November 8.

Rain and inclement weather delayed and hampered field activities on November 4 and 7. Wet field conditions restricted the number of accessible sites, mired the 4WD vehicle, diluted the soils electromagnetic gradients, and weakened the reflected radar signals.

DISCUSSION

Prior to the field work on reclaimed coalfield areas, expectations were high that the GPR would detect the contact between the reworked "topsoil" and the underlying minespoil materials. In most areas, this contact is abrupt and separates materials of highly contrasting properties (coarse fragments, particle-size, mineralogy, bulk density, etc.).

GPR results from the reclaimed coalfield sites were disappointing. The GPR failed to discern the contact separating the reworked topsoil from the minespoil. This failure was unexpected and attributed to: 1) wet field conditions (moisture weakens electromagnetic gradients and reduces reflection coefficients across interfaces); 2) similarities in the electrical properties of the two materials; 3) rapid rates of signal attenuation in the reworked topsoil material; 4) improper antenna selection or control adjustments; and/or 5) design limitations of the present GPR system.

Figure 1 is representative of the graphic profiles obtained at the reclaimed coalfield sites. Depth of signal penetration is generally less than one meter. Interfaces apparent in the upper part of the profile result from the differential compaction or layering of the reworked topsoil and the presence of point objects (multiple, vertically aligned, hyperbolic patterns) such as rocks or metallic artifacts. It is probable that the image of the topsoil/spoil contact has been masked by superpositioning of near surface signals.

The GPR provided interpretable and usable data in areas of Baxter (fine, mixed, mesic Typic Paleudalfs), Johnsburg (fine-silty, mixed, mesic Aquic Fragiudalfs), Sadler (fine-silty, mixed, mesic Glossic Fragiudalfs), and Zanesville (fine-silty, mexed, mesic Typic Fragiudalfs) soils. In these soils, for soil and geologic features, the effective depth of signal penetration is slightly greater than two meters. In similar loessial soils in west Tennessee, southwest Wisconsin, and southeast Minnesota, the effective depth of signal penetration was less than one meter. Undoubtedly, the source area, grain-size distribution, and/or mineralogy of the loess is more conducive to a GPR response in this, the most [illegible] of the aforementioned sites.

In figure 2, from an area of Sadler soils, the GPR has detected the presence and traced the lateral extent of the argillic horizon, the fragipan, and the underlying bedrock. In Sadler soil, the depth to bedrock ranges from 50 to 100 inches. The occurrence of included areas of moderately deep soils was greater than expected.

In figure 2, the fragipan is uniform in depth and expression. Experience has attested, that, with drier soil conditions, the image of the fragipan will become more expressed. Regardless of temporal variations in soil moisture, areas of Glossic Fragiudalfs can be separated on the radar imagery from areas of Typic Fragiudalfs. Soils of the glossic subgroup had E/B horizons separating the argillic horizon from the fragipan. The E/B horizon is a transitional horizon having recognizable properties of master horizons. This transitional horizon weakens the electromagnetic gradient separating the argillic horizon from the fragipan and produces a weak reflection and gray image. In areas of Typic Fragiudalfs this transitional horizon is not developed and the electromagnetic gradient is more abrupt. In areas of Typic Fragiudalfs this interface produces a strong reflection and a more pronounced (darker) image.

Figure 3 is from an area of karst topography. The GPR has effectively traced the irregular depth to the fine textured residuum (highlighted by a green line). The GPR provides an effective means to trace lateral variations in the depth to the residuum and to determine map unit composition.

RESULTS

This trip will be remembered not on the basis of how well the GPR performed on the investigated soils, but on how poorly it functioned on the reclaimed coalfield sites. Drier field conditions, operator experience, and modification of equipment design will undoubtedly improve the performance of the GPR on reclaimed coalfield sites. The GPR has unquestionable merits as a rapid reconnaissance tool for measuring and monitoring compliance with reclamation regulations. The trick is to make it work. Toward this goal, efforts will be expended.

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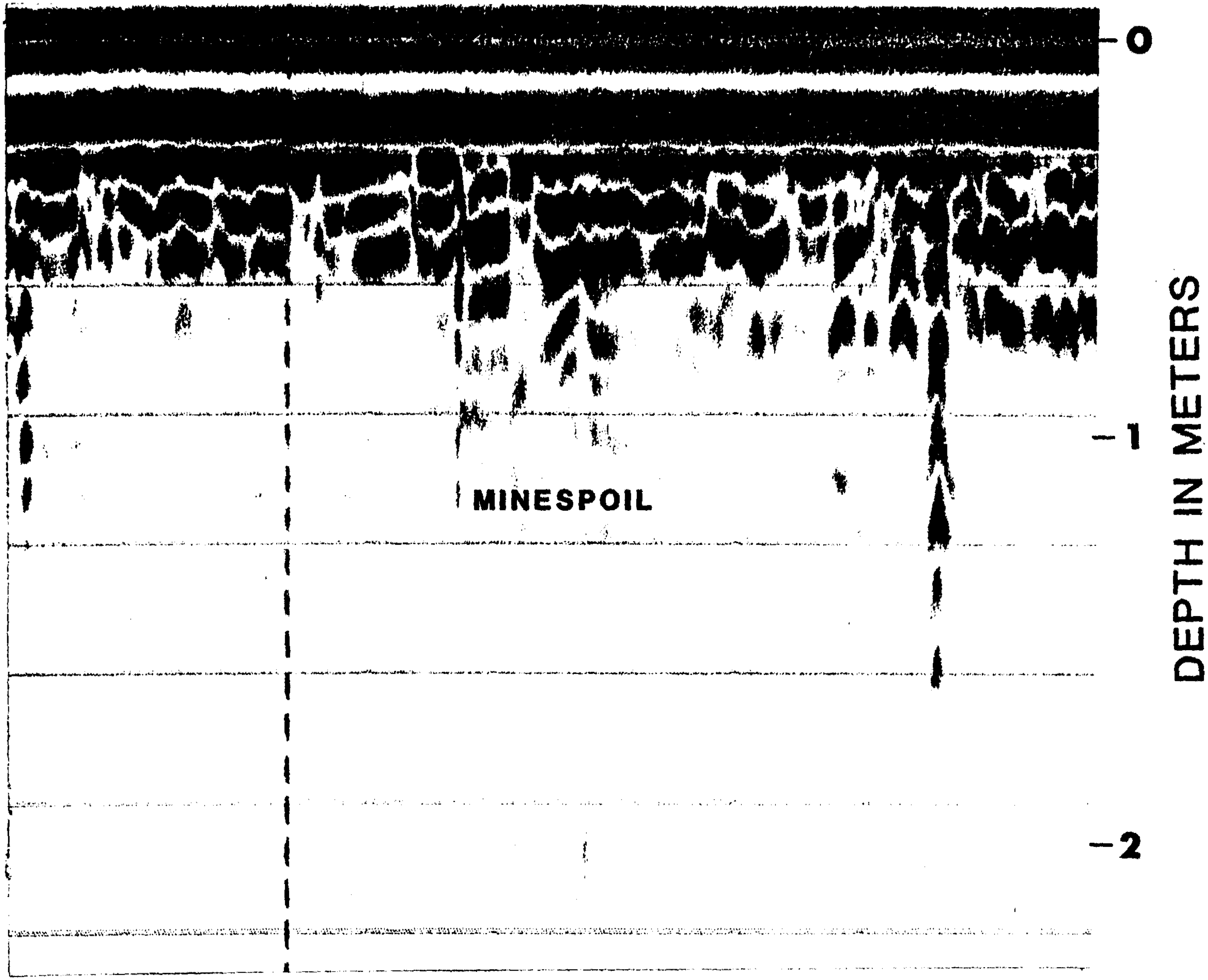
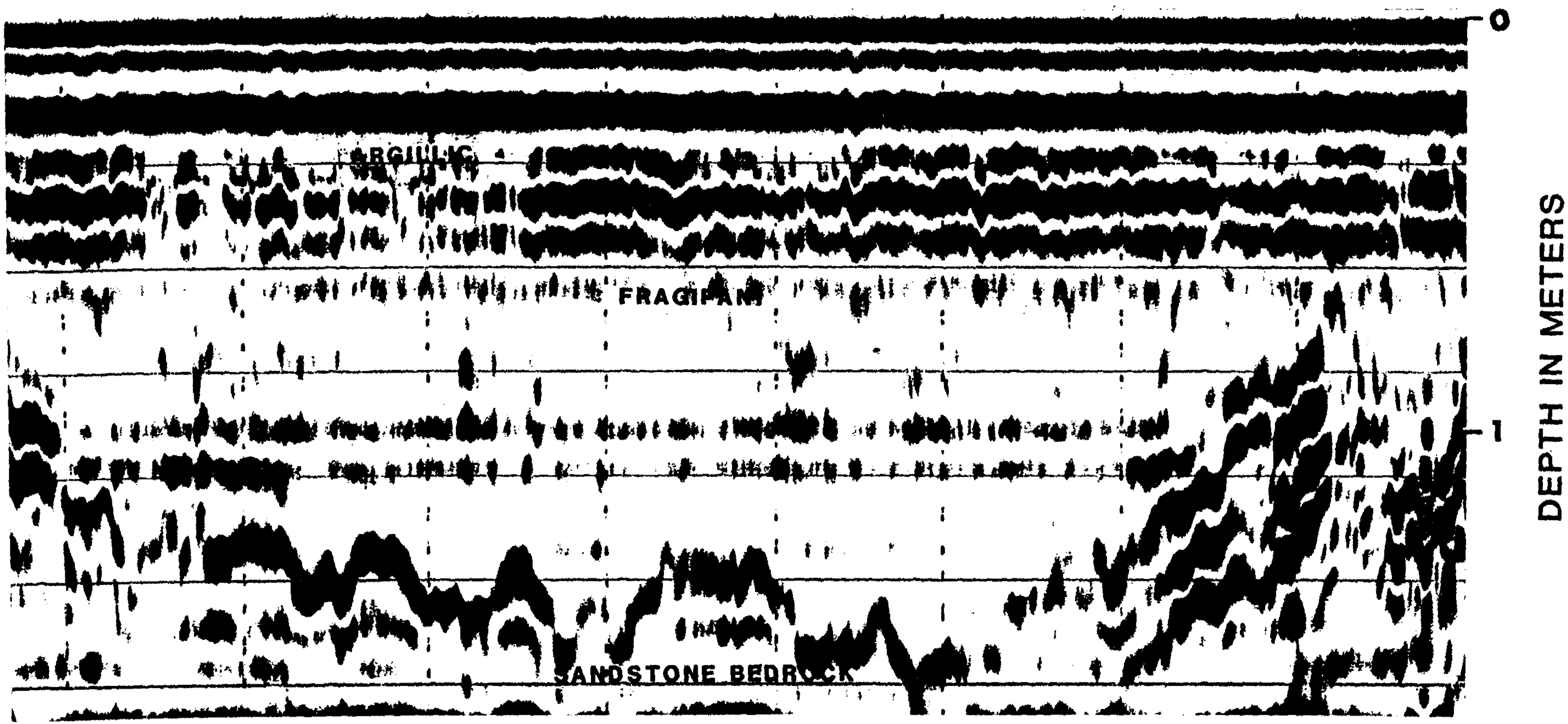
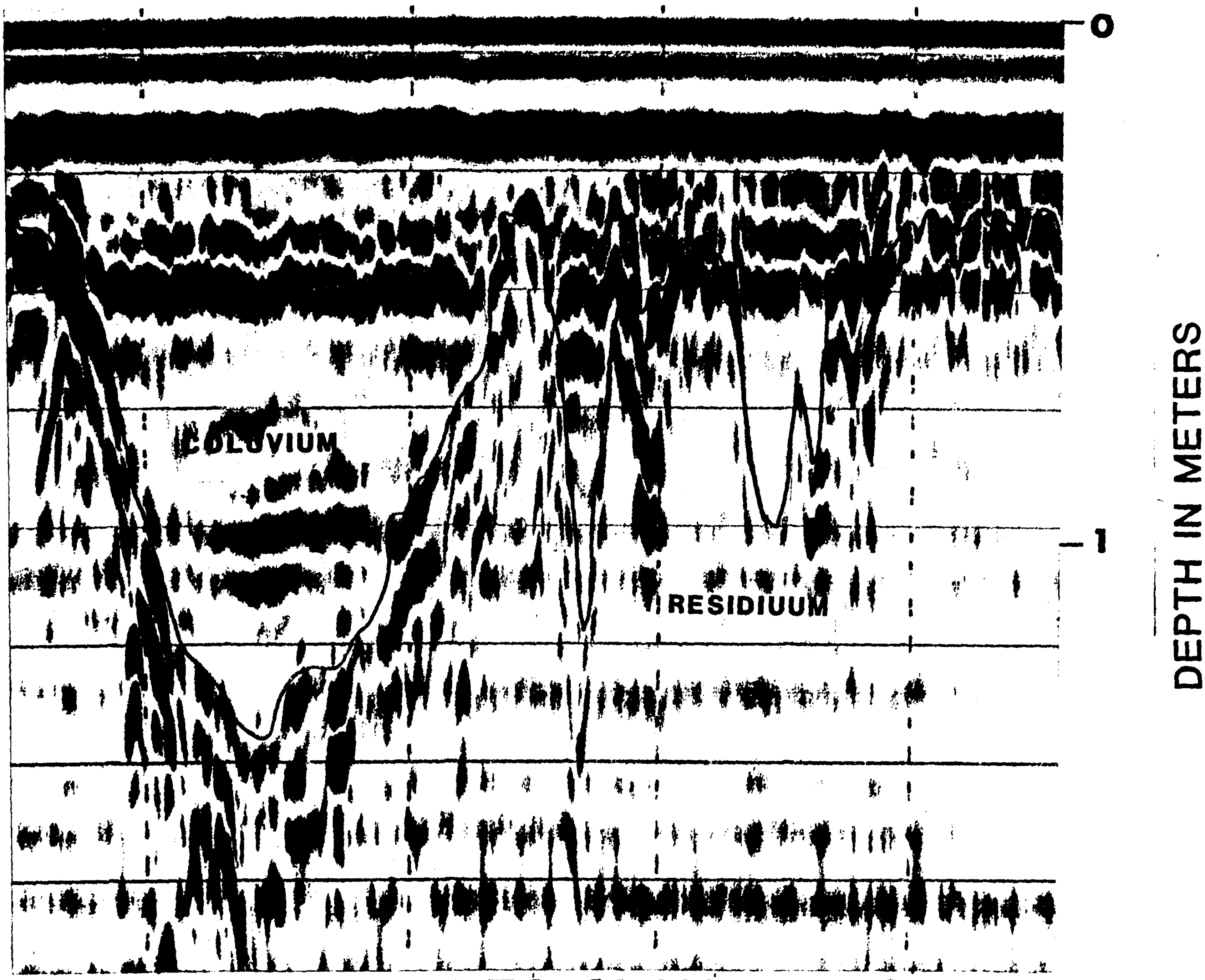


GPR PROFILE OF A RECLAIMED COALFIELD SITE



GPR PROFILE FROM AN AREA OF SADLER SOILS

(fine-silty, mixed, mesic Glossic Fragiudalfs)



VARIABLE DEPTH TO CLAYEY RESIDUUM
IN AN AREA OF BAXTER SOILS